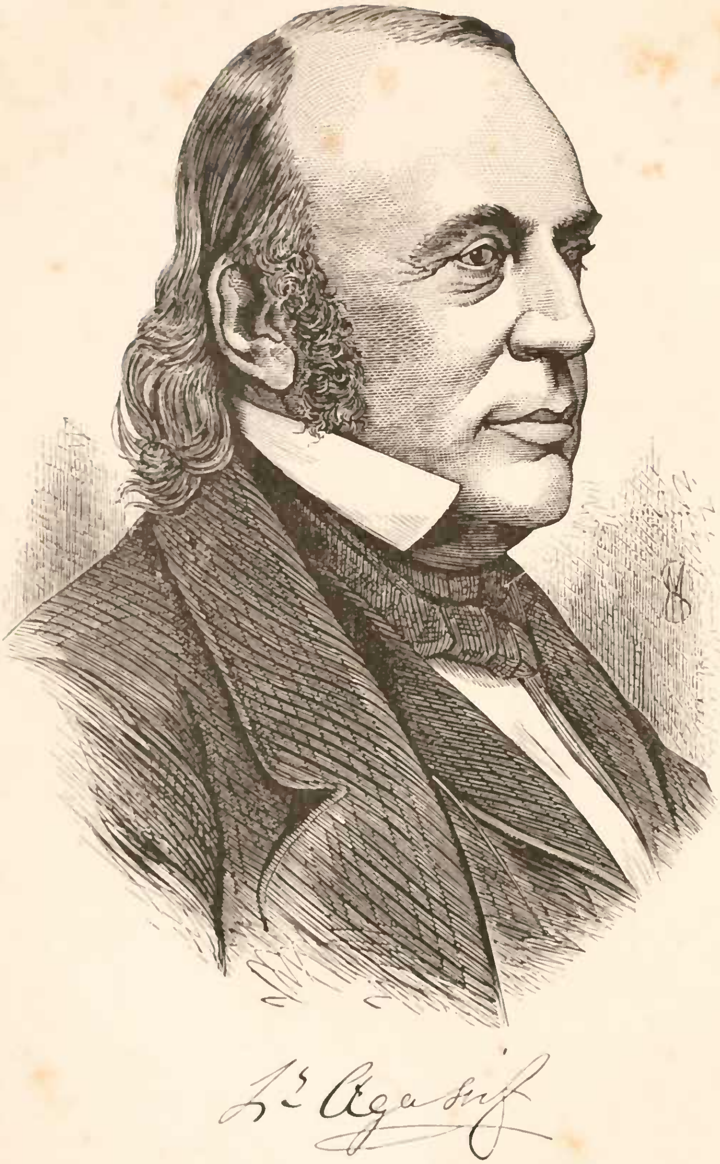
AGASSIZ,
PROCTOR,
BROWN-SEQUARD,
BAYARD TAYLOR,
AND 24 OTHERS.
ACADEMY OF SCIENCE,
THE WHEELER EXPLORATIONS.


Ls Agassiz

TRIBUNE

POPULAR SCIENCE.

BY

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AND CONTAINING "THE POET LONGFELLOW," BY JAMES T. FIELDS, AND "THE PRAYER OF AGASSIZ," BY J. G. WHITTIER.

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TRIBUNE POPULAR SCIENCE.

PART I.

TABLE OF CONTENTS.

PROCTOR—AGASSIZ.

There is no science that has been more illuminated than astronomy, by the discoveries of the last ten or fifteen years. Mr. Proctor, in the course of lectures which is here presented, exhibits the most recent theories warranted by the facts. Hence the freshness and charm of these lectures, their freedom from what is now the common-place knowledge of the text-books; and a certain rush and vitality about them, as if—which was the case—there were not time enough to tell their mighty tale.

To this story of the heavens we have added some chapters from the teachings of one who knew more of this globe and the life that dwells and has dwelt upon it, than any other man of this generation. We feel assured that thousands will welcome our publication of several of the lectures of Prof. Agassiz to the students of the Anderson School of Natural History on Penikese Island. Very little that was there said by that great teacher has hitherto found its way into print. The latest words of the old man eloquent will be found pregnant with the wisdom of his accumulated years.

SIX LECTURES BY R. A. PROCTOR.

A STUDY OF THE SUN.

THE FIRST LECTURE.

DISTANCE, SIZE, AND MASS OF THE SUN; MARVELOUS AMOUNT OF HEAT AND LIGHT EVOLVED; WHAT IS KNOWN ABOUT THE SOLAR SPOTS AND ATMOSPHERE.

The first of the series of six lectures was given on January 9, at Association Hall, by Prof. Richard A. Proctor, Secretary of the Royal Astronomical Society, London, and author of several noted works upon astronomical topics. The audience packed the capacious hall to its utmost limits. The treatment of the subject was largely facilitated by views illuminated with the oxy-hydrogen light.

THE LECTURE.

Ladies and Gentlemen: I need hardly tell you that a subject so wide as astronomy cannot be dealt with in a single course of lectures, except by way of survey. Every one of the subjects of my lectures might very well occupy a whole course. I have myself twice given a course of lectures on the Sun; two years ago on the stars; and I expect next May to give a course of lectures at the Royal Institution on the planets—the subject of the next lecture in my course in New York. Therefore you will readily understand that all of my lectures will be mere surveys. I only aim to present the leading features and those characteristic of modern research.

The subject of our lecture to-night is the Sun—not the most magnificent of all created objects, as indeed I shall be able to show you when I deal with the stars, but the noblest of all created things that minister to the wants of man. In long past ages there were men who worshiped the sun, and knelt down in adoration before him, because they believed he was the source of all good upon the earth; he was, in fact, their God. Although in this they forgot the Creator and worshiped the creature, yet if there was any fault it may be pardoned. How little we think when we see the sun rising as a ruddy globe above the horizon, involved in leaden-colored clouds—how little we think that at every instant that globe with a mighty force is attracting not only the earth but other planets far larger than the earth! Still less do we think how, not merely in the daytime, but through all time, that sun is pouring forth supplies of light and heat, infinitely greater than are required for the wants of this earth. Now let us consider first the facts we have to deal with, in order that we may see how large and how powerful he is, and thus thoroughly appreciate his physical characteristics when we come to consider them.

DISTANCE AND SIZE OF THE SUN.

In the first place, let us consider the distance and size of the sun, which I need hardly say are nearly related. There is a comparison by which we are enabled to indicate at once the relation of the sun to us in magnitude and distance. If this earth were represented by a globe one inch in diameter, then the sun's globe would be represented by an orb three yards in diameter. If the sun's globe in turn were represented by a globe one inch in diameter, then the distance would be represented by three yards; our earth a globe one inch in diameter, the sun three yards; the sun a globe one inch in diameter, the distance three yards. Now let us consider what an enormous distance that means. An Armstrong gun fires a bullet at the rate of 400 yards per second. A bullet fired at that rate, and maintaining it to the sun, would take 13 years to get there, and the sound of the explosion would reach the sun half a year later. In the case, therefore, of those men who worshiped the sun and raised their voices in prayer to him, if their voices could have been heard, and there were an atmosphere, a medium of intercommunication by which the sound of their voices could reach him, 13½ years would have been needed before their prayers could have reached their god. If there were a steel rod connecting the earth with the sun, and the earth were by it brought into communication with the sun, 300 years would elapse before the strain would reach the earth. Another consideration—and this was suggested by Prof. Mendenhall of your country—is this: Feeling is conveyed along the nerves 10 times slower than sound travels. If, therefore, an infant were born having an arm of the somewhat inconvenient length of 91,000,000 miles, so as to reach the sun; and if, while in the cradle in boyhood, he were to stretch out his arm and touch the sun, that infant might grow to the three-score years and ten allotted to man, or even to four-score, but he would never be conscious of the fact that the tip of his finger was burned. He must live 135 years before any effect would be experienced.

GRAVITY ACTS INSTANTANEOUSLY.

Light, which travels with such velocity, which travels 200,000 miles in a single second of time, takes eight minutes to reach us from the sun, so that when we look at the sun we see him not in the place he actually occupies in the ecliptic, but the place which he occupied eight minutes before. And this leads to the strange consideration that if gravity, the force by which the sun rules the earth, were to occupy the same time in passing over the interval between the sun and the earth that light does, the years would grow continually longer. Let us suppose the earth, traveling from my left to my right around the sun, which is directly opposite. When a body is traveling forward against a material shower, such as rainfall, the shower will appear to come somewhat from the direction in which the shower is moving. Thus the light from the sun comes somewhat obliquely to meet the earth. Suppose the force of attraction occupied the same time; that force would occupy a line, not from the sun but from a point on the right of the sun; it would draw the earth not toward the sun but somewhat in the direction toward which the earth is moving, and there would be a continued increase in the earth's velocity and an increase in the length of the year; and this would be manifested in a few years, and still more in the hundreds of years during which astronomy has been a science; and because there is no appreciable increase in the length of the year, it is shown that the force of gravity acts instantaneously; that it acts very much more quickly than light. Now that is a wonderful thought. That is a kind of force entirely unlike that with which we are familiar. If we strike the water, a wave travels along the surface. If we raise the voice in sound, it is conveyed along the waves of air, and there is a certain rate of transmission. Light would circle the earth eight times in a single second, but still it takes a certain time in traveling; but gravity, the sun's might, acts, so far as we can judge, instantaneously. It is one of the forces of which we are able to give no account whatever, for all our laws of matter are opposed to the conception of force acting otherwise than by contact. Newton is reported to have said that a man must be mad who could assume that any force whatever could act except by direct contact.

THE SUN'S MIGHT.

Now let us consider the might that resides in the sun. If the sun were merely an orb very much larger than the earth, as we see he is, there might still not be the force necessary to the sun as a ruler over the earth. Let me give you an idea of how large the sun is. I am in the habit, in England, when I wish to speak of the size of the sun, of informing my audience that "this country (England) in which we live, which seems to us so large, is nevertheless small by comparison with the earth, for if the earth were one inch in diameter, England would be a small triangular speck, which you could scarcely recognize." But I am afraid that to an American audience that comparison would be imperfect. In fact, I have heard that an American traveling in England found the country so small that he at once sought the central counties, and was even then afraid to go out in the evening for fear of falling off the little island. [Laughter.] We in England, whether it be the natural courage of our disposition or the effect of long habit, are not troubled with that feeling. But even America is so small compared with the sun, that if there were a spot upon the sun as large as the whole of America, it would be quite invisible to the naked eye. Indeed, if an object as large as the earth were placed immediately before the sun, and there appeared as a black disk, it would nevertheless require a large telescope to make it visible; 108 times does the sun's diameter exceed that of the earth, and the surface of the sun exceeds that of the earth 108 times 108 times, or 11,600 times, while the volume of the sun exceeds that of the earth 1,250,000 times. But the mass of the sun is not so much greater than the earth. It would appear as though the body of the sun were constituted of matter about a quarter lighter on an average than that which constitutes the earth, and the result is that the sun's mass instead of exceeding the mass of the earth 1,250,000 times, only exceeds it 315,000 times. But only consider what that means! If this earth were to grow in density until its mass were equal to that of the sun, then a half-ounce weight—one of those that are used to balance our letters—would weigh 4½ tons. A man of average weight would be drawn to the earth as a weight of 20,000 tons. An object raised from the earth a single inch would, in falling that short distance, acquire a velocity three times greater than that of an express train. Such is the might with which the sun rules this earth.

THE SOURCE OF HEAT AND LIGHT.

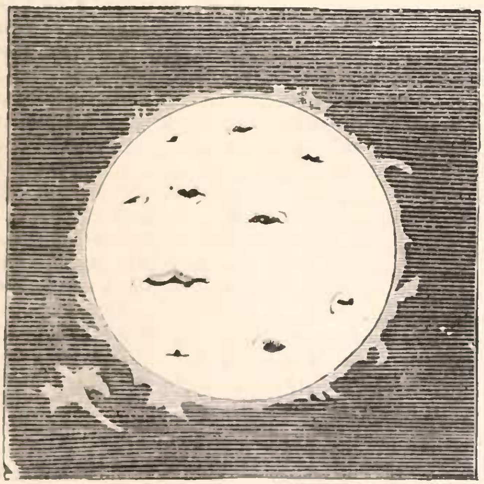
But now let us pass from the question of the sun's might to its heat and light. The sun is the source of all these forms of light and life which exist upon the earth. That is no idle dream. Every form of force upon the earth, every action that we perform, all the forms of energy we know of, even the very thoughts we think, may be said to come from the sun. It is by the sun's heat that life is maintained upon the earth.

And now as to the quantity of that heat. Sir John Herschel in the South of Africa made experiments to determine the actual quantity of heat that is received from the sun. The heat there was so great that at the depth of four inches below the sand the thermometer rose to 160°. He was able to cook a steak by placing it in a box covered with glass, and that inside another box with a glass cover; and to boil eggs hard. He made experiments, and found in the first place that about one-fourth of the sun's light and heat were cut off at midday by the air, and taking that into account, and making the requisite calculation for a large extent of surface, he found that the quantity of the sun's heat that fell on an area of one square mile would be sufficient to melt in a single hour 26,000 tons of ice. Well, now that is merely the quantity received by a square mile of the earth's surface. But the earth presents to the sun a surface (regarding her for a moment as a flat disk) 50,000,000 square miles in extent. And then how small is the quantity of the sun's light and heat that this earth actually captures. You have only to consider how small the sun looks in the heavens, and consider how small our earth would look beside him, with this small diameter compared with his, of one inch to three yards, and you can see how small a proportion of the sun's heat we capture. By a calculation which can be readily made, it is found that only the 2,000,000,000th part, or less than that proportion, of the sun's heat is captured by the earth; and all the planets together receive only one 227,000,000th part of the sun's heat. Here is another mystery the study of astronomy presents. Only one part in 227,000,000 parts appears to be applied to any useful purpose, and the rest seems wasted. It is not for us to judge of the operations of Nature. But here at any rate do we seem to find a confirmation of the saying of the atheist that sounds so strange to us, that "Nature in filling a wine-glass upsets a gallon." There is the sun's heat being continually sent forth, and only the 227,000,000th part received. Only imagine a merchant who spent large sums of money, and who employed only one cent usefully for every $2,000,000 of his income. And that is what the sun appears to be continually doing. The actual emission of solar light and heat corresponds to what would be obtained if on every square yard of the sun's surface six tons of coal were consumed every hour. In every second the sun gives out as much heat as would be given out by burnin

11,600,000,000,000,000 tons; and this earth on which we live, if its whole surface were glowing with the same heat as the sun, would give out in every second the same amount of heat that would be given by burning up 1,000,000,000,000 tons of coal. One million million tons of coal in every second of time—a globe only as large as our earth! while the sun, the great center of our system, gives out every second an amount of heat that would be given out by burning 11,600,000,000,000,000 of tons of coal, or about eight times the whole supply of coal supposed to exist in this earth. In every second the sun gives out the whole supply of that coal which we look at as inexhaustible, but which we are consuming at such a rate that in 3,000 or 4,000 years hence there can be but little doubt the coal will be exhausted upon the earth.

THE SUN'S SPOTS.

Now, we have to consider what the telescope and other instruments of research tell us about the globe. We have seen its size, its mass, what a wonderful amount of light and heat it gives; and now we have to consider what the telescope tells us. I need not go over the series of researches by which the aspect of the sun has been studied; but I will only remark that if Galileo and the others who studied the sun—if they had but known, as we know, how much we owe to the sun—they would with a hundred-fold degree of interest have studied that wonderful orb. At the beginning of their research they found the sun's surface marked from time to time with large spots, which will now be shown you



ACTUAL APPEARANCE OF THE SUN.

Reproduced from a picture of the sun as seen by Tacchini on the day of the eclipse of December, 1870; showing the sun spots and prominences.

I have a series of diagrams which I should have been very glad to have suspended all the time for you, but I found the size of the screen would not permit me. You will have the diagrams one by one before you, interspersed with lantern views, which by the kindness of Prof. Morton I can exhibit to you. By the first I will show you the general aspect of the sun, the way the sun appears with its various spots. That diagram now before you has been taken at the Cambridge Observatory It is a photographic picture of the sun. There are four such pictures, and they show you the different appearances of the sun. Sometimes there are a few spots; at others more; at others two zones appear to be strewn with spots.

It was discovered early that these spots are actually attached to the surface of the sun, that they are carried round, that the sun's globe revolves in about twenty-five of our days, carrying these spots along with it. Other features were soon recognized in these spots. We will have the second of these diagrams shown, in which you will have a larger picture of these spots, and other pictures will show you what will afterward be presented on a large scale—the appearance of bright spots around the spots called faculæ. The spots are not uniform in color, and have an outer fringe, while inside there is a dark part which the first observers thought was actually black. But no part of the sun's surface, so far as we know, would seem to be actually black. Certain of the bright parts are strained into white bright streaks, surrounding the spot, and when the lantern is used you will find clear views of that phenomena will be presented. We will next have a picture of the sun's spots presented, and afterward the photographic pictures of the spots brought before you. There is one other picture which, like the last, was taken at the Cambridge Observatory, and shows the features of these spots. They are well defined. The outer outline of the spot is sharply defined, and the outline of the central spot is well marked, and then there are white streaks from the central part towards the surrounding portion. All that surrounding portion, especially near the edge of the spot, is, on the sun, brighter than the rest of the sun's surface. Now we will have the room darkened, and these things will be shown to you by photographs taken by Mr. Rutherfurd. You will see these various spots, and you will have the assurance that you are not looking at a picture taken by the hand of man, but sun-painted, in which all the features were actually existing on the surface of the sun at the time; and meantime we will pass on to the consideration of various features that will have to be presented.

In this diagram you will perceive that the central part is surrounded by whitish streaks, called the faculæ, and you will recognize on the border of the sun's disk mottled markings, the first sign of the complexity of the solar surface. That is a feature which can be recognized in a telescope of three inches in aperture. We will have another of those pictures brought on the scene, differing from the last in the fact that there are spots of considerable size on this view of the sun. These spots are sun-painted and actual pictures of the spots themselves. You can recognize the half shadow boundary, and the greater brightness of the interior part—the mottled part, the border, and the bright facular streaks. But now we will have pictures of one and the same spot in various stages of its progress, and you will recognize the evidence by which Dr. Wilson of Glasgow in 1776 recognized the fact that spots are depressions below the surface of the sun.

PECULIARITIES OF THE SPOTS.

Here are various pictures of the same spot. They are all numbered, and you will see, first of all, the spots appearing on the edge of the sun, and you are able to look on the further half shadow part of that spot, and it would seem as if you were looking on the edge. The half shadow part around the dark region becomes more and more uniform in breadth. You see the shape of the spot, and the formation across it of a streak of bright light, and you see it gradually changes in shape. All these spots are actually sun painted, and you will recognize the fact that you are looking on the actual economy of the solar surface, able to review some of the processes really taking place there. You may not be able to find an explanation of these changes of form. They remain still a mystery of astronomy. The processes are continually taking place, although the sun looks so calm and still. I have spoken of the irregularity of the sun's surface, and we will now have a picture showing that irregularity on a larger scale. Father Secchi took a picture of one of those faculæ. If you look on the surrounding part as representing the general surface of the sun, you will see that the faculæ are very large, and distinguished from the rest by their brightness. The irregularities around the faculæ are not the rough mottling, but a feature more delicate. This was recognized by Herschel, and called by him the corrugation. He compared it to the irregularity of the surface of an orange.

Now you have another picture showing the same corrugations, the whole picture being devoted to that one feature. There are the corrugations, and you see them surrounding a small spot without a penumbra. Now you can recognize the justice of Herschel's description. These corrugations have given rise to a great deal of study in late times. You can recognize the central part of these corrugations as bright granules, but in preference I will use the term "rice-grains," because Prof. Langley has found it convenient to distinguish the rice-grains from still smaller spots to which the name of granules has been given by him.

The picture next to be shown will indicate the rice-grains, which are not so delicate as those Prof. Langley has discovered. Dr. Huggins in England has taken the picture, and from its regular aspect it has been called Dr. Huggins's floor cloth. Still I have very little doubt that he perceived these general features. You can see the general darkness of that portion where granules are few. These dark regions are the dark parts of that mottling which is seen in smaller telescopes. These rice-grains are not in reality small, although they look small in the telescope. Their length is about 600 or 700 miles, and the breadth about 300 miles; in other words, they are about as large as Great Britain. [Laughter.] The study of these objects led to a very singular theory. It was thought by one gentleman from the aspect of the spots that the sun is surrounded by double coating, the outer giving light, the inner coating only able to reflect the light, but with no power of its own to give light, and that when the inner coating is broken you see through the dark surface of the sun, and that surface may be so slightly illuminated and heated by surrounding cloud layers, that life may be possible there. Sir John Herschel said that whatever view we might form about these rice-grains, it was certain the greater part of the light and heat of the sun comes from them, and he thought that vital energy in living organisms might be the secret of that light; that, because vitality is connected with electricity, and electricity with light, some of these spots of 600 miles long by 300 miles wide, might be living creatures!

OBSERVATIONS OF ASTRONOMERS.

I now pass to the particular observations which suggested these thoughts. On the sun's surface there were observed "willow leaves," which gave rise to a great deal of controversy as to their character. You all see those willow leaves of Nasmyth. You will notice that the whole of the broad surface of the sun appears to be made up by the crossing of a multitude of willow leaves. They appear more distinctly in the central part, and are very well recognized on the outlying border of the spot. But when that matter was submitted to careful study, it was found that there was great occasion to doubt whether the long willow-leaved streaks existed all over the surface of the sun, and an astronomer of your own has given a good account of them.

But before I come to Langley's work I must give a picture by Father Secchi. It would appear that he, observing the solar spots in the clear atmosphere of Rome, was able to recognize the true nature of these streaks. The general surface of the sun is made up of that peculiar rough dotted appearance already described. It would seem as though from this general surface there was a gradual streaking out in the neighborhood of the spots. You will see that they spread around and across these spots, and are there quite distinct in character from the rice-grains in the general surface of the sun.

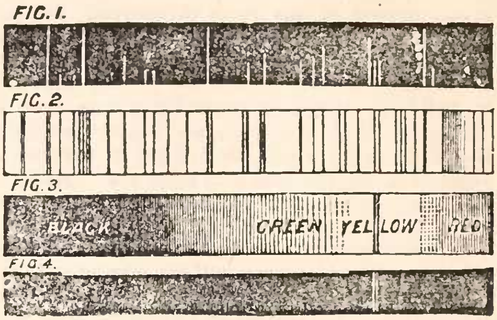
We will now have a picture from Prof. Langley, who worked in the neighborhood of Pittsburgh, at a hight of about 1,100 feet. He would seem to have been able to recognize the fact that the rice-grains may be divided into smaller particles. He has found that the greater part of the sunlight undoubtedly comes from these little specks of brightness on the surface of the sun, while the general level of the sun, the background on which these bright specks are projected, is very much darker. And the picture now presented is a drawing by Prof. Langley. It would appear to be the case that little more than about one-hundredth part of the sun's light is given by the dark background on which these bright specks of light may be seen.

I have to pass on to the spectroscope discoveries by which the real nature of this wonderful orb, whose appearance we have been considering, has been determined—I mean spectroscopic analysis. We have to consider what are the real substances in the sun, and what the processes taking place on that solar surface. In Langley's picture you will notice the details are on a minuter scale than in Fr. Secchi's picture. Langley has been able to recognize in these grains multitudes of granules, and in the neighborhood of the spots you will see how they lengthen out, how they seem carried across this dark region in the spot. In some places Langley has been able to recognize on the dark background of the spot what seem to be long filaments, the breadth of which cannot be less than 50 miles. They seem to be suspended vertically with respect to the sun, and in the neighborhood of the spot some wonderful force seems to sway them toward the center of the spot. These wonderful filaments are thousands of miles in length, and 40 or 50 miles in width. We will now consider the results of the spectroscopic study of the sun.

I will show you a diagram of the solar spectrum. You take the light of the sun, and you receive it through certain triangular pieces of glass, and the light of the sun is spread into the rainbow-tinted streak, which streak is crossed by a multitude of dark lines.

This picture, to which I now point, is a picture of the solar spectrum. On further investigation, it was found that an incandescent body used as a source of light, instead of having a rainbow-tinted streak crossed by a multitude of dark lines, threw a rainbow-tinted streak without any dark lines at all. It was also found that a gaseous body gives a spectrum different from this, consisting of two or three dark lines.

Here is the spectrum given by sodium in a vaporous condition; and that—a dark spectrum with bright lines—was found to be the quality of a spectrum given by a gaseous body.



COMPARISON OF SPECTRUM LINES.

Fig. 1. Spectrum of the solar prominences.
Fig. 2. Solar spectrum.
Fig. 3. Continuous spectrum, with dark lines of sodium.
Fig. 4. Double bright line: the spectrum of sodium.

I will now call your attention to a comparison between these results and the musical scale. The red light corresponds with the bass, and the purple with the treble notes, and then this rainbow-tinted streak without dark is the complete scale without breaks. The one with the dark lines is the scale crossed by dark chords. If a musician were to hear a piano played in another room out of his sight, and he heard a chord struck, he would know which it was, and in the same way, if you see that a gaseous light gives a certain kind of spectrum, the chemist knows what the light is; and it was found that the dark lines of the solar spectrum indicated vapors cooler than the sun's mass and cutting off a portion of the sun's light. These vapors are giving out a quantity of light, but being cooler than the sun, around which they lie, they cut off a portion of his light. Thus arise the dark lines, and the chemist only wants to determine the exact position of these lines to find out what elements are in the sun. Thus iron, copper, and other elements known to us were discovered to be in the vaporous atmosphere surrounding the sun.

A well-known German physicist came to the conclusion that certain elements giving out the bright line spectrum, give more lines the greater the pressure, and that the first lines given correspond to those seen in the solar spectrum. The research was continued at the Mint, where it is important in connection with alloys of metals, and Dr. Henry Draper, of your country, is continuing it. These researches will throw important light on the condition of the sun.

SOLAR PROMINENCES AND CORONA.

It was observed that the spots waxed and waned in number over the surface of the sun, and after half a century of research, that the spots increase and diminish (until they disappear altogether), and that the period within which they waxed and wane is about eleven of our years. After that was discovered, it was noted that the magnetic influences of the earth waxed and waned in about the same time. The magnetic needle which points in England to west of north, in this country not to due north, has a swaying motion as if endeavoring to move toward the sun. That motion undergoes variations, sometimes greater and sometimes less, and physicists watched, and they found that in about eleven years the swaying of the magnetic needle, which was so insignificant as to seem difficult of detection, undergoes a slight change which corresponds with the number of spots on the sun. When the spots are greatest it has its greatest sway, and when the spots are fewest it has the least sway. The aurora also was associated with the sun. But further evidence of these influences was needed, and it came in 1859, when a bright spot suddenly made its appearance on the sun, and it was found that the self-recording magnetic needle at Kew made certain jumps at the same instant; auroras appeared in both hemispheres, and everything proved that at that moment the sun had given out magnetic influences, not to our earth alone, but doubtless to Mercury and Venus and Mars, then to the asteroids and to Jupiter and Saturn. A new bond of harmony had been found within the solar system.

[A photographic picture representing prominences on the sun was here exhibited.]

In 1842 these were looked upon as belonging to the atmosphere of the moon, but they were proved in 1868 to belong to the sun. They were like garnets around a brooch of jet, and these were found to be actually existing on the surface of the sun. What were they? During the eclipse of 1868 that question was answered, and it was found that they are not flames or mountains, but masses of glowing hydrogen. It was by the spectroscope that it was discovered. Consisting of glowing gas, they would give such lines as these, and the four lines of the gas hydrogen were recognized.

A curious experiment will be produced by glowing hydrogen. Tubes are filled with hydrogen under a low pressure corresponding to the pressure which is believed to exist on the prominences of the sun, and you will have the true color of these prominences, shining with the true light of glowing hydrogen.

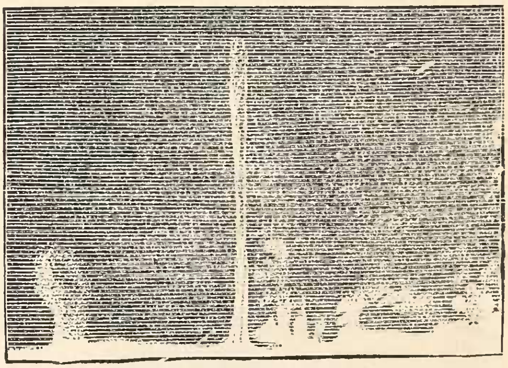
[An exceedingly brilliant experiment was here made, the hydrogen appearing to glow brightly even with all the lights in the room in full blaze, and showing an exact imitation of the solar prominences.]

A new method of research was applied; it was now known that the flames shone with a light that could be divided into separate lines in the day time. The spectroscope spread out these lines; they were visible. It was found even possible to see the prominences themselves.

[A picture of the sun's chromosphere was next produced.]

THE CHROMOSPHERE.

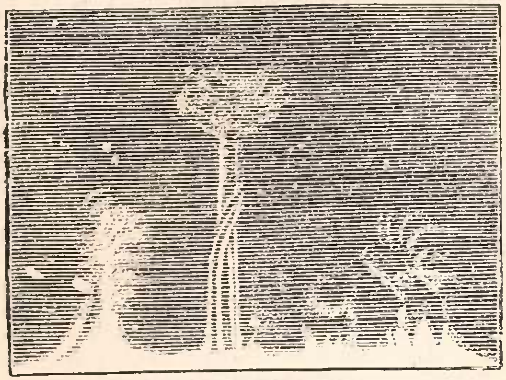
This ruddy matter around the sun is called the chromosphere. You will presently see injected into it a still more ruddy matter, as if there was an explosion on the surface of the sun. [A bright crimson mass was here shot through the chromosphere and slowly fell back. The audience applauded vigorously.] Processes such as this have been watched and have taken place on the surface of the sun, before the eyes of observers. Another of these experiments will be made for you by Prof. Morton's assistant, Mr. Wale. In this picture you see the whole field covered with ruddy matter, and this corresponds with diagrams of real pictures taken by astronomers.



ERUPTION PROMINENCES.

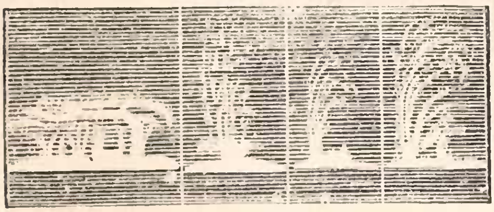
First stage of a prominence observed by Zöllner at 10h. 22m., Aug. 29 1869. Hight about 45,000 miles.

In this picture you see the explosion just as if a rocket was sent up, and here, in the next picture, one hour later, the upper part of the eruption sinking back to the surface of the sun. The next picture is one taken at the Cambridge Observatory. Nothing is clearer than that here some matter has been thrown forth from the sun. Here is a ruddy cascade of hydrogen, and there you see it gradually returning to a position of rest.



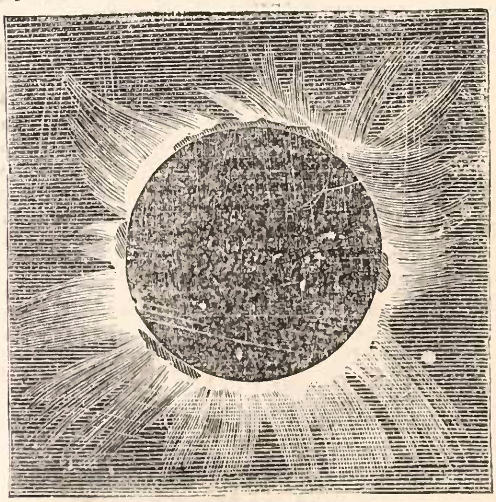
ERUPTION PROMINENCES.
Second stage of prominence observed by Zöllner at 11h. 20m., Aug. 29, 1869.

One thing on this subject is very suggestive, though its true meaning is yet to be discovered. The spots on the sun are arranged in two zones, and these correspond with the temperate zones on the earth. It is in these zones that the largest spots appear, and spots are never seen far outside these zones. In the other parts of the sun's surface we have a gradual spreading out of this ruddy matter, as if you should pour an oily liquid into water or other matter of a slightly different density. You see that matter spreading through the water. It is matter of one kind of density spreading through another. In the region outside of the spouting zone it is as if this hydrogen were floating about, finding its own level. The prominences are in many cases 80,000, in one case 200,000 miles in hight. Ten globes such as this earth might be piled one on the other, and only reach the hight of one of these. We have manifest evidence that there is really an eruptive activity in these spouting zones. In this picture you see how there was a real eruption, propelling something unseen, and carrying something away from the sun



SOLAR OUTBURST.
Successive stages of an eruption on the sun's surface, observed by Prof. Young of Dartmouth College, Sept. 7, 1871.

The first view shows what Prof. Young calls a long low-lying cloud of glowing hydrogen, only at the insignificant hight of about 20,000 miles. He was away about half an hour, and when he came back the cloud had vanished and nothing was left except these small bright fragments, and these fragments were being carried up. They were carried to a hight of 200,000 miles, and the rate was such that, taking due account for all the circumstances, there must have been a propulsion of matter from the sun at the rate of 500 miles per second. There is no doubt that there are motions of 100 or 120 miles per second, but this matter, according to calculation was carried up at the rate of 500 miles per second. A velocity of 380 miles per second would have been enough to carry it away from the sun forever. The greatest force which the sun can exert, either in attraction or propulsion, is 380 miles per second; anything greater than that will never come back. Now this was 500 miles per second; not, as I conceive, of glowing hydrogen alone, but disturbed matter coming from a lower stratum. Why should this matter have been invisible? If it had been from the interior of the sun, it would have given a continuous spectrum; no lines could be shown by a glowing mass; it would give a rainbow-tinted streak. But we have the evidence of the carrying out of something from the sun. Now this must have been a solid or liquid mass of great density, rifting its way through the hydrogen gas, and being carried outwards and onwards through space. What could it have been? If the sun is thus at times giving forth matter, what becomes of it? Our earth may possibly be exposed to that matter coming from the sun. On this point I shall have more to say in my lecture on comets and meteors.



RADIATION OF THE CORO
From a photograph made during the solar eclip

THE SOLAR CORONA.

I pass on to another object, the solar corona, which gives us further indication of the force acting outward from the sun. I have a third of those ingenious experiments by Prof. Morton to illustrate these various phenomena. We shall have the natural progress of a solar eclipse. The moon's dark body will pass over the sun's disk. In America the moon is allowed to travel faster than under ordinary circumstances, and an eclipse which usually takes about three hours will here take but a minute. [Laughter.] You will notice the formation of Bailey's beads, and see that the bright edge of light is broken up. Then instantly bursts out the corona. I am told that this really corresponds very closely indeed to what is seen during a total eclipse of the sun. Now what is that corona? It was once thought to be merely due to the sun's light shining through our atmosphere. When it was found that the prominences of hydrogen exist at a very low pressure, it was a natural conclusion that there cannot be a solar atmosphere extending to the hight of this corona. The pressure at the base would be enormously great. As time went on, it was seen that it must be a solar appendage. In the first place, we will have a picture taken by a noted French astronomer. It is a very remarkable view, so much so that considerable doubt was expressed; but that has now been all removed. In the eclipse of 1868 this question of the corona naturally came into great prominence. Now it was to be dealt with. The point was that pictures should be taken of it very carefully indeed. In 1869, a picture was taken of it by Mr. Gilman of New-York, which showed a new appearance—an appearance of radiation, as if it was combed out. You will notice all these streaks spreading out. Here is a picture of the same on a larger scale. In this I shall invite you to notice the number of minute bright specks. Mr. Gilman says they were there as distinct entities. Zöllner has noticed such bright specks constantly flashing out. They seem to be masses of incandescent, exceedingly bright matter. Now we begin to see that the corona gives evidence of a force going out of the sun. It seems to me that the evidence of such a force is to be found in photographic pictures. If we can show that during the progress of an eclipse the moon's dark body traverses the corona, it must be material belonging to the sun. We will have a picture showing the corona of 1870. It was photographed in Syracuse. So the doubt began to be removed that it is really a solar phenomenon, radiating in this wonderful way. Upon the confirming evidences and features here presented, not in a picture subject to artistic fancies, but from the corona itself, you begin to realize that there is continuous action outward from the sun, and that there are means by which this corona, extending a million miles from the sun, is repelled by some central forces. They do not seem to be constant, for in other pictures, taken in the eclipse of 1871, the corona was very much unlike this. This picture shows the corona photographed in India by Lord Lindsay's party. During the time of the eclipse six photographs were taken. By combining these pictures, instead of that radiation there are various curves of double curvature, as we call it. This will show that from the center of the sun a force is produced outward, and then there is a drawing back until a new force is exerted and there is another throwing out. So that there seems clear evidence that the corona belongs to the sun, and that it is acted upon by a propulsive force.

THE EXHAUSTION OF SOLAR HEAT.

Here, then, we have an immense mass of matter, glowing with an enormous intensity of heat, surrounded by vast flames, swept by storms of a nature we cannot conceive, surrounded by the glowing corona, which spreads out again into another phenomenon, the zodiacal light, growing more and more tenuous, and extending even as far as the orbit of Mars if not to the end of the solar system. The sun seems to us to be perfectly still. When we consider what we have learned about him we know that all the forms of uproar on this earth are as absolute quiet compared with what is taking place on his surface. Even the hideous groanings of the earthquake are surpassed a million fold by the disturbances on every square mile of that inflamed sea. This is no idle dream. This great central machine of the solar orb, the central heart, pulsates with life and will continue to do so until the fuel is exhausted. How does the sun maintain this fire? Why is there no gradual loss of energy? If the sun were a mass of coal of the same bulk, that coal, in the course of 5,000 years, would be entirely consumed, and the sun would be a mere cinder. If the sun were a mass of water, which has a quality of specific heat in its combinations by which it gives out more heat in cooling by any number of degrees than any other matter, in the course of 5,000 years it would lose 1,500 degrees Fahrenheit in temperature. There are two theories of the manner in which the sun's heat is kept up. One is by the downfall of meteoric matter. The other is that it is maintained by the gradual contraction of its substance, the same process by which the rest of the solar system was formed. In any case there is certainly a time in the far future when the sun's heat will be exhausted.

There is indeed one way in which we may imagine that the perennial supply may be continued. Our sun is traveling along through space, carrying with him the planets, the comets, &c., which circle around him as he sweeps onward, and it may be that he comes to new regions of meteoric matter, or, as it were, to fresh fields and pastures new, where the supply may be renewed. Whether this be so or not we do not know. But there is this process of exhaustion which must one day come to an end; and yet there is no contrivance by which that waste, that squandering of which I have spoken, may be prevented. Could it be, every year of that supply would be changed into 227,000,000 of years. The waste is continually going on. Verily we have here a problem which may well tax all our thoughts. Let us not dismiss it at once, as we are apt to do, with the thought that our new knowledge has shown us imperfection in the scheme of creation. Let us rather say with the Poet Laureate:

Let knowledge grow from more to more,
But more of reverence in us dwell;
That mind and soul, according well,
May make one music as before,

but vaster. [Applause.]

THE FAMILY OF PLANETS.

SECOND LECTURE OF R. A. PROCTOR

DISTINGUISHING CHARACTERISTICS OF THE INNER FAMILY OF PLANETS—MERCURY AND VENUS—THE EARTH, REGARDED AS A PLANET—LANDS AND SEAS, POLAR SNOWS, OCEANS, AND AIR-CURRENTS OF MARS — WONDERFUL CHANGES OBSERVED IN JUPITER'S EQUATORIAL BELT—SIMILAR FEATURES OF SATURN, URANUS, AND NEPTUNE.

The second lecture of the course on astronomy by Mr. Richard A. Proctor, Honorary Secretary of the Royal Astronomical Society, was given at Association Hall, January 15. The subject—"The Family of Planets"—was illustrated, like the first lecture on "The Sun," by means of a series of pictures and diagrams, made specially to illustrate Prof. Proctor's lectures in America. A large audience greeted the lecturer, who spoke as follows:

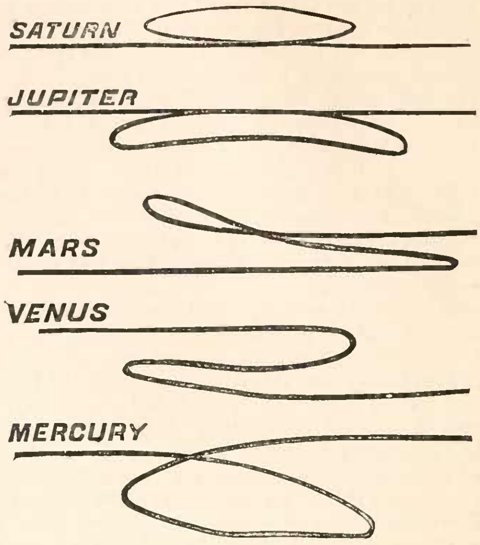
THE LECTURE.

The planets are so called from a Greek word signifying "to wander," because they change their position on the heavens. Unlike the sun and moon, the planets do not travel always in one direction round the heavens, but on looped paths, pursuing

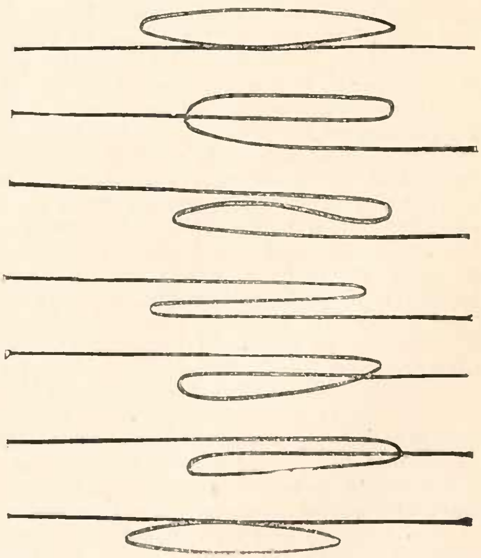
Their wand'ring course,—now high, now low, then hid,
Progressive, retrograde, or standing still.

In the first picture here shown you have views of loops pursued by the different planets named in the diagram.

In the next view you are shown how the loop traversed by any given planet (Jupiter in the illustrated case), varies in shape as the planet is pursuing different parts of its course round the heavens.



LOOPED PATHS OF THE PLANETS.

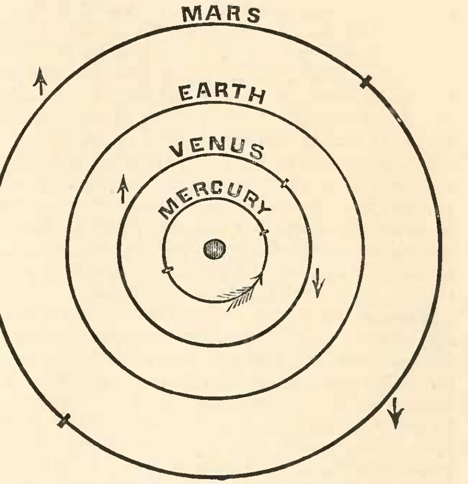


VARIETIES OF LOOPS TRAVERSED BY THE PLANET JUPITER.

It seems to me desirable, in taking the subject of planets, to consider them from the point of view of life in other worlds. Although it is not of any very great scientific value, the subject is one in which we all take interest. A simple method will enable us to remember readily the various facts regarding the planets. I divide the solar family into two parts—the interior family, Mercury, Venus, the earth and moon, and Mars; and the outer family, Jupiter, Saturn, Uranus, and Neptune. One of the facts is the utter diversity of character between these two families. I want to show that instead of being regarded as two similar families, they ought to be looked upon as two separate families, utterly unlike each other. Whatever we think of the outer family of larger planets ought to be derived from the evidences we have, and not from the analogy of our own earth. It is only the inner family of planets that we can judge by our own earth. And even in this case we must not fall into the mistake that life on other worlds must be like that of our earth. Our earth itself gives us some such lesson. If we saw one part, and heard of but were prevented from seeing the other parts, we might think that life would not exist under the varying conditions. Yet we know it does. Even very recently there was a very striking case in illustration. We all thought that there could be no life at the bottom of the sea; that in the deepest seas there was a great darkness and a pressure which must prevent life. At the depth of a mile or two the pressure is so great that when wood is carried down the water is forced into it, so that it will never float again. We know also that light is a desirable quality for all living creatures we are acquainted with, and we came to the conclusion that light could not exist there. But Drs. Carpenter and Thompson have let down their dredges and drawn up, from the depth of two or three miles, living creatures—and not merely living creatures, but having eyes and able to see, notwithstanding the darkness that was supposed to reign there. So unlike are the conditions there, that when these creatures were brought up where the pressure was less, they burst. There was quite enough remaining to show that they had been alive but had been torn apart when the pressure diminished.

That was one example. We might also consider the Arctic regions, and say how unlikely it would be to anybody in the temperate zones that life could exist there. How utterly unlikely, again, that life should exist in the torrid zone; or, again, when you climb the hights of mountains, and come to places where the atmospheric pressure is very much diminished, and great cold prevails, and all the conditions are unlike those that exist at the sea level, you would be certain no life could exist there, if it were not for the fact that we visit those regions and ascertain that life does exist there. So that in dealing with the different planets we need not concern ourselves to show that the conditions are absolutely like those prevailing on the earth. But it will be a useful thing to compare the conditions of things as they exist in those planets with what prevails on the earth.

In order to get rid of those numbers, which will be found in the text-books of astronomy, let us take relative conceptions as to the distance. If you call the distance of the earth 10, then for the distance of Mercury from the sun you have the number 4; Venus 7, and Mars 16. For the diameters of those planets we have Mercury 3,000 miles; Venus, 7,500 miles; for the earth, 7,900, and for Mars, 4,500. You see we have an increase upward to the earth and then downward, Mercury being 3,000, Venus 7,500, the earth 7,900—the largest of all these planets, and also dignified by having a moon; and then we have Mars with its diameter of 4,530 miles. All these planets rotate on their axes in about 24 hours. They all resemble each other in that respect. They all seem to have very similar densities, to be composed of matter of about the same density as of this earth, the density of our earth being about 4½ times, some say as much as 6½ times the density of water. It is somewhere between these values.



ORBITS OF THE INNER PLANETS.

To begin with Mercury, the nearest of all these planets to the sun. The feature which strikes us first in dealing with Mercury is the great heat to which that planet is exposed. Mercury travels on an eccentric orbit, and is exposed to a greater heat from the sun at certain times than at others. We have before us diagrams of the orbits. This inner orbit is the orbit of Mercury, and you will notice Mercury is at one time much nearer to the sun than in another part of his year. The year of Mercury is 88 of our days, so that in the course of 88 days Mercury passes from a very great heat when nearest, to a comparatively less heat when farthest from the sun. But, even when the sun's heat is least, it is much greater than that to which our earth is exposed. The quantity of heat received by Mercury varies from four times to ten times what we have. Now, that is really a serious difference. Only imagine what would happen to us if the sun's light and heat were increased four-fold, and then extend your conception to an increase ten-fold. I think I need hardly say that the heat in that case would be so great that creatures such as we are could not exist; animal life would be destroyed on the earth if the sun suddenly gave out from four to ten times as much heat as he actually does. Then, can there be inhabitants in Mercury? Some say that if only the atmosphere were very rare which surrounds Mercury, that planet could possibly have life there. In the Torrid Zone, at a certain hight you reach the snow line, and above that line there would seem to be no life; but yet it does seem possible that life may exist and does exist there.

But there is one circumstance that is overlooked in that. In reality when you go to the higher regions where the air is so rare, the sun's rays are not diminished. The air does not get warm; it does not prevent the heat from passing through it; it does not get warm, and in the shade the air is cold. But in the direct heat of the sun expose your hand, and the heat is more intense than is easily bearable. Even with snow and ice covering the mountain tops, the face and hands are blistered by the heat of the sun. We should have a more intolerable contrast in Mercury than in the case of an atmosphere like our own. There would be very intense heat under the direct rays of the sun, and comparative cold in the shadow, and life would be almost unendurable to us; and if the atmosphere of Mercury were so thin there would be evaporation of all the water, and that would be another condition opposed to ours. It appears to me that that difficulty is sufficiently great to make us doubt whether life can exist on Mercury; I will not say such life as can exist on the earth, but any of the higher forms of life, under these conditions.

LIFE IN OTHER WORLDS.

Mercury is a planet waiting for the time when life may exist on it; when the sun's heat shall be sufficiently reduced, and then life will be as comfortable as it is on earth. Here we are introduced to considerations of great importance in this point of view of life in other worlds. Though life now exists on the earth, there have been long successions of ages, during which life has not been possible on earth; and there may be long successions of ages during which life will be tolerable on the planets. A planet is intended to support life, but not for all time, but for a small portion of the planet's existence.

Now, coming to the gravity of the planets. The gravity of Mercury, owing to its smallness, is so reduced that one pound would only press about five ounces; and here we are introduced to a consideration of the importance of gravity to ourselves. We sometimes look on gravity and weight of matter as being an inconvenience rather than otherwise, but if it were not for gravity we should be continually at a loss; objects would not stand firm, and we should stagger for want of weight, and would be in that difficulty which we find in endeavoring to walk in water beyond a certain depth. As you know, divers wishing to walk about in deep water have heavy weights attached, so as to keep themselves in place.

It is an absolute necessity, therefore, that gravity should exist, and what we are in the habit of looking upon as an inconvenience is, therefore, in reality, a very important part of the earth's economy. If the earth's gravity were reduced to that in Mercury all the plants would suffer; flowers droop or keep their heads erect according to their structure, and it is absolutely necessary to continuance in life that a plant whose proper condition is that of uprightness, should remain so, and that that which droops should droop at a proper angle. It is shown that if that were not the case the stamens and pistils would not be properly adjusted for the fertilization of the germs. And so it has been remarked that the whole mass of the earth, from pole to pole, is engaged in keeping the snowdrop, the crocus, &c., in their proper position. In the case of Mercury gravity is so much reduced that all these things would be changed. The same difficulty applies to the planet Mars, which is so much smaller than the earth.

THE CHARACTERISTICS OF THE PLANET VENUS.

But I now pass from Mercury to the next planet, Venus. Venus is the most beautiful, and we would imagine from ordinary appearances to be the noblest of all except the sun and our moon. You will remember Milton's words:

> Now glowed the firmament
> With living sapphires: Hesperus, that led
> The starry host, rode brightest. * * *

But Venus, examined by the telescope, does not reward the astronomers so well as you might expect. She is too gloriously illuminated by the sun, and the application of the telescope is disappointing. Again, we never see Venus under proper conditions. You never see the whole portion of the illuminated surface. Look at this diagram. You have the path of the earth here, and the path of Venus is inside. When Venus is nearest to the earth the sun lies in the same direction, and therefore Venus turns her darkened side and cannot be seen. When beyond the sun his brightness obscures her. The only time Venus can be studied is when she is on the two opposite sides of her path, and then she is seen either as a gibbous moon or a half moon. We know, with respect to Venus, that she, being very much nearer to the sun than the earth is, must have a great deal more heat. Her heat is not so great as that of Mercury; still she has twice as much heat as the earth has. In other respects Venus is more like the earth. Although Venus has no moon, yet being nearer the sun she must have tides, and they are barely comparable with those that exist on the earth.

But there is one peculiarity in the condition of Venus that seems very unfavorable to life, as we know it here. According to the observations of the Italian astronomers, who seem to have been able to see spots on Venus, (probably on account of the clearness of the atmosphere,) which we cannot see at all in England, the axis, instead of being sloping at a small angle, is much inclined. Only for a short time would she have equal day and night, but when the northern pole is toward the sun, all the polar parts would be continually turned toward the sun; not merely a small part, but very nearly half of the planet on that side. When the southern pole would be turned toward the sun, that side would have a continual day, and there would be continual night over nearly half of the planet. So there would be a very great change in the condition of the planet in Winter and Summer. The year of Venus is about seven and a half months. It must be remembered that this sun shines with twice the size and gives out twice the heat that it does to the earth. The change between the two conditions of Winter and Summer would be even more serious than the extreme heat and cold in either condition. In explanation of this let us take New-York. You know the pole is raised about 41 degrees. In Spring the sun rises to a hight of about 50 degrees above the horizon, in Summer 23 degrees higher, in Winter it rises 23 degrees lower at midday. Suppose instead of 23 degrees the change amounted to 50 degrees. Then you would have at the New-York of Venus—you would have it 50 degrees higher in Summer, which would carry it 10 degrees north of the point overhead. The sun is circling about the pole, round and round. There would be day all the time, and then there would be that tremendous sun, with all the effect of tropical sunshine. The accumulation of heat in the Summer by Venus must be enormously great. Consider the Winter. There is the sun in the Spring 50 degrees above the horizon, but in Winter it is 50 degrees below. It does not rise at all above the horizon. It is continual night, and that after that extremely heated Summer. These changes are not agreeable to our ideas of the possibilities of life. They suggest the necessity—migration. That is absolutely necessary to certain classes of beings here on this earth. Now, human beings on the earth do not migrate, but the inhabitants of Venus, if there are any, must migrate so as always to be in parts where the sun does not rise too high. That would be quite possible; it may be an absolute essential condition there, not for a portion of living beings as here, but for all.

RELATIONS OF THE MOON TO THE EARTH.

I shall only pause to speak of the earth in relation to the moon. Our earth has a companion, the moon. We look upon it as a mere satellite, but it is another member of the inner family of planets. If you were a member of a world circling around some distant star, you would be unable to distinguish the motion of the moon from that of the earth. It is only from our earth that it seems to go around us. It really goes around the sun. Every world must have that peculiarity, that it must seem to its inhabitants to be the center of the whole universe. In Venus, Mars, in even the asteroids, each seems to be the center of the universe. Thus the astronomers of old time fell into the mistake of thinking the earth was the fixed center of the universe.

Mars, instead of being like Venus, is a planet that we can study very fully indeed. We have here the orbits; here is that of the earth, there that of Mars. A portion of the time the face of Mars is turned toward the sun and is also turned toward the earth, and thus illuminated is studied to great advantage. You can conceive therefore how it is that astronomers have been able to take such pictures as these of the planet, having features resembling those of the earth. There is an appearance of two bright white points at opposite sides, which have always been called the snowy poles of Mars. Herschel was the first to perceive that they waxed and waned in size. He noticed that the axis was inclined very much like that of our earth, or rather more than our earth, but so nearly like it that the same sort of seasons prevail. He noticed that when the Summer was in progress the polar regions seemed smaller than in Winter. That was the first thing to show that the planet was like our earth. Our snowy regions do not cover more than the arctic regions, and they occupy about the same proportions as those of Mars's surface. Since the polar snows do not extend further, therefore the same sort of climate it seemed probable prevailed there. Other features corresponding to the idea of the habitability of Mars were noticed. Some portions have a greenish hue, as though there were oceans. The planet's continents, or what we call continents, were ruddy; and white surfaces sometimes seemed to form over these continents or oceans, and to melt away during the day, as if clouds were being dissipated by the action of the sun.

THE VEGETATION OF MARS.

There were others, French astronomers, who suggested that the vegetation in Mars, instead of green, may be red. Spring may, indeed, come there, blushing like a maid. It was said, however, that we have no evidence that that is the case. How do we know that these green regions are oceans, or the white regions snow? It seemed somewhat bold to say so—to say that that must be the case. Might not the white region be frozen carbonic acid, and the ocean something altogether different from what we have on earth? That argument is put forward by Dr. Whewell, and it seemed very difficult to overcome it. A man might certainly be thought very bold, on considering that he never could come nearer to Mars than 30,000,000 miles, to say what its surface contains. But we know now as certainly as though we had taken water from it and had it analyzed by a chemist, or drank it; we know certainly that water exists there. The spectroscope comes in here. When the sun is not high above the horizon you recognize in its spectrum a number of sharply defined dark lines. As his light shines through the vapors of our atmosphere, the physicists came to know that these lines were due to water in our atmosphere. Here I take the opportunity to correct an injustice, of which I have been guilty to one of your leading physicists, Dr. Cook of Cambridge. I have been saying in my lectures that Secchi and Jansen found out that these streaks were due to water; but that fact had been shown in a much more scientific manner several months before by your countryman. He observed the sun, noted these bands as they first faintly made their appearance, while the sun was still high up. Then he took his hygrometer, and he noted that as the hygrometer showed greater moisture in the air, these bands became more distinct. He showed beyond the possibility of doubt that they were due to water in our atmosphere. Mars was observed in 1364 by Dr. Huggins, and it was noticed that across the faint solar spectrum of the planet, there were those water bands. They might have been in the atmosphere of the planet, or they might have been caused by the moisture of our own air. But Dr. Huggins determined to remove all doubt by turning his spectrum to the moon, which was low down; so if the bands of the spectrum had been due to moisture in our air, they would have been more clearly seen in the spectrum of the moon's light, but instead of that they were wanting. Therefore no doubt remained that they really belonged to the planet Mars, that there was vapor of water in the atmosphere of the planet. This was a most charming evelation. How could water exist there without also evaporation? All the operations of our atmosphere—storms, winds, rain, &c.—due to evaporation and precipitation take place in Mars. These white masses may be clouds.

One peculiar observation was made. A certain white region along the edge of an ocean in Mars appeared here, as the planet turned round. Mr. Dawes watched the planet during the whole night, and at 2 o'clock the whole of that cloud had disappeared, and he saw that ocean in great distinctness. It was then midday in Mars. That introduced a consideration of some interest as to the study of Mars. We want in that study not merely a clear earth sky, but a clear Martial sky. Another curious thing hinders observation. All around the planet there is an appearance as though its edge was covered with cloud. On one side it marks where the day is beginning; on the other where it is ending. The presence of the cloud, therefore, seems to indicate the gathering of misty clouds in the morning and misty clouds in the evening.

It has been said that after all, although there may be water there, there may not be an atmosphere carrying great cloud mists, but one so shallow that on account of the great cold, instead of clouds hoar frost is formed upon the surface of the planet in the night, and when the day is proceeding that hoar frost is melted, and the surface of the planet is exposed at once.

DIVERSITY BETWEEN MARS AND THE EARTH.

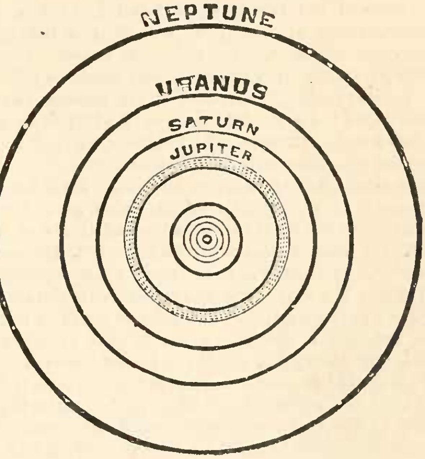
This theory in relation to Mars was that it was a disk or globe covered with a hoar frost, and having other peculiarities different from ours. That theory seemed to me so unpleasant that I put forward myself, or at least I adopted, the theory that Mars is a globe like our earth where all similar processes take place—rain, wind, storm, clouds, rivers, being produced, denudation taking place—everything seemed so much like the earth. But then came this annoying theory that would put Mars altogether out of the scheme of an inhabited world, that it was only covered at night by hoar frost, and that there was everything in Mars unlike the earth instead of like it. I determined to destroy that noxious theory, and I began an essay for the purpose. But I found as I went along that the new theory was as strong as the one I had adopted in its stead, and I finished that essay by advocating the theory that I intended to destroy. I found there was very good reason indeed to believe that Mars is in a condition quite unlike our earth; that it has a very rare atmosphere, that it has an atmosphere bearing the same relation to that of this globe that the oceans of Mars and its continents bear to ours. You will notice that the oceans in Mars are very much smaller proportionately than the oceans on our own earth. There is no Pacific there. In fact there is no Atlantic. You have only oceans comparatively small; the lands and seas are intermixed. You take the case of our own earth. The two Americas form a single island; Europe, Asia, and Africa form another large island; and we have the oceans around those islands. There is nothing of that in Mars. You can travel from any one part of Mars to another. You need not leave the sea or land, according to your taste, if you are an inhabitant of Mars. Here is a chart of Mars. There are the various divisions as I charted them down, and here you will notice you can pass by water from one ocean all around, on to the side oceans and again northward; in fact, there is no limit to the extent of the journeys. And there is a curious feature, the existence of bottle-necked oceans, with narrow inlets connecting them with the larger ones. A French student who recently dealt with that matter has shown that if our seas were to become shallow, the form of the oceans would be like that; there would be many bottle-necked seas. It seems therefore as if Mars had a smaller quantity of water in proportion to its surface than our earth. And so also in respect to the atmosphere; there will be much less atmosphere to each square mile; and altogether we have a condition of things quite unlike that I had previously supposed. And then there is the small gravity of the planet. If the gravity of our own earth were suddenly changed to the gravity in Mars, a pound weight would be reduced from 16 to 6 ounces, and the air would be reduced in the same proportion. At the hight of six or seven miles in a balloon ascent with Mr. Glaisher the air was so rare, Coxwell found the strength leaving him, while his companion was insensible. It was only by the skin of his teeth he escaped, for his arms being benumbed, he pulled the valve rope with his teeth. At the hight of seven miles the atmospheric pressure is reduced to one-fourth. And here, in the case of Mars, I am speaking of a reduction to one-sixth, which would happen; and if you add the consideration that the quantity of air is less, you have a rarer atmosphere, you have a condition altogether changed; so that light, as we know it, would become impossible, the cold would be greater than you can imagine, and the condition of things becomes altogether different. Evaporation would take place rapidly, and a considerable quantity of the vapor of water would rise in the air in daytime; snow would be formed and carried along by the currents—currents that would necessarily arise and carry it toward the pole, and there would be a gathering of snow at the poles which would be due in fact to the daily formation of snow and the continuous sweeping of those snows toward the polar regions. The author of that theory, Mr Matthew Williams, says the gathering of snow would tend to the formation of enormous glaciers, and then sometimes these large masses of snow would be broken up. I looked out for evidence against the theory, and I found evidence in favor of it. Gen. Mitchell of Cincinnati has given an account of an observation of Mars, in which a great mass as large as this white region was broken off, and seemed to him to be carried up to the polar regions. We never look at Mars nearer than 30,000,000 miles. You see that as large a mass was carried off as though a territory as big as Spitzbergen or Nova Zembla, or as large as England, were broken off by some great catastrophe. The idea suggested by the new theory as to Mars is that Mars may have been inhabited in past times, but is at present too bleak an abode. We know that on our own earth life ceases in those upper regions at the hight Coxwell and Glaisher reached, and in Mars life only of the lower kinds could possibly exist.

THE ROTATION OF MARS.

I have yet to make a few remarks about Mars. I have told you the planet has been charted. Its period of rotation has also been determined. It would seem strange that you could tell the time taken by a planet turning on its axis, exactly, within a few seconds, or part of a second. You see that spot in the middle of the planet. You could not be certain, within a quarter of an hour, whether that spot is in the middle of the planet. But if you note this, you can observe it in the planet in the second rotation. If you are a quarter of an hour wrong in that case, that quarter of an hour is divided between the two rotations. The difference is only seven and a half minutes. That is divided into three rotations the next day, and so the error is reduced to five minutes; and so on for a month, until the error becomes smaller, and you can let the planet pass away for a year, so that you can know when exactly it comes back and how many rotations it has made in the interim, and thus the error is still more reduced by rotation after rotation, until in the course of many years you get the time of rotation accurate within a second or much less. It had been shown by a certain German astronomer that the period of rotation of Mars was 24 hours 37 minutes and 23½ seconds, or thereabouts. Then another German astronomer, Kaiser, improved on that, and he made the period of rotation 24 hours, 37 minutes and 22 6-10 seconds. Well, then, an English student of astronomy, one who does not venture to call himself an astronomer, an English student, Mr. Proctor, thought he would try his hand at this problem. [Applause.] And to his great distress he found that his result was greater than the German's by a whole tenth of a second—that it should be 24 hours, 37 minutes and 22 7-10 of a second. Kaiser thought it necessary to go over his work and publish a paper on the subject. From his paper I found he seemed to make out his case very accurately indeed. There was a wonderful amount of German care and labor, many details; but I found, strangely enough, two mistakes. He called the years 1700 and 1800 leap years, whereas we know that in the Gregorian calendar they are not leap years, and that made all the difference. And when that was corrected, I found my theory of the planet was correct, and the actual time it turned around in was 24 hours, 37 minutes and 22 7-10 seconds. It may seem to you unnecessary to be so exact. But there is one important question which may be solved by such information as that. It has been found that our earth is rotating more and more slowly as centuries go by. The moon lifts the tidal wave; that tidal wave acts as a brake, as it travels in a direction contrary to that in which the earth rotates, and slowly indeed our earth is losing its speed. We cannot measure that change by any ordinary clock, because our clocks are set by the rotation of the earth. We time our clocks to the transit of the stars. How can we answer a question such as that except by having some true clock? Here is Mars, this small planet, a pocket chronometer, and we can have that chronometer's time, and so soon as we have her time we can compare with that our own terrestrial clock. There are well-marked places on the face of the planet, and there is this also, that the planet has nothing to disturb its rotation. The sun is so far away that the solar tides do not affect it; it has no moon, and the oceans are not suited to the formation of a tidal wave; therefore the change of the planet's rotation would be insignificant. The planet is a suitable clock for getting at our earth's rotation.

THE ASTEROIDS AND THE GIANT PLANETS.

I now pass from these planets to the asteroids. There are now known 134 of these minor planets. There is a theory in the books that the asteroids are produced by the bursting of planets. That is not correct. Observations on the orbits which would result from such a catastrophe completely demolish that theory.



ORBITS OF THE OUTER PLANETS.

Considering the giant planets, to which I next pass we shall feel that they may be quite unlike this earth on which we live. Consider the enormous size of Jupiter. We are accustomed to consider him larger than our earth: but it is not merely that; he is 1,230 times larger. Here is a difference altogether too great to be regarded as a difference of degree; it is a difference of kind. Our conceptions of Jupiter are necessarily different. We should expect it would be a different kind of body from that on which we live, and we find clear evidence of that as we consider him. We have views of the planets here, but they are not as clearly visible to this large audience as I require. I have better views, and I shall have the room darkened and the views thrown upon the screen.

As soon as you look on Jupiter you feel that you have to deal with a body altogether different from Mars and Mercury; altogether different from those which we have been dealing with. Compare these views with those of the planet Mars, and you will see that there is no similarity in the conditions. In Jupiter you have bands of clouds which have sometimes been compared to the trade-wind zones. But our trade-wind zones and bands of clouds upon the equator would not be visible from a distant planet.

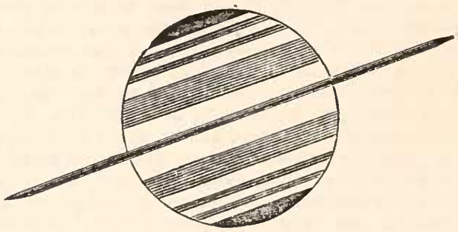
When Jupiter is brought on, you will realize how much Jupiter differs from Mars. You will feel when you look on these views of Jupiter, taken at Cambridge Observatory, that you have before you an atmosphere heavily laden with some kind of vapor or vapors, it may be many. Cloud masses traveling over the surface of lands and seas would show some degree of agreement in shape with the continents over which they traveled, and if disturbed by the wind they would be torn apart; but we find them great masses, as if their depth corresponded with their breadth, as if the depth of these cloud masses was as great as their length and breadth—everything that the telescope shows us leads to the conclusion that there is a deep atmosphere.

You have in the lowest right hand picture a very small round disc of one of the satellites of the planet Jupiter, and the diameter of it is 2,000 miles. Imagine the 20th part of that tiny satellite; that would be 100 miles. It is inconceivable that these cloud masses have no greater depth than the 20th part of that little satellite. You must feel that these cloud masses, as they appear, have a depth comparable with their length.

If the atmosphere of Jupiter were only 100 miles deep, the pressure at the bottom would be so great that the lower atmosphere would be a million of times as dense as platinum, the heaviest of all the elements. It is utterly impossible, of course, that any such atmosphere could exist; but that is the legitimate calculation, the pressure would be millions of times as great as ours, so as to produce a density equal to that of platinum. There is one peculiarity about the planet opposed to that idea. Instead of Jupiter being the densest planet, it is less dense than the earth Its density is one-fourth the real density of the earth and corresponds with that of the sun, and this seems to give an explanation of the difficulty. The great compression of the sun's attraction would make his atmosphere dense, but his enormous heat expands the atmosphere, and instead of being a dense globe, we have a globe less dense than the earth. Must it not be manifestly so in the case of Jupiter, and that by its great size it is brought more nearly in relation to the sun than to the earth, and must it not be like the sun in regard to the heat within his globe? You have the argument derived from the compression of the atmosphere of the planets. Again, the clouds are formed and carried around and around, and the planet carried around and around in 10 hours, the equatorial more rapidly than the temperate zones. Notice the equatorial band, brighter than the rest, and you will perceive that it corresponds with the equatorial band of the sun. There are no features in Jupiter like those in the earth; and all goes to show a planet more of the nature of the sun than like ours. But might not the appearances be those of ordinary clouds, after all?

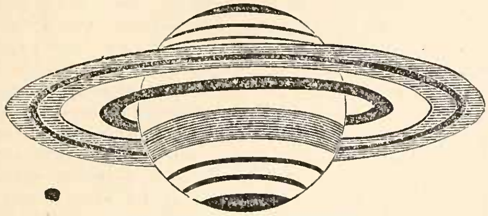
That can be tested by experiment. The light of that planet, instead of giving the same kind of light as if made of rocky matter and covered with stones, shines three times as brightly; it shines almost as brightly as if in the midst of a mass of clouds or snow. If Jupiter were purely white, you might say that it was only these clouds shining that we see; but in point of fact, Jupiter does not look white. Therefore you have the certainty almost that there must be an inherent light in it, and if it be inherent light, if the center of the planet gives it out, it must be at a heat corresponding to that of red-hot iron.

The satellites of Jupiter may be bodies well lighted, though not intended to supply light to the planet. All the satellites cannot supply the planet with 1-16th of the light which we get from the full moon. They are illuminated by the small sun of Jupiter, which is but the one-twenty-fifth part of our sun in size. We will have another picture of Jupiter. You see how processes are taking place which seem to have led to the uprising from some interior surface, perhaps a surface far down below the atmospheric envelope, the uprising of a great cloudy mass, surrounded by a dark border, which was distinctly visible to Prof. Mayer for hours. Everything, as I think, seems to show us that in Jupiter we have a scene of tremendous activity.



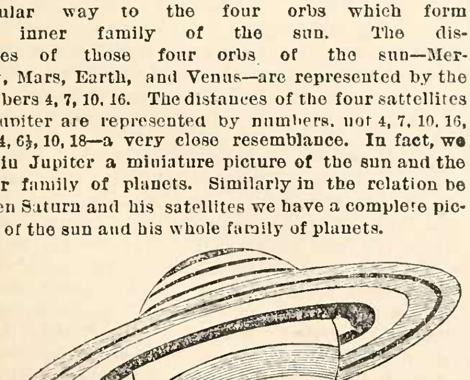
THE RING SYSTEM OF SATURN.

Now to his brother giant, the planet Saturn, with his glorious ring system. Those belts on Saturn correspond in kind to those that exist on Jupiter; and I might apply the argument on Jupiter to Saturn without any further explanation. This great belt of Saturn during the whole long year of Saturn—lasting 29 years of ours—remains persistently equatorial. Now the axis of Saturn is inclined very much as the earth's axis is inclined, but the equatorial belt never shifts, following the sun, as ours does, along the ecliptic. It seems by its position to show that it is produced by a force residing in the planet itself. Now there is one argument derived from the ring of Saturn. Those rings have been described by Brewster as glorious bodies reflecting light on Saturn, and making up for want of the sun. Instead of doing that, those rings cut off the sunshine. You will see how the rings appear when they are seen edgewise. The planet is in the full light of the sun, and the ring is cutting off every little light indeed, and no harm is done. But the planet changes and the ring shifts in position backward or forward as the year proceeds. Look at this picture illustrating those changes, and you will see that where the Winter of part of the planet is in progress when more light is wanted, the ring cuts off the light. So if we are to argue from creation, if we are to say the Almighty intended that to be the abode of life, we have at once an enormous difficulty brought before us. Instead of the thing being well-devised, it seems ill-devised. It seems as if the only time the ring reflected light was when it was not wanted, and when it was wanted the ring came and cut off a great part of the sun's light, and it does not cut it off for a short time, but for 8½ years a certain portion of sunlight is cut off, and for six of those years the whole of the sunlight is cut off by the ring.



THE ARGUMENT OF DESIGN.

That is an argument well worth considering. I am quite aware that in modern times men of science satisfied themselves that they had disposed of that argument, and I think there is a great objection to the argument of design. We are too much in the habit of assuming that we know the design of the Creator. Then comes one who says the creation does not fulfill that design, and it sometimes seems then, as if the beauty and perfection of the Creator's works had been done away with. The difficulty is not in believing there is design, but in becoming able to recognize what that design is. Now the two schemes of these great planets, one containing four and the other eight orbs, are not, as we are in the habit of supposing, insignificant. The largest of the satellites of Saturn is as large as the planet Mars, and certainly as large as Mercury. The least has a diameter of 1,000 miles. In the case of Jupiter, those four orbs of Jupiter correspond in a very singular way to the four orbs which form the inner family of the sun. The distances of those four orbs of the sun—Mercury, Mars, Earth, and Venus—are represented by the numbers 4, 7, 10, 16. The distances of the four sattellites of Jupiter are represented by numbers, not 4, 7, 10, 16, but 4, 6½, 10, 18—a very close resemblance. In fact, we see in Jupiter a miniature picture of the sun and the inner family of planets. Similarly in the relation between Saturn and his satellites we have a complete picture of the sun and his whole family of planets.



SATURN AND TITAN.

The largest of the satellites of Saturn is called Titan, and it is certainly larger than Mercury, and probably as large as Mars. How splendid must be the scene which the planet Saturn presents to its inhabitants! It does seem as though a scene of such wonderful beauty was not intended to remain without spectators. It presents through the telescope the most beautiful colors, the most wonderful symmetry—all presented to the inhabitants, if inhabitants there be. I pass over the interesting facts in the discovery of the outer planets because the time that remains is short.

It seems to me that Neptune and Uranus present an intermediate condition. They are not large enough to be supposed fit to be the centers of schemes of worlds to give out heat and light. They are further away from the sun than Jupiter and Saturn. But it seems to me they might very well be in an intermediate condition and still retain enough of the heat they originally possessed to be the abodes of light and heat—that is, inherent light and heat enough to sustain the life of creatures. What I want you to notice is the division of the solar family into two parts, perfectly distinct from each other; and I was very glad to see, in the recent gathering of the American Association for the Advancement of Science, that a distinguished mathematician of yours, Prof. Peirce of the Coast Survey, has arrived at the conclusion that Jupiter and Saturn are really unlike the earth. He arrived at his conclusions from mathematical results educed from the formation of those planets on the nebular hypothesis; I come to mine by a different path, but the conclusions are the same. So that I really think we may speak confidently that Jupiter and Saturn are not what they have been supposed to be, but are semi-suns, distinct from the inner planets.

Now a few words remain to me on the general question of life in the solar system. I must confess the more I study the matter, I am convinced we are not bound, in order to reconcile us to the Almighty's work, to adopt the theory that all or any considerable portion of the planets are inhabited. We look back at the past history of the earth, and we find that the Creator is, in our eyes, wasteful of His powers. But infinity can never be wasted. So, in the question of time there has been no special care to make available every instant of the existence of the different worlds. We find that for millions of years back our world was uninhabited, and we see, in regard to future conditions, that even though there should not be destruction from fire, life will probably by other causes pass away from the earth. So, far from considering that every member of the solar family must be inhabited at the present time, the chances really are millions of millions to one against any special planet being inhabited, because the time it has been inhabited, if judged in analogy with our own earth, must be a very, very small part of the whole time in which the planet exists.

Here, again, we are brought face to face with another difficulty: In the emission of light and heat from the sun there seems to be waste; but here, in reality, we are in the presence of infinite power, and we may say with the Psalmist that man cannot by searching find out God. "Canst thou find out the Almighty into perfection? It is as high as Heaven, what canst thou do? deeper than Hell, what canst thou know?" I think we may content ourselves with viewing the matter in that light. Men of science tell us on every side that science teaches them nothing of God. That is the very thing we are told in the words of the Scripture. "Thou canst not by searching find out God." Mysteries are brought before us which no effort on our part enables us to resolve. So far from inducing doubt, it should encourage our faith. As we are in the presence of infinite space and infinite time, so also are we in the presence of infinite wisdom and infinite power.

COMETS AND METEORS.

THIRD LECTURE OF R. A. PROCTOR

REMARKABLE COMETS OF HISTORY—REPULSIVE ACTION BY WHICH THE TAILS APPEAR TO BE FORMED—COMET FAMILIES OF JUPITER AND HIS FELLOW GIANTS—THE METEOR SYSTEMS—METEORS AND COMETS IN THE SUN'S NEIGHBORHOOD—EVIDENCE OF THE THEORY THAT METEOR SYSTEMS HAVE BEEN EXPELLED FROM THE GREAT PLANETS.

Prof. R. A. Proctor, F. R. S., gave the third lecture of the course of six, on Astronomy, under the auspices of the Young Men's Christian Association, at Association Hall, on January 17. The subject, "Comets and Meteors," was treated as in former lectures, by means of pictures and diagrams prepared specially for Mr. Proctor, and also by photographs, exhibited on a large scale by means of the oxy-hydrogen stereopticon of the Stevens' Technological Institute.

THE LECTURE.

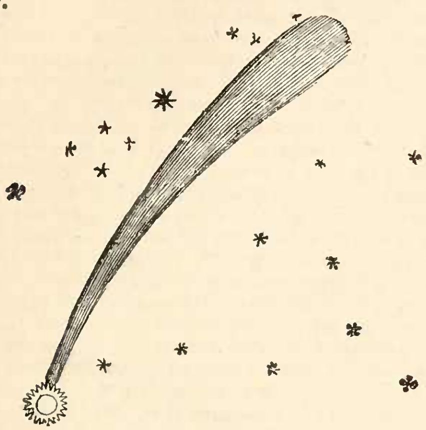
The longer I continue to give these lectures in America the more my difficulty seems to increase. When in Boston, I was asked to give twelve lectures, and feared it would be too great a task. Before I came over to America I thought it impossible that any audience would attend so many as twelve lectures; but since then, since that, difficulty has passed away from my mind, the feeling I have is that these lectures are not nearly enough to give the facts I would like to lay before you. Each time I give a lecture I feel more and more how much I have to omit. I mention this because I should like you to bear in mind that if I seem to bring the facts too rapidly before you, it is due to the difficulty under which I labor. I feel that I am taxing an audience greatly by bringing facts before them, one after another, with such rapidity. It is only the confidence I have in American audiences which impels me to go on with these lectures, bringing on these facts without giving time, as it were, for any rest of mind. I desire you, however, to recognize the difficulty under which I labor.

The subject I have to deal with to-night is really a fit subject for twelve lectures. It is full of mysteries, and full also of great discoveries which have recently been made. To deal with it in one lecture is a somewhat ambitious attempt. We have, to begin with, the great wonder that comets and meteors should in any way be associated, they are so unlike each other. Comets are very large bodies, much exceeding the sun in magnitude and the largest of the stars, and having that mysterious faculty that they possess of coming from fathomless depths of space, after journeys which must have lasted over millions of years, rushing up toward the Sun, passing close around him, and then passing away with no hint as to what depths of space they will fly to. It is a strange fact that we should have to associate with bodies like meteors, so small in dimensions that a child could in many cases carry them, bodies so large that our sun sinks into insignificance in comparison with them.

THE COMET'S COURSE EXPLAINED BY GRAVITY.

Now let us pass to the facts most important in this matter. Again, I remind you that I am obliged to leave out the facts dealt with in our text-books of astronomy, to take the more striking facts associated with the views taken by astronomers of the present day. To begin with comets. We have in the first place the fact that comets come from outer space, and after traveling almost directly toward the sun for a long period of time, circle around him, and pass away again into the depths of space. There is a fact which seems at first to remove them from all the ordinary laws of motion, certainly all the laws presented by the planetary system; but it was precisely in that, especially, that comets first gave astronomers a proof that there was no resisting the truth of the law of gravity. Newton took the comet of 1680, and having found that it was traveling on a parabolic course—better described as an exceedingly long oval—was able to say that that comet would follow such and such a course, although its orbit was of an entirely different nature from the planets, and continually changing day by day. Yet he said: "I will follow that body and tell precisely where it will go;" and it was this mastery of Newton over the laws of celestial motion that first convinced astronomers of the truth of the laws of gravity. The comet came and followed the precise path that Newton suggested. Let us see how the comet moved. It came traveling up toward the sun, seeming to move directly toward him, marked among all comets by the directness of its path toward the sun. When it was within a sixth part of the sun's diameter it circled around him and then passed away on a track precisely like that on which it had arrived. Like all other comets of distinction it had a long tail, and as it approached the sun, that tail extended, according to the known laws of comets, away from the sun, and was thus carried behind the comet; but as the comet passed around the sun—and passed around it in a few hours—when it was seen on the other side, a long tail—I cannot call it th;

same tail—a long tail, 90,000,000 miles in extent, was seen, no longer carried behind the comet, but traveling now in front of it; and in the day or two that that comet was lost sight of, that long tail was thrown out by the retreating comet. Now that comet had taken four weeks in approaching the sun over a distance of 90,000,000 miles, though having, at starting, all the velocity with which it had arrived; but in less than four days that wondrous tail, 90,000,000 miles long, was thrown out in front of the body.



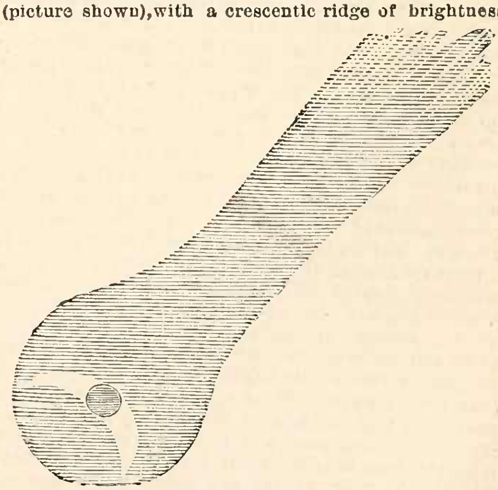
COMET OF 1680.

There is a fact which either shows us we have to deal, as to a comet's tail, with matter which has not been formed in reality, but is some way made to become apparent to us, or else we have to deal with a force incomparably greater than gravity. This repulsive force of the sun seems incomparably greater than that of gravity. Gravity had led that comet over a distance of 90,000,000 miles in four weeks, and it threw out its tail in four days. There is the first evidence of this mighty repulsive force of the sun. The comet came so close to the sun—a distance only the 160th part of that which separates our earth from the sun—that the heat to which it was exposed was 25,600 times greater than the heat endured by our earth. There then was a heat which we might very well imagine would destroy the very substance of our elements. All the materials on our earth would, under such a heat, be vaporized. Newton assigned a path to the comet of 1680, but was not able to assign a period to it. He was not able to say for how long a time it would pass away before it returned; but in the case of Halley's comet, Dr. Halley not only calculated the path the comet would follow, but he looked through the annals of astronomy to see if there were any comet traveling on the same path. He found one in the year 1607, and another in the year 1531, and noticing that the interval from 1607 to 1682 was not very different from the interval between 1531 and 1607—76 years about—he concluded that the comet had a period of 76 years, and he boldly presented the prediction that in the year 1759 that comet would return to our neighborhood. The prediction was an exceedingly bold one, and it was the first time an astronomer had ever ventured to say a comet would follow a certain path at any given time; and there was this interesting circumstance about it, that when that comet returned, the astronomer who predicted it would long since have passed away.

SUCCESSFUL PREDICTION OF A COMET'S RE-APPEARANCE.

When 1759 came astronomers went over the calculation made by Dr. Halley, and they found, from their greater mathematical experience, how that comet might be dealt with. They were able to tell the very month, and even predict the day. They said upon April 13, 1759 with a limit of error of one month, this comet would come back to its point of nearest approach to the sun. It actually returned, and made its nearest approach to the sun on March 13, 1759, or just within the limits of error. They did not know at that time that the planets Uranus or Neptune existed, and these had exerted their influence on that comet.

But when the return year 1835 was approaching, astronomers had learned about Uranus, though Neptune had not been discovered, and also how to deal much more perfectly with the processes of mathematical analysis involved in calculating the course of celestial bodies; and they said this comet would return in November, 1835, and they put the dates between Nov. 12 and Nov. 16. A German astronomer, Rosenberger, gave the exact date as Nov. 13. The exact date on which the comet did make its nearest approach to the sun was on Nov. 12, and certain strange facts were noticed. As it approached the sun it presented a very remarkable head, which you recognize here (picture shown), with a crescentic ridge of brightness.



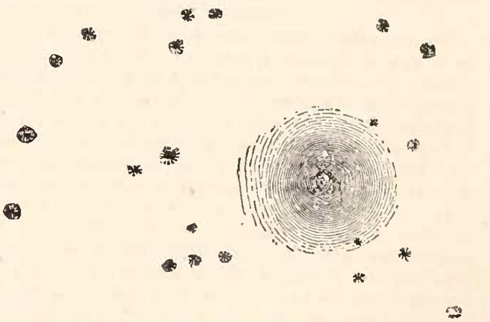
COMET OF 1835.

It seemed as if it were forced from side to side by some disturbing force exerted by the sun. That comet passed around the sun, made its nearest approach, and came around on the other side, passing southward. Therefore it was observed by astronomers of the southern hemisphere that, instead of presenting the appearance it had when it approached the sun, it appeared not only without tail, but even without any head. It appeared as a small bright speck, like the small central part within that crescent, which you see here. Nothing distinguished that comet from a star except the fact that it was moving slowly over the heavens, and as days passed on it increased, so that in 17 days it increased 70 times in size. It seemed as if it were trying to develop a long tail, but it passed away before a tail had been developed. It was noticed that there seemed to be a power in the sun to raise from the nucleus of that comet vaporous matter, which was, again, swept away by the sun; and Sir John Herschel at that time said that, in his opinion, that was the nature of the economy of a comet—that matter is so raised, and that the sun has power over that matter to repel it.

EVIDENCES OF THE REPULSION THEORY.

You notice I am dwelling on that fact of repulsion. I want to show that power of the sun in repelling matter from it. I will now deal with one of those small comets, very curious, indeed, in their history. We have here all the evidence we can get, although it is not very striking. In the year 1770 a small comet made its appearance, which, having been watched for a time, was found not to be traveling in one of these long oval paths, such as are here presented; but in a path which, instead of having one of these long periods, was completed within a period of 5½ years. It was called, from the name of the astronomer, Lexell's comet. It was never seen again. Astronomers then were led to inquire what had become of this comet. Tracing it back, they found it was in a path so near to Jupiter that the giant power of that planet arrested it in its course, and sent it out on a path entirely different from what it was before. It was useless to look for it. This question then arose: How was it that this comet of very striking appearance had never been seen before? Traveling in a period of five and a half years, how was it it had never been seen? They traced it back and calculated its path, and they found that the same giant hand which sent that comet away had introduced it. That comet, in 1667, approached quite close to Jupiter; so close, in fact, as to intrude itself among its satellites. Jupiter is not the planet to stand any nonsense of that sort, and so compelled it to follow another course. Another five and a half years, and another five and a half years, and then it was again seized by Jupiter, and sent outside of the solar system, and where it has gone nobody knows. There is rather a curious fact in connection with the history of the French revolution. Blanqui, a republican, was imprisoned, and he took it into his head to write about comets, and something made him look on Jupiter as a sort of policeman, and he described Jupiter as being always patrolling on the watch for comets. When they came near he drove them into the perilous straits, and it was well for the comets if they could escape from that time forth. But still there is one point about this comet of Lexell worth notice. It had gone into the midst of Jupiter's satellites. The satellites are not large objects, and if the comet had any mass he could disturb them; but instead of that all those satellites are still traveling the path they had before that comet had arrived, and we learn, therefore, that that comet at any rate was mere vapor, had no power and no weight, although it was much larger even than Jupiter. It had no power, no weight or attractive influence to disturb those little satellites which Jupiter manages so easily.

Now we come to another comet—that seen in 1848, which is really interesting, as traveling on the shortest period of any comet we know of, a period of three years and four months. It is noteworthy on this account, that this little comet seems to be getting closer and closer to the sun, traveling always on a shorter and shorter period. It is apparently retarded by the influence of some matter occupying space. It may seem a strange fact to say that it is retarded, and yet it is traveling more and more quickly. But that is the effect of retardation in any instance. If our earth is to be retarded, the effect will be that our earth will travel more and more rapidly, because the effect of the retardation would be to get the earth nearer and nearer to the sun, and all the time she is being retarded by resistance she would be hastened by the pull of the sun drawing her inward, and when she arrives so that she travels on the path of Venus she will travel as fast as Venus, and when traveling the path of Mercury, she will travel as fast as Mercury, then faster and faster until in the course of time she will fall on the sun. This comet is traveling faster and faster on a smaller and smaller orbit.



COMET OF 1848.

But I pass from that, and go to one, the facts revealed by which are among the most curious—I mean the comet which was discovered in 1826. It was carefully watched, and it was then found that this comet had been seen before by Caroline Herschel and others, and a path was assigned to it, having a period of six years and eight months. Now this comet was in the first place remarkable, because its path crossed the earth's path; and, indeed, on the next return, in 1832, astronomers announced that that comet would actually cross the earth's path, and many thought that that meant that there would be a collision, and great alarm was excited. A member of the Paris Academy said it was imprudent for astronomers to make such an announcement, for in 1771 announcements made in that way had frightened the people out of their wits. In 1771, a hundred years ago, tickets were offered for sale purporting to be reserved seats in Paradise, and people actually bought those tickets. [Laughter.] In 1832 they were not quite so bad, but still they were much frightened, and many unfortunate circumstances happened in France on account of that fact. They required to be told—and then they were not comforted—that the mere fact that the comet passed the path of the earth would not interfere with the earth; that the passage across the path of the earth would not injure the path, for the path was not a material thing. The people were frightened, and they were not certain that astronomers had calculated the path so exactly that there would be no collision. But that passed away, and nothing more was heard until 1846, and then the comet was found traveling on its usual path, and to the great astonishment of astronomers it was announced that the comet had divided into two parts, each having a distinct head and nucleus. It was noticed by Capt. Maury at the Observatory at Washington; but strangely enough, on the night when he observed the comet had doubled, the records of the German Observatory showed the comet to be single, and it would appear, therefore, that the greater clearness of the atmosphere in America had enabled him to recognize the change before it was noticed in Europe. Two separate comets traveled along, side by side, and the strange circumstance was noted that they interchanged light; sometimes one and sometimes the other was brighter, as if there were communication between them. They were a kind of Siamese twins. They passed into space, and astronomers thought they could watch the comets again and ascertain how they were separated, but the comet was never seen again. The year 1866 came around, and astronomers calculated the path of the comet. They looked for it. They examined the path over the heavens a great distance on either side, but they failed to recognize that comet. I told you that comet passed the path of the earth, and there are other systems which also cross the path of the earth. It was suggested that the comet had encountered meteor systems and split up, and was again and again split up, and so vanished. You will see there was an important connection between that and what we have learned since about the comet's history. The year 1872 came, and that comet was again looked for. Other calculations were made as to its path. It was looked for more carefully, but in 1872 it was not seen. I leave its history for the time, presently to return to it.

WHY SOME TAILS ARE STRAIGHT AND OTHERS CURVED.

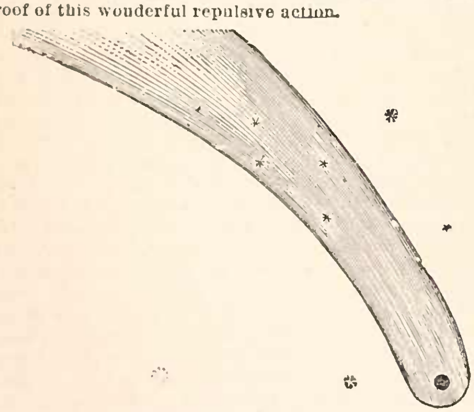
There was a comet seen in 1858, and called Donati's comet. Here is a picture of the comet as seen in England, and it looks like a plume, but in America that comet was observed to have not merely the plume-shaped body, but also a perfectly straight tail, and in some pictures two straight tails. Let us, in the first place, deal with that comet. Why should th tail of a comet be curved? The position of a comet' ail is due to repulsive action, and if that rep e action take place immediately, it is qui clear the tail will be swept into a straight line; and if you look at a straight line, no matter how placed, it would look straight. But if the process of repulsion takes place at a moderate rate, the tail would appear curved. You can understand that a curved tail behind a comet is due to repulsion not taking place instantaneously. The head of the comet consists of two kinds of matter—one was repelled with moderate velocity, very great but moderate by comparison—and the other repelled with great velocity, and so swept off into a straight line. It would be manifest to you, that being the case, since there was a separation of the matter in the comet's tail, that if the comet's head was complicated in structure, there would be an intermixture of the two kinds of matter, and the portion of the matter more readily repelled would escape, carried off by the other tail, carried off into the curved tail, and at last would be swept away; and perhaps a little later another portion would be swept away, and so you would see extending from the curved tail various streaks of this matter. You have here a picture of the curved tail, and you will notice the variety of streaks thrown out from that—thrown straight out, indicating the action of that kind of process we have been describing. Matter more easily repelled was carried away with the matter less easily repelled, and from time to time some parts were swept off, so that there was a combing out of the tail of the larger part, while the straight tail remained perfectly distinct all the while. There was a curious fact indeed; and it seemed to dispose of Tyndall's theory that the tail of a comet is not produced by repulsion, but a certain kind of action produced behind a comet, and bringing out as it were from space cloud-like matter. Here is a process which seems perfectly to correspond with the theory of repulsion, and it seems explicable in no other way. So that there is some force in the theory of a repulsive power exerted by the sun.

EXPLANATION OF THE PLURALITY OF TAILS.

I must remark at this point that we owe to Prof. Newton of Yale College those views as to the formation and behavior of that comet's tail. They occurred independently to Sir J. Herschel; but I found a paper containing a complete account of all the phenomena of that tail had been published many years before. Now let us consider the way in which the head is formed. There is the comet as it first appeared as a small round object, not more distinguished in appearance than the comet of 1843. In time the comet became lengthened, and then grew out a tail. There was in the first place the formation of a crescent-shaped object, and from either side of that object matter was thrown off. The tail became divided behind the head. As time passed, all around the central bright part of the head, matter was raised from the head of the comet, even as Herschel had found matter was raised from Halley's comet; it was raised and then condensed and formed an envelope around the comet Over our rain-clouds the vapor of water is raised, and the process of cloud formation takes place again, so that we see two layers of clouds; so after a time we begin to notice two envelopes were formed, and in fact you can see the third envelope beginning to be formed

When those three envelopes were formed, that was the time when the comet, as seen in America, had three tails. It seemed as though the three envelopes each of them gave the material when a tail was to be formed. And we are led in that way to an explanation of another comet, a very well-known comet, the six-tailed comet of 1744. This was called the six-tailed comet; but it seems to me that when we view the matter in the way we have been considering it we should look upon that comet as a three-tailed comet, not a six-tailed. You will see clearly in a moment that there is good reason for reducing the number of tails.

A comet such as the comet of 1811 has around its head an envelope formed, and from either side of the envelope there is a bright streak, with a dark space behind the head of the comet. We don't call a comet such as that a two-tailed comet; we say it is a one-tailed comet, with the sides of the tail exceptionally bright. If we call that tail, where there are two bright streaks, a single tail, I think we should call this tail where there are six bright streaks a three-tailed comet. We should regard the two outer streaks as the outer streaks of the tail, the two next as the outer side of the second tail, inside the first, proceeding from an inner envelope as in this case, and the two inside streaks as the sides of the third tail. That seems to be the more natural explanation of the matter. And then we remember what we are so apt to forget, that comets have three dimensions, that they are not merely displayed before us as a picture, with length and breadth, but they have thickness also. If you view them from any part they would present the same appearance. That six-tailed comet is really a three-tailed comet, with one tail inside the other, and doubtless it had three envelopes around the head, and from these envelopes were streaming away those tails—another proof of this wonderful repulsive action.



GREAT COMET OF 1811.

Now, if we consider the aspect of the head of Donati's comet, we shall recognize something of the solar action by which the head and tail are formed. Here [referring to the chart] is the head of the comet. Here you recognize the different envelopes, connected one with another by bright streaks, and you can perceive that from these envelopes appear streaks of bright matter swept away on either side of the head. In the other picture, taken at a later time, the two streaks are distinct, one from another. Here is a wonderful process, and remember the scale on which it is going on. Dr. Holmes spoke with poetic license of ten million cubic miles of head of that comet, and ten million leagues of tail: the tail was many times as large as Dr. Holmes's numbers.

I must briefly touch on the theory of Dr. Tyndall, and it is well worthy of attention. Dr. Tyndall went through this experiment: He had a long tube, apparently clear of all material substance except air, assumed to be pure air, and what happened? He allowed a small quantity of vapor to pass into it by taking a small piece of blotting paper, immersed in water, allowed to dry, and then put into the tube, and merely letting the air pass upon it. It seemed as if nothing was carried in, yet when the light from the electric spark was let into it a cloud made its appearance. He opened the tube, and swept everything away except an invisible residue. The light from the electric spark was made to shine upon it again, and the cloud again was formed, so that Dr. Tyndall said he had an exact analogue of the tail of the comet, and he considered that the head of the comet, depriving the solar rays of heating power by not allowing the heat to pass through, left the actinic power of the rays in the matter behind the head of the comet, bringing down out of space clouds formed in matter not belonging to the comet, but brought down as the comet's tail; and Dr. Tyndall considers that he can represent not merely the formation of a comet's tail, but all the appearances presented by the head of even Donati's complicated comet.

CONNECTION OF METEORS WITH COMETS.

I pass from these facts, wonderful as they are, and introduce the subject of meteors. For a long time meteors were looked on as phenomena of our atmosphere, but facts began to be observed which led to a different conclusion. One fact was that the meteors occurred in showers on certain days. Take, for instance, the Nov. 13 shower. What could it mean? Why should a shower of meteors take place on Nov. 13? There is no reason why meteors should show brightly on the 13th of November or any special day, so far as the earth was concerned. But, on Nov. 13, the earth is passing a particular part of its course. In November the earth, revolving around the sun, when she reaches that part of her course is saluted by certain missiles which strike her atmosphere from without, and become illuminated in passing through it. The inference is this. If a traveler in passing along a certain road found himself in a certain place always saluted with a shower of stones, he would conclude that some mischievous persons infested that part of the road and amused themselves at his expense. By the way, this illustration which I made in a former lecture, was strangely misinterpreted in a morning paper. I spoke of idle schoolboys throwing stones at a traveler; it was described as an occurrence happening in England, and to my horror I found it in one of the morning papers that it was cus.

tomary in England to salute travelers with missiles [Laughter.]

We suppose the sun in this place, and the earth in passing here is saluted with a shower of stones. Thes stones would be carried by attraction to the sun, and there would be an end of the matter. How then does it happen that for centuries the earth is thus saluted on passing there by these meteors and that the force of gravity has been resisted? If these stones have a motion of their own, they can travel around the sun; there can be always a stream by which the earth can be saluted with a shower of stones at that particular place. To remove all doubt, let us reason in this way: If there were bodies traveling that way [indicating it on the chart], and the earth was passing there, these stones passing over a short part of their course, and the earth passing over a short part of its course, there would be a shower encountered by the earth. Suppose a shower of rain is falling from a particular part of the heavens, all the drops seem to come from a particular part of the sky,—from a particular direction. Thus also would appear the shower of stones, only instead of having a certain relation to the horizon and the point overhead, they would be related to that particular part of the starry heavens; they would seem to rush from a particular part of the heavens; and this has been actually observed.

Prof. Newton of Yale College notified to the astronomers of Europe that there would be a great shower of November meteors in 1866 plainly visible both in America and Europe. In point of fact it was not well seen in America but in England, and we know the difference of time is only a few hours, so that you see how closely he made his calculation.

PERIOD OF THE METEOR STREAMS.

As to the period in which they travel their course, it is a third of a century. That was the actual time when the last great display took place, Arago being one of the astronomers who described it most closely, and Humboldt described another shower in 1779. If they travel on their course, having a period of 33 years, we might account for the recurrence.

But this seems too immense. These objects, a few grains in weight, have been traveling on such a course of 33 years, which would correspond to a course carrying them far away outside Uranus, and that seemed to Prof. Newton too grand, and showed that if they traveled a thirty-third part of the year the same course that ourselves would follow, in another year they would be a thirty-third part behind, and the next year another thirty-third part behind, and the third year another thirty-third part behind, and so on until the end of 33 years, they would be brought to their place again.

But, meantime, a strange fact had been discovered. The comet of 1862 was noticed to pass that part of the earth's orbit corresponding very closely with the course in which the August meteors seem to come from, and Schiaperelli said they may be associated with the comets, and Schiaperelli concluded that the meteors follow in the train of the comets, and supposing this to be true, it was possible to give the November meteors a period of 33 years, which before seemed incred-[illegible], and they would have such and such a course; and that being the case the astronomers thought they would look for comets in the paths of meteors. They found that a comet had been observed that very year 1866, traveling in that very course. There was another strange coincidence—a small comet was seen traveling over the course assigned to these meteors. Prof. Adams undertook to show that the November meteors can have no other course than 33 years. It had been noticed that where the earth encountered these meteors that part of the heavens had been slowly advancing in the direction which the earth travels—the shifting of the nodes owing to the attraction of the celestial bodies—and Prof. Adams calculated whether the perturbation would be such if a year and a 33d part were the true period of these meteors, and he found that the perturbation would not be so great. He then took a period of 33 years and he found that the perturbation would be as large as it was observed; so that he was the first to demonstrate that they did travel in 33 years.

Everything seemed to be done to show that the meteors traveled in the track of the comets. But one test remained, and that was to predict that after a comet had passed a certain place there would be a shower of meteors, and the prediction would be confirmed; then there would be a new kind of evidence. And that evidence was given by that very Biela's comet which frightened people so much in 1832, which vanished in 1866, and was again looked for in 1872. Alexander Herschel, in England, predicted that when the earth came to that part of her orbit, Nov. 26, 1872, there would be probably a great display of meteors. That happened. It was a glorious display in England and America, but it was still more gloriously seen in Italy, where it appeared with all the glory of the large meteors, with a great number of minute ones. That shower came from the foot of Andromeda, or the exact path that the comet would have followed if it had struck the earth. Then came in a curious feature. It was suggested that since this meteor shower had struck the earth, why should not the astronomers on the other side of the earth look out for them or the comet there? It was said that it was Biela's comet which had struck the earth. It touched the earth on Nov. 29. The comet was looked out for near the shoulder of the Centaur. A nebulous object was seen and identified. The next morning it was seen again and it had shifted. That was not the end of the matter. Astronomers made a calculation to see if the meteor path accorded with expectations, but found it did not; they were far behind—many weeks behind. So it seemed shown that there were streaks of meteors traveling from the direction of the comet's course. These are a few facts that show that meteors are associated with comets. More than a hundred meteor streams are encountered by the earth within a year. It has been discovered by Prof. Newton that this earth encounters about 400,000,000 meteors every year. We have then a very striking feature in the economy of our solar system. The meteors are following the course of the comets. In fact, there is every reason to believe that there is so great a gathering of cometary matter following these meteor tracks, that when we see the sun in an eclipse we should see a gathering there, as we do see in the corona.

EVIDENCE THAT METEORS ARE EXPELLED FROM THE LARGER PLANETS.

In this lecture I promised to give some account of what was expelled in those great explosions from the sun. If I was to say that the comets were shot out of the sun, you might be startled, or if I asserted that they were also thrown from Jupiter and Saturn. But the evidence of that is very curious. In the first place, we know that matter is shot out from the sun, with a velocity so great as to be carried far away from him, and so would travel forever away into space. That has only been observed a few times, but it is probably very frequent. The matter which was expelled, if it struck the earth at all, would strike in the daytime. If the sun is over there and the earth is here, the side of the earth toward the sun will be the illuminated side. The meteoric matter coming from the sun can only strike the illuminated part, which is the daytime. You throw a stone at any object, it must strike the side of the object you aim at, that is turned toward you. Humboldt mentioned that the largest number of meteoric masses had fallen in the day-time. But then this is scarcely sufficient. The larger aerolites have been examined and their microscopic structure studied. Sorby of Sheffield has examined them, and says they consist of a number of small globules, and were evidently originally in a vaporous state before assuming their present state, or were at one time in that condition. Then came a chemical analysis by Prof. Graham and Chandler Roberts of London. They found in the iron of the meteoric mass more hydrogen than iron contains in a natural condition. Prof. Graham, who was a very good chemist indeed, said that in his opinion certainly that meteor, that iron, had been expelled from one of the stars that people space. He pointed out that there were stars that contained hydrogen in their atmosphere. These are some of the facts connected with the larger meteoric masses. How shall we account for these meteoric streams of which I have been speaking? I have mentioned one as traveling close to the path of Jupiter. All comets of short period have paths closely approaching those of some of the large planets. That particular one went close to Jupiter, about seven years ago, long before the explosive power of the sun was noticed. I call them Jupiter's comet family. Sir John Herschel said that it was very curious that they had that relation. If we put forward the theory that Jupiter expelled these comets, we have a very startling theory, but many of the theories which have been propounded, some of the most important character, and which have proved to be true, have been the most startling. It is said that as Jupiter, Saturn, and Uranus go on their paths, they draw in the comets which travel close to them, and capture them. I made a calculation about the November meteors to see how close they must go to the path of Uranus in order to be captured, and found that they must approach nearly as close as the nearest satellite. Only those which came almost in contact with the planet could be captured. Now, if they were shut out when Uranus was as a smaller sun, then it would be explained, whereas we find great difficulty in imagining that a comet coming out of space would be captured bodily by a planet like Uranus. Let us consider thus: if comets are expelled from a planet, they will be carried along with the forward motion. If it could appear that some of them went backward, then we would have no evidence of the theory I have been advancing. If most of them travel forward, then we should have some evidence for the theory. Now there is this curious fact that all the comets of short periods, the whole of Jupiter's comet family, travel forward. They do not travel in all directions of slope; all have a very moderate slope to the path of the planet. They do not have the slope even of some of the asteroids. That is precisely what we notice—that they travel very much with Jupiter. Taking the balance between the two theories—that of expulsion and that of capture—it seems to be in the favor of the more startling one—that Jupiter has had the power to expel these objects.

The comets that are coming from interstellar space have some of them taken eight millions of years to make their journey, and we have no reason to think that it is their first visit to our solar system. They seem to be floating from sun to sun. During these immense periods of time our sun and the whole of the solar system have undergone changes. Donati's comet is an illustration of one of these long periods. The facts must be remembered, that while showers of meteors are unusual phenomena, meteorites fall every day and every hour of the day. Our earth is absolutely growing by these falls. The time is actually past when the earth is growing visibly, but yet immense amounts of matter are added to it in this way. And not only the earth, but the moon and Mercury, and we may say all the planets are growing under this meteoric downfall. How are we protected from this downfall, with 400,000,000 of them every day? The rate at which they arrive is very much more rapid than that of a bullet. If there was no protection we should certainly be destroyed. That protection is the atmosphere. When a meteor encounters the atmosphere its velocity is first reduced, and then it is consumed through the heat which is generated, and falls in the shape of a vaporous dust. On the tops of mountains the material of these meteors has been found.

[A diagram of the appearance of the sun's corona was shown.] It would appear here as if there was an aggregation in the sun's neighborhood of the matter thrown off from the sun with the aggregated gathering of the meteoric masses. These appearances of changes taking place, not merely in the present but in all past time, teach us the reality of the truth of those words of the Psalmist, "The heavens declare the glory of God." They seem to have a real meaning. "The heavens *declare* the glory of God; and the firmament sheweth his handiwork

Day unto day uttereth speech and night unto night showeth knowledge. There is no speech nor language but their voices are heard among them."

TRANSIT of VENUS—The MOON

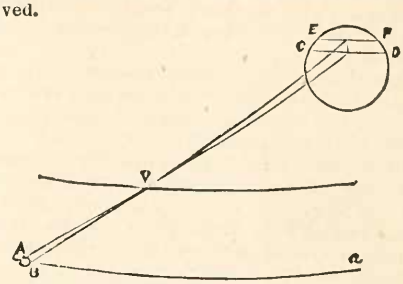
FOURTH LECTURE OF R. A. PROCTOR.

HOW THE TRANSITS OF VENUS ARE OBSERVED—THE IMPORTANCE OF THE TRANSIT OF 1874—THE MOON'S ASPECT AND MOTIONS—HER SERVICES TO THE EARTH—LAPLACE'S IDEAL MOON—LUNAR PHOTOGRAPHY—THE MOON DESTITUTE OF WATER AND AIR—THE MOON'S PROBABLE HISTORY, SHAPE, PRESENT CONDITION, AND APPARENT VOLCANIC PHENOMENA.

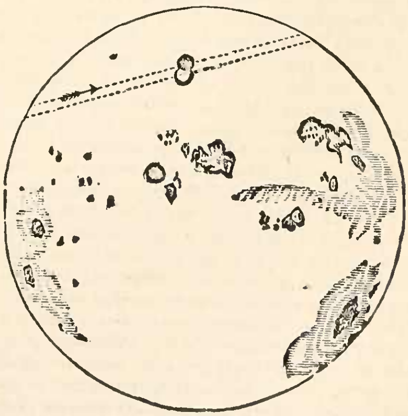
Prof. Richard A. Proctor delivered the fourth of his series of lectures on Astronomy at Association Hall on Jan. 19, the subject treated being "The Transits of Venus and the Moon." Ingenious diagrams were employed to depict the various appearances of the moon as observed through the telescope, and delineate the path and points of view for the coming transit of Venus, which occurs this year, and which is at present a topic of greatest discussion and interest to astronomers. The audience was very large, and the lecture was listened to throughout with the closest attention.

THE LECTURE.

It has seemed well to the gentlemen who have arranged this course that a few remarks should be made upon a subject at present attracting great interest among astronomers—I mean the question of the approaching transit of the planet Venus. You know, of course, that on this transit depend the best methods of determining the distance of the sun, and that upon determining the sun's distance depends our estimate of all the dimensions of the planetary system. Therefore that is the fundamental problem of astronomy, because when we pass on to the stars also, our ideas depend on that one fundamental measurement of distance. Now it happens that the planet Venus, by coming between the earth and the sun, enables us to measure that distance in a manner very easily explained. We know that the distance from Venus to the sun is to the distance of the earth from the sun as five to seven. If observers at the north and at the south of the earth's globe look at Venus at a time when she is directly towards the sun, the southern observer will see Venus at the highest of those stations, and the northern observer will see her at the lowest of those stations; say they are 6,000 miles apart; then we know the distance apart of the lines that Venus appears to have traveled on the surface of the sun is 15,000 miles, and then we know the whole diameter of the sun is so and so, because we can compare it and know it is proportionately so much larger. We ascertain the diameter of the sun, and if we know the size of any object and know how large it looks, we know how far away it is. You see that having this distance of 6,000 miles we ascertain that distance of 15,000, and afterwards, knowing the diameter, we know the distance of the sun. But then it is not possible for observers to note the planets at two points like that, because they are not in communication. Those two observers at distant places cannot work at the same moment. The southern observer watches Venus crossing the sun's face on the northern track, the northern observer sees her on the lower track, and if they note how long a time she takes, they determine how long those two tracks are, and then it is a simple problem in geometry to tell the distance of one from the other. That is Halley's method. Again, you will notice that the observer who sees Venus traveling this longer course will see the transit begin earlier than the observer who notices her traveling the shorter course. Therefore, if one observer is placed where Venus begins as early as possible, and another is placed on the earth where Venus begins as late as possible, by comparing those two moments it becomes a mere geometrical problem to tell where those chords are and how far apart they are. This is Delisle's method. Halley's method requires only two observations of the length of time Venus takes. If they have a very ordinary kind of clock, so long as it does not gain or lose during the time their observations are in progress, their result is achieved.



DELISLE'S METHOD OF OBSERVING THE TRANSIT.
A, B, stations on opposite sides of the earth. A a, part of the earth's orbit. V, Venus. C D and E F, apparent paths of Venus on the sun.



SUN'S DISK WITH TRANSIT THUS OBSERVED.
Upper and dark image of Venus as seen from Southern Hemisphere; lower and light image as seen from Northern Hemisphere.

But the case is very different with those observers, who employ Delisle's method. They require to know the absolute moment, because one observer is as far away as possible on the opposite side of the earth from the other. They cannot communicate, and, therefore, the only way they can compare their time is by knowing the true time at their station. But in order to know the true time it is necessary that the longitude should be known. Suppose in England a certain event happened at 5 o'clock in the afternoon; then you will know it in New-York as earlier by five hours. It would certainly be difficult to be accurate within a second or two. Now, in order to apply Delisle's method the two observers must know the true time of their stations within a second or two, and while this obstacle might be surmounted in such places as Greenwich, Washington, Paris, &c., yet it would be very difficult to do it in a desolate place or island on the earth's surface; and that is the difficulty of Delisle's method. [It is very well worth noting that during seasons of observations made between Greenwich, Paris, and Washington, the Washington observers, by making a comparison between those results, found the true difference of longitude between Greenwich and Paris. American astronomers were the first to give the true difference of longitude between Paris and Greenwich.] You will notice what we have to do in these two methods are two very different things. Halley's is easy, and the other is difficult.

Then comes the history of those matters by which the observations of the next two transits have been determined. By an unfortunate mistake in 1857, repeated later in 1868, the Astronomer Royal of England came to the conclusion that Halley's method could not be applied to the year 1874, and he came also to the conclusion that it could be applied to the transit of 1882. Therefore, observations were to be made by that method in 1882, and expeditions would have been prepared for that purpose, when I chanced, in looking over the arguments of the Astronomer Royal, to discover that he had arrived at a conclusion that was erroneous. I found those statements must be reversed; that it is in the transit of 1882 that the latter method must be applied, while this year Halley's method can be employed with great certainty. I made the statements accordingly. These pictures indicate the point on which my reasoning was based. Here is the earth as seen from the sun at the moment the transit begins. Therefore at any place now in view the beginning of the transit must be seen. Here is a picture showing the earth when the end of the transit of 1874 can be seen. Now, you notice the beginning occurring here in North Asia, Japan, &c.; the end can also be seen in those regions. So that the beginning and end are thus seen. There is nothing to be done but to place observers in those parts of the earth and they, seeing the beginning and the end, will know the time it takes. Southern stations also exist, as you see, for seeing the whole transit. Therefore, there is nothing to prevent northern and southern observers from making those observations necessary to Halley's method. The northern observer will notice Venus at the lowest of those lines, while the southern watcher will see the uppermost or shortest of those lines. Everything they want is ready for them, and all that is necessary is, that another observer should be sent to this part of the earth, to this more desolate region [pointing it out on the diagram], and then the whole thing can be accomplished.

In the transit of 1882 there is a different state of things. Here is the surface of the earth at the beginning of the transit in 1882. Here is North America. New-York and Washington are there, and the beginning and end of the transit can be seen from that northern region; but there is no southern place where the whole of the transit can be well seen. There is a great change between these former features and those we have now. The transit will only last four hours in 1874. The chord of the transit is very short. In 1882 you will notice South America is carried right away the other side of the earth, and the result is there will be a very great change in all the stations. You will notice the only southern station where the beginning and end of the transit is ever seen is in Possession Island, and another here at Repulse Bay. But although they are in view there, they are so close to the edge of the disk at the beginning of the transit that at that moment the sun, I found, would only be four degrees above the horizon. It becomes a difficult problem, a very difficult observation, to tell within a second or two when Venus touches the inside of the sun's edge, and that observation cannot be made when the sun is so low down.

MR. PROCTOR'S EFFORTS TO OBTAIN A HEARING.

Then you see the condition of the two transits. You may know that America has done more than her share in that matter. There are as many as seven stations to be occupied by North American observers in these northern regions, and then, beside, they are sending observers to this southern region. In this controversy, I must admit I spared no efforts. At the beginning of last year, when I found the time was drawing near, I used all means to get my views urged as strongly as possible. The whole controversy has been about this point: whether England will change the arrangements originally made to select and search out the place in which to see the transit from the Southern regions. I spared no efforts—writing in daily, weekly, monthly, quarterly papers, for which I was abused right and left—to insist upon the true views of the matter. It is objectionable always to insist upon views, unless there is good reason and the time is near when a decision must be taken. Feeling that no time was to be lost, I for the moment neglected that rule, in order to press my arguments; and last June, at a meeting at the Greenwich Observatory headed by Prof. Adams, the greatest of astronomical mathematicians, it was proposed that measures should be taken to search over the sub-Antarctic regions, and the proposition was unanimously carried by all the astronomers present. That has already been done, and I hope good results will be obtained. One other point I noticed in making my examination. By another great mistake of the Astronomer Royal—who, it should be remembered, has other duties to perform at Greenwich, which take up all his time—this particular region on the chart here in India, where the beginning and end of the transit will be seen, was overlooked. It happened that the name of the map fell exactly on that region and obscured it, so that the mistake arose. I recognized that region, and after a shorter struggle of about two years that region has been selected for a new station, so that the transit will also be observed from that point.

If I mention this, it is because some reason must be given in excuse for the opposition of a comparative beginner against one not merely standing high, but deservedly standing high, as does the Astronomer Royal. No man living has done so much for the cause of astronomy, given so many years of his life to the work, and has labored so energetically in it, as the Astronomer Royal. But the time was approaching when it would be too late to speak, and many years must pass before a similar occasion would return. This induced me to come forward, and nothing would have led me otherwise to take so energetic a part as I have done in this matter. Now I leave this matter of the transits of Venus to pass to the study of the moon.

THE MOON AS A GIVER OF LIGHT.

When I dealt with the subject of the sun, I spoke of the worshipers of the Sun, who knelt down to him and regarded him as the ruler of their destinies, but there were nations who worshiped the moon, and if we inquire into the reason of such worship we very readily find it. We notice that Job speaks of the moon as *walking* in brightness, and he speaks, too, of the subject of the moon's worship. It was natural that men should worship the moon. The ancients worshiped any body that seemed to move upon the heavens, and, therefore, they worshiped the sun, the moon, and the planets.

Now this orb that moves around the earth seems to be there in order to give light during the night time. Let us see what astronomy has taught us. It teaches that the moon is very much smaller than the earth, with a diameter of 2,100 miles. She is distant from the earth 238,828 miles. The surface of the moon is less than the earth's in the proportion of 1 to 13½. In other words, the surface of the moon is about 14,600,000 square miles, equal almost exactly to the surface of North and South America. It is also equal approximately to the surface of Europe and Africa taken together. If the moon is the abode of life there is plenty of room for life there, and it is an interesting question whether she now can maintain life. We know that the volume of the moon is to that of the earth as 1 to 49½, while her density is rather less than that of the earth, so that her mass is to the earth as about 1 to 81.

First of all, as to the offices of the moon. If it is shown that she discharges important offices to the earth, you will see that we are no longer bound by the argument of design to recognize her as the abode of life. First, we know she serves for the division of time. She gives light by night. God set His lights in the expanse of heaven, the greater to rule by day and the lesser by night alternately. There is a service performed by the moon which is so regular as to suggest that perhaps the Almighty intended the moon for that special purpose.

Laplace went so far as to say if he had made the moon he would have made it much more useful to man. He would have put it four times its present distance away from the earth, when it would be far enough away to be a full moon and give a regular light continuously by night. The first objection to this is an astronomical one; for of all nuisances the moon's light is one which the astronomer dislikes most, especially at a time when he wants to study some nebulæ, or some barely visible comet; at those times the moon's brightness seriously interferes with his observations; and I am surprised, indeed, that Laplace, himself an astronomer should have suggested so inconvenient an arrangement as that. But there are other difficulties. If the moon is in that condition she would always have to be opposite to the sun. The sun would go around once a year and the moon also. The moon would no longer be a measure of time, she would no longer rule the tides in the same way. She now raises a great wave called the tide-wave, represented in hight by 5. You have another caused by the sun, represented by 2. Those two waves are sometimes combined in a single wave, and act together, sometimes opposing, sometimes coalescing. According to these changes, the tide varies in hight from the difference of 5 and 2 to the sum of 5 and 2. That is to say, 3 the least hight and 7 the greatest. That is a very important matter. It is of great service, as any one who lives by the seashore knows; it is of great interest to the shipbuilder and merchant that there should be variable tides, that there should not always be high tides, nor always low. That important service would not have been subserved by the moon if the consideration suggested by Laplace had prevailed. There is another very important service. The moon enables the astronomer or seaman in long voyages to ascertain the longitude, which is nothing more or less than the true time at the observer's station. If she moved 12 times more slowly she would be less fit to indicate the time in exactly the same degree as the hour hand of a watch is less fit than the minute hand. There are other very great and important advantages of the real moon over that suggested by Laplace, which I wonder did not occur to a mathematician such as he, the only man who ever lived of whom it can be said "He was the rival of Newton." He himself said Newton was fortunate in having lived before him. In another man it would have been rank conceit, but in Laplace it was considered as a just statement. Yet he failed to notice, when he suggested this moon's being four times further from us, that under his conditions if spread so as to give the same light, the material of which the moon would be made would be lighter than any solid element known to us. I think it was well that the Almighty did not take counsel from Laplace in creating the moon.

TELESCOPE VIEWS—THE MOON HOAX.

I pass from these considerations to the telescopic study of the moon. When we think how near the moon is, the planet that comes nearest to us being 130 times further away than the moon, certainly the hope would seem natural when Galileo first turned his telescope to the moon that he would discover signs of its fitness to be the abode of life. We know what happened. He found there a surface covered with mountains so that he compared them in number on the moon to the "eyes" on a peacock's tail. Where there appeared to be dark surfaces of a level nature he called them seas. He found them to be really solid, and afterward telescopic observations went on, and all that was found was the gradual enlargement of these features, and the revelation of new details, but nothing to suggest that life existed on that arid surface. Men went on hoping that with telescopes of increased size more would be obtained. It was thought that with Herschel's great telescope something more would be determined. Herschel thought he could recognize in the bright part of the moon signs of volcanic action, because he saw a faint light as of volcanic eruption. We know it was only the reflected light of the earth.

Other efforts were made, and it was at that time that some one in America, a Mr. Locke, conceived the idea of publishing that strange book, the Moon Hoax, which misled not only the mass, but those who were well educated. There was great ingenuity displayed in the method of its construction. There is the conversation between Brewster and Sir John Herschel, the enthusiasm of Brewster, which is very comically described, as he leaps from his seat and, catching Herschel by the hand, exclaims, "Thou art the man!"

Then a curious appearance of different flames, and then animals which seemed to escape away whenever the observer tried to fix his attention upon them; and the Bat-men—monstrous creatures—and the comparison between these Bat-men and the militia of London. At this point the story seemed too absurd for belief; yet we can imagine the impression it made, when some one wrote to Sir John Herschel from America, asking if it was true, and urging means of conveying religious instruction to the poor benighted inhabitants of the moon. [Laughter.] And, strangely, at a quite recent time, the idea has been suggested of studying the moon, so as to discover living creatures there, by the same method. I saw a few days ago in an American paper an idea based on the same mistake that existed in that Moon Hoax, only there it was not a mistake but a trick. If you have the image of the moon photographed to perfection, it seemed as though you might magnify that image by the microscope and see objects of half a mile or less in size, if not recognize living creatures. But this is the same mistake as those make who believe in the transfusion of light. What the astronomer does when he sees the moon through a telescope, or when he takes a photograph of the moon is to magnify the image as much as it will bear. If he interposes a screen and tries to magnify the image, he is magnifying a moon less perfect; his best chance is by looking through the eye-piece at the image in the focus of the telescope. There is a limit in the telescope beyond which it cannot be increased. I heard, a few days ago, that the observatory to be established on the Rocky Mountains will bring the moon within thirty miles of us; but that is impossible. It is not a question of a place above the atmosphere, seeing the moon through the rarer parts of the atmosphere, but the optical difficulty. **The optical image** formed by the object-glass of the astronomer has defects, and if you magnify it you magnify the defects. When you get beyond a certain point it is useless to magnify the image as it appears, and there is no hope of any telescope larger than Rosse's to get a close view of the moon. [The best view of it obtained, perhaps, is that at the Cambridge Observatory.] We have images here taken by the Cambridge refractor, and there are all the details, as you see, of the craters and flaws and irregularities of surface, but no sign of life can be seen.

EVIDENCES OF ABSENCE OF ATMOSPHERE.

When we begin to inquire into the relations of the moon, we see how hopeless it is to expect signs of life. We have an orb having no atmosphere, or a very shallow one. This is shown by the fact that shadows thrown by the lunar mountains are seen as these black parts, indicating that there is no considerable atmosphere. An observer watching our earth from the moon would not see black shadows but dark shadows, of greater and greater darkness, but there would be a certain amount of light in the valleys all around the mountains; for we know we can stand on a mountain top when the sun is rising and see that the valley below is not black: there is twilight there, and it comes from the atmosphere. If there were atmosphere in the moon, an observer from the earth would see shadows thrown all around the mountains, but not black ones. The blackness of the lunar shadows shows that there is no illuminated sky such as ours, no atmosphere to illuminate those regions, and that is the first proof that the moon has no appreciable atmosphere.

On our earth, as you know, there is a twilight surface extending a very great distance, which divides true sunlight from the place where there is no sun, and the twilight surface extends over 18 degrees on the earth. On the moon we can recognize no twilight surface whatever. Look at the earth from the moon, the picture of the "new" earth, when the earth is between the sun and the moon, and there would be seen all around the black disk of the earth this twilight. We, as you know, on the contrary, when we have a full moon, see the edges sharply defined; it is only the same circle, no extension on either side by twilight surface. That is the second proof of it. Yet another proof of it. When the moon passes over a star, the star flashes out suddenly; if there were an atmosphere round the moon, that star would be seen precisely as our sun when sinking. When he sinks, though he seems not to pass below the horizon, yet he is really below it, and a line drawn from the sun to the earth would pass below the horizon. There can be no doubt that if you are looking at the earth from the moon, you would see the stars close around the earth, when they were really behind it, they would be raised by refraction of the earth's atmosphere. Now, in the moon's case, we see nothing of that kind. A star, even some telescopic star, is visible in one moment on the moon's edge, and the next it is gone. These are three convincing proofs that the moon has no appreciable atmosphere, and if it has no atmosphere. there can be no life such as we know. There may be life of other forms inconceivable, and it would be idle to inquire what they may be. I believe there is no life. I find a limit to where life is on our earth. We may say the conditions on our earth are not the same throughout—greater or less light, less moisture or more moisture; but we find that these conditions really limit life on the earth; beyond a certain hight on the mountains there is no life except of mere animalculæ and these carried up by the air; and so far as analogy teaches us we must believe that there is no life in the moon.

THEORIES TO ACCOUNT FOR THE CRATERS.

Besides, there is no sign of water. We can recognize regions, such as those inclosing the floors, which are sometimes perfectly level, and sometimes show streaks and marks, and they always remain unchanged. If there were water, the water under that shallow air would be raised into the lunar atmosphere, and increase or decrease these markings.

Now, it certainly seems probable at first sight, while the aspect of the moon is such as I have described, that at one time or other there must have been a great amount of vapor around it. All the craters must have thrown out enormous quantities of vapor. There are those who say, as Prof. Mallett of England, that there are no volcanoes without the action of water. If that be the case, these signs of past volcanic action in the moon are due to volcanic eruptions, and there must have been water on the surface. What has become of the water? There are four suggestions made in reply. One, that a comet carried away the lunar oceans and atmosphere. We give up that at once. It was the theory of Whiston, who accused Newton of being jealous of him, and Whiston's name has been nearly forgotten. He thought that a comet would cause the destruction of the earth by fire, and that one had already done so by water. But we know that while the moon might get something from a comet, no comet could draw anything from the moon.

Another one I was once attached to, is that the surface is covered with frozen snow. I was one of those who held this theory, and as it is exploded I will take it for my own. Say the white surface is covered with snow. That whiteness must be accounted for, and there are signs of a great downfall of snow, and glaciers, and the atmosphere also may have become frozen. Carbonic acid gas may be frozen into something like snow. The objection to that theory is that the moon is not white: it is more nearly black than white. I dare say you remember Dr. Tyndall's telling you that if the moon was black, it would yet be white in the sky. Measures of its light have been taken, and it appears that it is no whiter than weather-beaten brown sandstone. Sir John Herschel discovered it thus. He noticed the moon setting by a mountain of sandstone, and their respective reflections of light were the same. Certain parts of the moon are brighter than others, and from Zollner's observations it seems that these may be looked on as white, but great portions of the lunar regions are probably darker very much than our ordinary skies.

Another explanation is that the lunar oceans have been withdrawn into the substance of the moon. Mars has oceans smaller than ours, when the earth is compared with his dimensions; and we may suppose it due to the withdrawal of a portion of the water into the planet. The planet in cooling contracted and left spaces into which a portion of the water withdrew. We should find reason for believing that Mars, a small planet, in cooling, cooled so much that all the water would be withdrawn into the interior. But there is a difficulty in that; the atmosphere remains unaccounted for, and it seems difficult to understand that any atmosphere of moderate extent would be withdrawn entirely within the lunar cavities and give no sign of existence.

There remains yet another theory—that the moon is egg-shaped, and the center of gravity being displaced on the further side, has carried to that side the oceans and air of the moon, and that the side of the moon never toward us may be a comfortable abode of life. The little end of the egg toward us has no waters, and they are drawn to the further side. The one objection to that is, that if the moon is egg-shaped, the oceans and the atmosphere ought to be on this side instead of the other. If the more pointed end of the egg-shape were toward the earth, it would correspond to a hill of matter, to a pile of it on our side. That pile of matter would act as an attracting cause and draw the oceans and the atmosphere from the further side to this side; and we find, so far as I can see, no theory accounting for the displacing of any former oceans or atmosphere in the moon. We have great difficulties to account for, and we may find reason to doubt whether the signs of volcanic action indicate eruptions, or whether they may have been produced by forces acting from outside.

PHOTOGRAPHIC PICTURES OF THE MOON.

We will now have the room darkened, and pass to the examination of this picture. This picture of the moon in the first quarter is not that which you see with the naked eye. You see it left for right, because in the telescope one always sees it this way, and it is preferable to follow the plan in the books on astronomy and show the pictures as shown by the ordinary telescope. We will now have the second and third quarters. The photographic study of the moon was commenced by your American countryman, Dr. W. H. Draper, in 1810, and one of the works we study is so much in advance even of those men of the present day that we owe a great deal to Dr. Draper. He began in 1840 his photographic work on the moon, and that work greatly increased in perfection. Mr. De La Rue of England got a mastery of photography, and Mr. Rutherford of New-York made maps which Mr. De La Rue acknowledged frankly were better than any one of his, owing to the clear atmosphere of New-York. Dr. Henry Draper made lunar photographs earlier. I have had no opportunity of comparing his with Mr. Rutherfurd's, and I should be sorry for you to suppose that in the superiority attributed to Rutherfurd's photographs

I was making a comparison between Mr. Rutherfurd and Dr. Draper.

There you have a picture of the full moon, and you will notice how exceedingly dark these ridges are on the bright upper region of the moon, and that wonderful region which is called Tycho, and that wonderfully bright region where crater overlaps crater, even as it is there shown by the photograph and more remarkably by a telescope of great power. Dr. Schmidt of Athens has been counting the number of these craters, and that number has gone on growing greater, until at last a map of so many has been made that they cannot be distinguished one from another. This work of Dr. Schmidt's was the noblest work of that kind that exists, and it is very unfortunate that we cannot get money enough in Europe to publish it, and make him some remuneration for the work of so many years. We will now have a map of the gibbous moon, passing on to the third quarter. This picture is by Mr. Rutherfurd. Around the right of the moon we begin to see a region about which a very important discussion has lately taken place. Low down on the right is a small dark round spot, on this curved bright streak. In the middle of that is this dark round spot, called the Floor of Plato. It looks very dark indeed, especially in the case of the gibbous moon. In the next picture you will see how it becomes apparently lighter. When this is looked at closely, and certainly when looked at through a telescope, it is found that it looks lighter at the time of the quarters than at the time of the full moon when brightly illuminated. Now, it has been suggested that on that spot some process of vegetation is taking place. In that case we should have a very striking fact of some change taking place there. Unfortunately for that, it happens that there is also a strong argument against the theory that there has been any real change there. Of course when you view the spot at the time of the quarters you have shadows thrown; and in contrast with those shadows, the floor of that spot naturally looks lighter. Whereas in the case of the full moon, all around it there is a brightly illuminated region. The mountains have a great illuminating power, and therefore by contrast the spot looks dark. I have made the calculations myself, and found that that is absolutely the case; instead of growing dark with the full moon, it grows lighter. It is a mere subjective effect, and we have not the evidence we hoped for, evidence of change. There is an illustration of that fact in the appearance of the satellites of Jupiter in their transit across the face of that planet. They look black by contrast, but start into brightness as soon as they move off the disk of the planet.

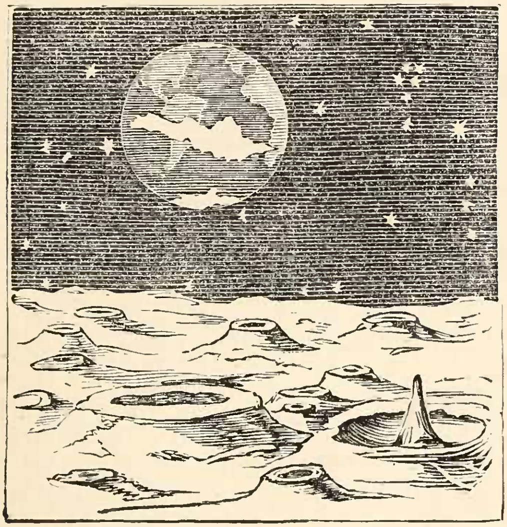
THE LUNAR MOUNTAINS.

We will have this other picture, which De La Rue said was better than any he ever took himself. We have here the moon in the third quarter. Here is the lower region, the Floor of Plato, here the lunar Apennines, here the crater of Copernicus, and here the lunar crater Aristarchus, the very region where Sir John Herschel noticed a bright spot which he took for an eruption. The fact was that that very bright spot, by reflection of the earth's light, became visible. That was the truth of it. We will now have a picture of the very same thing, only more distinctly shown; the details are somewhat more distinctly shown. The Apennines can be very plainly recognized, passing in a curved streak upward. Here is Copernicus, here Kepler, and here Aristarchus. From these three centers there is a radiation, and it appears clearly to observers that the strata were upheaved at different times; the later ones seem to break through the earlier ones. It is hoped that by that characteristic we can learn something of the chronological order in which the changes of the moon's surface took place.

This picture has been enlarged by Mr. Rutherford. Here is Copernicus and here you see the Apennines on the lower lightened side. The moon you see is covered all over with these irregularities. We know how volcanic eruptions are brought about. First there is a gradual contraction of the skin, the outer crust of the earth; a mechanical effect is produced, gases are generated, and these gases escape out of the mouth of the volcano. If any such processes happened upon the moon they must have been much more violent. But then one would have thought that any one of these lunar craters, the largest being two or three or four miles across, would have been large enough to let all the gas in the whole moon escape. Now, what was the necessity of so many? It was suggested by Dr. Hook that in a former state of existence, there was a bubbling, and as the bubbles broke these circular openings were formed. We will have another picture brought on, still further illustrating this. Here you will see the Floor of Plato again, and the Apennines also, seen running across toward the left of the picture. This crater is the crater Aristarchus.

We will now have that carried away, and have another series of pictures of a different kind. We will have two pictures of the Floor of Plato. You will notice that the shadows there are thrown on the Floor, in the picture on the right. In the picture on the left, where it is morning, you will notice how that long bank differs from the appearance as presented on the right. You recognize how far the appearance of the moon may change, from a mere change in the illumination, and how difficult it is to say that changes are going on, from noticing the apparent changes. Here is an illustration. It appeared that a certain crater had vanished, as though a sort of cloudy matter had been thrown out. When the supposed volcanic eruption ceased, the hills apparently had been made more sloping, and the crater could not be so well seen. But unfortunately for this supposed evidence of change, the crater has again appeared as before. Our moon changes and shifts, not merely with regard to the sun, but to the earth, and, by a calculation of mine, I find that 1,300 years must elapse before you could see any part of it again in the same view exactly.

You have now a picture of the lunar crater Copernicus. This picture is very different from that taken by other observers. It is quite manifest that the skill of the artist has worked out the picture in a certain way and as another will work it in another way, it is by comparing the two that you are led to think that there was a change. I must mention that the moon is unlike our earth in its general conditions, in nearly all the important respects which we associate with it. The total day lasts 29½ of our days. While the day lasts so long, the year is very much less than ours. It is only 346 of our days. It may seem rather strange that as the moon is a planet, in reality, that therefore it has a year less than ours; that it ought to be the same as ours. But there is a slow tilting of the moon, corresponding to the precession of the equinoxes. That shortens our year by a few hours, but in the moon it shortens it for a few days.



AN EARTH-LIGHT SCENE ON THE MOON'S SURFACE.

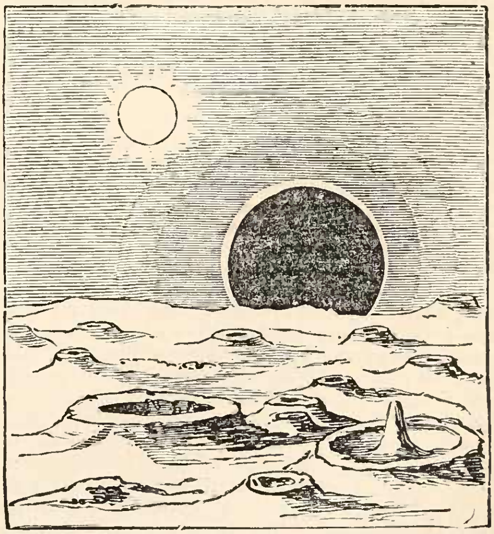
There you have a picture of the lunar crater Copernicus as it might appear to the inhabitants of the moon. It was drawn by James Hamilton of Philadelphia. You will notice the earth suspended as a moon to the inhabitants of the moon. The earth is, according to my conception, too small. It would appear to them as a moon 13½ times as large as the moon appears to us. We will have a picture of the lunar crater Tycho, from which those great radiations extend, which give the moon the appearance of an orange, and which caused Dr. Holmes to liken it to a peeled orange. [Laughter.]

Always in these lunar pictures, these imaginary ones, the mistake is made of introducing signs of weathering which we know to be due to the effect of rain, or more remarkably to the effects of snow. We know that the peaks of our mountains are becoming more and more worn down by the glaciers. But as there is no water in the moon, there cannot be any rain or any snow, and therefore none of these effects of denudation can be seen.

Here is an ideal picture of the Apennines. You will notice the peculiar slope of them. Again we have the erroneous signs of weathering. You never see mountains like those except where snow is.

IDEAL VIEW OF MOUNTAIN SCENERY IN THE MOON.

In the picture you are supposed to be looking at the Apennines from Aristarchus.



SUNLIGHT SCENE ON MOON'S SURFACE: EARTH SHOWING ITS DARK SIDE.

Here is a picture in which you are supposed to be looking at them from Plato. You will also see a little work of the imagination here; a little village is interposed, probably the dwellings of inhabitants of the moon who were to have received religious instruction from the earth, for you perceive there is a church there. [Laughter.]

We will have a picture brought on showing the wonderful way in which the moon is covered with craters. It is different from the appearance of craters and mountains as we picture them to ourselves. When you look at that you will begin to think that there is some other operation at work there than that which produces our mountains and the few craters we have. You seem to have an appearance produced by boiling over, or the pouring down of some very heavy rain, as a heavy rain on a muddy surface produces pits like these. As regards Dr. Hook's explanation, I need hardly say that bubbles would probably not be formed so large as that, and no forms of matter known to us would be coherent enough to form these of miles in extent. We seem forced to a theory very startling, that we had on the moon's surface a pounding down of meteoric missiles, not necessarily solid ones, but a falling down of meteors on the plastic surface. It seems to me to be the only theory left. At the present day it is estimated that over 400,000,000 meteors fall through the day, but the result is very slight indeed. I have found that the earth would require 400,000,000 years to have her diameter increased a single inch by them. When we look back upon the past history of our system, we see signs that there was a time when larger meteors and more splendid comets were at hand to be absorbed in the solar system. While the earth was still in a form of vaporous matter the moon was rolling on, still plastic, and these meteors falling down upon her surface would produce that pitted appearance.

I will have the room lightened up again while the small lantern is prepared, and then I will have three pictures of the residue from boiling a calcareous solution. You will see how very much like my pictures are those of the moon. I will undertake to say that all those who are not acquainted with every nook and cranny of the moon will be deceived by these, especially the third and last one. You will notice that there appear in them seas which have terraces around them.

I will now invite you to notice what was suggested to me by Dr. Barnard of Columbia College, that we have in the solar system the signs of a beginning and of an end. Jupiter and Saturn have made progress to a further state than the sun, but are still full of life and energy. Then in the progression comes our earth, and Mars, and Venus, and Mercury, which have lost most of their inherent heat. In the moon we have a body seeming to have lost all its inherent heat, and to have neither water nor air. All these signs of progression seem to point to the day of creation and teach us to look forward to the time when these processes began. We seem to see signs of beginning. There must have been a beginning of these processes which in the moon have come to an end. Looking forward we see that our sun—the youngest as it were, so far as signs of passing on at old age is concerned—will one day lose heat, and all the other members of the solar system will have lost theirs. There seems to be an end of our solar system, a beginning and an end marked, and in that respect astronomy differs from other sciences, which give us no such signs of a beginning or end.

CALCAREOUS RESIDUE LIKE MOON PHOTOGRAPH.

In this picture of the residue of a calcareous solution before you, notice the black region around the crater and signs of terraces. You have in the next picture no terraces visible. Ninety-nine observers of the moon out of a hundred would not be able to tell me that this is not a photograph of some part of the moon's surface.

There is one point I intended to touch on more fully. I spoke of the possibility of any planet only being intended to be inhabited during a short time of the existence of the planet,—millions of years before it was fit, being followed by millions of years after it became unfit for habitation. Let us have an illustration of that. If it were known that some gentleman in Brooklyn only intended to remain at home ten minutes on a given day, and you did not know whether it was morning, noon, or evening, and you called at random, you would be surprised to find him at home. Take any particular time in the same way, and consider the chances that the planet is inhabited in it. The chances are small; much more in favor of the present moment belonging to the millions of years before or the millions of years after it becomes fit for habitation. That is the case with the moon, I feel tolerably certain. That the moon has long since passed the time when it was fit to be the abode of life was touched upon in the second lecture, and that Jupiter and Saturn have not reached the time when they are fit. But though we are much more likely to see a planet when it is not fit for habitation, we must take the immense number of them into consideration. There are millions of stars and millions which no telescope can reveal. And you have the chances reversed; and though for every planet inhabited now there may be millions not inhabited, yet the number inhabited must be many millions. So that we get rid of the painful thought that our insignificant planet is the only one inhabited. We get rid of the difficulty that the greater number we know of are not fit for habitation, and we can address the Creator in the language of the poet,

> God of the granite and the rose,
> Soul of the sparrow and the bee;
> The mighty tide of being flows,
> Through countless channels, Lord, to thee.
> It leaps to life in grass and flowers;
> Through every grade of being runs;
> While from Creation's radiant towers,
> Its glories flame in stars and suns.

THE STAR DEPTHS.

FIFTH LECTURE BY R. A. PROCTOR.

THE SEEMING CALM OF THE STAR DEPTHS COMPARED WITH THE REAL VASTNESS OF THE MOVEMENTS TAKING PLACE WITHIN THEM—DISTANCES AND DIMENSIONS OF THE STARS—DOUBLE AND COLORED STARS, AND CAUSE OF THE COLOR—THEORIES OF THE STELLAR UNIVERSE—DISTRIBUTION OF STAR-CLOUDLETS, AND NEBULÆ—THE LECTURER'S PREDICTION—MARVELOUS EXTENT AND COMPLEXITY OF THE SIDEREAL UNIVERSE.

Prof. R. A. Proctor's fifth lecture, and last but one, on the discoveries of astronomy, was given Jan. 20. at Association Hall, and was equal if not superior in scientific interest and entertainment to any of the previous four. The subject treated was "The Wonders of the Star Depths," and the lecturer set forth in clear and at times eloquent language the various hypotheses which have been put forward in regard to the mysterious occupants of space. Additional interest was created and the subject more clearly explained by means of pictures illuminated by the powerful oxyhydrogen stereopticon of the Stevens Technological Institute, under the skillful management of Prof. Morton. The audience was very large and strictly attentive.

THE LECTURE.

LADIES AND GENTLEMEN: I have seen in one of the papers a question relating to a point of great interest in the history of our earth; that is to say, the gradual change of the earth's rotation period. It is supposed to have been demonstrated that this effect is due to the action of the tidal wave, which really acts as a brake, because the tidal wave travels in a direction opposite to the earth's rotation, and the question asked is, How much does the earth's rotation lose, at what rate is the great terrestrial clock losing time? I made a rough calculation, and I found the loss is so small is this: that at the end of 2,000 years the terrestrial time would be about three minutes behind what it would be if the earth were to continue to rotate from this moment onward without any change—three minutes in 2,000 years. You will perceive, therefore, that as that is the accumulated loss, that the actual loss of the earth is so very small that a million of years will have to elapse before any really serious change in the earth's rotation period or the length of the day takes place.

THE CALM OF THE STAR DEPTHS.

If you look at the sky in a calm, clear night, such as you have in America, "when all the stars shine and the immeasurable heavens break open to their highest," the thoughtful mind is impressed with the feeling that a solemn calm reigns in those infinite depths. This is the idea suggested to the poet. Nor does any other view present itself to those who study the first teachings of astronomy. We know that the stellar sphere is carried from east to west as the sun and moon are carried, in the period of a single day; and we know if we watch the heavens night after night, at the same hour, there is a motion from east to west taking place in the course of a year. And there is yet one other motion by which the whole sphere of the heavens seems to gyrate about an axis, the period of that gyration being 26,000 years. But we know quite well that these motions are not real, that they are produced by our earth's motion. It is the earth rotating on her axis in the course of a day, which causes the heavens to appear to turn round in that time. It is the earth traveling around in an orbit which causes the heavens to have a yearly motion. And it is the earth gyrating, like a gigantic clock, in that period of 26,000 years, that causes the whole sphere of the heavens to seem to gyrate in that period. But so soon as we pass from those first teachings of astronomy, and consider what has been taught us by modern discovery, we see that where there seems to be rest there is an activity compared with which all the forms of life on our earth are insignificant. Every one of the stars that seem so still, is traveling through space many miles in every second of time. The very least of these orbs—some star so faint that it is only visible by momentary scintillations—is an orb in every second of whose existence there is more life and energy than is sufficient for the wants of this earth for hundreds of years; and the least change of those stars, whether by an increase or diminution of brightness, corresponds to an accession or diminution of life and energy comparable to the supply which the earth receives from our sun during hundreds of years.

In the first lecture I reminded you of the activity of the sun; that that orb is the scene of activity, of tumult and energy, compared to which all the forms of uproar known to us are as nothing. Every one of these stars has enacted in it a similar scene. Therefore you will see how utterly different is the reality from that which is presented to the mind. You look at the heavens in this country of clear skies, where everything looks so far off, and the stars seem so still, and the heavens appear so tranquil — seeming so suggestive of calm and peace, while in reality you are looking at the most stupendous scene of activity. And now let us reflect on the facts from which we have learned that this is the actual condition of the stellar heavens. In the first place, we have to over the body, and trampled on by some 10 or 12 persons over her limbs and belly and chest, and still bore it all without any sign of pain whatever.

As regards the power of producing anæsthesia, it seems to me unfortunate that the discovery of ether was made just when it was. It was, as you well know, in 1846 or 1847 that the use of ether as an anæsthetic was begun. It started from this city. At that time in England Dr. Forbes was trying to show from facts observed in England, and especially in India, from the practice of Dr. Esdaile, that something which was called mesmerism, but which, after all, was nothing but a peculiar state of somnambulism induced in patients, gave to them the idea that they were deprived of feeling; so that they were in reality under the influence of their imagination, and operations were performed that were quite painless. I say it was a pity that ether was introduced just then, as it prevented the progress of our knowledge as to this method of producing anæsthesia. My friend, Prof. Broca, took it up in 1857-8, and pushed it very far; and for a time it was the fashion in Paris to have amputations performed after having been anæsthetized by the influence of Braidism or hypnotism. A great many operations were performed in that way which were quite painless. But it was a process which was long and tedious, and surgeons were in a hurry and gave it up. I regret it very much, as there never has been a case of death from that method of producing anæsthesia, while you well know that a great many cases of death have been produced by other methods.

EFFECTS THAT BORDER ON THE MIRACULOUS.

Not only anæsthesis may be produced, but the secretions may be very powerfully affected by the influence of the mind over the body. Here we find facts of great importance indeed. There are many facts which show that the secretions of milk may become poisonous for a child from a mere emotion in the mother, and especially from anger. And if it were not the duty of every one to avoid anger it would certainly be the duty of a young mother who has to nurse a child. There are cases, although they are not common, in which death has resulted; and alterations of health in children from this cause are very frequent. A great many men who have reached an adult age owe their ill health to such an influence in childhood.

Every one knows, also, that the secretion of bile, the secretion of tears, and the secretion of saliva are very much under the influence of the nervous system. The purging of the bowels, which depends on a secretion there, or a secretion in the liver, is also much dependent on the influence of the imagination. The Emperor Nicholas tried to see what power there is in the imagination in that respect. Bread-crumb pills were given to a great many patients, and, as a result, most of them were purged. In one case a student, not of medicine but of theology, having the idea that the word pill meant a purgative, looked for "pill" in the dictionary; and the first kind of pills that he found there was one composed mainly of opium and henbane, both astringents, and capable of producing great constipation. He wanted to be purged, and took a certain number of these pills, and instead of becoming constipated he was purged just as he wished to be. [Laughter.]

Vomiting may be produced in the same way. Du Cres, a French physiologist, tells of a trial made in a hospital by a nurse who went around and gave to all the patients a very harmless kind of medicine, and then told them that she was sorry that she had by mistake given them all very powerful emetics. Out of 100 patients, 80 were affected as if they had taken the most violent emetic and vomited for a long time.

This we see on a very large scale on seaboard every Summer. I have no doubt whatever that sea-sickness is in a great measure due to that, and if you could go on board of a steamer with the idea that you would not vomit I am well satisfied, from experiments I have made, that you would escape a great deal of sea-sickness, if you did not escape it altogether. One fact I recall is very interesting. A person had crossed, on one occasion, a small bay when it was very rough. There was a man playing the violin on the boat. The person I refer to was terribly sea-sick and vomited a great deal. He had not, of course, made up his mind that he could not be sick. However, the point is that after that he could never hear a violin without vomiting. [Laughter and applause.]

To pass to something more serious: You have all heard of what are called the *stigmata*—marks representing the wounds on the limbs of Christ. Those marks have appeared in persons who have dreamed or imagined that they were crucified and suffering the pains of Christ, having invoked the goodness of God to let them have that suffering to punish them for their faults. The most remarkable fact of that kind is that concerning St. Francis of Assisi. There is no doubt that he had the mark as clear as possible. If you compare with this fact one which is related by Dr. Carter you will have the explanation of it. Dr. Carter says that while a mother was looking at her child who was standing at a window with the fingers on the border of the window just under the lifted sash, she saw the sash come down with great force and crush the three fingers of the poor child. The mother remained unable to move, feeling immediately a pain on the three fingers at the very place where the child had been injured. Her fingers swelled, an effusion of blood took place and ulceration followed and she was a long time in being cured. If in the case of this mother the imagination could produce such results, you will see in the case of the stigmata the imagination may have been equally powerful.

PERFORMANCES OF RELIGIOUS DEVOTEES.

The mind in a state of emotion has also great power on the heart, the breathing apparatus, and several other organs. The most important of the facts here—which I must say I committed the fault of denying for a long time—are those which relate to the fakirs of India. You know that they may remain dead to all appearance for a number of days, and it is even said for months, without any change occurring in their body, without any change in their weight, without their receiving any food. They show neither circulation nor respiration, as their temperature had diminished very considerably, and altogether present a series of effects which are certainly very marvelous. But marvelous as it is, the testimony of some officers in the British army who are men of perfect veracity leaves no doubt as to the possibility of the fact. But in the light of the fact that I mentioned in my first lecture, that I had a dead animal in my laboratory lying for several months without any sign of decomposition, in a temperature varying from 40° to 60° during day and night, we can understand that these fakirs may remain able to live although they do not live—that is, do not have actual and active life. But why, you will say, do they come out? Admit that there is in us a power which is quite distinct from our ordinary power of mind, which is quite distinct from what we call consciousness, which during our sleep is awake and watches; with this admission and the facts I have mentioned before, we have all the elements, I think, for an explanation of what has been said about the fakirs.

I find, unfortunately, that the time presses so that I shall be obliged to pass over a good many facts and come to the miracles of La Salette and to the miracles accomplished at the tomb of Father Matthew, and also what has been said of a great many other instances of recovery from illness. I cannot but believe that there is no need of appealing to any other power than what we know of imagination for the explanation of what takes place in those miracles. They are very curious, but hardly more curious than what we see when we know without doubt that imagination is the cause of such a change. The cure of any illness which does not consist in any disorganization of the tissues can often be accomplished when the person thinks that it can be done. If we physicians, who treat patients every day, had the power to make them believe that they are to be cured, we certainly would obtain less fees than we do, and I must say that the best of us would rejoice at it. There is no doubt at all that if we could give to patients the idea that they are to be cured they would often be cured, especially if we could name a time for it, which is a great element in success. I have succeeded in this way sometimes, and I may say that I succeed more now than formerly, because I have myself the faith that I can in giving faith obtain a cure. I wish, indeed, that physicians who are younger men than mpself, and who will have more time to study this question than I have, would take it up, especially in those cases in which there is a functional nervous affection only to deal with, as it is particularly, though not only, in those cases that a cure can be obtained. Indeed a cure may thus be obtained in certain organic affections; even in dropsy it may lead to a cure. You know that it will stop pain; that going to a dentist is often quite enough to make a toothache disappear. [Laughter.] I have seen patients come to me with a terrible neuralgia, who dreaded the operation I was about to perform, and, just at the time I was to undertake it, ceased to suffer. [Laughter.]

LIMITS OF NERVE FORCE—LAWS OF HEALTH.

I think I have shown that the power of nerve force is exceedingly various; that nerve force can be transformed into chemical force, into motion, into electricity, into heat, into light, and so on. But what are the limits of the action of nerve force? I may say that the limits of the action of nerve force, except after it has been transformed into other forces, are our own body. Those persons who think that by an imagination, or by an act of will, or by the action of a mesmerizer, we can send in any part of our body an influence that can modify it, those persons make a great mistake if they think that this can take place by forces distinct from nerve force in the subject in which the action takes place. If we divide a nerve going to a part, never mind how much we may imagine that we can move the muscles to which it goes; never mind where we go to be the object of a muscle, we shall not have the least action in the muscles to which that nerve went. That nerve is absolutely outside of our control. Nerve force cannot be propagated to parts that are not in connection with the nervous centres. This fact is a death blow to the view that there are other forces acting in us than mere nerve force. To continue the illustration of this fact: If the spinal cord, which establishes communication between the brain and the various parts of the body, is divided, the parts of the body that are below that section are separated absolutely from any act of will, any act of imagination, any act coming from emotion, in fact, from anything that comes from the brain. There is, I repeat, no force in our system other than mere nerve force for the transmissions that may come from the brain, as the seat of the imagination, the seat of emotion and the seat of the will.

I shall now add but a few words on the production and expenditure of nerve force. Nerve force is produced as you know through blood. It is a chemical force which is transformed there into nerve force. This nerve force accumulates in the various organs of the nervous system in which it is formed during rest. But if rest is prolonged, then it ceases to be produced. Alteration takes place in the part which is not put to work. On the other hand, action which is so essential to the production of nerve force, if prolonged will exhaust force also, but produce a state distinct from that of rest. Rest will produce a lack of blood, while over-action may produce congestion. The great thing, therefore, is to have sufficient but not excessive action.

There is another law which is that we should not exercise alone one, two, or three of the great parts of the nervous system; since thus we draw blood to those parts only, and the other parts of the body suffer. In the due exercise of all our organs lies the principal rules of hygiene. This view, you know, comes from a physician. It is not in agreement with what the poet Churchill wrote:

> "The surest road to health, say what you will,
> Is never to suppose we shall be ill.
> Most of those evils we poor mortals know,
> From doctors and imagination flow."

Unfortunately Churchill died a victim to this view that doctors were murderers. He died of a fever at the age of 34, and that because he had been too careless about calling in a doctor to help him. But it is certainly true that the great rule of health is not to lay imagination aside, and this is why I have quoted these verses. Imagination, on the contrary, is to be appealed to far more than we do, and this is one of the great conclusions that I hope young physicians will keep in mind.

To conclude with these great rules of hygiene, I should say that we should not spend more than our means allow us. Many commit this fault. As before said, we should make an equal use of all our organs, and of the various parts of the nervous system. Those who employ the brain suffer a great deal from inattention to this law.

Lastly, there should be regularity as regards the time of meals, the time and amount of action, the time and amount of sleep—regularity in everything. It is very difficult indeed to obtain it. But there is in our nature more power than we know, and if we conform ourselves to the law of habit things will soon go on without our meddling with them, and we come to be perfectly regular, although we perhaps had naturally a tendency not to be.

In conclusion, I have to thank the audience that has listened to me so patiently through these long and disconnected lectures. [Loud applause.]

ERRATA.

Page 14, col. 1, line 18: for "days," read *years.*

Page 33, col. 2, lines 10, 11: for "had the power of conveying various sensations in it of other things," read *is portrayed in the nerves and that they carry with them its animus.*

Page 33, col. 2, line 15: for "Thomas," read *James.*

Page 34, col. 1, line 60: for "both astringents," read *and an astringent substance.*

Page 34, col. 1, line 66: for "Du Cros," read *Durand de Gros.*

Page 34, col. 2, line 10: for "recall," read *have heard stated.*

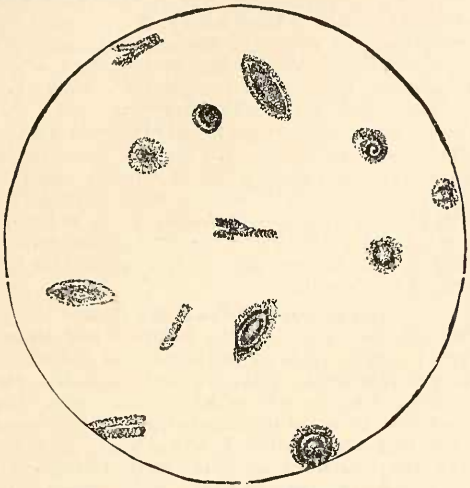
but yet, perhaps, is better suited in other respects for observing nebulæ. You will have next another picture brought on showing a different appearance from that now on the screen. You will have the great spiral nebula, as seen from the Rosse Observatory, and not indicating all the enormous extension of that nebula. You see there a process as though some great quantity of nebulous matter had floated in with a spiral motion, traveling through a resisting medium, and in approaching the center it traveled on a spiral course. One argument in reference to that is that it was matter of small density traveling in matter somewhat less dense. Here is another different picture of the great Orion nebula, which has been compared to the mouth of some gigantic sea monster That picture was obtained by Sir John Herschel with one of his father's telescopes that he used at the Cape of Good Hope, and to show the effect produced by different telescopes on the appearance of nebula, we will have that picture removed and place another picture of the same nebula on the screen, the picture obtained by Bond when using the great refractor of the Cambridge University.

And let me here mention the superiority of the retractor at Cambridge to the Rosse telescope, and let me allude, also, to the possibilities of great future discoveries by means of a telescope to be five feet in aperture, which it is said your optician, Alvan Clark, proposes to make, at a cost, I believe, of $1,000,000. That amount will be wanted. It seems a considerable sum. But if any one can do it it is Clark, for he is unrivaled as an optician. Cooke of England was the only optician comparable with him, but Mr. Cooke is dead. I have never had an opportunity of making any comparison between the great telescope of Cooke, 25 inches in diameter, which is used in an inferior atmosphere, and was completed in the hands of his successor, and those of Clark. The telescope at Washington is 26 inches in aperture. But now that Cooke is away, Clark is the greatest of living opticians, and if a telescope is to be made of enormous aperture, to be used in California, it is to be hoped he may be spared to make it. Another picture is now brought on the screen—Orion's nebula. You see these irregular starry clouds. They give a spectrum altogether different in character from the spectrum given by star-clouds consisting of separate stars. These last give a rainbow-tinted spectrum, showing they consist of suns resembling our own in structure. This nebula now on the screen is called the true lover's knot. Nebulæ such as that give spectra indicative of the gasiety of the source of light. They spread through all these wonderful depths of space. Remember their distance from us, and the length of the earth's orbit by which it is measured. We have the diameter of that orbit as 183,000,000 miles. Compared with the stars' distance, the whole orbit of our earth sinks into insignificance. And remember that the least of these stars—its mere disk—has enormous heating power; then remember how great the distance from star to star of those shown in this view, and then consider that this nebulous matter is spread between these stars and continues from one star to another, and then you have an idea of the wonderful extension of that matter. Neptune has a diameter 30 times greater than the earth, and a globe such as that, if placed on that picture, would be less significant than the little star to which I point; and when you come to the nebular hypothesis, when you come to consider that fully, you will find that of the nebulous mass that exists in that space there is abundantly sufficient material out of which solar systems could be formed. We will now pass to another system, showing a great nebula, which is remarkable in this way, that it has varied in brightness. There seems to be an association between the nebula and the star to whose influence it seems exposed. Herschel noticed a star in Argus which at one time appeared to be a star of the second magnitude; fifty years later it had sunk to the fourth magnitude; when Herschel noticed it, it was of the second magnitude, and it rose to the first while he was at the Cape of Good Hope, and when he came home he heard that it had risen until its brightness exceeded every star in the heavens with the exception of Sirius. At this moment that star can only be seen on the darkest and clearest night. It shows now with luster less than the one-hundredth part of what it had a quarter of a century ago, suggesting this idea, that many of the planets are not fit to be abodes of life. So there are many stars of which this is a type, stars which are unfit to be the centers of circling worlds, simply because their light is so variable. If that star were the center of a system, a quarter of a century ago it was a great deal too bright, if on the other hand a quarter of a century ago it gave out the right kind of light, it is now too faint. We will pass from this object to another which illustrates the connection between the nebulæ and stars. For a long time the theory was that this nebulous matter was far away out in space from the stars, but when you look at the group such as you now see, you will recongnize the fact that there is a connection between the nebulous mass and stars. We will have here a portion of the great Orion nebula, which is found to have branches extending from the central part of the nebula to the star Iota and upward to the star Epsilon, and you will observe nebulous streaks stretching from star to star. You may view them as the fingers of a mighty hand, showing beyond all possibility of question there is a real connection between the nebulous matter and the star seen in the same view.

The great astronomer, Kepler, discovered the three fundamental laws of the solar system. Now, he imagined that the center of the universe was the solar system. He considered that the light and heat of the sun spread out and was caught up by a shell, inclosing the stars, and there was none of the waste of which I spoke in my first lecture, and he made a series of calculations which have not the least trustworthiness in them, and came to the conclusion that the shell of the universe is 70 miles in thickness.

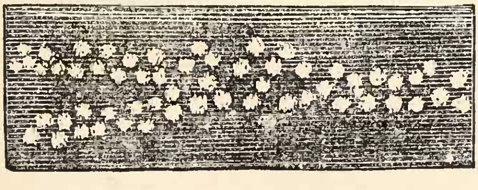
I now pass to Wright's theory, which is commonly ascribed to Sir William Herschel, that our starry system is one of several starry systems. As you know, Herschel gauged the heavens, and, because he found the stars were great in number in the direction of the

Milky Way and in its neighborhood, he concluded the starry system is a great extension toward the zone of the Milky Way, and because that zone is divided in one part, he concluded the system is cloven in that direction, and he came to the conclusion that that system is like a cloven disk. According to that theory, the nebulæ would appear to be a number of galaxies of stars.



WRIGHT'S THEORY OF THE UNIVERSE.

But another astronomer noted that the Milky Way was not of that uniform structure which the theory of Wright seemed to require. It is like a cloud, and there is sufficient to indicate that the Milky Way consists of clouds of stars. The next picture will show you a section of our starry system based on that view, and in that section there is supposed to be a multitude of comparatively small spherical clusters of stars According to Lambert, these spherical clusters form together a cloven, flat disk.



LAMBERT'S THEORY OF THE UNIVERSE.

Then came the work of Sir William Herschel. And here I point out that error in our books of astronomy, repeated over and over again, of supposing Herschel's theory to be that our starry system is like a flat disk. It must be remembered that we cannot take the labors of Herschel, extending as they do over half a century, and treat all as if they all were part of one work. His essays in the Philosophical Transactions cannot be treated like a book written at once, and we must note how he tells us that he himself changed his mind. But in the Milky Way he thought the stars were spread uniformly. "I am convinced," he said, "by prolonged examination, that the stars in the Milky Way are differently spread from those which lie immediately around." He used the same telescope, and he counted the stars in different localities. That was the first part of his method. In other sets of observations he used different telescopes; first a small one, and then a larger, and then a still larger one, and he dealt with the difficult parts of the heavens where the stars are clustered so richly that the telescope refused to show them separately; and then he used a more powerful telescope, and considered that he was penetrating further and further into space. That was when he was nearly fourscore years of age, and there was a possibility that any error in that method would not be detected by him, and he failed to note that if he were looking at a small cluster of stars, and looking at them first with a small telescope and then with a more powerful and still another more powerful one, if he were really passing further and further on, that cluster, instead of being a spherical group, would be spike-shaped, a projection of stars extending out backward from our earth, which is inconceivable, when we consider the immense number of these clusters on our Milky Way.

What I wish and hope to do, is to carry on that system of star gauging, combined with this system of Herschel; to take one telescope and survey the whole heavens, counting the number of stars in different directions; not a field here and a field there, as Herschel did, but field after field, little square fields, side by side, in the heavens, counting the number and mapping the results; and then seeing where the stars shown by that telescope are richly or poorly distributed. Then take a telescope of higher, and afterward another of higher power; seeing, after each set of observations, whether the rich regions seen by one correspond with the rich regions seen by another telescope, and so knowing something of the heavens. Suppose you were looking at the sky and saw large birds spread irregularly over it; if you noticed that there were small birds also spread over it, that where the large objects were the small ones were also numerous, you would conclude that these large and small objects formed a single cloud—were intermixed as it were—and be certain that the large and the small ones were intermixed in the same clouds. That conclusion would be important in our star system.

I pass to the results of the investigations of Struvé of Germany, who numbered the stars and found that large and small stars are rich in numbers in the Milky Way, and inferred that there is an intermixture of them, and that the star system has not the shape of a disk, but that what was supposed a disk has no limits. I pass to some maps which I made as a beginning toward a system of star gauging, and I have not been able to go far; but these few maps are an indication of the method.

Here are all the stars on the northern heavens, on a scale absolutely necessary to this kind of work, of surface projection, and you will notice that here is the Milky Way, and here are gatherings of stars. I invite your attention to the dark region here. We shall now have the southern heavens brought on, and there is a more marked gathering of stars in certain parts. There is a bright region here, known as the Magellanic Clouds, and that part of the heavens is so bright that when it is above the horizon it has the same effect as the rising of the young moon, and you will see how poverty-stricken that other region is all around it.

The next map is one containing 324,198 stars. I thought I would pass from stars visible to the naked eye to those brought into view by a small telescope; there were 40 charts, and I thought if they were included in a single chart the result could not fail to be of interest. If my view is true, that there is an interspersion of large and small stars, the telescope ought to bring in stars gathering more richly in the Milky Way than elsewhere. There is an equality of light elsewhere, but a rich region in the lower part. That is the zone of the Milky Way, and by thus mapping the stars in it, the Milky Way is distinctly brought into view. There are the Pleiades in the Milky Way and the head of the Bull, and here is a region where comparatively few stars are seen.

Now I shall ask you to notice that a work of that kind must proceed slowly. There is a want of laborers in the field. There is always a possibility that we may gather in laborers here and there, and there is a possibility that I may gather assistance here in this way. What is wanted is laborers to gather in. Any one can survey the heavens with a telescope, and it is only necessary to carry out that survey on a uniform plan, and then the work done will fit in with the work done by another observer.

If you consider this map with its 324,000 stars, you will readily perceive that it takes time necessarily. Give a single second to each star, and it amounts to a considerable time. The time I gave to that map amounted to 400 hours, nearly.

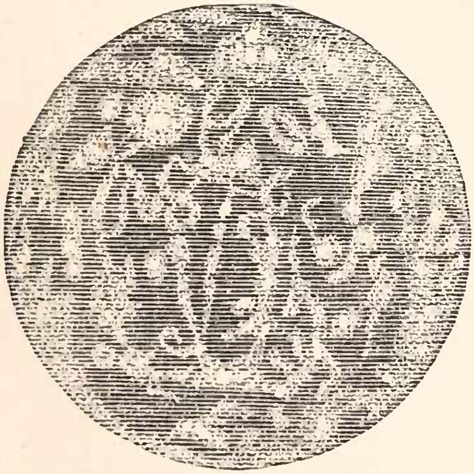


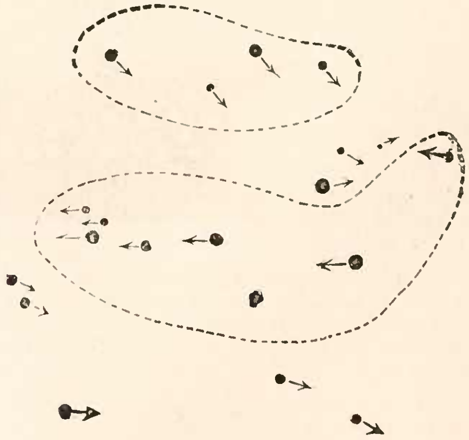
ILLUSTRATION OF MR. PROCTOR'S THEORY OF THE UNIVERSE.

Take a more powerful telescope, and the number of stars will be not merely increased but multiplied. With a 12-inch telescope you will get a greater number, and take one like Herschel's—18 inches in aperture—and 20,000,000 stars will be seen. There is a tremendous work, and the results will be worthy of the trouble; and this is the only means we have of ascertaining the architecture of the heavens.

We have to note here that the stars all move. There is a wonderful process going on all around. The sun takes his family along. He is called a fixed star, but in reality he is moving rapidly. The stars have a wonderfully rapid motion. I know not which is the more wonderful, the rapid motion or the relative immobility of the still heavens. The process of change in a block of granite is relatively greater than those processes in the still heavens, yet these stars are every one traveling 20 and 30 miles in a second, and not a star in the heavens but has some motion. Every one of them is traveling so rapidly, and yet if when a man was born the heavens were mapped at his birth, and he were to live threescore years and ten, or even fourscore, at the end of that time the aspect of the heavens, to all ordinary observation, would be the same as at the man's birth.

THE MOTIONS OF THE FIXED STARS.

We will now have upon the screen a few maps in which I have jotted down the motions of the stars, of all the stars whose motions have been measured. Here also you will see the rate at which they move. These little arrows show the direction in which and the rate at which they are moving. I have been obliged to make the length of each of them correspond to the motion of the star in 36,000 years, that is that each of them must take 36,000 years to go to the other end of its little motion arrow. A great many of them travel in the same direction, showing signs of being related together. We shall have another map showing the region of the Twins. These two stars seem to be drifting toward the Milky Way, like waves toward some mighty shore.



THE DRIFTING STARS OF THE GREAT BEAR.

Now we shall have a picture brought on showing the seven stars of the Great Bear. Five of these stars are traveling in a common direction and apparently at a common rate. Now these stars are notable also in having the same kind of a spectrum, that leading order to which Sirius belongs. It has the strongly marked lines of hydrogen. They must be really much further away than these other stars, those in the upper measure, and they are really further away. What, I thought, when I noted that drifting, was that they belonged to a drifting family, and prophesied that when Dr. Huggins should apply means of determining the recession or approach of a star, this would be found to be the fact. The experiment was made and my prediction verified. Our knowledge of this fact is based on a very simple principle. Light comes to us by a series of waves. If we are approaching the source of these waves, they seem to come quicker; if we are receding from it, they appear slower. If you are swimming in the water and meet the waves, they seem to have narrower crests. It is the same with sound. If you are on a railroad train when another train is approaching upon which the bell is sounding, when that train passes you will notice a sudden change in the sound from acute to grave. So it is with light. If we are approaching a star with rapidity, the waves will be shortened; otherwise they will be lengthened. The lines in the spectrum will be displaced, and we shall know whether the star is approaching or receding. Dr. Huggins found that these stars were receding at the rate of 17 miles in every second of time.

There is another sign of change in the stars; a gathering in a certain region. There is, in point of fact, a vast variety where everything seems so regular. Look at the milky way in a dark and clear night, curdled in one part, branching in another, and how the branches separate, gathering in nodules of lightness and then fading, and then believe that the star systems are so regular as you suppose! It is infinitely more full of variety and vitality than you have supposed. Now we will have a picture, which I have drawn very roughly, to show the variety existing in the star system. We see there streams and nodules and branches of brightness, and it seems to me that when the astronomer has penetrated into the recesses of the Milky Way, that he has no more reached the bounds of the universe than at the beginning of his research. He has only examined more and more minutely a particular corner of the star system. It really extends on every side, around and around that system, and we have no reason to believe that we can reach the bounds of the star system. The telescope brings into view, beside the larger stars, minute starry flakes; and if the telescope could be made stronger, it would bring into view more and more, and we should find that the extent was really illimitable.

We find a group of suns of which our sun is a single member. Then again we pass to systems brought into view by the telescope, and find that the star system to which our sun belongs is only a part of that one—an atom in space. The astronomer can give the figures, but he can no more express their significance to himself than he can unfold their limitless meaning to others.

RICHTER'S DREAM.

I do not know that I can conclude my lecture better than by quoting Richter's dream, in which he shows the feebleness of man's imagination in the presence of the infinite wonders of the universe, as translated by our own prose poet, De Quincey:

God called up from dreams a man into the vestibule of Heaven, saying, "Come thou hither and see the glories of My Kingdom," and to the angels that stood around His throne He said: "Take him! Strip from him his robes of flesh, cleanse his vision, and put a new breath into his nostrils; only touch not with any change his human heart, the heart that weeps and trembles." It was done, and with a mighty angel for his guide the man stood ready for his infinite voyage; and from the terraces of Heaven, without sound or farewell, on a sudden they swept into infinite space. Sometimes, with the solemn flight of angel wings, they passed through Zaharas of darkness, through wildernesses of death that divided the worlds of life; sometimes they passed over thresholds that were quickening under prophetic motions from God; then, from beyond distances that are counted only in Heaven, light dawned as through a shapeless film; by unutterable pace they passed to the light, the light by unutterable pace passed them. In a moment the blaze of suns was upon them, in a moment the rush of planets was around them.

Then came eternities of twilight that revealed, but were not revealed; on the right hand and on the left towered gigantic constellations that by self-repetitions and answers from afar, that by counter-positions, built up triumphal gateways whose archways, whose architraves, horizontal, upright, rested, rose, at altitude of spans that seemed ghostly from infinitude; without measure were the architraves, past number the archways, beyond memory the gates. Within were stairs that scaled the eternities around; above was below and below was above, to man stripped of gravitating body. Depth was swallowed up in hight insurmountable; hight was swallowed up in depth unfathomable. On a sudden, as thus they rode from infinite to infinite, on a sudden, as thus they tilted over abysmal worlds, a mighty cry arose that systems more mysterious, that worlds more billowy, other lights, other depths, were coming, were nearing, were at hand.

Then the man sighed and stopped, shuddered and wept. His overladen heart uttered itself in tears, and he said: "Angel, I will go no farther, for the spirit of man acheth with this infinity. Insufferable is the glory of God. Let me lie down, and hide me in the grave from the persecution of the Infinite, for end I see there is none." And from all the listening stars that shone around there issued a choral voice: "The man speaks truly. End is there none that ever yet we heard of." "End is there none?" the angel solemnly demanded; "Is there indeed no end, and is this the sorrow that kills you?" But no voice answered, that he might answer himself. Then the angel threw up his glorious hands to the heaven of heavens, saying, "End there none to the Universe of God! Lo! also, there is no beginning!"

THE SOLAR SYSTEM.

LAST LECTURE BY PROF. R. A. PROCTOR.

BIRTH AND GROWTH OF THE SOLAR SYSTEM—THE NEBULAR HYPOTHESES OF HERSCHEL AND LAPLACE—HERSCHEL'S FIRE-MIST—A THEORY ACCOUNTING FOR CERTAIN STRIKING FEATURES OF THE SOLAR SYSTEM AND ITS CHIEF PECULIARITIES—HINTS TOWARD A THEORY OF THE STELLAR SYSTEM—TRIBUTE TO PROF. PROCTOR BY HIS AUDIENCE.

It is comparatively rarely, in a large city, that an audience takes such special pains to express its grateful acknowledgments to a lecturer, and especially one who is not a countryman, as did Prof. Proctor's listeners on the evening of Oct. 22 at Association Hall, on the occasion of the last lecture of his series on the discoveries of astronomy During the delivery of the course of lectures just concluded, the good-will displayed by American audiences towards the distinguished Englishman, which has been shown, as Prof. Proctor himself remarked feelingly, by silence, by attentive consideration, and by appreciative applause, has been very marked; and after the cordially-worded resolutions of acknowledgment had been passed, the scientist responded in a few heartfelt words which proved his thorough recognition of these facts. The subject treated by Prof. Proctor was "The Birth and Growth of the Solar System, with an Exposition of the Nebular Hypotheses of Herschel and Laplace."

THE LECTURE.

LADIES AND GENTLEMEN: I was rather horrified when I came into the room to find circulating a certain paper regarding myself. [This was a biographical sketch with a portrait.] I really have not the least objection to this, but should like the audience to know that I had nothing to do with its circulation. [Applause.]

There are few subjects more difficult, more full of perplexities, than the thought of the origin of the solar system. The powers that have been given to man—not the individual, but the race—have been great. The mysteries that lie around him are greater yet, and it seems almost hopeless that man should be able to recognize anything as to the laws according to which our system arose. And yet that is a very fit subject on which man may exercise his thoughts. It seems to me it is well for man to follow out the paths that seem to lead him backward toward the origin of our system. He need not be afraid, whatever his religious feelings may be, to follow out those paths, so long as they lead him to facts. It may be that as he follows them he will find views that he never entertained before; it may be that he will find much perplexity; but inasmuch as the work is a study of science—that is to say, a knowledge of the works and ways of God—it cannot but lead to higher ideas of the wisdom and omniscience of the Almighty.

I offer this preface to my treatment of the subject of the evolution of the solar system, because, strangely enough, many look with doubt and almost with aversion on inquiries of that sort. They seem to be afraid that too much will be discovered. They are men full of religious feeling, but they doubt, and I think that the conscientious student of science may justly say to them, "O ye of little faith! Why are ye so fearful?" But I think both the student of science and the theologian should have charity, one towards the other. It does seem to me a misfortune when we find on the one hand the believer in religion taunting the student of science who takes this special work for his own, speaking of him as an infidel and as if his purpose was evil. On the other hand, I cannot adequately express the indignation I feel when I hear the student of science—sometimes it happens; thank God! it is not often—expressing doubts as to the real truthfulness, and impugning the religious belief of those who differ with him. On each side there should be charity. There is a great deal of truth and of the love of truth in human nature. Both sides are seeking for the truth, and it seems to me the greatest possible misfortune when they fall out with each other.

THE EVIDENCE OF GROWTH IN THE PLANETARY SYSTEM.

Now if we look around at the condition of the planetary system, we find much to lead us to the belief that it grew to its present state; that there was a process of its development. Take the primary planets. In the first place, we see that all the planets circle in the same direction around the sun. There are eight primary planets, and 134 asteroids, and all these bodies travel in the same direction around the sun. Then every one of the bodies whose rotation has been determined, turns in the same direction. Moreover, the four satellites of Jupiter, the one of our earth, and the eight of Saturn, travel still in the same direction; and we find only one exception, in the case of the satellites of Uranus, which may be said to travel in the opposite direction, if, the course of travel being nearly upright as compared with the planetary orbit, they can be said to have any direction. As far as they have any direction, however, it is worthy of note that it is a contrary direction to that which the planets travel around the sun.

Well, I find so many of these similarities, concerning which we are bound, I think, by the laws of probability, to believe that they arose from some process of evolution. Of course we may believe, if we choose, that the Almighty ordains everything in that way; that every planet was created in the first place moving in that direction; that thus it was everything about us was formed. The student of geology, too, may learn of the existence of living creatures on the earth hundreds of years past; but we may believe, if we choose, that all those fossils are signs planted there by the Almighty; that they are not the remains of living creatures, but mere appearances It seems to me that

that is a painful belief, making the Almighty God give evidences that merely lead men astray. And, therefore, when we find these facts in the solar system, it is natural and right for us—our reasoning powers not being given to us for nothing—it is right for us to try and conceive how that state of things arose. The actual probabilities are great against anything like chance distribution of the solar system, particularly when we remember there are 142 primary and secondary planets, and when we take into account their motion alone, each circling around the sun in the same direction. The chance that one is going in one direction and the next going in the same direction is only one chance out of two, and the chance that a third would go in the same direction is only one chance out of four; the chance that a fourth would go likewise is only one out of eight; a fifth, one out of 16; so we must go on doubling until we find that the chance of 142 planets going around in the same direction—I hope you will be patient while I tell you the number—is one in 2,774,800,000,000,000,000,000,000,000.000,000,000.000,000. [Laughter and applause.] But that is not all. The way in which the planets travel is a fact in itself that seems to indicate a certain process of evolution by which they have a particular motion.

LAPLACE'S NEBULAR THEORY.

Now if we consider the way in which that motion arose we are first led to the hypothesis of the French astronomer Laplace. Laplace, in his explanation of this motion, had the idea that there was a great nebulous mass having the sun in the center, extending on either side far beyond the present breadth of the path of the uttermost planet, that is, a path of 5,000,000,000 miles diameter, and the nebulous system of Laplace extended beyond that. That mass was intensely hot and vaporous, and it was rotating, and as the rotating mass contracted and it began to rotate more rapidly, the result was that a ring was thrown off by centrifugal force. In time the ring would gradually break up, its parts would gradually amalgamate; many parts would have different rates of motion, and different parts would encounter each other, and in the course of millions of ages there would be an amalgamation into one mass, having the same direction of motion that the nebulous mass had, and traveling around a center which was the sun. But as this minor mass went on contracting it would follow the same law as the original body which gave birth to it. It would go on contracting, and go round more and more rapidly; perhaps it would throw off true rings, which would become satellites. So the earth was formed; she turns on her axis in 24 hours in the same direction, while she takes 365 days in going around the sun. So it was with Jupiter and Saturn and all the planets—all in rotation in the same direction. That process would go on until one planet after another was formed. And so it was that the solar economy, as we at present know it, would arise.

That is a rough account of the nebular hypothesis of Laplace. It seems to me that there is great difficulty in the way of accepting it. In the first place, we have nothing to lead us to believe that a great nebular mass of so enormous dimensions and extreme tenuity could rotate as a whole or exist as a whole. We have no evidence to lead us to believe that the rings of Saturn are a continuous solid. We know they could not exist as nebulous rings, and we have now as the accepted theory that they are a multitude of separate satellites that could not have existed as a whole and rotated as a whole.

Another point: That nebulous mass rotating by uniform process, if contracting, must give birth to a uniform system. There would be some law associating the planets' distances with their dimensions, and that, as we know, is far from being the case. We have three parts of the solar system—the inner planets, the asteroids, the outer planets. The sun is 751 times as large as the outer ones; the outer ones over 200 times as great as the inner ones. Take any one of these families, and we find apparently no law in their arrangement. Among the inner planets, there is first Mercury, a very small planet; then Venus, very much larger; then the earth, still larger, and dignified with a moon; but then we come down again to Mars, which is a small planet. Then we have the asteroids, mere specks, 134 of them. Then take the outer family, and there is still no progression. We have the largest of the planets, Jupiter; then Saturn, also immense, and then the planets Uranus and Neptune, about equal in size but smaller than Jupiter or Saturn. Laplace's theory does not explain why the family of least dimensions should be in the middle, and the larger one outside and the smaller near the sun; and we have no account of the relations of these bodies by his theory, and only an explanation of the general facts first noted.

ASTRONOMERS LIKENED TO A COLONY OF MAY-FLIES.

We are led, therefore, to another theory, and I adopt what appears to me a suitable method of illustrating it. If we imagine a colony of small insects, of the May-flies or ephemera, which live but a few hours, and living in and having as the center of their domain a large tree, these ephemera are not able to ascertain anything about that tree in their time of existence, as they live but one day. But we may suppose them to be reasoning beings, and that they have handed down from one to another the discoveries made by their ancestors, and they proposed to ascertain in time, by exercising their intellectual powers, the laws according to which the tree grew, and something of the future of the tree. They would trace back the history of the tree and arrive perhaps at some notion by comparing that tree with others, and that it sprang from a seed, and they would do as we do, and think that was the beginning of all things, for this tree would be their universe. If they were told by some thoughtful May-fly that the tree resulted from the contraction of a great mass of vegetable matter, they might remain satisfied with this notion for a long time, but if they found by observing other trees that there were no such vegetable masses contracting in that way, it would be just on their part to look to another theory, and finding the process of growth, they would trace back the process and say that it was the result of the quite different process of tree-growth to that stage.

They would recognize the process and trace it back, and say that the tree did not contract from a vegetable mass, but sprung from a small vegetable mass, and grew by the addition of matter.

Then I think there is another point to notice. They may reject the notion formed of the vegetable mass, and say very reasonably, that with all due respect to the opinion of so highly eminent a May-fly as he who propounded the condensation theory, whole days have passed since they have formed truer ideas. So I think it is with the theory of Laplace; we have a great respect for him, for he was the greatest mathematician that ever lived after Newton. But we must consider these wonderful facts that we have recently learned about the planets—about the sun's conditions, about the heated condition of Jupiter and Saturn, about the relation of comets and meteors. We have learned that the earth is growing, though not appreciably; as I have stated to you, the earth increases only one inch in diameter by the fall of meteors in 400,000,000 years. We can hardly call that growth at all, but still, like the tree after it it has ceased to grow, and only lives, the present development of the earth shows us, leads us, to look back at the distant past, when the meteor system was more numerous, and the whole solar system was growing. It seems more natural to look at the process as a process of accretion than of contraction from some nebulous mass.

THE THEORY OF ACCRETION.

We will now have the room darkened, and this process will be illustrated on the screen. With this new view of the matter, does it promise to give us light on any questions which were previously unanswered? Will it explain how the planets are arranged in the manner in which they are? We shall find it will. You have a picture illustrating the great difference in size between the outer part and the inner part of the system. Here are Uranus, Neptune, Saturn, and Jupiter, and here in the lower right-hand corner you will notice a circle only as large as represents the planet Uranus; within it are Mercury, Mars, the Earth and Moon, and Venus. We might imagine a great nebulous mass like the fire-mist of Herschel, in space, gradually approaching towards the sun, approaching spirally. We might conceive *that* as the beginning of all things, like the tree from the seed. We know that as one nebulous mass passes into another by condensation, heat and light are produced.

There is evidence that these nebulæ are gaseous. Well, then, these nebulous masses would be thrown into the great center. There would be one center of aggregation. That center would grow continually in size and power, gradually draw in more and more matter to it, and the more it drew in of these nebulous masses, the greater its power would become. How then does the secondary aggregation take its origin? I suppose that would arise not in one direction only, but some in one and some in another, with a superabundance in one direction; great subordinate masses would be formed, perhaps, not continuing separate for any length of time. In the neighborhood of a great central aggregation, a gathering of that kind could not form, for the reason that the motions near the great central aggregation would be very rapid. Take our sun, which is the original center of aggregation, and we find that in the sun's neighborhood the motions are very rapid. A body coming out of space and falling into the sun would reach the sun at a velocity of 380 miles a second, and if only going around the sun, would travel 290 miles a second, but at the distance of Jupiter the velocity of an arriving object would be only about 12 miles a second; therefore it would be easier for an aggregation to form at that distance, some great distance from the center. It would not have to overcome the tremendous velocities which an aggregation would have to master in attempting to form near the sun; it would have time to catch the flying masses. A secondary aggregation at a considerable distance from the center would not suffer from this great velocity. An aggregation there would have greater power over matter around it, and a larger and larger aggregation would form, and as it became larger and larger it would be more and more mighty; by a sort of geometrical progression it would grow larger and larger, while all the objects attempting to form within its influence would be kept down, reduced in size. Thus we explain the fact that we find Jupiter, the greatest aggregation, at a much greater distance than the inner family of planets and the asteroids.

Beyond Jupiter we come to another system, which shows signs of greater activity and development. At Saturn's distance the motions would be less rapid than at Jupiter's distance. There would still remain a great quantity of matter out of which an aggregation would be formed, and so we should find Saturn, not so large as Jupiter, because the matter would naturally decrease outwards from the sun, but owing to the smaller velocity there would be a greater freedom of aggregation, and so we have Saturn, with a ring around it, and its eight satellites. And then we next come to Uranus and Neptune, and they are smaller, because the quantity of matter diminishes with distance. Then take the inner family, close to the sun. Close to the sun, they are prevented from accumulating much by the sun's neighborhood, because of the tremendous velocity of matter there, and they are consequently small. Passing far out again, we find the influence of Jupiter beginning to be felt, Jupiter resisting the formation of an aggregation within his influence. The combined influence of Jupiter and Saturn preventing aggregations from forming, results in the smallness of Mars; and close within the path of Jupiter's influence we find the zone of asteroids, each too small to form a planet.

That is better than Laplace's theory. It is not to be expected that you could have a complete account of those relations, neither could you by theory explain the size and color of every bough and leaf, and the details of arrangement of a tree.

COMPLIMENT TO AN AMERICAN ASTRONOMER.

And now I shall allude to the strange results obtained by Prof. Daniel Kirkwood, of Bloomington, Indiana, whom I have called the Kepler of modern astronomy from the way he has looked out for relation after relation, and the connection between the different relations of the planetary system. His researches are worthy of all praise. His results are full of interest. He took the paths of the asteroids and arranged them in their order of distance, and he found certain places where, for some distances, there were no asteroids. There are asteroids at a great number of distances from the sun, extending over 400,000,000 of miles, but there were gaps, like those between the rings of Saturn, and the way in which Kirkwood explained this was: he noted where the gaps occurred, and he found them corresponding to the paths of asteroids having periods commensurate with the period of Jupiter; and a student of astronomy knows that this commensurate period must have led to great perturbation. The periods of Jupiter and Saturn are as the numbers two and five, and when there is a conjunction in different parts of their orbits the perturbation takes place there, and they disturb each other, producing what is known as the great inequality of Saturn and Jupiter. In the same way Jupiter would disturb the motion of the asteroids, if they had a period like his own, and would prevent them from forming, his mass is so much greater. And so you will find there are no asteroids in those particular spaces. This supports the theory that the solar system arose from motion and aggregations of discrete masses; not from the contraction of a great nebulous mass. The rings of Saturn give further evidence of the same. The gap in Saturn's rings—the gap in the true ring—corresponds in position to the place where this influence would affect the paths of little satellites traveling between the rings. There on the screen before you is the great Spiral Nebula as observed by Rosse, and there you see two central aggregations. As we look on that nebula we find its condition unchanged year after year, and recognize in the slowness of any perceptible change taking place, evidence corresponding to the nature of its being. Herschel and Laplace had a somewhat similar theory in regard to this nebulous matter and the stars. Herschel's theory was based on the fact that he recognized in the heavens signs of a luminous fire gathering toward certain centers of aggregation. There are parts of the heavens where he noticed that the whole field was lit up with a faint light, and he made the strange mistake of supposing that by increasing his telescopic power he could see the fire-mist better. But the real fact was he could not see it as well. If you want to recognize that fire-mist—and America is the best place to look at it—have no telescope at all. Use a telescopic tube, but with no magnifying power. I wish I had the keenness of eyesight for it. Provide yourself with a tube shaped like a telescope, with the thinnest glass, and place disks in such a position before your eye-piece so as to hide the stars of any particular constellation; carefully observe the heavens and you will have a clearer view of any fire-mist than you would by the telescope. The telescope will not make luminous bodies brighter. You look at the moon with a telescope, and you think it looks brighter, but it does not. The intrinsic brightness is not increased in the least. By looking, one eye through the telescope, and the other not through it, at the moon, you will find that although to the naked eye the moon is smaller, it is much brighter than in the telescopic view. The fire-mist Herschel recognized, if it is in the heavens, should be viewed without a telescope.

ASPECTS OF THE NEBULOUS MASSES.

I shall next pass to the gathering in of the fire-mist toward particular parts of the heavens. We will have a series of those views on the screen. These views are of different kinds of nebulæ. Nebulæ may be looked upon as flowers in a garden in different stages—one springing from the earth, another in full bloom, and another in seed time. There you have a nebula after it clusters, and other pictures will show you the immense varieties of those nebulous masses, and I would remind you that the number of these nebulæ is something enormous. There are as many nebulæ discovered as there are stars visible to the naked eye. Those pictures before you exhibit different kinds of nebulæ. You see the size of the great nebulous mass, gathering toward certain centers of aggregation. Herschel thus illustrated how out of the great mass of fire-mist, stars might be formed. There you see three stars, and now we will have another picture in which still other forms of aggregations will be seen. There are certain of these nebulous masses in which the stars form single clusters. When examined by a powerful telescope the most wonderful complexity is found in those nebulous masses. Other pictures will show you the process of the formation of stars. There you see a quantity of nebulous matter in certain parts gathering toward the center. And now we will pass to a series of pictures showing the way in which these nebulous matters cling around stars; and those are on a larger scale, and you will see the nebulous matter apparently drawn toward the various stars.

Then, you will recognize the great difference between the way in which that nebular mass is forming and Laplace's theory. We shall have the room more darkened for some time, as these nebular pictures do not show sufficiently unless the room is darkened; and we will have the pictures brought on rapidly one after another, the next three or four of them illustrating the same theory.

In the first you perceive three rich stars, and the nebulous matter there also is rich. There you will recognize the same features. You notice the dark spots between the nebular regions, and the stars always in the brighter part of these nebular regions, and evidence of the gathering in of it toward the stars, but we have no evidence of Laplace's view of a rotating nebular mass.

We will have another picture, and it will be a bright one. Here the nebula would appear to have changed in shape. Here is one view of a nebula, and the next one taken by Lascell of the same nebula, differs materially from it. This nebula is called Omega from its resemblance to the Greek letter. The same nebula is in the picture by Lascell, and it is so changed that it is difficult to believe that it is the same object. This leads us to the idea that these masses change in form. This is a view of the heavens, illustrating the variation of the different parts of the heavens in brightness. This is the bright region in the southern heavens of which I said that when it rises above the horizon the effect is the same as is caused by the young moon. There is in the midst Eta Argüs. This is a nebula which varies in shape, and the star in it varies from the first to the sixth magnitude.

Here we see fresh signs of variability in space, which bear on the birth and evolution of our system. We see that the sun was once variable, and the planets were stars of all variations in the early history of our system. While the aggregation was taking place, the sun would at some times blaze with flaming glory, and there would be an interchange of brightness, regular or irregular, as masses of matter were aggregated into it.

As to the question whether the sun is likely suddenly to have a defalcation of brightness, consider how some of the stars vary in brightness, and the thought is suggested that the same may happen to our sun. The process of evolution may be so far incomplete. Careful observations made by the English astronomer Hind and others—a process not very much carried on in this country—show that the stars vary very much in brightness; but that observation must be carried on a long time before sure results can be obtained.

VARIATIONS TAKING PLACE IN THE STELLAR HEAVENS.

In the constellations, if we can imagine that there were figures resembling the bear and the lion in shape in the old times, and if we find now no traces of them, the idea is suggested that there has been a change, and I was once disposed to think this was the case; for I could not think how the early nations could imagine a bear, for instance, if there was no such shape in Ursa Major. But by making the figure of the animal larger and studying the head, and, as was suggested to Dick Swiveller by the Marchioness, by making believe a good deal, we can make it out. The four limbs of the Bear are differently placed here. View that group forming the head, and there is a certain resemblance to the peculiar snout of the head of a Bear. The stars are small, but on a clear night you can recognize a certain resemblance to the head.

We have here the head of the Lion, the figure being larger than is usually depicted, and including several neighboring constellations. The grouping of stars all around gives really some resemblance to the head of a lion. That group which I have made the tail is the constellation Coma Berenicis. Perhaps, after all, the stars never did vary much. There is enough there to make an imaginative people think there was the figure of a lion. In these seven stars of the Bear the middle star has varied much, having declined from being as bright as the others. We cannot be certain that our sun may not diminish or increase in brightness. That middle star was once as bright as the rest, and now it is greatly reduced. This next picture shows how the great nebula in Argo has varied. Now, we have two pictures, in one of which is the figure like a key-hole, and on the next it is greatly varied and everything is so changed as to show that the nebular mass is drifting hither and thither; that the regions of the fire-mist contain drifting masses. We shall have more pictures tending to show the disposition of these nebulæ over the heavens. The cloudlets of stars are found to be spread with a strange variation over the Milky Way, and not uniformly; and that has been put in evidence to prove, I know not why, that these star cloudlets do not belong to our stellar system. But the diversity—the two parts of the heavens so diverse, one filled with nebulæ, the other with star cloudlets—seems to show that there is a connection between the parts. We have the idea that in the Milky Way, where the stars are rich, the circumstances were favorable to the formation of stars and star clusters; the star cloudlets are more numerous in the Milky Way than elsewhere, whereas outside of it circumstances were not favorable to the formation of stars, and the process of aggregation not being so rapid, these nebulæ were formed.

Here you have a picture showing a dark region and the nebular masses complete. Notice the northern nebular masses and these streams coming out. Here it is extending toward a small cluster of nebulæ. The Milky Way contains star clusters, and outside of it are separate stars. In the star clouds we find a multitude of stars discernible with the telescope, but so closely clustered as to be irresolvable, and in these masses or cloudlets we see proof, we have a certainty, that the sidereal system is not a mere aggregation of stars, but contains all varieties, nebulæ, star-cloudlets, and stars of all varieties; and that it resembles the solar system, not in uniformity, but in variety of structure. In studying its laws we have a problem of enormous difficulty, but one which must one day be solved. Man cannot stand unsatisfied in the presence of such a problem.

THE MOTIONS OF THE STARS.

Here is a picture showing the stars in the northern heavens, with arrow-heads attached. You notice that there is a hope, by comparing maps of this nature and making them more perfect—there is a hope of ascertaining why these move this way, and these this way, and of determining the way in which they arose, and what was the nature of the scheme out of which the present universe sprung.

You will notice those of the northern stars with their little star arrows. On the next map you will see those of the Southern Hemisphere. It is a matter for great congratulation that here in America a map of the exact positions of the stars is being made, so that a hundred years hence all these motions can be detected. This is a noble work, the real value of which will only be known a hundred years hence, and its promoters deserve a great deal of honor. [Applause.]

Now, I wish to bring before you a series of pictures, showing, on a somewhat better scale, the appearance of that chart of many stars which was shown at the last lecture. It is the beginning of the third process, the process of star-gauging. The picture now before you represents the central part of that chart of many stars. The central one is the Polar Star. In the lower part there is a region of greater brightness, and in the next picture you will see how the position of the Milky Way is clearly indicated. In the next, in the upper part there is much greater brightness. Cassiopeia can be recognized. In the next picture, joining this on the right, you can see the Pleiades and the cluster in the sword-hand of Perseus, and the Milky Way going across from the upper right hand to the left hand. And then there is that dark region of which I have spoken. The next picture will naturally be of the Twins. You have again the Milky Way. Here is the constellation of the Dog and the two Twin stars, and now we are coming to the region where the stars are fewer. In the next picture we begin to approach the Milky Way again. We have gone nearly round the heavens. One other picture carries us to the richest part of the Milky Way and the constellation of the Swan. We see the rich gathering of stars in that constellation. Now we will have the whole picture of the northern heavens again shown, not the same one, and you will see how the Milky Way is mapped out by these stars. You can see the Milky Way carried right round that picture. You begin to see the evidence we have that the Milky Way is a stream of stars gathering together, large and small. We see it as a spiral, as it were. Looking at it in that way, we begin to recognize how the nebulæ may have formed it; how in the very beginning of things it was formed; how at the outside of the spiral, the agglomeration gave birth to stars much further apart. While we cannot go much further than the star system, that is not the end of the matter. We look back into abysmal space and see these processes taking place. We look back from the formation of the solar system to the stellar system and to the sidereal system. We begin to see that there are processes still further back. "Lo, these are but a portion of God's works; they utter but a whisper of his glory."

TRIBUTE TO PROF. PROCTOR BY HIS AUDIENCE.

At the conclusion of the lecture, Mr. Morris K. Jesup, President of the Young Men's Christian Association, stepped upon the stage and said:

I am sure, ladies and gentlemen, that you will not desire these most interesting lectures by our friend Mr. Proctor to close without some expression on your part of our appreciation of their great interest. Our friend Mr. Charles Butler will offer some resolutions for your action.

Mr. Butler—I am sure we shall all like to have Prof. Proctor know how grateful we feel to him for the enjoyment and instruction his lectures have given us. I have been asked to say, on behalf of the audience, how much we appreciate the opportunity that we have had of following him, night after night, to that world of thought where none but a master's hand could lead us. I have to bear messages of gratitude, not only from those who, like himself, had already studied "other worlds than ours," but from so many of us as have been turned away and upward from the earth, which absorbs us in our daily occupations. That some of the light he has shed upon our hearts and minds may in some form be reflected back to him, that at least he may have some share in the enjoyment of his visit to our country, and that he may have a happy return to his own, is the wish of many warm American friends.

I propose the following resolutions, expressive of the sense of the audience:

Resolved, That we who have attended the course of lectures given by Prof. Proctor, Secretary of the Royal Astronomical Society of London, desire to express our appreciation of the masterly manner in which the subject has been presented, making plain things so difficult, and bringing to us the latest results of the study of the noblest of sciences.

Resolved, That we desire to express our admiration of the generous spirit in which the achievements of his cotemporaries, including some of our own countrymen, have been recognized and described.

Resolved, That the reverend and Christian spirit in which he has unfolded the wonders of astronomy has made us recognize more fully than ever before that "the heavens declare the glory of God," and to declare with the Psalmist, "O Lord, how manifold are thy works! in wisdom hast thou made them all."

Resolved, That in tendering our grateful acknowledgments to Prof. Proctor for this course of lectures and for the pleasure and instruction we have derived from them, we cannot refrain at the same time from expressing our best wishes that his visit to our country may prove a source of happiness to himself, and that his career in the future may be as eminently successful as it has been honorable and brilliant in the past.

MR. PROCTOR'S REPLY.

Prof. Proctor replied: I thank you, ladies and gentlemen, very earnestly for the kindness with which you have expressed your thanks to me. I felt that I had really undertaken a task of considerable difficulty in condensing into a series of six, my lectures on so vast a subject. I knew there was no difficulty in bringing these subjects before an American audience, if I only had sufficient time within which to deal with them; but to deal with the whole subject of astronomy in six lectures was really a very great strain upon the endurance of an audience. But for the way in which they have been received, and the way they have been followed, and the close attention with which they have been listened to, I am very grateful to you indeed. The only feeling of regret I have had has been that I could not transfer some of your enthusiasm for science, especially as it is represented in the numbers that come to hear of these things, to my own people at home.

In regard to the resolutions, which are so kind and complimentary, I can assure you, speaking from my heart, that during my whole stay in America—more than three months—I have not had one experience that has not been altogether pleasing. Everything has been more than gratifying. The kindness I have received on all hands has been very grateful to me, indeed, and very remarkable, too. I had no thought when I came over here of meeting with anything like that kindness.

There is one thing I would like to mention. Many have addressed letters to me, have proposed to call upon me, and invited me to call upon them. I wish to say that I have felt unable in many cases to do so, however much I desired it, or even to return an answer to some of the letters, unless a short answer, which is worse than no letter at all. I trust that any of these—some of whom may be here present, will recollect the difficulties under which I have labored. I feel that it is well these difficulties should be known; and I now thank you heartily, not only for the resolutions that have been passed, but for that greatest kindness that can be shown by audiences to a lecturer—attention to and consideration of what he has to bring before them. [Great applause.]

The audience then slowly dispersed, many remaining to exchange pleasant greetings with the lecturer.

Prof. Agassiz's Lectures at Penikese.

THE PRAYER OF AGASSIZ.

BY JOHN G. WHITTIER.

From The Christian Union.

On the Isle of Penikese,
Ringed about by sapphire seas,
Fanned by breezes salt and cool,
Stood the Master with his school.
Over sails that not in vain
Wooed the west wind's steady strain,
Line of coast that low and far
Stretched its undulating bar,
Wings aslant along the rim
Of the waves they stooped to skim,
Rock and isle and glistening bay,
Fell the beautiful white day.

Said the Master to the youth:
"We have come in search of truth,
Trying with uncertain key
Door by door of mystery;
We are reaching, through His laws,
To the garment-hem of Cause,
Him, the endless, unbegun,
The Unnameable, the One,
Light of all our light the Source,
Life of life, and Force of force.
As with fingers of the blind
We are groping here to find
What the hieroglyphics mean
Of the Unseen in the seen,
What the Thought which underlies
Nature's masking and disguise,
What it is that hides beneath
Blight and bloom and birth and death,
By past efforts unavailing,
Doubt and error, loss and failing,
Of our weakness made aware,
On the threshold of our task
Let us light and guidance ask,
Let us pause in silent prayer!"

Then the Master in his place
Bowed his head a little space,
And the leaves by soft airs stirred,
Lapse of wave and cry of bird
Left the solemn hush unbroken
Of that wordless prayer unspoken,
While its wish, on earth unsaid,
Rose to heaven interpreted.
As, in life's best hours, we hear
By the spirit's finer ear
His low voice within us, thus
The All-Father heareth us;
And his holy ear we pain
With our noisy words and vain.
Not for him our violence
Storming at the gates of sense,
His the primal language, His
The eternal silences!

Even the careless heart was moved,
And the doubting gave assent,
With a gesture reverent,
To the Master well-beloved.
As thin mists are glorified
By the light they cannot hide,
All who gazed upon him saw,
Through its veil of tender awe,
How his face was still uplit
By the old sweet look of it,
Hopeful, trustful, full of cheer,
And the love that casts out fear.
Who the secret may declare
Of that brief, unuttered prayer?
Did the shade before him come
Of th' inevitable doom,
Of the end of earth so near,
And Eternity's new year?

In the lap of sheltering seas
Rests the isle of Penikese;
But the lord of the domain
Comes not to his own again;
Where the eyes that follow fail,
On a vaster sea his sail,
Drifts beyond our beck and hail!
Other lips within its bound
Shall the laws of life expound;
Other eyes from rock and shell
Read the world's old riddles well;
But when breezes light and bland
Blow from Summer's blossomed land,
When the air is glad with wings
And the blithe song-sparrow sings,
Many an eye with his still face
Shall the living ones displace,
Many an ear the word shall seek
He alone could fitly speak.
And one name forevermore
Shall be uttered o'er and o'er
By the waves that kiss the shore,
By the curlew's whistle sent
Down the cool, sea-scented air;
In all voices known to her
Nature own her worshiper,
Half in triumph, half lament.
Thither love shall tearful turn,
Friendship pause uncovered there,
And the wisest reverence learn
From the Master's silent prayer.

TEACHINGS OF AGASSIZ.

LECTURES DELIVERED TO THE ANDERSON SCHOOL OF NATURAL HISTORY.

The following reports of some of the lectures delivered by Prof. Louis Agassiz before the Anderson School of Natural History on Penikese Island, during July and August, 1873, have been compiled from the note-books of students present at their delivery. Though necessarily incomplete, and to a certain extent fragmentary, they will be found, as far as they go, substantially accurate; and it is believed that in them the more important of Prof. Agassiz's discourses at Penikese are fairly represented.

FIRST WORDS TO STUDENTS.

PROFESSOR AGASSIZ'S OPENING LECTURE AT THE ANDERSON SCHOOL, DELIVERED JULY 9, 1873.

LADIES AND GENTLEMEN: Were I about to teach a class in the ordinary sense I should make a very different beginning. My intention is not, however, to impart information, but to throw the burden of study on you. If I succeed in teaching you to observe, my aim will be attained. I do not wish to communicate knowledge to you, you can gather that from a hundred sources, but to awaken in you a faculty which is probably more dormant than the simple power of acquisition. Unless that faculty is stimulated, any information I might give you about natural history would soon fade and be gone. I am therefore placed in a somewhat difficult and abnormal position for a teacher. I must teach and yet not give information. I must, in short, to all intents and purposes, be ignorant before you.

The very first subject to which I will call your attention is one where you would naturally come to me with questions. Do not ask them, for I shall not answer, but I shall try to lay out your work in such a way that you will find your own path without too much difficulty. What is the nature of the soil, and what is the geological constitution of this island? I believe I know all about it; but I wish to prepare you to solve this problem, which is, by the way, no easy one, for yourselves. Try first to find how the island lies. We have no compass, but our main building runs East and West. Let that be your compass. You will find position an essential element in the study of geological characters. Perhaps you have already noticed the general outline of our island. You may have seen that a gravelly, water-worn neck of land connects a smaller island with the main one, and that the two run parallel. What is the meaning of the curve between these two islands? What is the meaning of the flat beyond the curve? What is the meaning of the loose materials about us? What is the meaning of bowlders scattered over the surface? It would be easy to explain all these features upon well known theories, but I should do you a poor service by any such ready-made interpretation.

There are many other points to be considered before you will solve the problem. You must, for instance, distinguish the difference between materials in contact with the water and those above it; between the various dimensions of these loose materials and their relative size as found above or below the tide level. What relation does the island bear to the adjoining islands? How are they connected? When you have occasion to do so, extend this inquiry to the main land. These are the elements for a comprehensive appreciation of the way in which this island has been formed. This investigation would in itself be enough for a Summer's work. If you could answer me in two months the questions I have put to you here. I should say you have indeed done well. I want you to learn practically how wide is the field of science; how much investigation of a valuable kind may be found even in this small area. And the method of investigation you apply here will enable you to examine the same subjects wherever you live. You will find the same elements of instruction all about you, where you are each teaching; and you can take your classes out and show them the same lessons, and lead them to the same subjects you are now studying here. And this mode of teaching children is so natural, so suggestive, so true! That is the charm of teaching from Nature herself. No one can warp her to suit his own views. She brings us back to absolute truth as often as we wander.

Until our apparatus comes of various sorts which has not arrived, we must occupy ourselves with the geology, and I would advise you to begin by collecting all the various kinds of rock on the island. You will be surprised to hear, perhaps, that you will find on this small space three-fourths, perhaps nine-tenths, of all the rocks in the United States.

With these and a few words on the animals the students were already begining to collect, the mode of handling them, &c., this introductory address closed. It can hardly be fairly appreciated by any one who did not hear the next session two or three hours later, after the first ramble was over, when the Professor collected his class again, and drew them out by questions, and without telling them anything except a few facts which they could not by any possibility find for themselves in the neighborhood, showed them what they had in their own minds, and led them by comparison and combination to understand the significance of what they had already observed. This second exercise showed the freshness and originality of this mode of instruction from which routine was banished, and in which all progress depended upon awakening and stimulating the mind by a direct contact with Nature.

THE ART OF TEACHING.

HOW STUDENTS SHOULD BE EDUCATED.

GENERAL PRINCIPLES OF INSTRUCTION—METHODS OF IMPARTING KNOWLEDGE IN NATURAL HISTORY.

No one felt more deeply than Prof. Agassiz the need of a change in the methods and aims of public instruction. He was a constant friend and adviser of the teacher as well as the helper and inspirer of the pupil. The essential object of the course at Penikese was, first, to show teachers how to learn, and then to show them how to teach. Prof. Agassiz felt that there was great need of getting out of the traditionary ruts, especially in methods of instruction in natural history. In the earlier part of the student's course he deemed it of much more importance to learn how to observe and investigate than to acquire by rote a mass of facts heaped together for the student's convenience. He distrusted the methods of the books, and aimed to bring the student into direct and immediate intimacy with nature herself. This for years had been his method at the Museum of Anatomy. The great number of excellent teachers—not a few of them shining lights in the courts of science—who were graduated from that institution, shows with what success.

In conducting the school at Penikese, Prof. Agassiz introduced the method which he had pursued at the Museum with so much success. One of his first endeavors in the laboratory and lecture-room was to expound his views of the proper modes of teaching.

Never attempt to teach, said the Professor, what you do not know yourself, and know well. If the School Committee insist upon your teaching anything and everything, decline firmly to do so. It is an imposition upon the teachers and pupils alike to require a teacher to teach that which he does not know. This much-needed reform has already begun in colleges, and I hope it will continue. More can be done in this way to improve our system of education than in almost any other.

It is a great mistake to suppose that *any one* can teach the elements of a science. This is indeed the most difficult part of instruction, and it requires the most mature teachers Not much progress can be made until people are convinced that everybody is not capable of learning everything, and that teachers should not be expected to master every department of human knowledge. Do you expect the great artists of the world to be good Latin or Greek scholars, or good mathematicians? No more should you expect a teacher to be perfect in all departments of knowledge. To have a smattering of something is one of the great fallacies of our time. A teacher ought to know *some one thing well.*

Select the most common things for instruction, so that the pupil cannot take a ramble without meeting the objects about which he has been informed. Train pupils to be observers. Never attempt to give instruction in natural history without having your pupils provided with specimens. The most common specimens, as horseflies and crickets, will do as well as any. Let your pupils hold the specimens, and make them observe what you say.

In 1847 I lectured in Milton, Mass., and I insisted that every person present should take a grasshopper, and hold it, and look at it. It was an innovation at the time. Help me to make it a universal method throughout the country. Accustom pupils to bring in the specimens themselves. Induce them to go to the next brook or stone wall to get their own text books, for which they pay nothing. Some specimens are difficult to preserve, and it is delicate work to accustom pupils to handle specimens carefully. The earlier this training is begun the better. The author of the Anatomy of the European Cockchafer, before commencing his investigation of this animal, abstained from all stimulants for weeks so that he might have full control over his muscles.

The study of nature is direct intercourse with the Highest Mind. When you sit down to natural history work, it should be with the intention to give yourself up to the thought. It is unworthy an intelligent being to trifle with the works of the Creator. Even to a materialist they are the works of the highest power. A laboratory of natural history is a sanctuary, in which nothing improper should be exhibited. I would tolerate improprieties in a church sooner than in a scientific laboratory.

Talk about your specimens and try to make the pupils observe the most telling and striking features. When you collect a specimen be sure to find out what it is, and make full memoranda of everything pertaining to it. Do this in every case. You have chances to find new things unknown before. Collect carefully and preserve well, so that the specimens will tell the story of the animal. There should be a little museum in every school-room; half a dozen species of radiates, a few dozen shells, 100 insects, a few fish, reptiles, birds, and mammals would be enough to teach well. De Candolle, one of our most scientific botanists, said he could teach all he knew of botany with a dozen plants. It is better to have a few forms, well known, than to make pupils acquainted with many hundred species the first year; better be well acquainted with a dozen specimens, as the result of the first year's work, than to have $2,000 with which to buy a large collection.

When you are collecting, be sure to make a careful record of the locality from which each specimen is obtained. In this way you can do good work for science by assisting in the determination of the geographical distribution of animals. A specimen, the locality of which is not known, has but little scientific value. Every specimen in the Museum of Comparative Zoölogy is a genuine specimen, the locality, donor, date, &c. of all being carefully recorded.

The first thing to be determined about a new specimen is not its name, but its most prominent character. We can study the plan of the radiates, we can learn the type, from one specimen as well as from another, or from many. It is unnecessary to know a great variety in order to know many.

THE BEST BOOKS.

DIRECTIONS FOR SELECTING BOOKS FOR STUDY.

A CRITICISM ON PUBLIC LIBRARIES—RARITY OF WORKS OF VALUE ON NATURAL HISTORY—TOO MANY BOOKS ARE MERE COMPILATIONS.

Though Prof. Agassiz was strenuous in his efforts to encourage original research and immediate acquaintance with Nature, he did not overlook the value of books. His words of direction and warning in this respect are of great importance to the student.

My design, he said, is not to exclude from your attention all books whatsoever, but to deter you from reading the host of worthless books upon Natural History which were written hastily by men who knew little or nothing of the subject, and mainly to make money. If I can teach you to discriminate between those things worthless and those valuable in books, I shall have accomplished very much. Not every report of facts is correct. I have nothing to say against infallible creeds, but a great deal to say against infallible science. The best books for study are monographs from men who have made the investigation of a single branch the work of a lifetime. Take the jelly-fishes, for instance. They have been well studied; but the most valuable literature on this subject is contained in foreign languages. We have one good work by Dr. Almons in English, and a beautiful monograph of the naked-eyed medusæ by Edward Forbes.

What we need is books of this kind, which shall be accessible to students. There is not in this country a library where a student of science, acquainted with his subject, can resort, confident that he shall find what he needs. Of course I do not speak of the incompleteness of libraries in the department of history or general literature. The people are liberal but they do not know this need, and therefore it has not been supplied. I look to you for help in forming libraries. To you more than to any one else we must look for improvement in this direction. We have a fine library at Washington, the library of Congress, yet in its scientific department it is complete only in one particular, that of scientific periodicals. It has records of the transactions of scientific and learned societies in all parts of the world. In Philadelphia there is a good library of zoölogy, valuable in the department of birds, but deficient in other departments. The Boston Society has a good miscellaneous library. Our Museum library at Cambridge has a good collection of books on fossils. But there is nowhere a complete scientific library, and only a half dozen of those which pretend to be such libraries are fit to be studied at all. Thousands of worthless text-books are printed which are compiled and abridged by the scissors from better books, but there are few text-books of original research. We are not productive. We are used to getting our information second-hand. I think it is a misfortune that there are so many separate libraries, instead of a few centers, where scientific books, no matter how expensive—and scientific books are expensive, and it would not be wise for you to attempt to make your own libraries what you might wish—might be collected and circulated to surrounding schools or held for consultation. There need not be many such centers. One would be enough for New-England. As it is, we have too many separate centers of information. It would be better if the five colleges of Massachusetts—not to go beyond that State—were united in one. Even then its resources would be insufficient.

The chief difficulty with European books is that only European animals are illustrated in them. Text-books of zoölogy and botany should be made in the country where they are to be used. Other and more exact sciences are universal in their subjects, but natural history must have different text-books for each country. Those plants and animals should be chosen for illustration in text-books which are most common, which will meet the eyes of the greatest number of students. At the same time they should be typical species, such as are *telling* (a favorite word with the Professor) in as many directions as possible. I have not the requisite knowledge of the geographical distribution of typical forms to enable me to make such a text-book of zoölogy for this country. I feel myself competent for such a task, said the Professor, only in the departments of fishes and radiates.

As a cyclopedia of Natural History, Cuvier's Animal Kingdom, the last illustrated edition, is to be recommended as the most trustworthy and complete.

It is a library in itself. It is the best work of its kind in any language, and ought to be in every school library. It is the fountain from which are drawn all the illustrations of modern text-books.

Huxley's Comparative Anatomy is the best work on that subject extant. Owen is to be used cautiously as a work of reference. Wood's Natural History is useful, but poorly written.

Darwin's Animals and Plants under Domestication is the best and fullest presentation of the facts. His monograph on Cirripedia is a model of full and accurate investigation. Prof. Agassiz paid a beautiful tribute to the character of Darwin as a naturalist, as an investigator, and as a man. His Naturalist's Voyage Around the World is, he said, comparable to Humboldt's Cosmos—a work which the Professor held also in the highest estimation and earnestly recommended to students. Darwin, he thought, was a man whom every one that knew him must love. Prof. Agassiz never placed his opposition to him on any other than scientific grounds.

At the request of students, Prof. Agassiz gave a list of his own works and of several other works of special value to the student of Natural History, as follows:

Agassiz's Contribution to Natural History of the United States, four volumes, $6 to $10 per volume.
Agassiz's Essay on Classification, quarto, $2.
Agassiz's Methods of Study, $1 50.
Agassiz's Geological Studies, $1 50.
Mrs. Agassiz's Seaside Studies, $2.
Travels in Brazil, $5.
Huxley's Comparative Anatomy, $2 50.
Owen's Comparative Anatomy, three volumes, $3 to $10 per volume.
Cuvier's Animal Kingdom.
Wood's Illustrated Natural History, three volumes, $4 to $5 per volume.
Darwin's Animals and Plants under Domestication, $6.
Packard's Guide to Study of Insects, $4
The American Naturalist, $4.
H. J. Clark's Mind in Nature.

On another occasion, at Penikese, administering advice to students, Prof. Agassiz said, "Know one field well." In order to understand the relations of the different branches of human knowledge, of science, read its history. Read Cuvier's Development of Science, De Blainville, Pouchet, and others. Linnæus and his school gave birth to the study of Natural History, inspired the whole world. Science has been built anew since the middle ages.

Gegenbaur's Comparative Anatomy is the best work of its kind, but his classification is faulty. He becomes lost in complication of structure and multiplicity of details, and fails to detect the true affinities of animals. There is danger in paying too much attention to details. When one becomes absorbed in details he loses all capability of broad views. But there is no investigation so special, if made with a view to comparison, but that it will help one. Gegenbaur paints his pictures singly, as though there were no resemblance between the different things he paints.

Until you know an animal, care not for its name. This whole world is a school for us. Science became what it is by the hardest possible investigations, under difficulties which are in great part removed by the finding of animals so abundantly in America.

Under the present system of education in the United States, it is hardly possible to make the study of Natural History permanent and effectual. There ought to be as many naturalists as there are schools, under the present system; for to teach it, one must know something about it. A system should be established which would allow the teachers to be specialists and to go through the different grades of schools with the same branch of study. Prepare a student to do well for himself. Awaken the power of observation that will enable him to find his way for himself. I always give new students a box of different specimens to find out what they can do with them. Do not wish to pour into students what they cannot hold. My way of teaching is by demonstration, in which a pupil has a great deal to do himself.

I would warn you against manufacturers of books, men who are mere compilers, who know nothing—of their own knowledge—of the subjects about which they write. Go to the sources of information. You would not read Shakespeare from commentators and translators. Consult your own knowledge. Remember, too, that science is the recovery of the ideas that were in the Creative Mind. Love, devotion, simple humility, and submission to Nature, not an endeavor to control Nature, give success to the naturalist.

BASIS OF CLASSIFICATION.

THE STRUCTURAL RELATION OF ANIMALS

MEANS OF MAKING CORRECT COMPARISONS BETWEEN DIFFERENT ORDERS OF CREATURES — THE CLASSIFICATION OF FISHES—A VIGOROUS ONSLAUGHT ON THE DEVELOPMENT THEORY.

Classification in Natural History has a meaning, and is not a human contrivance. In classification we must shut out from the field of investigation all that which is arbitrary and empirical. Our classification, to represent nature, must conform to it. It is a mistake to single out certain special features as a standard, and adhere to these only. Classification is a difficult matter, and as such we must recognize it. We ought to know and confess the limits of our information. Those who have an answer for every question must make up answers. It is hard to say, "I do not know," especially for teachers. But I would trust no one who has not the courage to do it.

Be sure that the methods pursued predetermine the results. It is as important to be careful of methods as of facts. Every chemist knows this. Chemistry and Physics are far in advance of Botany and Zoölogy as exact sciences. The chemists and physicists test their methods with more care than do naturalists. The astronomer goes further still, and takes his own physical organization into account. He applies a correction to his observation, which is known as the "personal equation." The personal equation should be allowed for by naturalists.

Linnæus, who had an eye for affinities such as few men ever had, was the first to introduce some considerations on the classification of fishes, which have had a permanent influence. He separated fishes like sharks and skates, with cartilaginous skeletons, from the bony fishes. Then he divided the bony fishes according to the position and characters of the fins. Astedi opposed this classification, and though at first unheeded, Cuvier afterward adopted his idea, which was that bony fishes should be separated into classes—*Acanthopterygia*, with sharp spines in the dorsal fins, and *Malacapterygia*, fins without spines.

When I began to study, I wished to identify fossil fishes with those now living. But after studying fossil fishes for many years, I found that the old classification, based upon cartilaginous and bony skeletons, would not answer. I tried the scales to see what basis they would offer for classification. I divided the scales, according to their form and structure, into four kinds, to which I applied the names, Cycloid, Ctenoid, Ganoid, and Placoid. When this classification was compared with that of Artedi, it was found, curiously enough, that the Cycloids and Ctenoids included almost exactly the same species as the Acanthopterygians and Malacopterygians. Fishes like the sturgeon and garpike, including all fossil fish from the Silurian up to the Cretaceous, not counting sharks, have Ganoid scales. Sharks and skates have Placoid scales.

The sturgeon was the battle-field of naturalists for 10 years, but the question is settled now, and the sturgeon is classed with the garpikes and other Ganoids. Johannes Müller found no two fishes more closely allied in anatomical structure than garpikes and sturgeons, which I had already shown to be closely allied with respect to their scales. The garpikes have reptilian characteristics.

We see the importance of grouping animals by their general resemblances, criticising every step as we go. Do not not take up definite features as distinctive characters, but take the whole animal and classify by a general resemblance of all the features.

Johannes Müller, the master of Comparative Anatomy at present, has made divisions resting upon distinctions which are physiological and not zoölogical, considering things of paramount importance which ought not to be so considered. The presence or absence of the nictitating membrane he makes the basis of a distinction between two classes of sharks, while in reality every vertebrate at a certain stage of growth has a nictitating membrane. He divides selachians into two classes, according as they have or have not spiracles, when really there is a perfect gradation from those which have none to those which have perfectly developed spiracles; thus widely separating animals which are closely related in structure.

Embryology will lead to better things; but we should not follow the indications of embryology implicitly, but question every step. It will show us differences akin to the difference among adult animals. In the egg the structure is simple. The progress in structural complication is consecutive. We must examine the character of our standard as well as of our facts.

The classification of mammals, though further advanced than that of birds, is still not based on the true affinities of structural complication. The manatus, or sea-cow, for instance, which is usually classed with the whales, is shown by the study of fossils to be closely allied to the elephant. Batrachians are closely related to one another anatomically. The lowest batrachians resemble the embryonic forms of the higher batrachians. Among true reptiles, no embryonic affinities can be traced as in batrachians. The embryo turtle does not resemble any other reptile. At no period in its life is it snake-like or lizard-like; but at a very early stage it resembles birds. It points forward, not backward. It is on anatomical grounds, structural complication, that we place the lizard before the snake and the turtle before the lizard. The crocodiles stand before ordinary lizards in complication of structure. They also have characteristics that ally them to the extinct fauna of past geological ages. Though snakes are later than the geologic representatives of crocodiles, crocodiles are higher than snakes.

A synthetic type is a group of animals in which characters found independently in other groups are found combined. Lizards are a synthetic type. They are comparatively old in geologic time, and these geologic forms are not among the simplest, for the first reptiles were higher than any that ever followed. Make transmutation of this if you can. It is not true that animals have followed each other in successive progress and development.

Prophetic types are animals that at an early period combine characters which are found in animals of a higher order in later time. We have among these a natural series from lower to higher structures. The gradation is a structural gradation, and in the embryonic condition as in batrachians. In turtles, the embryonic condition points higher than themselves. Winged reptiles were a prophetic type; they anticipated birds. Embryo birds point backward to the pterodactyl and to the plesiosaurus.

There are those who assume that the earliest animals must have been simple in structure, but each type starts with higher species than most of those that follow. Selachians and ganoids, which are the earliest fishes found, are infinitely superior in complication of structure to any that come after them in geologic time. Yet there are men who call themselves naturalists, who, in face of the facts which have been known for 20 years, say that the amphioxus was the first-born of vertebrates, and resembles the ascidians. It is not only false but it is a lie. No bony fishes have ever been found in any of the older rocks.

Take another case: The earliest embryonic features do not necessarily resemble the oldest forms. If it were so we should expect to find chimeroid fishes in the earliest formation, which is not the case, as the Chimeræ are not found below the Jurassic. Sharks and skates, which are higher in structural features, are found even as early as the Silurian period. Selachians stand very high in the class of fishes, and they are the earliest of the globe. Their eggs are few and large; the embryo is large, and they have gestation in the sense that mammals have. Yet gestation is not found in the reptiles, which come later, nor even in the birds. We have to make a leap to the mammalia to find anything similar. This means that these fish have the highest structural features of the highest vertebrates. They indicated what was coming. That the lowest animal appeared first is a fallacy, and all talk to the contrary is revolting dishonesty. In order to classify animals we should be familiar with the facts of geology; should know the order of succession of animals in time.

RADIATES.

A radiate is a spheroidal body with a vertical axis, the poles of which have unequal value, and the segments of which have unequal value along their vertical line. Radiates do not radiate in all directions as the books say. All their parts stand in equal relation to a vertical axis having unequal poles. The vertical axis may be so extremely lengthened or shortened as to make radiates of very different appearance. But they represent the same plan. A knowledge of plan is an essential aid to the thorough study of any animals.

Eleven systems of nomenclature are used to describe radiates when one system should and would do as well. This is the hight of absurdity. The radiates constitute one primary division of the animal kingdom. Radiation and radiation alone holds together as an organic unit polyps (corals), acalephs (jelly fishes), and echinoderms (star fishes); and when Lückart proposed to separate polyps and acalephs from echinoderms and make an independent sub-kingdom of them under the name Coelenterata he carried science backward. Change is not always progress. Huxley, Haëckle, Lückart, and a majority of German naturalists are wrong in their tendencies. They lose sight of plan in complication of structure. They mistake the mode of execution of a plan for the plan itself. Radiates which are simple are just as much radiates as those which are complicated.

Echinoderms, acalephs, and polyps present three modes of execution of one plan of radiation. In polyps the radiating partitions or septa are thin and blood-like, generally numerous, never fewer than six, and sometimes there are hundreds. In acalephs the divisions between the cavities are very thick, and the cavities themselves are reduced to mere thin tubes communicating with the central cavity. In echinoderms the cavities are entirely separated and the septa meet.

Radiates may be long, cylindrical, and wormlike, as in the holothurians, or they may be mere flat disks, as the flat sea-urchin and some jelly-fishes. Their details may be very different. The shape does not determine the class. Those features of animals which constitute analogies are general resemblance, not based on identity of structure. Homologies are resemblances based on identity of structure. Resemblances based on similar combinations, on general external appearance, are often mistaken for resemblance based on identity of structure. That is, analogies are mistaken for homologies, as in the case with whales and fishes. Analogically, whales are referred to the fishes, but homologically they belong to the mammals.

There is a certain amount of bilateral symmetry in all these radiates. There is one, and only one, vertical plan on either side of which the parts are symmetrically arranged. The natural attitude of an animal and the normal position may be quite different. The normal position is the position in which we must place an animal in order to compare it with the order of its class. Acalephs naturally have the mouth downward. Actiniæ naturally have the mouth upward. Holothurians lie upon the side. These are the natural attitudes, but for comparison we must place their axes all in one direction, place them in the direction natural to the majority; that is with the mouth upward.

RADIATES IN PALÆONTOLOGY.

Cuvier and Lamarck were the founders of the science of palæontology. Cuvier gave the science its present form. He studied the fossil vertebrates and Lamarck devoted himself to the invertebrate fossils. Echinoderms have great palæontological importance. They are the best preserved of all fossils, and are found in the very lowest fossiliferous rocks. They have been found on every geological horizon, and the chain of their existence, as we have it is complete. Darwinists cannot say that the transition links will be forthcoming. Each epoch has its own peculiar, well-marked forms, and there is no transition.

The order of echinoderms, which figures most prominently in palæontology is the order of crinoids, or stone lilies. They have a faint resemblance to a star-fish, supported on a pointed stem, which is fixed to the rocks. During the tertiary period and at the present time, there are crinoids without stems, as the comatula. The comatula is not a star-fish, as some text-books say, but it is a true crinoid. The young comatula has a stem, and is attached to the sea-weeds, but it drops the stem when it reaches maturity. One interesting fact is that the oldest crinoids were most firmly rooted to the ground, and their arms or rays were very small. In these forms the stem and root elements prevail. In later times the arms become more fully developed, and the animals are less firmly rooted to the ground. This progression continues until in the Tertiary period, and at the present time we find free, moving crinoids with well developed arms, which closely resemble the higher order of star fishes. There is a steady progress from early to later times. This is beautifully shown by the class of echinoderms. We have the same picture in their embryology. The older adult forms resemble the embryonic forms of later times. The embryo of comatula is like the adult Silurian crinoid. Such facts as these have led to the misconceptions of the transmutation theory.

I may say here that the best sources of knowledge of crinoids are the reports of the American Geological Surveys.

The constituent or radiating parts of a radiate have been called segments; but we need another word to express this idea. I think I have found a good name for these fundamental parts of a radiate; it is spheromere, a segment of a spheroidal body.

In closing his lecture, Prof. Agassiz said: "Do we recognize in the manifestations of physical forces, as heat and electricity, anything indicative of thought and combination? Is there anything that shows that the lowest should be first? Do we not have in this series which I have indicated an evidence of intelligent action which we do not find in physical forces? Nothing but a presiding intelligence could produce these wonderful gradations from the simple to the complex. Therefore I am opposed to Darwinism."

AMERICAN GLACIERS.

THE ICE SHEET WHICH COVERED THIS CONTINENT.

EVIDENCES OF THE GLACIAL PERIOD IN AMERICA—A LECTURE DELIVERED BY PROF. AGASSIZ, AUG. 4, 1873.

LADIES AND GENTLEMEN: The facts by which we recognize the passage of glaciers over our globe are very different in different parts of the globe. The parts that have been studied are so different that the evidences are as diverse in Europe and America as we could well expect. This is chiefly owing to differences of climate. The evidences of a general glaciation are best known in Europe, but they are tolerably understood in North America, and have been observed in South America. They have also been noticed in Asia, Australia, and parts of Africa, and there is no doubt that the whole of our globe was colder than it now is at a time not far remote, geologically speaking. The chief differences between the aspects of glacial phenomena in Europe and America I will endeavor to explain to you.

Not in Switzerland alone, so admirably exhibited on this map of its mountains made by Guyot, but in the Pyrenees and south of them, in Austria, in the Caucasus—everywhere, the remains of glaciers are found in connection with mountains. Both sides of the Scandinavian range are full of great fiords, which extend all round Norway and Sweden, and it is probable that in the north of Sweden there were formerly great glaciers trending into the White Sea. In 1840 I first explored Scotland, and found traces of glaciers descending from her mountains. There, as usual, I found the radiation of great masses of ice from mountain-centers, and yet there were not wanting indications—few, but very telling—of still greater masses spread all over the country, without reference to inequalities of surface. For there were marks of glacial action on the tops of the highest ranges—scratches from north to south. Dr. Buckland, of the University of Edinburgh, following my suggestion, first found them on the very summit of Shehallion, and to him we owe the first fact of that general glaciation which preceded all other. So, high up on the Scandinavian mountains, scratches are abundant, and all trending Southward.

What are the characteristic features of glacial action in this country? With the exception of evidence of a few local glaciers in the White Mountains and elsewhere, all other traces are the marks of a glaciation which has been uniform, and from north to south. When first coming to this country, in 1846, we stopped a few hours at Halifax. I ran up from the steamer to the fortress, and there saw what

I had anticipated—striæ, scratches, grooves, north and south, and I have since traced them across the continent. There are local variations which can be explained, and a tendency toward the east which can be accounted for by the easterly direction of the continent and the character of the Atlantic coast. I might say much just here on the motion of ice, and upon its reservoirs, but I shall merely mention that the movement of ice masses is meteorological, depending on the moisture which falls, and the difference in the amount of moisture in higher as compared with lower regions. All these considerations, together with differences of temperature, determine the motion from colder to warmer, from a region of greater to one of less condensation. All the conditions which determine motion along a mountain slope are not the features of the slope, but the accumulation of moisture (snow) in the higher regions. Thus the prevailing north-southerly direction may be combined with local effects varying it to some extent.

All phenomena of glaciers outside of mountain tracts exhibit a north and south direction, with an easterly trend, which I think is owing to the depression of the Atlantic Ocean as compared with the land, and were it not for this slight easterly coast-slope the line of movement in the United States would be quite perfect; as it is, the deviation is comparatively slight, the distinction being essentially from north to south. This will appear very evident by some additional facts.

No part of the country yields *native* copper except the vicinity of Lake Superior, where it occurs in large masses. Now, bowlders of native copper are found scattered over all the Western States, bearing marks of glaciers—a true index of transportation by a body moving southward; for we can trace them right back to their original beds. In the eastern part of Massachusetts occurs the "Roxbury pudding-stone," a peculiar conglomerate readily recognized, and you find loose bowlders of this pudding-stone on this very Island (Penikese) and all the way between here and Boston, but none north or west. Here are, in east and west, indications of a movement of these loose materials, and if you examine rocks along the Great Lakes you see the same, as exemplified by the presence of certain crystals for instance. Therefore, as a broad front extending from the Rocky Mountains to the Atlantic, we have the marks of masses of ice all moving in the same direction.

It would be very important to know how thick the ice was. Have we any means of ascertaining this? Look at the plains about Portland (Me.), or those to the north of the White Mountains. They are everywhere glacier-worn—exhibit abundant evidence of having been planed by the advancing ice. As you ascend the slopes of the White Mountains you meet continually the characteristics of glacial phenomena, even above the clouds, for the sides of the mountains are striated, scratched, grooved, and polished in parallel lines having a north-southerly trend. There is no set of hills lower than that whose summits are not scored. Mount Desert, 1,300 feet high, is as polished, grooved, and scratched as any rock at present under agency of glacial action. So that you here have the evidence that the ice has moved over them as on a level surface, and you find the same bowlders south of the White Mountains that you do north of them, showing that that range was no impediment to the glacier. Now how much higher must a mass of ice be than its obstacle in order to glide over it. Experiments have proved that about as much ice above as below will carry the mass over. Here, then, we have data for estimating that the ice covering these regions and working southward must have been from 10,000 to 15,000 feet thick. Such a mass is heavy, and it moves, and moves uniformly, and it is to such a moving mass that we must ascribe all the present configuration of the continent.

By uniform abrasion of rocks, evenness of their surfaces over a large extent, and like trend of furrows is meant. It is quite remarkable as a peculiarity of American drift that it consists of three distinct kinds. There are large expanses covered with sand, loam, and round pebbles, amounting to considerable dimensions; and there is other drift that only incloses round bowlders. You would travel a long way in Europe before you found such. Why? Because on this side ice covered the whole continent, above which there were no mountain peaks, while in the Old World, on the contrary, the glaciers were restricted to the mountain regions, and the debris which fell from the peaks was carried to the foot of some glacier, or was precipitated by the way, as rough and angular as when it was torn off. With us, however, the loose materials imbedded in the glacier, or plowed up by its foot, were all the time grinding to powder between the mass of ice—which was studded underneath like a gigantic rasp, with rocks frozen into it—and the solid rock *in situ*, over which the glacier was moving. The glacial phenomena of America are thus essentially different from those of Europe. That kind of accumulation (sand, loam and pebbles) which we find most frequently, is made of the dust rocks that would break up readily, and others too hard to be reduced to powder, and you thus have a mixture. But when the ice moved where the rock was soft, there are no bowlders or pebbles left in its track. This is the case over Illinois and Indiana, where no erratics are found, because the rock north of those States was too soft to withstand the grinding power of the glacier. Clay slates, clay limestones, &c., when crushed, would make loam and clay, and you have in some sections immense beds of soil without pebbles, which have been ground down by this all-smoothing plane.

You see, therefore, that we may have three kinds of drift differing only in respect to the liability of their components to be reduced to sand. Now I would mention a few features very peculiar in North American drift. These may be well observed in the lake region of Western New-York, in the innumerable lakes trending north and south, with their northern outlets and southern inlets. In all the glacial phenomena are very plain. I have seen them on Cayuga Lake. There you may see that the sides of the lake are well scratched and grooved, and there is little doubt that the depression and shaping is due to ice. Evidently there came a time during the retreat of the glacier when this lake region was the southern extremity of the ice-sheet, and formed many fiords exactly similar to those at present indenting the coasts of Norway and Greenland. But when the great ice-sheet presented these fiords on its southern margin, they were covered with lateral and terminal moraines, and at the southern end of the lakes you have to this day concentric moraines just as you find them now in Switzerland. One thing I want to impress upon you : These indications are as plain as sign-boards. It requires no imagination to find them, and you must shut your eyes if you would not see.

Now these moraines extend south at intervals, 12 of them, before you reach the hills from which the lakes are now fed. The lakes are drained in a south-northerly direction, and the currents encroach and react upon these moraines, tending to destroy the appearance of their true origin. You may observe these same phenomena in connection with all other lakes in the northern half of our country. I have seen them at dozens of lakes in Maine.

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Anybody who will study any of the road-cuts or gravel-pits, or make observations as he rides along in the cars, may satisfy himself of alternate bands trending north and south, consisting of clay, &c., more or less wide in accordance with the geological constitution of the region to the north of them, whence the drift came. You have in every one of these bands, both material from the starting point, and material gathered up by the way. Ice as it moves along will take up and imbed in itself much of the looser material it passes over. I have been repeatedly under Alpine glaciers, and seen them paved underneath with rocks, large and small, which are all the time grinding over the surface like a huge file. These materials, frozen into the glacier known as "bottom drift," may turn and get scratched in every direction, but the surface below will only get scored in the general direction of motion.

These bands may be one or twenty miles wide, or only a few yards. One locality has long been known, and yet has remained a puzzle—the "Richmond Bowlders"—in Western Massachusetts, where you have seventeen or more parallel ridges trending from north to south. To the north of Richmond are three ranges of hills running east and west, and at right angles to them these seventeen ridges trending southward. These ridges are made up of bowlders from the different hills, all of which can be traced back twenty miles or more to the three ranges of hills. It has been a puzzle, because the transportation of this great mass of material was supposed to have taken place on the back of icebergs or glaciers. But our drift is bottom-drift, which the ice-sheet picked up in its labored, grating passage over the three ridges that stretched across its path north of the town. It is only a special case of the general law by which bottom-drift is carried over all inequalities under the glacier and is not at all an exceptional feature, yet Lyell in his Antiquity of Massachusetts makes a physical puzzle out of it. Conceive seventeen rows of icebergs moving along in stately and well-ordered ranks, and all dropping at particular points their load of rocks! These evidences are being gradually effaced in many places by meteorological agencies.

In the southern hemisphere you find exactly the same phenomena, but in reverse order. At Montevideo I first observed the northern limit of glacial action. There are rounded hills, truncated, polished, and shaped as no other agency ever fashions them. There continue all along the coast of Patagonia and through the Straits of Magellan the same features which have been observed in the northern hemisphere ; but everywhere the direction is from the south toward the north, from the Pole toward the Equator. So that we can no more doubt that a great cap of ice covered the southern hemisphere than that a similar cap spread over the northern.

At Talcahuano in Chili a trend of scratches westward toward the Pacific appears, and this seems to confirm the fact that a great oceanic depression is sufficient to influence the course of such a glacier both as to direction and rapidity.

The same facts which obtain in the northern apply as well in the southern hemisphere. Another indication I will mention. Whenever a hill stands east-west, and slopes north and south, in the northern hemisphere, the northern slope is affected by the glacier passing over it, but the southern slope is not considerably. In the southern hemisphere the southern slope would of course be the one roughly used, while the north would escape. After passing the Straits of Magellan, everywhere the southern slopes of the hills were smoothed, while their northern faces exhibited rough, untrimmed surfaces, showing how the ice-foot had plowed up one side and fallen in a great unwieldy arch, or bridge, down the opposite. This, as you see, is a sure index of the direction of march, and it is as plain there as in the United States. Indeed, I would like to call attention to the fact that all the marks upon the rocks are as fresh in one hemisphere as in the other. There is no indication by which I can distinguish the effects in one from those in the other. I say this because some geologists have assumed that a difference of climate, owing to certain processes, brought about the glacial period; and that the northern hemisphere must have been first affected. But all the evidence leads me to think that the causes were astronomical and more powerful than supposed, so as to produce a period of cold in the northern and in the southern hemisphere simultaneously. I cannot believe that there has been that alternation in the plane of the Equator which some students have suggested.

One more remark: North of Talcahuano, as far as Santiago, is a valley of bowlders, beginning at Chiloa, at the level of the sea, but ascending gradually northward till at Santiago it is many feet above the sea. In that direction has moved the ice, and you find all along the valley the material it has carried. On the east side of the Andes, and on the west, where the low coast range lies, you have something similar to Switzerland between the Alps and the Jura. This is occupied by erratics, and the explanation which has been found wrong in Europe will no longer do for this locality.

The northern edge of the ice melted first; hence, in the northern part of the valley stratified deposits lie along in terraces from Santiago gradually south, and these alone would afford the most direct evidence, even if we were not acquainted with the other indications. I am satisfied that all these terraces were formed at a time when the ice-sheet terminated at each of them, and banks were made in which there is no trace of marine origin. Here we have something similar to the concentric ridges south of Cayuga Lake—a parallel instance which shows the identity of the phenomena in both hemispheres and how entirely theoretical is the idea of alternate subsidence and elevation.

EXTRACTS FROM ANOTHER REPORT OF THE LECTURE.

The following portions of a report obtained from a different source, while in some cases repeating the foregoing expressions, are for the most part important additions without which the lecture would be imperfectly represented:

There is evidence of a great continental glacier over Europe, overriding all the local glaciers of a later time.

As the great European glacier waned, its southern margin gradually retreated toward the north, leaving in the mountain fastnesses and elevated valleys of the Pyrenees, Alps, and Juras the local glaciers which have done so much to remove the traces left by the great ice-sheet, and which give shape to the present topography of those regions.

The mountains of Scandinavia—the Scandinavian Alps—were for a long time a center of glaciation, from which radiated in all directions immense ice streams which fed the sea with icebergs very much as the Greenland glaciers do to-day. As the great ice-sheet continued to wane it is probable that the local glaciers of the northern parts of Norway and Sweden may have commenced a retrograde motion, and moved in a south-northerly direction toward the Arctic Ocean. Northern Europe is covered with evidence of extensive glaciation, and the many fiords which indent the shores of the Scandinavian Peninsula and of Scotland are but the mouths of the great ice rivers.

Eastern North America is a comparatively flat country, and contains but few mountains, therefore when the continental ice-sheet began to wane it left but few local glaciers behind it. Traces of local glaciers have been found in the mountains of Maine and New-Hampshire.

With these few exceptions, there is over the whole continent north of the 40th parallel, evidence of a universal glacier which moved in a north-southerly direction. The east of south trend of the glacier over New-England is accounted for by the great depression of the Atlantic, which gave the glacier a tendency to move in that direction.

No part of this continent affords native copper in large masses except the Lake Superior region. Loose bowlders bearing marks of glacial action are found all over the States south of Lake Superior, while none have ever been found north of this lake. This is strong evidence of the north-south direction of the motion of the glacier.

The pudding-stone of Roxbury, Mass., which extends westward to Foxboro, affords similar incontestible evidence in support of this point.

Bowlders of this pudding-stone are scattered all over South-Eastern Massachusetts, a few having even found a resting place on our own little Penikese. Facts of this kind might be multiplied almost indefinitely did our time permit.

Mount Washington bears distinct glacial scratches and groovings within 200 or 300 feet of its summit, and all the other mountains and hills of New-England, New-York, and about Lake Superior are evenly scored over their entire summits. These great inequalities of the surface were not sufficient to interrupt the onward progress of the great ice-sheet, nor even to deflect it from its course. On the shores of Lake Winnipiseogee we find bowlders identical with those to the north of the White Mountains, which shows that these mountains were not sufficient to interrupt or deflect the onward motion of the glacier.

The numerous lakes and ponds or lakelets which abound in the drift latitudes are a peculiar and one of the most characteristic features of American drift. The lakes of New-York may be taken as typical examples of the lakes produced by our North American glacier.

The facts are these: The lakes trend N. S., being elongated in this direction; they have been cut out of the solid rock; their bottoms and sides are scored and grooved in a N. S. direction; along their margins are lateral moraines; about their southern ends are numerous concentric terminal moraines, and their inlets are at the southern and their outlets at the northern ends. Lakes Ithaca and Cayuga exhibit all these phenomena particularly well.

The explanation is that these basins were excavated by the terminal points of the glacier during its retreat. The numerous terminal moraines indicate haltings and oscillations in the retreat. Many of them are as distinct and moraine-like as any to be seen in Switzerland to-day. Wherever the southern margin of the ice-sheet was elongated into points and capes during its retreat, these lateral moraines were possible, such as we see bordering these lakes. Curiously enough, the water now flows in a direction directly opposite to that in which the glacier moved. Substantially the same phenomena are repeated in Maine and Minnesota. These New-York lakes are probably synchronous with the fiords of Maine.

In the Northern Hemisphere the northern slopes of the hills are most strongly marked by glacial action, while in the Southern Hemisphere the reverse is true, and the southern slopes bear the deepest impress of the moving ice.

No evidence or indications of any kind are afforded by nature showing that the glacial phenomena of the two hemispheres were not synchronous.

The theory of the Scotch astronomer, Croll, based upon the precession of the equinoxes, from which he concluded that the glaciation of the northern and southern hemispheres must have been alternate as to time, is wholly gratuitous, and does not account for the totality of the phenomena.

DRIFT PHENOMENA.

American drift material contains no angular blocks or bowlders such as are so characteristic of most of the European drift. The reason of this is that the American glacier had no lateral or medial moraines, and the drift material was all formed under the glacier where it was impossible to escape abrasion. American drift exhibits considerable variations, depending on the kind of rocks over which the glacier moved, and of which the drift is made.

The north-southerly motion of the glacier tended to form these different kinds of drift into bands and lines running south from the rocks from which they were derived.

There are a number of such bands crossing the State of Massachusetts, and they may be found more or less distinct over the whole country. The width of any band depends in great measure upon the east-westerly extent of the rocks from which it is derived.

North of Richmond, Mass., are three ranges of hills, trending in an east-westerly direction. Running south from these ridges are seventeen or more parallel lines of drift. Some of the lines start from the southern ridge, some from the middle and others from the northern ridge, but they are all distinct and separate. The average length of these lines of drift is twenty miles. This Richmond drift has been a great trouble to all geologists; utterly unintelligible, unexplainable by any other than the glacial hypothesis.

But the true explanation is simple enough. All our drift is bottom drift. When the glacier passed over the disintegrating summits of these Richmond hills, the masses of rock became frozen into the bottom of the glacier, and once in that condition their transportation over the succeeding ridges was a mere question of time, and they would be carried in rectilinear, parallel courses from their points of derivation until dropped by the melting or breaking of the ice.

Lyell, in his " Antiquity of Man," attempts to explain this Richmond drift phenomena. He attributes the whole thing to icebergs, and his explanation involves as complete a physical impossibility as can be conceived. Beware of explanations made to suit a particular case, especially when the explanation requires an ocean that could not exist, and icebergs that move as icebergs are never known to move.

THE RANGE OF NORTH AMERICAN GLACIERS.

Within the present precincts of glaciers we find along their sides and terminations loose material which in all cases is derived from the higher regions from which the glacier came. Glaciers bring down a variety of loose materials detached from the rocky bed on which it rests. Lateral, terminal, medial, and bottom moraines are absolute facts. The terminal moraine is formed by the union of all the other moraines at the foot of the glacier. It is a mineralogical collection containing specimens of all the rocks over which the glacier has passed.

What can we make of that with reference to the extent the great glacier might have reached, and the manner in which the glacial age was ushered in? It is generally assumed that the glaciers commenced in the Tertiary period, and gradually expanded until they reached their maximum size, and covered those parts of the world which bear the imprint of the agency of ice. But we find on analyzing the conditions and phenomena of glacial action, that this assumption of the gradual extension of the continental glacier is not justified. If it were so, we should find at the outer limits of the glacier a huge terminal moraine composed of rocks from all the territory over which the glacier had moved. Suppose the glacier of Greenland to begin to swell and advance south, it would push the bowlders and loose material before it. We should be able to tell how far it had advanced by the mineralogical constituents of its terminal moraine. We find no such thing anywhere, but we find traces of glacial action within limits that far transcend the region over which such constituents could have been transported. Let us connect what we know to make a readable history.

American geologists have taught us that native copper, identical with the Lake Superior copper, is found all over the Western States to the latitude of 40 degrees. Now, we know that the glacier extended much further south than this, and if it had expanded gradually over the country, we should find this Lake Superior copper at its southern limit. On Penikese, we find pudding-stone that is not found out of Massachusetts. It must have traveled from Roxbury, while the glacier has been traced to South Carolina. In New-York, minerals are found in the drift which are found in place in Canada, but which are not found in Kentucky, though erratics are found there. These are loose facts, and must be studied with the utmost accuracy to find how these materials have been transported. We must find the north and south limits of these materials. In Canaan, Western Massachusetts, there is a ridge from which it is known certain bowlders to the south have been derived. We deduce from this a number of conclusions of great interest. Lake Superior copper is strewn over about 500 miles of latitude. The distance traveled over by any one set of bowlders is always much less than the total extent of the glacier. In the Alps, where the glaciers move on steep slopes, and where the slope accelerates the motion of the glacier, the maximum motion is one foot per day; the minimum motion is 30 feet per year. If we only knew the motion per year of the Greenland glacier we should have a better measure for our own continental glacier. If the Arctic explorers had not met with obstacles we should have been able to apply it now. Since we have no positive data, we can form some idea of their motion by the number of icebergs which they send forth annually; for these icebergs could not exist but for the advance of the glaciers into Baffin's Bay, where their ends are lifted by the water, broken off, and floated south. We do not know what these icebergs amount to, though it would not be difficult for an observer at the south end of Baffin's Bay to ascertain approximately by counting the number of icebergs that pass a given point annually.

But we will, to be within bounds, assume that our Continental glacier moved as fast as 100 feet per year. At that rate it would take 50 years for a bowlder of Lake Superior copper to have traveled a mile, and to have traveled to its utmost southern limit, 500 miles, would take 25,000 years; but it probably took a much longer time. If a rock in place south of Lake Superior should be found in the shape of bowlders further south than the southern limit of copper bowlders, it would be an additional evidence in support of this point.

Although Lake Superior copper is not found south of the 40th parallel, yet there is evidence that the glacier extended as far south as Charleston, S. C. The interpretation of these facts is that the glacial period came on rather rapidly, through cosmic changes such as have produced other changes in the geological appearance of the earth, and we know that such changes have taken place. The Pyrenees, 10,000 feet high, did not exist prior to the cretaceous period. The Juras, 6,000 feet high, are not as old as the Jurassic, and the Alps, 15,000 feet high, were upheaved by the Tertiary. So we are familiar with the fact that great revolutions have taken place over the surface of the earth. Causes now operating are not sufficient to produce all the geological phenomena of past ages, Lyell to the contrary notwithstanding. Mountain ranges could not be produced without revolutions which could not be measured by causes now operating. These will explain a variety of phenomena, but are inadequate to account for the present aspect of the globe.

The glacial period was comparatively recent, subsequent to a time when our earth was much warmer than now, when the rhinoceros inhabited our Western prairies, and the mastodon and elephant roamed over Siberia and the high latitudes of this country. That this tropical state of things was changed rather suddenly is proved by the fact that mammoths and other large animals have been found frozen in the ice in Siberia, with the flesh and skin still on them, and so well preserved that the wolves and dogs will eat the flesh. A great climatic change came on very suddenly; these animals became frozen in the ice, and have remained frozen ever since.

Now let us go over the globe to our imagination and see to what the facts lead us. A snow-storm in Siberia sufficient to bury these animals so that they would remain frozen to this day could not have been limited to Siberia and North America. The laws of the distribution of moisture are such that when large masses of snow accumulate in the north the influence will be felt in the south, so that the snow would be simultaneous over both hemispheres. A great cosmical Winter set in over the globe which extinguished life to an extent not yet determined. This statement has not the value of a barometric observation, but still has a value, and is not a wild assumption based upon no premises.

Within the north portion of our hemisphere the glacier passage is well marked, decreasing toward the tropics. The glacier also covered to a small extent ~ tropical regions, and produced slight changes. When the copper was left uncovered by the ice, then all to the south of Lake Superior had disappeared, but still covered all the land to the north. During this glacial Winter the annual snow-fall must have been much less in the tropical regions than in the north, just as it is at the present time. Now, can we determine how much or how little snow there was anywhere? We concluded that there were 10,000 feet over the tropics. That does not imply that there were 10,000 feet over the tropics. How much, then? This it is desirable to ascertain, so as to be able to lay down the isothermal lines for that period. When Cuttyhunk and the other islands of the Elizabeth group were the terminal moraine of the glacier, our climate was like Baffin's Bay. Fifteen degrees further south, or about the latitude of South Carolina, the climate of New-England must have prevailed, and at the hight of the glacial period a climate similar to the present climate of Labrador must have prevailed at the mouth of the Amazon. As soon as the ice began to wane the tropics became free from ice, and the southern limit of the glacier gradually retreated to the north, so that a better condition of things prevailed in low latitudes, while the north end of the continent was still under the ice.

Europe, as compared to America, is a mountainous country; they are a distinguishing character. The European glaciers, in past as well as present time, were limited by valleys more or less narrow, and the glaciers all had the usual lateral and terminal moraines which are now a prominent feature of those valleys. But in America we have no such narrow valleys except over narrow areas. Over the broad expanse of the prairies and plains there are no lateral moraines, the glacier being continental in its extent, thus rendering lateral moraines out of the question.

The North American glacier was uninterrupted from the Arctic Ocean to Alabama. The general tendency of the ice sheet over the States bordering on the Atlantic Ocean was to move N. W. to S. E. All the small but marked irregularities are to be accounted for by local glaciers or local obstacles in the way of the continental glacier. Almost all the bowlders in North America are rounded, but those of Europe are mostly angular. This proves that in our North American glacier we had no lateral or terminal moraines, and that our glacier was continental in extent. We could only have had lateral or medial moraines in North America, where the mountains reached above the immensely thick sheet of ice. There are few or no large bowlders south of the line from Washington west. And here must have been the end of the glacier for a long time. Another line of terminal moraines extends along the southern shore of Maine and through the White Mountains. A third line is along the north shore of Lake Superior. The glacier must have been then over the Southern States. There may have been terraces forming in the valleys of the south before the ice began to melt in the north. The borders of the ice no doubt protected the land from the erosion of the sea. But when the glacier began to wane, the bowlders dropped by the glacier would be worked over by the sea, and the surf would roll up a wall of water-worn pebbles, which would be mixed with the material brought down by the ice. The warm water of the ocean would also eat into and hollow out the front of the glacier.

THE FORMATION OF GLACIERS.

Whenever a glacier in motion meets an obstacle which it cannot remove, the glacier breaks, forming crevasses. Inequalities in the sides and bottom of the valley in which a glacier moves are the chief causes of breaks and crevasses. The round, vertical, deep holes found in glaciers are formed where a stream of water produced by the surface-melting of the ice pours into a crevasse, thus forming a cascade which bores out the ice to a great depth.

When the cataract has penetrated through the glacier it will form pot-holes in the rocky bed below. These glacial pot-holes are now found in places far removed from living glaciers, perched upon mountain sides or high ridges, where no ordinary river or torrent competent to produce them could have flowed. Anterior to the glacial hypothesis no reasonable explanation could be given of the production of these ancient pot-holes. No one has done so much in tracing to their origin erratic bowlders as Prof. Andrew Guyot.

At the foot of the glacier of the Aar are 30 terminal moraines, denoting halting-places in the retreat of the glacier.

There are proofs that the glacier which covered the plain of Switzerland, between the Alps and the Juras, was 6,000 feet thick. One of these proofs is that there are immense quantities of erratic bowldes scattered over the declivity of the Jura facing the Alps many of which are more than 6,000 feet above the Plain of Switzerland.

Some of these erratic blocks are of immense size, containing from 40,000 to 60,000 cubic feet, and many of them can be traced to their homes in the Alps. Evidently the glacier which transported them across the valley must have been at least 6,000 feet thick.

The rocks in *situ* in the Plain of Switzerland are scratched, scored, and grooved in the direction of the Juras; the same course indicated by the bowlders and moraines as the course of the glacier. Stretching transversely across this valley from the Alps to the Juras are immense trains of bowlders, which are the lateral moraines of the ancient glacier which once filled the valley.

Between these lateral moraines the surface is covered with just such material as we would expect from the bottom moraine of a glacier, viz., a heterogeneous layer of large and small rounded bowlders, clay and sand, laid down without any order or arrangement whatsoever. On top of this old bottom moraine are angular blocks that once formed the medüan moraine of the glacier that transported them.

One of the great terminal moraines of the North American glacier crosses New-England about the latitude of the White Mountains. The White Mountains were once a center of glaciers. At Mt. Desert are evidences of local glaciers. There is great danger of confounding local with extensive continental glaciers. Continental glaciers preceded in point of time the local glaciers; the local glaciers being the remnants of the continental glaciers.

NOTABLE EXTRACTS.

MEMORABLE WORDS OF PROF. AGASSIZ.

REMINISCENCES OF THE PENIKESE LECTURES AND SOME OF THE MORE REMARKABLE EXPRESSIONS.

Prof. Agassiz could never content himself in a lecture upon a scientific subject, however pressing the time, to deal with his subject without bringing in some advice of general import, some practical suggestion of universal application, and giving some specimen chipped from that substratum of primeval truth, which seemed to crop out wherever he stood. Human nature and the common ethics of everyday life were a not-neglected part of his natural history. "His life was a bundle of hints." It was therefore not at all extraordinary that he interpolated the following remarks into his scientific lectures to the Anderson School:

You have already discovered that we know but little, and that three-fourths of your questions we are unable to answer. We only know how to investigate, and that you must learn, and we can only guide you. No one can make observers of you, but you may be put under favorable circumstances. One thing I would recommend; that you set aside all conceit. Nothing is so humiliating as the study of nature, and so beneficial. She is always right, though we may mistake.

All knowledge is individual. It must be your own and not that of anybody else. Your having a firm memory will not suffice ; you must assimilate as you digest food. We must find out facts for ourselves, and when we teach we must teach our pupils to find out for themselves. It is the bane of our schools to confound men with knowledge. By this system a whole class of powers is allowed to lie dormant.

Encyclopædical knowledge is a fallacy : it is made up and not in accordance with nature. * * * Underneath you may have a solid nucleus of investigation of every department, but you must be in some direction a specialist. Then you can judge of others by the attainments you have made in your own specialty.

Now for the general application. You must study the history of science—not in manufactured text books, but look at the best books. For a universal view read Humboldt. Study the relation of facts to one another. That is the reason he is so great, and he has a keenness of perception which no one else has. The "Views of Nature" was his first step. He then fortified himself by investigations in every branch of physics and geology, and so meager were his sources of information that he had to go everywhere to determine in different latitudes by minute investigations the certainty of his conclusions When Humboldt first published in a little paper of twenty pages the results of these world-wide studies, he laid the foundation of isothermal science. He sketched it exactly as it now stands, only now it has has grown into a beautiful picture. Now, that kind of outline sketches you should try to secure everywhere.

Dissect as much as you can ; learn to do it neatly and well, and work patiently at the same thing—so you will have a standard. As your guide in the study of structure I would recommend Gegenbaur. He is the best authority on comparative anatomy. Yet there are difficulties. Gegenbaur has an insight into relations of structure according to anatomy, and he is very comprehensive; but he has no sense of zoölogical affinity. He sees similarities and relations but no general resemblances.

An *Egg* is a cell formed in a cavity which, by its peculiarities, grows larger than an ordinary cell, and has in it the potentialities of life.

Döllinger was really the founder of Embryology, but published little. Von Baer was his pupil, and all Embryologists have followed in his tracks. Döllinger would work hard, make his discoveries, invite one of his students to walk, tell him all, and then invite him to publish. I lived four years under his roof, and my scientific training goes back to him and to him alone. I have learned much from others, but from him alone I learned how to work.

All these unsatisfactory theories are untenable when made to tell what is not in them,—as when we make the Vegetable tell of the Animal Kingdom, and animals tell of the human soul.

Dare to be inconsistent. As long as consistency in adherence to a wrong idea is a republican virtue, we are not on the road to progress.

Prof. Agassiz ever evinced an earnest desire to keep students from wasting their time over worthless books, and was at a great deal of pains to discriminate for us between genuinely good works and mere compilations or worthless text-books, and strongly inveighed against the publishers of trashy scientific books, and the subterfuges and placing of "vile temptation before teachers by offering a percentage," by means of which they got them introduced into the schools.

What we want, said he, in popular education, is the elements of a higher culture. Let it be known that our colleges are not aristocratic institutions, but are available to the poor and lowly. If they are not so now, we must make them so. Everything we can do in that direction will be a blessing to the country. This is a digression from the business of the day, but I make it purposely that you may understand just how I feel on these subjects. We ought to know each other in all these particulars. There are great business concerns engaged in the manufacture and sale of these worthless books who are our greatest enemies. They are really circulating educational poison, and I beg of you don't shrink from rebuking them at every opportunity. I have aroused very serious opposition to my work by stating these things openly, but I shall continue to do it as long as my strength lasts.

Prof. Agassiz gave a brief bibliography of each subject as it was presented, and these short booklists are now regarded as among the most valuable of students' memoranda. Often they would be accompanied by a word of comment, as when he good-humoredly described a book of De Blainville's as "critical, satirical, diabolical,—and yet immensely comprehensive!"

Nor did he hesitate (having given a well merited cautionary talk) to put at the students' disposal many books out of his own library. His library is unique in its number of books of foreign authorship not elsewhere to be found in this country, and a large part of them are presentation copies from their distinguished authors. He seemed familiar with the history of Zoölogy from Aristotle to Huxley, and the different phases which the science has assumed under its controlling influences. He had not only had such an extensive acquaintance with naturalists as to make zoölogical history for the past half century a part of his own experience, but had also made a special point of its acquisition, as for their advancement he urged others to do.

Another thing which adds incomparably to the value of his library is the presence of hundreds of plates of all sorts of little-known animals, in as many varied stages of embryonic development, different circumstances and conditions of life, or transient phases of appearance or dress, as the specimens obtainable made possible. These were all drawn and colored under his own eye by accomplished artists; and their value in the study of zoölogy only those can fully appreciate who are pursuing the special studies which they illustrate.

As he talked of books so he spoke of men. Speaking of Strauss Durckheim, whose whole life was spent in studying and describing the bones and muscles of the domestic cat and the structure of the common European Dorbug (*melolantho vulgaris*), he described how he had seen him sit "day after day with a cat in his lap feeling of the muscles. He was a thorough Frenchman."

Lückart, when he proposed the *Cœlenterata* as distinct from echinoderms, did great wrong to Von Baer, and carried, for the time, science backward.

Cuvier and Lamarck were the founders of palæontology, and not much has been added since, and Cuvier really made it what it is to-day. The picture has been filled up, but Cuvier for the vertebrates, and Lamarck for the invertebrates, made the science.

Darwin is one of my best friends, and I honestly like him; I wish all scientists were as friendly as well.

Leopold von Buch was a man of indomitable endurance. He explored all Europe on foot for the sake of studying its geology. I have known him to go from Berlin to Stockholm for the sake of comparing a single fossil shell with one there; or to start for St. Petersburg with only an extra pair of socks in his pockets Yet he was a noble of Germany and welcome at the Emperor's Court. It is to him geology owes its present form. He was a pupil of Werner, but had freed himself from Werner's errors.

The Professor sought to encourage despondent ones by such records as this of Lyonnet, but he himself, a monument of his own indefatigable industry and application, was our greatest incentive to steadily keep to our climbing up the hill of science. He said: Lyonnet studied for years the anatomy of the larvæ of the moth of a caterpillar (*crosus lignipenda*), which lives in the wood of the European willow. He wanted drawings made of his work, but could find no draughtsman, so he learned drawing himself, and his figures are the wonder of the scientific world. For their sake he was admitted to the Academy of Arts. Then he wanted his drawings engraved, but could find no engraver, and so learned how and engraved his own plates. His book and his life are models of the most extraordinary patience, perseverance and skill.

One afternoon, as the students were all quietly at work in our laboratory, Prof. Benjamin Peirce of the Coast Survey came in. His visit was a complete surprise, and Agassiz's greeting was characteristic. He shouted, "Hallo, Peirce!" ran and threw his arms round his neck and kissed him. That day the Professor was in his most genial mood, and just before tea there was a sort of public talk between the two great teachers, who seemed as delighted at being together after a few weeks separation as school-girls. Prof. Peirce related that not long ago, as he was about to start for Washington to appeal to Congress in behalf of the needs of the Survey, Prof. Agassiz bid him good-bye with the injunction: "*Tell them* (Congress) *that it is their duty to do something to elevate the character of the nation.*"

The conversation opened with some ideas in reference to the nebular hypothesis, viewed mathematically, and drifted through all sorts of median subjects to a statement by Prof. Agassiz, of his feelings upon certain religious questions. Among other things he said:

I am denounced in Europe as one who derives my scientific idea from the Church, and am regarded by my church-going friends as an infidel, because I will not be dictated to. Have with traditional belief and dogmatic science nothing to do—scrape it off. If we are weak let us fall back upon tradition and belief for support, humbly; if we are strong let us see what there is outside of belief, and don't care what the world says.

That evening, when it became sufficiently dark the powerful stereopticon was produced, and the images of live animals (minute sea-life) were thrown upon the screen. The shapes and antics of some of the specimens—immensely magnified as they were—were very funny. Wishing to point out some notable feature in the creatures, Prof. Agassiz approached the screen, and in so doing stepped into the beam of light, when instantly his silhouette was cast upon the broad white surface with a glorious effect never now to be forgotten. It seemed to shadow forth that distant day when future students of nature, looking back, shall see the head of Louis Agassiz standing alone and majestic against an unoccupied background of American Science.

A RAINY DAY AT PENIKESE.

THE SCHOOL AT ITS WORK.

AN ENFORCED STAY ON THE ISLAND—THE STUDENTS AND PROFESSORS AND THEIR METHODS OF WORK —STUDIES WITHOUT BOOKS—A THEOLOGICAL DISCUSSION—AGASSIZ'S DISBELIEF IN DARWIN, AND DARWIN'S RETALIATION.

The Anderson School of Natural History at Penikese, was famous from its start. The fact that a seaside laboratory devoted to the study of living forms was to be founded, proved in itself sufficient to awaken a widespread interest, for no similar experiment had ever been attempted; and when in addition to this the friends of education were informed that the directorship had been intrusted to one of the most famous zoölogists of his time, its success was assured. Prof. Agassiz entered into his work with his usual enthusiasm. He was ably assisted by Count Pourtales of the U. S. Coast Survey, Dr. J. S. Packard of the Peabody Institute, Prof. Burt G. Wilder of Cornell University, Mr. Waterhouse Hawkins of Sydenham Palace fame, Mr. Bicknall the microscopist, and others.

In a little ravine between the two hills the island of Penikese can boast is the quondam Summer residence of Mr. John Anderson, which served as the private quarters of Prof. Agassiz and his assistants. It is an unpretending structure of frame, with a pretty lawn sloping to the east, ornamented with a little group in iron of a boy and swan. Behind the house stands the barn, used last Summer as a dining-hall, and near by are the laboratories. These are two barrack-like structures, united at their midway by a third much shorter one. It is in the design to use both of the main buildings for laboratories and dormitories, reserving the smaller one as a lecture-room. At the time of my visit, last Summer, but one of the buildings was in use.

I shall endeavor to describe the scene just as it was presented to me. Entering at a side door I find the institution in "full tide of successful experiment." Arranged along the side of the room are numbers of small but firm tables; in the middle of the room stand acquariums; on the walls, diagrams; suspended from the ceilings are dried tissues of various animals: running entirely around the room is a single shelf, appropriated for bottles of specimens. At one end of the apartment is a huge black-board, with a hopeless arabesque of colored chalk marks thereon, and at the other, shelves for books, and cases of alcohol. What earnest groups are there about the tables! Men and women engaged in study—teachers themselves, now pupils. But few books are seen, for their use is discouraged. I notice among those on the tables Harvey's "Marine Algæ," Packard's "Entomology," and Agassiz's "Methods." I wander at will from table to table, overlooking the workers.

One table seemed to be devoted to those strange creatures, the horse-shoe crabs. Turning from them to a specimen which Dr. Packard has dissected, that gentleman calls my attention to its wonderful net-work of blood vessels so different from all others of its class, and shows me some exquisite injections of them by Mr. Bicknall lying on the table in a glass dish containing the eggs of the same animal, The doctor is watching their development. He was the first to note its peculiarities, and is now repeating his former experiments for the benefit of his pupils. Dr. Wilder is engrossed in his dissection of the nervous system of a fish. He is interrupted accasionally by a student who is not sure of the accuracy of a note she has taken down from the last lecture, or a gentleman asking for alcohol to preserve some specimen that excites his desire for permanent possession. I see in a shallow dish of salt water beautiful polyps confidently expanding their flowery disks —Zoöphytæ—properly called—plant-animals aptly named; here the flesh-like *Alcyoninm* and there the dun *Anemone*. In some dishes are seaweeds, in others shell-fishes. Yonder is an admiring group of students watching the movements of a seaworm. It is a pity we have no prettier name for that graceful form upon whose sides the hues of the rainbow are playing. Truly it was a limp unsightly thing enough when it was dug out of the sand last evening at low tide; but now in the clear sea-water, itself almost as transparent, it lies revealed an all-day wonder I see another group standing, and hear the inspiring voice of Prof. Agassiz, who has slipped in from the cottage unawares, and is now explaining the growth of a spiny radiate. These little, green, dime-shaped animals are the young of this other form looking like the lid of a hunting-watch. "This young form has been referred to a distinct genus," says the Professor; "but observe, if you please, the position of the terminal pore—on top in the immature, at the rim and even beneath in the full-grown animal." Agassiz moves off to look over the work of a German artist, who is engaged in drawing a young skate, which has been removed from an unlaid egg. It is an exquisite little creature, with loose, feathery tufts for gills, the entire body of a delicate salmon color. The Professor is delighted with the specimen. We hear it said that it is a great discovery, this particular stage in the development of the skate. "No human eye has ever seen it before." The professor is satisfied with the drawing. "Das ist sehr herrlich." Thus the scene varies. Groups form and break, and, to end it, all too soon the toot, toot of the dinner-horn declares recess.

After dinner, the students reassemble. This time to listen to a lecture from Prof. Agassiz. He delivers an eloquent discourse on Types of Animal Life. He speaks without notes; uses few gestures. He tells us of the varying standards for comparison in different groups of animals, their distinctness—of their immutability. In the Batrachia, that is, the group of animals having a tadpole stage, this standard is obtained by the study of their development. But in the reptiles it is otherwise, for here, in place of development, which is an indifferent standard, we must take a comprehensive view of all the structures. Other animals, such as some of the fishes, do not reveal their type in its perfection, but continually remind us of something higher yet to come. There are prophetic types; for while some fishes, as the sturgeon and the gar, remind us of reptiles, others again, as the sharks, hint of forms yet higher than the reptiles, viz., those having social instincts and which retain their young in close relation to their own tissues. The Professor became warmed up as he alludes to the doctrine of evolution. "Some," cries he, "would have us develop the *Amphioxus* (fish) from an *Ascidian* (mollusk)—two utterly remote types. This is worse than an absurdity—it is a lie!" It would give Darwin a new sensation to hear this. After the lecture, more looking into dishes and more off-hand table demonstrations and explanations. Then supper and darkness. After supper the horn gave another toot. "What now, boy?" "Lecture this evening, Sir!" And now, as a closing exercise of the day, we have a fine stereopticon exhibition by Mr. Bicknall, of corals, insects, and injections.

The following day, Thursday, dawned gray and desolate; beating winds and pelting rain. The sea, even in the haven between the islands, was full of angry caps. A heavy surf beat the shore, and the air was filled with flying scum. No getting away to-day, so indoors again. It is an ill wind that blows no one good. While a prisoner at Penikese I was the witness of a scene on that rainy Thursday which will never be forgotten by those present. It was historical of two things—of the first rainy day at Penikese, counting its birth as an institution, and of the first recorded meeting of the friends of Natural Theology. How the former came about, "Old Probabilities" has told us. How the latter, perhaps no one can tell. The spirit of the chronicle is as follows: About the middle of the forenoon, the hour announced that a lecture would be delivered—this time by Prof. Wilder—on the "Structure of Fishes," the wind was blowing fiercely about the buildings, and the rain was beating steadily against them, keeping up a constant clatter against the window-panes. In strange contrast to this outside commotion, was gathered a little audience of perhaps 50 persons of both sexes. Their ages ranged from 25 to 45—earnest, eager, all above the average in native intelligence.

Prof. Agassiz informs the class that Prof. Peirce of the Coast Survey, at present a guest of the School, has consented to address them prior to the lecture. The gentleman thus called upon arose. He is of medium hight, with a head recalling that of Longfellow, and a voice of rare quality and sweetness. He said: "It affords me the greatest pleasure to be with you on this occasion, gathered here to-day, remote from the busy world, that we may upon our return hence to our respective duties be made stronger by our temporary retirement. You are here in the pursuit of a high office. You are here to disseminate the doctrine of the wisdom of the pursuit of truth. We need that this should be done. We have wealth enough, energy enough, nay, too much, for the the thirst of gain and power is our consuming evil. It is the cause of the all-pervading corruption; it is the great danger now threatening our country. It can be saved, in my opinion, only by inculcating in the people love of truth, scientific truth particularly, since its cultivation tends above all other forms to elevate the mind. It should be pursued not for any material reward it may promise, but for its own sake. It is to the influence of Prof. Agassiz that we are indebted for this institution. No man has been of greater benefit to this country. He was the first to free science in America from European dictation; he has erected a wide-spread interest in the cultivation of the natural sciences; and on this account has been everywhere an object of the deepest respect. His influence has not been confined to natural history, but has affected the physical sciences as well. As a physicist I have recognized the difficulty of associating the two. Yet that such an association exists there is no doubt. But the processes by which the mathematician approaches the subject are far removed from those employed by the naturalist. The modern doctrine of evolution, for example, has a different meaning when applied to inanimate things. The nebular hypothesis, as you know, is based on evolution, yet far removed from the premises of that same doctrine, as it is alleged, is displayed in animated nature. With the former it is at all times the same matter which is displayed, the condition or state of that matter alone varying. In the latter, in addition to the matter itself being various, we are continually confronted with the knowledge that there is something which evades our research. We mark the human soul as something distinct from the human body. Now if we can prove that there is something in the vegetable which is not in the animal, something in the animal which is not in the vegetable, or something in the nature of man himself which is not in the nature of the animals beneath him, no attempt to prove a transition between their material semblances here severally displayed will avail. I am inclined to believe that something of the kind exists; that is to say, that there is a proper vegetable presence which is immutable, and can therefore never become animal; there is a proper animal presence which can never become vegetable, and so on. In truth, what is is probably what has always been. Plants were from the beginning plants, animals animals, and men were men."

The Professor sat down, and a silence ensued. And now for a lecture on fish. Not yet. Prof. Agassiz, who has been sitting listening with all his ears, cannot keep still now that the subject of evolution has been broached. As well imagine St. George with arms at rest when the dragon is seething before him. "We are very glad to hear," said he, "such testimony as this from one who commands his department. We learn from it the errors of those who are so wedded to their own fancies, who would twist all knowledge to make it suit some pet theory." He believed the present aspect of the doctrine of evolution to be in great part the result of this bias in judgment. He insisted upon honesty of purpose in investigating nature. Among the many causes which have interfered with progress has been the influence of tradition, and the fear of offending the proprieties. He valued tradition; it was the mainstay of the weak in spirit and the wavering in purpose. But to the strong he would say, cut loose from it. He had been accused by his European friends of being influenced by the church, while by others in this country he has been denounced as an infidel. Do not mind the opinions of the prejudiced and bigoted. For himself he cared nothing for these expressions. Be careful of one thing only, "faithfulness to truth as you believe it."

He had struck the sympathetic chord. Prof. Peirce is on his feet, to show by example the value of discussion. "The greatest general truths," said he, "had always resulted from the clash of opposing theories. All that was needed was the eager following of truth as each one saw it. In the history of geology Prof. Agassiz has told us that from the discussions of the Neptunists and the Plutonists have arisen a more thorough knowledge of the scope of the agency exerted by water and fire in the formation of the earth's crust than would have been possible without that stimulus." He, in addition, spoke of the lasting good resulting to the study of logarithms by the contentions between the French and German mathematicians over a trivial subject apparently, viz.: Which was the better sign, the letter c, or the letter h?

Some one in the class here suggested that the same kind of good to natural history might result from debates between the evolutionists and the non-evolutionists.

"Well," replied Agassiz, rather evasively, "personally I like Mr. Darwin very much; he is my friend."

Here a cluster of pupils began making merry.

"What is it? Let us have it!"

A Voice—"Darwin's son Frank was once told that Agassiz did not accept evolution. 'That's all right,' said Frank; 'father does not believe in the glacial theory.'" [Laughter.]

"Well, now," said Agassiz, turning to Prof. Wilder, "Dr. Wilder, give us some fish."

But no, we were doomed to go without that course to our feast.

Dr. Wilder arose—a prompt, nervous man, with a crisp, well modulated voice. "Prof. Agassiz," he began, "is the director here, and when he says anything is to be done, it is done. But I must confess that, after listening to the delightful exercises of this morning, I have become rebellious, and I *won't* say anything about fish." [Laughter.]

The Doctor then went on to say how he had been reflecting on the subject of freedom of thought as a necessity to true progress, and deemed it a fit occasion to have the position of the scientific world with respect to the theological world fairly defined. He then boldly launched out into the field of the relations between natural and revealed religions. He contended that there should be no compromise. The Bible and Nature stand confessed as the revelations of the one God, and, moreover, it was never intended they should conflict.

I cannot follow him, nor the remarks which his address called forth. The occasion had become a solemn one. A long silence ensued after this last topic, which had grown so naturally out of the first address of Prof. Peirce. Each one was apparently thinking the same thought, drinking in the same influence. I felt as well as others present, while the storm beat about us, as one withdrawn from the world for a time. As I now write of that scene, its truth and beauty return in all their force.

CAUSES OF THE DEATH OF AGASSIZ.

On Jan. 26, 1874, Dr. Morrill Wyman of Cambridge, Mass., completed his work on the autopsy of Prof. Agassiz, and made a report, from which the following interesting statements are taken:

The autopsy was made at Cambridge, Dec. 16, 1873, by Drs. R. H. Fitz and J. J. Putnam; present, Drs. J. B. S. Jackson, J. Wyman, C. Ellis, M. Wyman, and S. G. Webber. It was conducted in the interests of science, and in accordance with the wishes of the great naturalist, expressed several years ago.

The arteries at the base of the brain showed evidence of extensive chronic disease of their lining membrane, with narrowing of the caliber of the carotids. In these arteries were very important changes. Commencing at an inch below the anterior edge of the pons varolii and extending downward, the walls of the left vertebral artery were stiff, in part calcified, and its linings loose. At half an inch from the point just mentioned, immediately over the left olivary body, was a reddish-yellow, opaque, friable plug (thrombus) completely obstructing the vessel; still lower was another more recent, but probably ante-mortem, plug. The first was one-quarter of an inch long, the second four inches long. A third plug, an inch long, was above the first, and touching it.

In the left ventricle of the heart, there was a firm organized clot of the size of a peach stone attached to the wall at the anterior portion near the septum; around this clot a more recent one had formed, its center softened and granular. From this, probably, some small portions had been carried by the blood to the arteries in the base of the brain, doing their part in obstructing them and causing the fatal changes above described. The lungs were adherent to the ribs on both sides of the chest, the evidence of old inflammations. The other organs were healthy.

THE TRIBUNE FOR 1874.

A year ago the Editor of THE TRIBUNE promised to make this journal during 1873 a much more valuable and complete newspaper than it had ever been before. Its facilities for the collection and transmission of intelligence from all parts of the world had been largely increased; its staff of associate editors, correspondents, and reporters had been strengthened by the engagement of some of the ablest men in the profession; and the Editor was resolved to spare neither pains nor money in the effort to make THE TRIBUNE the very first newspaper in the world.

He points to the achievements of the past twelve months with pardonable pride. While THE TRIBUNE has retained all the excellent features that made it such a favorite in former days, it has exhibited an enterprise and acuteness in its news department which have been the wonder of all its old friends. Remembering that the chief function of a daily journal is to give its readers the fullest, the best arranged, the most attractive, and the most readable history of the occurrences of the time, it has devoted its best energies to this business, and its success has been universally recognized and applauded. The year has been fruitful of startling events, and every incident has found in THE TRIBUNE its promptest, most accurate, and most perfectly equipped historian. A TRIBUNE correspondent was the only civilian who witnessed the surrender of the Virginius, and his picturesque description of that transaction, transmitted by telegraph, is the only account the public has yet seen of an incident upon which depended for many weeks the question of peace or war. THE TRIBUNE published the only full and exhaustive account by Atlantic telegraph of the terrible Ville du Havre disaster, giving all the incidents of that catastrophe ten days before other journals received them by the slow course of the mails. It distanced all competitors in its thrilling story by cable of the adventures of the Polaris castaways. It anticipated every other paper in the country, and even the Government itself, by its graphic narratives of Custer's battles on the Yellowstone. The elaborate and deeply interesting letters of its special correspondent in the West gave the only complete account of the Farmers' Movement ever published in an Eastern paper. The reports of THE TRIBUNE presented the important proceedings of the Evangelical Alliance in this city with a fullness and accuracy everywhere the subject of enthusiastic praise. During the panic its daily history of Wall Street made it absolutely indispensable to business men; and its special correspondents afterward described the condition of affairs in the manufacturing districts with an ability which no other paper seriously rivaled.

These are mere instances of the uniform success in the most important branch of journalism which has steadily attended THE TRIBUNE throughout the year, and may therefore be fairly taken as an earnest of what THE TRIBUNE is likely to do hereafter. Its purpose in 1874 is to surpass its previous record, constantly increasing the efficiency of its organization, adding to its resources, and keeping up its ancient celebrity as an organ of cultivated and thoughtful men, and a high authority in literature, science, and the arts. It will continue to devote especial attention to the proceedings of learned bodies, to education, to scientific discoveries and explorations, to new inventions, to agriculture, to the promotion of American industry, and to books, pictures, music, and the drama. Its financial articles have won a peculiarly high reputation, and will still be a prominent feature in its columns. Its reports of the markets have long been distinguished for fullness and accuracy, and its quotations have been accepted as standards in the cattle, produce, and provision trades for many years. Its reports of local affairs are acknowledged to be the most accurate, intelligent and complete; its domestic correspondence is always fresh and valuable; and abroad it is served by the ablest writers and keenest observers engaged upon any American periodical.

While it never can be a neutral in politics, THE TRIBUNE is entirely independent of all parties and all partisans. It believes that the mere organ of a clique cannot be a thoroughly good newspaper, and cannot be trusted for impartial and just comment upon current events. It maintains with the old fervor and will always defend the Republican principles of equality and justice with which, under the control of its illustrious founder, HORACE GREELEY, it was, for over thirty years, identified. But it values parties solely as means for procuring honest government on sound principles. For the partisans who deplore exposures of corruption or imbecility in high places as likely to hurt the party and hinder their success in holding on to the offices—who insist that a journal of their faith must follow their lead, execute their plans, and defend their acts, it has no feeling save contempt. Standing by its old landmarks, it defends the constitutional guarantees to the liberty of the citizen and the sacredness of the Nation's faith with its creditors, insists on the duty of Protection to American Industry, champions all proper measures for developing the material resources of the country, urges wise means for restricting the evils of Intemperance, seeks sedulously to foster the commanding interests of Manufactures and Agriculture. But it holds itself aloof from all entangling alliances, waits on no Caucus or Convention for its opinions, aims to judge every political act, of whatever party, separately as it arises, on its own merits, and maintains the liberty of candid and impartial criticism. During the present session of Congress its telegraphic reports from Washington, where it maintains the strongest force of experienced correspondents ever assembled there in the interests of a single journal, will be found incomparably more valuable and more interesting than those of any of its cotemporaries. And finally, in the editorial discussion of public affairs, THE TRIBUNE endeavors to combine the utmost frankness of expression and independence of thought with a strict impartiality of judgment and that dignity and refinement of language which befit a family newspaper. It wastes no space in wrangling with other papers, pays no attention to personal abuse, and reserves its columns for its readers' interests, not its Editor's grievances.

That there is a popular appreciation of that sort of independent, vigorous, enterprising, and high-toned journalism of which THE TRIBUNE is now the chief representative in this or any other country, is sufficiently proved by the results of the past twelve months. The close of 1873 finds this paper more prosperous than it has been at any previous period of its history, and the new year opens for it with the most brilliant prospects. In a short time its mechanical facilities will surpass those of any other journal in the world ; and on the completion of its new and magnificent building it will be enabled to introduce various improvements of the most important character.

THE SEMI-WEEKLY TRIBUNE.

THE SEMI-WEEKLY TRIBUNE has grown very rapidly in public favor of late. In addition to a careful summary of the news it contains all the best of the foreign and domestic correspondence and leading articles of the Daily: it gives specially the scientific intelligence (including the proceedings of all American scientific societies), with the best of the book reviews, and the miscellaneous matter relating to education, the arts, religion, &c. It has all the commercial news and market reports; all the agricultural articles of the Weekly; and gives, moreover, regularly a serial work of fiction, presenting in the course of the year three or four of the latest productions of the most popular novelists. As it takes only a few select advertisements, it is enabled to give an unusually large proportion of reading matter, and may be called, considering the extent and variety of its contents, the cheapest newspaper in the world. It is published every Tuesday and Friday, and reaches nearly every post-office east of the Mississippi within one or two days of its issue.

THE WEEKLY TRIBUNE.

THE WEEKLY TRIBUNE has been for the space of a generation the Farmer's favorite paper. Besides a complete condensation of the news of the week, a selection of literary and miscellaneous reading, and a full page of the best editorials from the Daily, it contains in every number a greater amount of agricultural matter than is furnished by any distinctively agricultural paper. This is prepared expressly for its columns by the best agricultural writers and practical farmers in the

United States; and as its contributors are in every part of the country it will be found equally valuable in New-England, in the South, on the Pacific slope, or in the Mississippi Valley. Great attention is paid to all subjects connected with the Farm, the Garden, and the Household, and some of the original articles every week are illustrated with woodcuts. The market quotations of farm produce, cattle, provisions, breadstuffs, dry goods, and all kinds of merchandise, are exceedingly full and scrupulously accurate. The utmost care is bestowed upon the typographical arrangement of the paper, and the print is always clear and legible, and generally larger than that of any other New-York paper.

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Tribune Popular Science.

PART II.

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FEATURES OF RECENT DISCOVERY.

The admirable letter of Mr. Bayard Taylor on the discoveries of Dr. Schliemann in the Troad presents a more complete and intelligible account than could be gleaned by a laborious perusal of the fragmentary narratives which that explorer has published. In this brief page all the essential features are condensed which lie scattered through volumes. The treasures of antiquity brought back by Dr. Schliemann are of the highest archæological value, aside from their classical interest. It will be hereafter regarded as the great good-fortune of this generation, that it has unearthed not only the probable ruins of Troy, but those of a far more ancient city beneath them, that had grown and flourished and decayed ages before the armies of Greece advanced to the seige of Ilium.

The lectures of Dr. Brown-Séquard on the Nerves, cover a field of knowledge hitherto not much trodden. There is force in his urgent appeal to the younger members of the profession to extend these inquiries, and in the strange and novel features which he presents in these lectures there is ample evidence that the study will prove as interesting as it is important. The causes, character, and means of remedying many of the most obscure and painful diseases to which the human frame is subjected, are here indicated, and the argument is enlivened by much that is curious and entertaining.

Although in a certain sense the outgrowth of his former lectures, the present series of discourses on astronomy by Mr. Proctor is entirely new. They may be described as carrying out to their limit the thoughts that naturally arise in astronomical investigations, and they attempt, in the light of the most recent discoveries, the solution of the most far-reaching problems which can be presented to the human mind. Nor does he limit himself to the scope of the mere materialist in these discussions; he treads with reverent step the infinite abysses of the heavens, and leads us from nature up to nature's God.

ANCIENT TROY.

vide Littell. 1564.

THE RESEARCHES OF DR. SCHLIEMANN IN 1872 AND 1873.

ACCOUNT BY BAYARD TAYLOR OF THEIR RESULTS—FOUR CITIES EACH BUILT UPON THE RUINS OF THE PRECEDING ONE—THE SCÆAN GATE—PALACE OF THE KINGS—TREASURY OF GOLD AND SILVER ORNAMENTS AND UTENSILS.

[FROM A REGULAR CORRESPONDENT OF THE TRIBUNE.]

GOTHA, Germany, Feb. 10.—Another chapter has been added to the "Tale of Troy divine." Of all the discoveries of the last twenty-five years, inestimable as is their collective contribution to our knowledge of the Past, not one is so remarkable and unexpected as the recent finding of storied Ilium, after a sepulture of more than two thousand years, during which the very site of it had been forgotten. It is even more surprising than the re-discovery of Nineveh by Layard, since the mounds of Nimroud and Kuyounjik sufficiently indicated the site of the old Assyrian capital; while Ilium itself, and the whole history of the Trojan war, have narrowly escaped, of late years, being relegated to the region of pure myths by modern scholarship. All this is suddenly changed: many a finely-spun archæological theory is rent like a cobweb: Homer is gloriously rehabilitated, and the very arms and ornaments of the Dardan heroes and heroines are delivered into our hands. Fragmentary reports of Dr. Schliemann's excavations in the Troad have from time to time appeared in the newspapers, and his great success, last year, in finding what is conveniently called "The Treasury of Priam," has been duly chronicled throughout the world; but now, for the first time, we have the entire history of the undertaking and its results. The narrative, accompanied by 218 photographic sheets of illustrations, is published by the firm of F. A. Brockhaus, in Leipzig, to whom I am indebted for one of the very earliest copies. I lose no time in preparing for THE TRIBUNE a résumé of the work as complete and intelligible as the space will allow. Even if I felt myself competent (which I do not) to examine the conflicting views of German scholars by the light of the ancient authorities, I should prefer to let Dr. Schliemann have his full say. He has nobly earned it; and I shall therefore confine myself to the plain statement of his own arguments and conclusions.

SKETCH OF DR. SCHLIEMANN.

Before beginning the history of his discoveries, it may interest the readers of THE TRIBUNE to learn something about the man who has made them. It will do us Americans no harm to find that "self-made men" are not peculiar to our race and soil. Ours, when they are successful, are noted, and grandly so, for giving of their substance, hardly for their own intellectual achievements. We have had, as yet, no such specimens as Roscoe, the Liverpool merchant, or Grote, the London banker. Dr. Schliemann ranks with these latter, as an encouraging illustration of the fact that "business" need not prevent, or even materially retard, the development of high intellectual qualities. Starting in life with absolutely nothing, he achieved wealth by the time he was forty-one years old, and now, not yet fifty-two, he has won a permanent fame.

Heinrich Schliemann was born in the Grand-Duchy of Mecklenburg in 1822. His father was very poor, but had received an indifferent classical education, and was very fond of repeating episodes from the Iliad to his young son. The latter learned some Latin during his early school years, but all his chances ceased at the age of fourteen, when he was put into a grocery-store in the little town of Fürstenburg. There, for nearly six years, he weighed, packed, swept, and did all other coarse duties, sixteen hours a day, saw only the lowest and most ignorant class of the people, and seemed to have forgotten almost all he had ever learned. One evening a drunken miller's apprentice came into the grocery and declaimed a hundred verses of Homer in the original Greek. He was the son of a clergyman, had failed at the University, and the father's desperate attempt to make a decent miller of him was about to fail also. Young Schliemann was so enchanted by the sound of the Greek, not one word of which he understood, that he used all his pocket-money to buy three glasses of brandy for the student-miller, on condition that he would three times repeat the Homeric lines. "From that moment," he says, "I never ceased to pray to God that He would enable me to learn Greek."

Having injured his breast by lifting a heavy cask, so that he was no longer able to work in the grocery, he went to Hamburg, and in a state of desperation shipped as cabin-boy on board a vessel bound for Laguayra. He left port on the 28th of November, 1841, and just two weeks afterward the vessel was wrecked on the Texel. With great danger and hardship the crew was saved. Schliemann made his way to Amsterdam, intending to enlist as a soldier; but finding himself on the point of starving to death, he pretended to be sick and was sent to the hospital. Finally, a German merchant discovered and assisted him, and the Consul procured him a situation as errand-boy in a mercantile house.

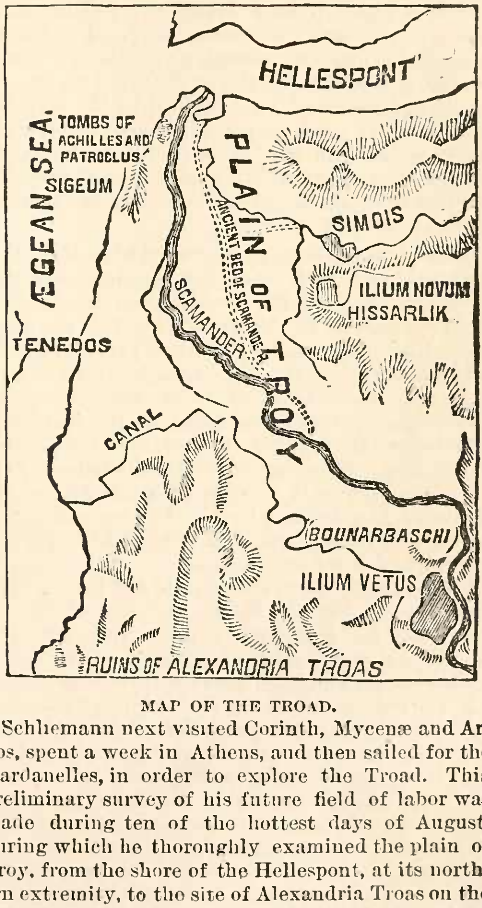
His salary was 800 francs a year, and the half of it he instantly devoted to his education. He inhabited a miserable garret-room, without fire, for which he paid eight francs a month; his breakfasts were rye mush and cold water, and his dinners never cost more than three cents apiece. After learning to write a good legible hand, he began the study of languages; but his memory was so deficient, through lack of use, that he was compelled to carry his books with him on his errands, and study by snatches as he walked or waited. At the end of a year he knew English and French, and his memory had improved so wonderfully, that he acquired a good commercial knowledge of Italian, Spanish, and Portuguese, by giving only six weeks to each language. But these studies and the running of errands from morning till night did not work well together; they damaged each other. Schliemann's principal refused to give him a better position, but by great good fortune he obtained a place as clerk and correspondent in the house of Schröder & Co., Amsterdam, with a salary of 2,000 francs a year. He soon perceived the business necessity of a knowledge of Russian, and set to work to learn it. There was no teacher to be had; the only books he could procure were an old grammar, a dictionary, and a Russian translation of Fenelon's *Télémaque*. His habit of studying aloud, in order to accustom his ear to the sound of foreign languages, was so annoying to the tenants of the neighboring rooms that he was several times obliged to change his quarters, but in spite of these disadvantages he was soon able to write Russian letters and to converse with Russian merchants who visited Amsterdam. In 1846 the firm sent him to St. Petersburg as its business agent. A year afterward he established a commercial house of his own, and for eight years thenceforth devoted himself with such energy to the building up of a large business, that no time was left for the prosecution of further studies. Finally, in 1856, he was so far successful that he yielded to the old desire of learning Greek, the fascination of which he had dreaded, as a possible interference with his other duties. With the aid of two Athenians, he mastered the chief difficulties of Modern Greek in six weeks, and in three months afterward was able to read Homer with ease. In two years more he was familiar with nearly all the ancient classics. In 1858, having acquired wealth and leisure, he left St. Petersburg, and spent more than a year in travel, visiting Italy, Egypt, Syria, and Greece, and adding the Arabic to his catalogue of tongues.

By the end of 1863 Schliemann found that he was a rich man and retired from business, resolved to devote the remainder of his life to archæological studies. The following year he started on a trip around the world, visiting India, China, and Japan. Returning in 1866, he settled in Paris, and prepared himself for archæological explorations in Greece by three more years of hard study.

FIRST RESEARCHES IN ITHACA AND THE TROAD.

In the Summer of 1869, with the Iliad and the Odyssey in his pockets, Schliemann started on his first tour of research. Landing on the island of Ithaca early in July, he spent about a week in endeavoring to identify the localities of the Homeric narrative. His own narrative, by the by, is almost Homeric in its terse, picturesque simplicity. He seems to have believed, in advance, that he should find all which he went to seek, and he accordingly finds them—the palace of Ulysses, the Grotto of the Nymphs, the home of the swineherd Eumäus, and even ten of the twelve stalls for swine, in the neighborhood of the fountain Arethusa. But this faith is pardonable, when we consider the narrow limits of the island, and the fact that there remain only one grotto, one fountain, and one acropolis, which suit the conditions of the story. In Ithaca, where the people have no traditional history except that of the Odyssey,—where in every family, at this day, the first-born daughter is always called Penelope, the first son Odysseus and the second Telemachos, Schliemann was hailed as a friend and benefactor. The inhabitants of every village flocked together to hear him read Homer, in return for which they gratuitously entertained him with the best they had. He thus describes his visit to Leuke, on the northern end of the island:

> It was noon when we reached the village, and since I desired to see the ancient valley of Polis and its acropolis, I decided to make no stay in Leuke. But the people begged me so earnestly to read some passages from the Odyssey, that I was finally obliged to comply. In order to be heard by all, I had a table placed, as a rostrum, under a plane-tree in the center of the village, and then read with a loud voice the 23d Book of the Odyssey, from the opening to the 247th verse, wherein it is related how the Queen of Ithaca, the best and most chaste of women, recognizes her beloved spouse after twenty years of separation. Although I had already read the passage numberless times, I was always freshly moved whenever I perused it, and the magnificent lines made the same impression upon my auditors. All wept profusely, and I was obliged to weep with them. After the reading was finished, they begged me to remain at least a day longer, but this was not possible.



MAP OF THE TROAD.

Schliemann next visited Corinth, Mycenæ and Argos, spent a week in Athens, and then sailed for the Dardanelles, in order to explore the Troad. This preliminary survey of his future field of labor was made during ten of the hottest days of August, during which he thoroughly examined the plain of Troy, from the shore of the Hellespont, at its northern extremity, to the site of Alexandria Troas on the south, and the base of Mount Ida on the east. Most archæologists had fixed upon the little Turkish hamlet of Bounarbashi, some ten or twelve miles from the sea, as the site of *Ilium Vetus* (Ancient Troy), and persisted in considering the main stream—the Turkish name of which, *Mendere*, instantly suggests

"Scamander"—to be the Simoïs. They placed *Ilium Novum*, the later Greek city, mentioned by Strabo and other authorities, at the point now called *Hissarlik* ("the place of the Castle"), a broad plateau of no great hight, at the end of one of the low ranges of hills which stretch into the plain from the base of Ida. This position is just three miles from the site of the Greek camp at Sigeum. A glance at the outline map I send will make the topography of the Troad easily intelligible. I should explain that the term *Ilium Novum* is not used by the ancient writers. It appears to have been an invention of the French traveler, Lechevalier, who visited the Troad in 1788. But it is a convenient designation for the later Greek Ilium, and I quote it in this sense.

Schliemann's familiarity with Homer satisfied him, at once, that the latter had seen every locality which he describes. In fact, this impression is strongly forced upon every one who visits the spot. I have twice looked upon the plain of Troy from the deck of a vessel passing between it and Tenedos, having on one hand the sky-piercing peaks of Samothrace in the distance, towering over the low intermediate hills of Imbros, and on the other the broad, uncultivated fields of Troy, divided by the sinuous thickets which mark the course of Scamander, with Ida, furrowed with piny glens, in the background, and the snowy crest of "topmost Gargarus" over all. You remember, no doubt, the charming description of the scene in "Eothen."

In ten days Schliemann convinced himself, in the most practical way, that the Mendere was the Scamander and not the Simoïs, that Bounarbashi could not possibly be the site of Troy, that the huge natural acropolis near it had never borne "Priam's lofty house," and that *Ilium Novum* had been simply built upon the rubbish of *Ilium Vetus*—in short, that whatever was to be found of the real Troy must be sought for under the surface of the plateau of Hissarlik. His chief reasons are the following:

1. After sinking a number of small pits on the hights of Bounarbashi, he found no trace of a city having ever stood there. The primitive "bed-rock" was reached, in many instances.

2. The tumuli, called after Hector and Priam, have been opened, but contain no evidence of having been used for sepulture. Between them and the citadel are the remains of a small town, which could not have contained more than 2,000 inhabitants.

3. The citadel, which has been supposed to be the *Pergamos* of Priam, has a hight of 450 feet: its sides fall at an angle of 45° at first, and finally of 65°, so that Hector and Achilles, in their triple race around the walls of Troy, could hardly have made the break-neck descent. The substructions of the ancient edifice on the summit are so limited in space, having only one entrance—a door a yard wide—that they never could have belonged to the citadel-palace of a place so populous and important as Troy.

4. The distance from Sigeum (nearly 10 English miles) is so great that the marches back and forth of the Greeks from their camp to the walls of Troy, as described in the first seven Books of the Iliad, could not possibly have been performed in the time mentioned by Homer. Troy must have stood much nearer the sea, or the poet indulged in a reckless exaggeration, with which he has never been charged.

5. Instead of the two fountains mentioned by Homer, there are no less than thirty-four at Bounarbashi, their united outflow forming a strong stream (called the Scamander by former archæologists), a part of whose waters are carried to the Ægean by an ancient canal, to prevent the plain from being inundated during the Spring floods.

6. Mount Ida is not visible from any part of the hight of Bounarbashi.

At Hissarlik, however, Dr. Schliemann found all the conditions required. Moreover, a number of passages in ancient authors, especially Strabo, all indicated that the later Ilium occupied the site of the older city. The distance to Sigeum is three English miles; the Scamander flows between; Mount Ida rises clearly above the eastern horizon, and a smaller stream, coming down from the northward, sufficiently represents the Simoïs. The situation is grand and imposing, overlooking plain and sea. The circumference of the walls of the later city is about three miles, which, supposing they indicated the site of the ancient Trojan walls, would not be too great a distance for the triple race of Achilles and Hector. At Bounarbashi the space which must necessarily have been traversed is nearly double. Finally, the whole surface of the plateau of Hissarlik is covered with fragments of marble and pottery, which can be nothing else than the debris of the later Troy. No one can deny that these are fair and reasonable grounds. They have been sharply assailed, of course, by stay-at-home scholars; but the man who digs day after day on the supposed site of a city to satisfy himself that its bones are not there, who tries to run around its circuit, and travels back and forth between it and the established locality of the Grecian camp, has an excellent claim to be heard. Immediately after his return to Paris, Dr. Schliemann published a volume called "Ithaca, the Peloponessus, and Troy"—but it does not seem to have attracted any general attention. In it he gives his views concerning the site of Troy, feeling sure, probably, that no one else would be likely to anticipate his secret purpose of returning to the spot and undertaking an excavation.

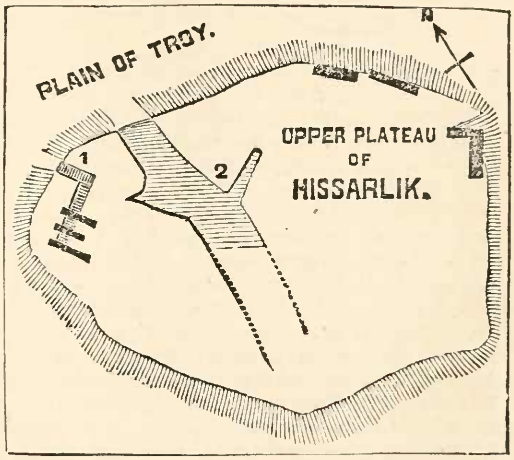
RETURN TO THE TROAD.

A few months after the publication of his volume Schliemann returned to Greece. From this time Athens has been his permanent home. Before beginning again his researches, he married an accomplished Greek lady, who won his heart by her enthusiasm for his labors and her knowledge of Homer. I have no detailed account of his explorations at Hissarlik in April, 1870, further than their result and the cause of their being suspended.

The plateau on which the later Troy stood is about three miles in circumference and 80 feet above the level of the plain. Its northern side rises very abruptly; on the west and south it slopes off gradually, while on the east it is separated only by a slight depression from the low spur of hills which stretch out from the chain of Ida. At its north-western corner rises a second plateau, 26 feet higher than the first (106 feet above the plain), and nearly 1,000 by 700 feet in length and breadth. Schliemann instantly decided that the latter must be the citadel of Priam, and felt more than ever sure that its accumulated rubbish might cover some distinct remains of "Troy town." He was further strengthened in this belief by the discovery of an ancient bed of the Scamander, much nearer the plateau of Hissarlik than the present one. The presumed Simoïs had united with it at a point about two-thirds of a mile from the foot of the mound, thus forming just the battle-field described in Homer as being bounded by the Scamander, the Samoïs, and the walls of Troy. Hiring a few laborers, he began to dig at the north-western corner of the higher plateau, and at a depth of 16 feet came upon a wall six feet thick, which is now conjectured to have been a small fortification of the time of Lysimachus (306 B. C.). Hardly had this been reached, when the owners of the soil, two Turkish farmers in a neighboring village, who used the plateau as a sheep pasture, prohibited Schliemann from digging further, unless he would pay them 12,000 piasters (about $500) as damages, and bind himself to fill up the excavations again after he had finished. He offered to buy the land, but they positively refused to sell it at any price. In this dilemma he turned for help to Safvet Pasha, one of the most enlightened members of the Sultan's Cabinet, in whom he found a man capable of understanding his object and ready to render assistance. The result was that the ground was despotically purchased by the Turkish Government for 3,000 piasters ($125) and Schliemann obtained permission to make researches.

Here, however, a new difficulty arose. The newly-established Museum of Antiquities in Constantinople claimed possession of every object which might thenceforth be exhumed throughout the Turkish Empire; and Schliemann was too experienced a man of business to go on with a great undertaking at his own risk and cost, and lose his chance of treasure-trove. The firman which he asked for, before beginning his labors, was only obtained, finally, through the aid of Mr. J. P. Brown, for twenty or thirty years Secretary of the American Legation at Constantinople. All these matters, however, were not settled before the beginning of October, 1871; and even then the Turkish Government ordered that all excavations should be made under the eyes of an officer appointed for the purpose, whom Schliemann was obliged to pay $1 per day.

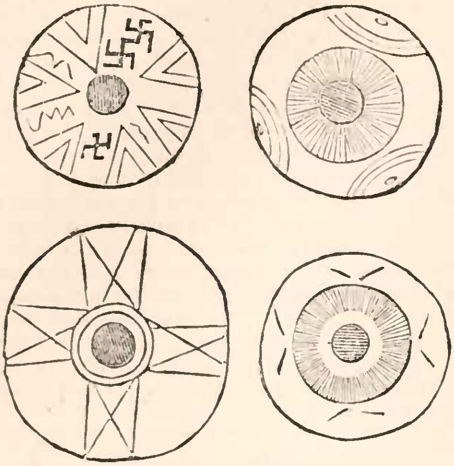
On the 11th of October the work was begun with eight men, but on the second day afterward 74 men were employed in removing the upper soil. Firmly believing that the remains of the famous temple of the Trojan Minerva were under the higher plateau, which he already called the Citadel of Priam, Schliemann relinquished his excavation at the north-western corner, chose a starting-point further east, and laid out a broad cut from north to south across the highest part of the plateau. His plan was to cleave the upper and lower plateaus down to the original soil, believing that the ruins of the ancient Trojan city would be found under all the accumulated rubbish of the subsequent ages. Immediately under the surface the workmen came upon the foundations of a building of massive hewn stones, belonging to the first century of our era. These were removed with great labor and hurled down the steep northern slope of the mound. Under this masonry, which ceased at a depth of six or seven feet, the soil was composed of pottery, ashes, and *débris* of all kinds, filled with relics of the past of the most unexpected character. The excavations were carried on until the 20th of November, by which time the cut had reached an average depth of 33 feet. After penetrating about 25 feet below the surface remains of massively constructed houses appeared, and the antiquarian yield assumed a very different chracter. The Winter rains, which set in toward the end of November, obliged Schliemann to suspend labor until the following Spring.



SITE OF THE EXCAVATIONS.

1. Schliemann's Excavation in 1870. 2. Same in 1871. — Roman Walls.

So far, no positive indication of Troy—as he then supposed,—had been brought to light; but the relics which had been unearthed were so various and so remarkable, that the time and expenditure had been richly repaid. The results of this beginning may be briefly stated as follows: At a depth of from 3 to 6 feet were found copper coins and medals of Sigeum, Alexandria Troas and Ilium, an enormous quantity of ornamented terra-cotta disks, and substructions of houses built with Roman cement: from 6 to 13 feet no hewn stones, ashes and calcined soil, with traces of fires everywhere, quantities of oyster and mussel shells, tusks of wild boar, vertebræ of sharks (which are not now found in the Ægean), and some rude specimens of pottery; at the depth of 13 feet, great quantities of stone axes, lances, weights and other implements suddenly appear: a little lower, pottery of very elegant form and fine quality, decorated with the owl's-head, phallic emblems, knives of flint, needles and spoons of bone, a few copper nails, and a great quantity of curious terra-cotta disks, with a hole in the center, and adorned with an almost endless variety of decorative lines, many of which seem to have an emblematic character.

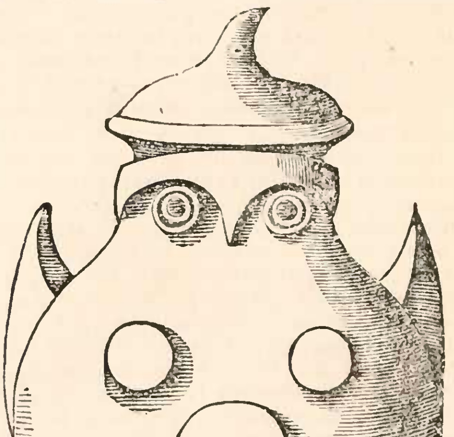


TERRA-COTTA DISKS.
The Two Upper, Trojan—the Lower, Pre-Historic.

At the depth of from 23 to 33 feet the relics again change. Having already reached the stone period, as he imagined, Schliemann was amazed to find below it weapons of pure copper of unusually elegant forms. The vases, urns, and drinking vessels were not only quite original in design but very beautiful, brilliant, red, yellow, green or black in color, but without ornamental designs. At the first-named depth (23 feet) the houses were of large sun-dried tiles, with door-sills of stone, but 10 feet deeper they were wholly of enormous blocks of stone, without mortar. In short, the grade of civilization exhibited by the remains increased as the excavation reached an earlier age. This unexpected discovery only increased the desire to penetrate to the lowest historical stratum, and there find, perhaps, some engraved relics of the lost Ilium.

On the 1st of April, 1872, Schliemann, accompanied by his wife as usual, reached the Troad, and resumed operations with a force of 100 workmen. He brought with him two overseers, furnished by Mr. Latham, director of the railway from the Piræus to Athens, and M. Laurent, a French engineer, who made a careful survey of the localities. The expenses thus assumed for the excavations amounted to something more than $1,000 per month, omitting the Greek holidays (which, added to the Sundays, make 147 idle days in the years), and estimating the wages of the common laborer at about 35 cents per day. I can only give a hasty outline of the progress of the researches. Interesting as it is, from first to last, the mass of details would only confuse the reader who is simply desirous of knowing how Troy was found and what was found there. Schliemann began by laying out the plan of a new cut, 46½ feet deep, and 233 feet (English) broad, through the upper and lower plateaux, including therein his cut of 1871. The engineer calculated that the amount of débris to be removed would measure 78,545 cubic meters—about 90,000 cubic yards—all of which it was necessary to move to the steep northern declivity and shoot upon the plain below. At the proposed depth it was supposed that the bed-rock or at least the original soil would be reached.

On beginning to enlarge and deepen the excavation of the former year, the soil was found to be swarming with small poisonous adders, called *Ant'elion* by the people, because their bite is said to produce death before the going down of the sun. Finding that the workmen handled them with impunity, and even were bitten without any results, Schliemann discovered that they had prepared themselves by drinking freely of a decoction of "snake-root," which grows upon the plain. He judged it prudent to prepare himself against danger by using the same antidote. The discoveries made during the first three weeks, when a depth of 48 feet was reached without finding the bottom of the ruins, were chiefly remarkable for their indications of a much earlier civilization than is ascribed to Troy. The figure of the owl-headed Minerva, on vases and other ornaments, became so frequent that Schliemann saw therein a certain symbol of the Trojan goddess. He insisted that the *theo glaukopis Athene* of Homer means, correctly translated, "the goddess Athene with the owl's face," and drew a new faith in his theory from this interpretation. With regard to the primitive symbols of the original Aryan race which he discovered, I will mention them after finishing the history of the exploration.



VASE WITH THE OWL-HEADED MINERVA OF TROY.

The owl-face on this vase is not to be mistaken. The circles below represent the breasts, rudely hinting at both bird and goddess, in one. This emblem is repeated, not only on pottery, but on the pendants of the golden ear-drops and diadems which were afterward found in the so-called House of Priam.

By May, Schliemann had 130 laborers employed, and divided the force, placing a part of the men under the charge of a Parian Greek, named Photidas, who had worked seven years in the gold mines of Australia, and understood tunneling. The great cut through the plateau was now driven from both ends, but the difficulty and danger arising from the masses of crumbling earth on either side greatly delayed the undertaking. Photidas and one of the men were buried by the slide of a huge mass, but were fortunately saved by some wooden props and dug out before they were suffocated. The eastern part of the plateau belongs to an Englishman, Mr. Calvert, who has a large farm on the site of the ancient Thymbria, and Schliemann made an agreement with him to sink another excavation on the eastern side of the great cut. At the very beginning of this new work a Doric triglyph was discovered, with a bas-relief nearly a yard square in the interspace, representing the Sun-God driving his four-horse chariot. This piece of art, certainly of the age of Lysimachus, is purely Greek, and therefore purely beautiful. The horses resemble those on the frieze of the Athenian Parthenon.

Having reached the original soil on the northern side of the mound, Schliemann determined to run an oblique ditch, 150 feet wide at the top, and half that breadth at the bottom, to intersect the main cut. In proportion as he advanced, he was struck with the fact that the remains of massive cut-stone houses, copper weapons, vases of elegant form and rare and curious symbolical figures ceased suddenly, at the depth of about 33 feet; while, below that depth, to the primeval, undisturbed earth, at 45 to 48 feet, a new and apparently much older class of relics was found. The same result had been attained, the previous year, in the spots where a greater than the average depth had been reached; so, now, instead of breaking up these ancient walls and removing them, the explorer decided to ascertain their extent and character. By the end of July a wall six feet thick and nine feet high was discovered, at a depth of 42 feet, on the northern side of the plateau, and a tower, 40 feet in diameter, based on the bed-rock, on the southern. Twenty feet of the tower were still remaining, and the mass of loose blocks scattered around it indicated a much greater original hight. Inasmuch as both these massive ruins, on opposite sides of the mound, evidently belonged to the same period, and to the walls of houses occupying a plane connecting them, it was clear that an important city, inhabited by a highly civilized people, stood—not upon the original soil, but—upon the rubbish of a still earlier settlement, whose remains were 14 or 15 feet in depth below it. It was only by degrees, however, that Schliemann convinced himself that the masonry belonged to the Troy of Homer, which, itself, must have arisen upon the ruins of some pre-historic capital, of whose people we can only say that they belonged to the Aryan race.

Until the 14th of August, a period of four months and a half, the work was patiently driven forward. Then fever broke out among the workmen, the overseers were taken down, and the aspects became so unfavorable that Schliemann reluctantly stopped work for the year and returned to Athens. He first, however, laid bare enough of the tower to find that it was connected with strong walls on both sides; here, moreover, two copper lances were discovered. The number of articles, great and small, unearthed since the beginning of the enterprise, already amounted to more than 100,000! The evidence of successive historic periods was now clear, the chaos of fragments began to speak with an intelligible voice and language, but the name of Ilium was not yet so distinctly written that the modern world must perforce read it.

EXCAVATIONS IN 1873.

By the 1st of February, 1873, the work was again resumed, but little was done before the 1st of March, when the weather became fine, the Greek holidays were less frequent, and the workingmen, to the number of 158, were gathered together. After clearing away the washings of the Winter rains, Schliemann followed the wall on the northern side of the plateau until he reached a part which was strongly buttressed. This, and other indications led him to believe that he had found the site of the Trojan temple of Minerva. Further excavations seemed to confirm this view; they laid bare the foundations of a building 280 by 70 feet in dimensions, formed of huge unsculptured blocks, and nowhere more than six feet high. The earth above it, however, was filled with an immense mass of sculptured fragments.

It is impossible, within the space at my command, to describe the various objects discovered from day to day. Schliemann's previous experience had, by this time, enlightened him as to the proper direction of his labors, and he sought to strike upon something which would serve as an indisputable landmark. The accumulation of terra-cotta disks, vases, idols, stone weapons, copper knives, needles, household utensils, with an occasional gold or silver ornament, continued; but the collection was already great enough for archæological purposes. The high tower, the connecting walls, the foundation of the temple, and the remains of houses covering the same stratum of ruin upon which the former stood, promised more important results. With this view he made various detached cuttings at the edges of the plateau, carrying them down to the level of what he was now convinced was Trojan masonary.

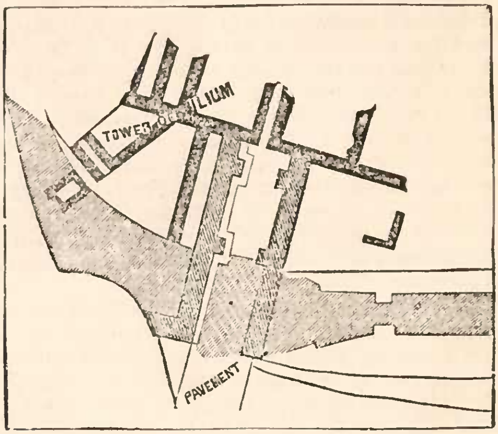
In the beginning of April, at a depth of 27 feet, a house of eight rooms, adjoining the great tower, was discovered. The walls were about four feet thick, in some places 10 feet high, showed traces of a coating of lime or stucco on the inside, and were, in many places, calcined and blackened by fire. In some of the rooms were earthen jars, for wine or other stores, between seven and eight feet high, and in front of the house a stone altar, for offerings, of a rude, primitive form. A little further there was a great mass of human bones, among them two entire skeletons wearing copper helmets, within which the skulls were well preserved. To the explorer's Homeric enthusiasm nothing more could be added: ruin, conflagration, warriors, helmets and lances—here was Troy!

From day to day the store of beautiful vases with the owl-faced Minerva upon them increased. At the level of the tower and the ruined dwelling all objects wore a distinctively Trojan stamp. A few days later, near the tower, a street was discovered. It was 30 feet below the surface, 16 feet wide, and paved with stone blocks about four feet square. Schliemann immediately wrote, on making the announcement: "Beyond the least doubt it leads to the Scæan Gate, which cannot be more than 150 yards distant from the tower." He ordered 100 workmen to carry on the excavations with all speed in that direction. In order to secure the tower and the adjoining house from spoliation by the Greek and Turkish inhabitants, to whom the walls would have been a most welcome quarry, he informed the workmen that Christ had once visited King Priam, and walked along that very street, on entering Troy. A little shrine with a lamp and picture of Christ was also placed on the corner of the tower, which thus very soon became a sacred place to Moslem as well as Oriental Christian.

Early in May, the excavation of the street, after having led to the finding of another large Trojan house, upon the ruins of which a dwelling of the later Greek period had been erected, terminated at a massive double gate, the copper bolts of which were found among the rubbish. There could be little doubt that this really was the Scæan Gate, in mentioning which Homer always uses the plural. The first entrance is about 11 feet wide, with a smooth massive pavement, from which a roughly-paved way leads to the second entrance, 20 feet further to the north-east. The foundations of the large Trojan house, lying between the gate and the tower, proved to have been built upon a mound artificially formed of the ruins of the prehistoric city. Its situation, its stately dimensions, and the treasures afterward found in its chambers, seem to justify the discoverer in calling it, if not the House of Priam, certainly the house of a prince or ruler of the Trojans.

A great quantity of beautiful and curious vases of the finest workmanship were found in this house. Among them were several of a peculiar form, with two flaring handles and two ears for drinking. Schliemann sees in the latter the *depas amphikupellon* of Homer, which, he insists, ought to be translated simply as "cup with two handles." This is a minor point, in the presence of so many more important discoveries, but it may be of interest to some persons.

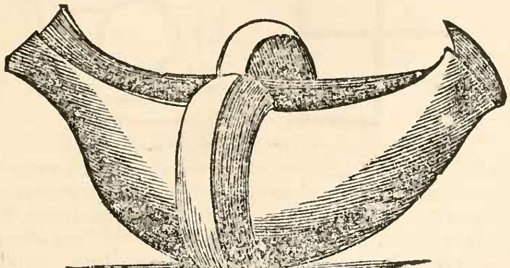
The discovery of the Scæan Gate of course directed all further exploration to the neighborhood of that locality. The position corresponds to the description of the Iliad. It is at the north-western corner of the wall of Troy, and from the high tower near it, old King Priam could have had a clear and complete view of the battle-field on the plain, between the Scamander and the Simoïs. So, when Dr. Schliemann, after having rummaged through half the remaining ruins of Troy, takes the only large, stately mansion among them all, standing between the tower and the Scæan Gate, and calls it "The House of Priam," I think he does not deserve to be treated by certain German *savans* as if he were an impertinent school-boy. Let him have his House of Priam—and let us, too, so call it—whether Priam ever lived in it or not. For my part, I have far more faith in historical tradition than many people of greater wisdom: but I am always delighted whenever the research of our wonderfully explorative age justifies the tradition; and they are not.



GROUND-PLAN OF THE SCÆAN GATE.

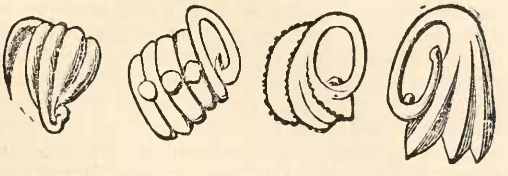
Schliemann's explorations are like a play in five acts: 1869, '70, '71, '72, and '73,—the interest increasing until it culminates in a grand *dénouement*, and then the curtain falls. During the month of May and beginning of June the rubbish, 50 feet deep, of three or four thousand years, was slowly cleared away, and the foundations, at least, of Homer's Scæan Gate looked once more across the plain of Troy, to Tenedos and Imbros and the Samothracian Ida. Then—what particular day it was he does not tell us,—the city wall running southward along the edges of the great mound having been further laid bare something happened, which I must allow him to tell in his own words:

Immediately beside the House of Priam I came upon a copper object of a most remarkable form, which attracted my attention so much the more because I fancied I saw something golden glimmering behind it. A stratum of red ashes and calcined ruins, four or five feet thick, rested on this copper article, and above the stratum towered the wall of fortification, twenty feet high, built of great loose stones and earth, and evidently belonging to the period after the fall of Troy. In order to secure the treasure from the greed of my workmen, and save it for human knowledge, the greatest haste was necessary; so, although it was not yet time for breakfast, I immediately proclaimed "rest!" to all. While they were eating and reposing I cut out the treasure with a large knife, not without the greatest exertion and the most fearful danger; for the loose, tremendous wall above, thus undermined, threatened every moment to topple down upon me. But the sight of so many objects, each one of which was an invaluable contribution to our knowledge, made me foolhardy, and I forgot the danger. The transport of the treasure would have been impossible without the help of my wife, who stood ready, and packed in her shawl the articles as I cut them out, and carried them away. The first thing found was a large oval shield of copper, with a raised rim, and a boss in the center. Then came a copper pot, nearly 18 inches in diameter, with two handles; a copper tray, 1 inches long, with a small silver vase, welded to it by the action of fire; a golden flagon, weighing nearly a pound; two golden goblets, one of which weighed nearly a pound and a quarter (600 grammes), and had two mouths for drinking—a small one for the host and a large one for the guest. The latter had been cast, but the former, as well as the flagon, were of hammered work. There were, further, pieces of silver which were probably "talents"—the *talanta* of Homer—three silver vases, with two smaller ones; a silver bowl, 14 copper lance-heads, the same number of copper battle-axes, two large two-edged copper daggers, a part of a sword, and some smaller articles.



THE DOUBLE-MOUTHED GOLDEN CUP, FROM THE HOUSE OF PRIAM.

All these objects were closely packed in a quadrangular space, surrounded with wood ashes, and near them lay a copper key, 4 inches in length,—whence Schliemann conjectured that they had been packed in a wooden chest, which, left behind in the terror of the conflagration, was afterward covered by the ruins of the falling beams and walls. Within the House of Priam, on the inside of the city wall, he found a helmet and a silver vase about 7½ inches in hight, in which were two diadems of golden scales, a golden coronet, 56 golden ear-rings, and 8,750 small gold rings, buttons, &c. The fashion of all these articles has no resemblance to the ancient Egyptian or Assyrian ornaments: the Trojan jewelry, no less than the pottery, is entirely original. Whatever symbolic forms it assumes (with the exception of the owl of Pallas) point toward the far-off, mysterious home of the Aryan race in Central Asia. The value, by weight alone, of all the gold and silver found in or near the House of Priam, has been estimated at $20,000.



GOLDEN EAR-RINGS, FROM THE HOUSE OF PRIAM.

Schliemann now hastened to bring his labors to an end, and thus secure the results of what he had already accomplished. He broke away a large part of the upper wall which rested on the ashes where the treasure was found, enlarged the excavation around the Scæan Gate, and opened new rooms of the royal house; but little of interest was found except a tablet of red slate, with an inscription in some unknown language, and three silver bowls. He also, by sinking a number of shafts in the lower plateau of Hissarlik, and finding nowhere any trace of either Trojan walls or Trojan pottery, convinced himself that ancient Ilium did not extend beyond the circuit of the upper plateau, and could hardly have contained a population of more than 5,000 inhabitants. This, however, is no measure of the power of the Trojan State, or the auxiliary forces which it could bring into the field. The large, heroic canvas of Homer, he argues, has misled the antiquarians, and he points to the fact that Athens was famous when the Acropolis—smaller than the *Pergamos* of Troy—inclosed the whole of the primitive city.

On the 17th of June the researches came to an end. What has been uncovered will be left so, and it is to be hoped that the legend of the Savior's visit to King Priam will take root among the ignorant modern Trojans and preserve the walls which no other argument could make sacred to them.

Schliemann's wonderful success in 1873 was due, in a great measure, to the conclusions which he had reached during the excavations of 1872. He continued the classification of the ruins and the relics they contained, and soon found that they might be divided into four distinct strata, each of which represented a long historic period. Further comparison convinced him that the third of these strata, counting from the top, was the only one which met the requirements of Homer and Greek tradition; consequently, here was Troy. But under Troy there was an earlier layer of ruin, varying from 13 to 20 feet in depth, before the primitive soil was reached. This discovery is hardly less interesting than that of the position of Troy. It carries the antiquity of the city back into that immense, shadowy past of the human race, which stretches like a mysterious twilight land behind our oldest history. The geographical position of Ilium explains its importance in those far-off ages. The gorges of Ida protect it in the rear; seated at the junction of the Hellespont with the Ægean, it made a station between Colchis, at the eastern extremity of the Euxine, and all the Grecian, Egyptian, and Phœnician coasts; the rich plain around it furnished abundant supplies, which could readily be exchanged for foreign merchandise, and as its people became rich and impregnable within their citadel-town, the other and ruder tribes in their neighborhood would yield to their power. It is certainly older, by a great many centuries, than Athens, and its immemorial importance was no doubt the first cause of the jealousy of the sensitive Greeks.

The topmost historical stratum, which is only 6½ feet in depth, seems to begin about the year 700 B. C., when a Grecian settlement was established there under the Lydian dynasty. From that period, coins and inscriptions indicate the subsequent centuries until about the middle of the fourth century of our era. There are no later coins or medals than of Constans II., whose reign ceased in 361 A. D. Schliemann is of the opinion that the city was destroyed at that time, or soon afterward, but gives no conjecture of the manner of its fall. It seems to me that the raids of the Goths, then settled on the northern shore of the Black Sea where they built fleets, even sailing through the Bosphorus in proud defiance of Constantinople, to ravage the coasts of Greece and Asia Minor, give us an easy explanation The Greek Ilium, which covered the whole of the lower plateau of Hissarlik, must have contained 100,000 inhabitants. It was a rich, and at that time doubtless, a luxurious city, clearly visible from the waters of the Hellespont, speedily reached and incapable of resisting such stalwart invaders.

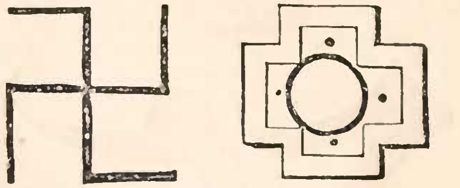
We have thus an age of 1,050 years for the first 6½ feet of rubbish. At this depth the Greek masonry suddenly ceases, and a stratum 17 feet in thickness intervenes between it and the massive buildings of the Trojan era. The relics here found are of a perplexing character, and will give plenty of work to the archæologists. The walls are built of earth and small stones, but the abundance of wood ashes shows that the city—or the successive cities—was chiefly built of wood. If the chronology of the Trojan age can be approximately established, it will, of course, give us the duration of this intermediate belt of ruin; at present, it is scarcely possible even to guess.

The ruins of Troy form a stratum averaging 10 feet in thickness, the depth (from the surface) reaching from 23½ to 33½ feet. Since the foundation of the city is conjectured to have taken place about 1400 B. C., and its fall and destruction by fire to have occurred about 1100 B. C., this would give three centuries for the formation of ten feet of ruin—which is quite sufficient if we imagine a small but crowded city, with houses of more than one story and much wood-work, of which the ruins give ample evidence. The marks of intense heat are everywhere manifest. When the Scæan Gate was first uncovered, the pavement seemed uniformly perfect; but at the end of two or three months the stone blocks along the upper part of the street, which had been exposed to the flame, crumbled almost entirely away, to a distance of 10 feet from the Gate. The other blocks, protected by their situation, remain solid, and promise to stand for centuries.

Finally, *under* Troy, there is a fourth stratum of ruin, varying from 13 to 20 feet in depth, as I have already stated. The age of this is a matter of pure conjecture, since the vicissitudes of the city's history—frequent destruction and rebuilding—would have the same practical effect, or very nearly so, as a long interval of time. We have anywhere from two to five thousand years before Christ—taking Egyptian, Phœnician, or Pelasgic remains as guides—as the date of the foundation of the *first* Troy.

REMAINS OF THE FIRST PERIOD.

Filled with his Homeric enthusiasm, Schliemann gives us, in the present work, only fragmentary and imperfect accounts of the characteristics of the earliest ruins. The most remarkable feature, perhaps, is the superiority of the terra-cotta articles, which indicate a greater degree of taste and skill than those in the subsequent strata. From the beginning down to the Greek period, the evidences of a *gradually declining civilization* are so clear, in the discoverer's opinion, that they must be accepted. The early vases are of a shining black, red or brown color, with ornamental patterns, first cut into the pottery and then filled with a white substance. Only one piece of painted terra-cotta was found. The inhabitants of the city were certainly Aryans. This fact is illustrated in their manner of building, and also in the frequency of the earliest Aryan religious symbols, upon the terra-cotta disks—especially the two forms of the Cross:



ARYAN SYMBOLS—THE CROSS.

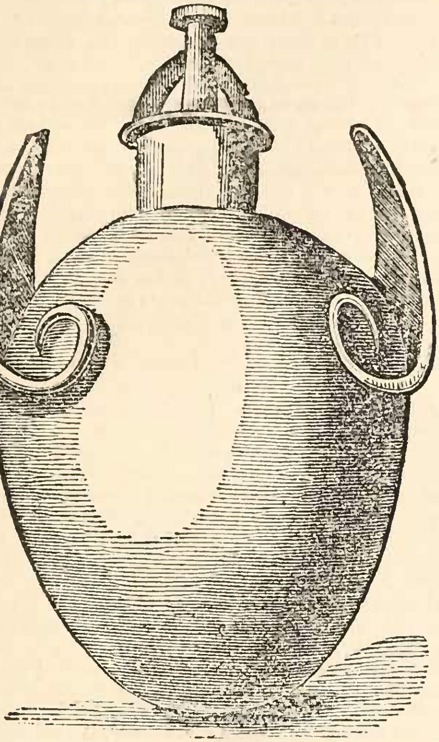
The first of these symbols refers to Fire, or rather the birth of fire, the legend of which, in the Sanskrit *Rig-Veda*, has such an astonishing resemblance to the outline of the Christian theology. The other appears to be a modification of the same idea. Since the path of early Aryan migration westward from Central Asia seems to have been by way of the Caspian and Black Seas, it is reasonable to suppose that one of its many dividing and subdividing currents found a permanent resting-place in the Troad.

REMAINS OF THE SECOND, OR TROJAN PERIOD.

I must not omit to mention that, among other evidences of the destruction of Troy by a fierce conflagration, Dr. Schliemann found a layer of slags of melted lead and copper, in some places an inch thick, extending over the whole site of a city. The blackened walls, the masses of wood-ashes and calcined stone, filling up the chambers of the ruined houses until a rough plain was left for the next city-builders, would, however, have been a sufficient confirmation of the Greek legend. With the exception of the large and stately edifice of massive stone between the Tower and the Scæan Gate, nearly all the houses of Troy were built of unburned brick (afterward partly burned and hardened by the conflagration), with sills of hewn stone. The size and character of the large house, together with the greater excellence of the vases found in its chambers, the helmeted skeletons at its doors, the heap of human bones, suggesting a desperate defense, and finally the treasures of gold and silver found beside it, on the city wall—all these circumstances so distinguish it among the other and less important ruins that it may well have been a royal residence. The number of articles collected is so enormous, and their character is so unusual and various, that I cannot undertake to describe them in detail. Only one inscription was found, and that in unknown characters. I copy, from Schliemann's photographic atlas, the form of a singular vase found in the House of Priam.

The owl-headed Minerva was frequently recovered, especially upon another large vase in the royal house. Many of the urns and jars are made with shallow channels passing around the middle, to hold the cords by which they were suspended. Of articles of pure art, there were only found a flute made of bone, and a fragment of a four-stringed lyre, of ivory, elegantly carved. The Aryan symbols, including the two forms of the Cross, also constantly occur among the relics of Troy.

CURIOUS VASE FROM THE HOUSE OF PRIAM.



REMAINS OF THE THIRD, OR POST-TROJAN PERIOD.

The foundations of Troy, as we have seen, were 33½ feet below the present surface of the plateau of Hissarlik; but after the destruction of Priam's city the site upon which the next-comers built was 10 feet higher. Who these people were cannot yet be ascertained, but that they were also Aryans seems to be certain, from the recurrence of the same religious symbols, which can hardly have been used for a merely decorative purpose, since the forms of their pottery are quite different from those of the Trojans. They show the same degree of decadence in art, in comparison with the latter, as these manifest when compared with their unknown predecessors. Their architecture, moreover, shows a great falling off. The houses were constructed of small stones, loosely held together with a rough plastering of earth: the huge square blocks of "Troy town" appear no longer. One or two walls of the period are made of sun-dried bricks. The débris is of a dark-gray color, mixed with ashes, and contains enormous quantities of shells and fish-bones. Pieces of two lyres were found, a very few copper weapons, and a great many stone axes and knives of flint or diorite, of very fine workmanship.

After rising to the depth of 13 feet from the surface there is another change, hardly determined enough to make a new historical division. The signs of convulsion—dumb hieroglyphics of lost historical events—which prevail throughout this third stratum gradually become more marked. The great increase of wood-ashes and the scarcity of walls—even of the previous rude walls of earth and small stones—indicate the existence of a city built of wood. The signs of copper implements wholly cease, and all weapons and utensils are of stone, but of quite inferior workmanship. The vases and vessels of terra-cotta again show a different fashion; yet, most singularly, they are covered with the same ancient symbols. There is more than one evidence of a general conflagration. If at that unknown period—certainly before 700 B. C.—Troy was a wooden city, it must have been frequently destroyed and rebuilt. It would be very difficult, otherwise, to account for 17 feet of rubbish in four or five centuries, when the 1,050 years of the Greek city only left six feet behind them. Here is a great and deeply interesting field of further research.

REMAINS OF THE FOURTH, OR GREEK PERIOD.

The Greek settlement, which Schliemann conjectures to have taken place about 700 B. C., has left but few relics anterior to the age of Lysimachus (306 B. C.). But we know (*Herodotus*, VII., 43) that Xerxes, in 480 B. C., on his way to Greece, came to the Troad; that he landed at the mouth of the Scamander, visited the "citadel of Priam," and sacrificed 1,000 beeves to the Trojan Minerva. We also know of the Macedonian Alexander's nude pranks at the mound of Achilles; so that the age of the Greek city may be tolerably well ascertained without consulting its ruins. The bas-relief of Apollo, which appears to have stood between two triglyphs of a small temple, has been pronounced by Prof. Brunn of Munich, one of the best living authorities, to belong to a period between the middle of the second and the end of the fourth century before the Christian Era.

Inasmuch as the Greek relics found at Troy belong to the historical age, I shall not describe them further. Two curious coincidences, however, must be mentioned, before I close this long, yet all too-brief report. Several of the terra-cotta disks, belonging to the third or post-Trojan period, prove to be precisely identical in shape, size, and emblematic decoration, with those found in the lake-dwellings of Northern Italy. Both refer directly to India, to the Sanskrit myths of *Pramantha*, the far earlier origin of the Greek *Prometheus*. An ancient vase, with a belt of curious characters around it, which Schliemann at first supposed to be merely ornamental, but afterward imagining they might have some affinity with Phœnician, sent to M. Burnouf, is probably the first evidence of a connection between the Ægean and China. M. Burnouf declares that the characters are early Chinese, perfectly legible, and constitute the sentence: "For the earth causes to spring from ten labors ten thousand pieces of stuff."

There is, of course, a vast deal more in Dr. Schliemann's narrative volume, and his atlas of 218 photographs, giving us four or five thousand pictures of the exhumed objects, than I am able to mention here. I have confined my labor to the narration, as clear and intelligible as possible, of his achievements. Inasmuch as his own story is very broken and fragmentary, my task has not been easy; but I feel sure that the American reader will be glad to receive as much as I have been able to give. B. T.

BROWN-SEQUARD'S LECTURES.

The following course of six lectures was delivered by Dr. Brown-Séquard of New-York, at the Lowell Institute, Boston; beginning Feb. 25, and closing March 18, 1874:

NERVOUS FORCE—THE FIRST LECTURE.

TRANSFORMATION OF LIGHT, HEAT, ELECTRICITY, AND CHEMICAL FORCE INTO NERVOUS FORCE—A GUINEA PIG SURVIVING AFTER THE MEDULLA OBLONGATA WAS CUT AWAY—NERVES KEPT ALIVE FORTY HOURS AFTER SEPARATION—COMPARATIVE POWER OVER THE NERVES OF OXYGEN, STRYCHNINE, AND THE WILL—THE UNITY OF THE NERVE FORCE.

[FROM AN OCCASIONAL CORRESPONDENT OF THE TRIBUNE.]

BOSTON, Feb. 26.—The popularity of this course of lectures may be seen from the fact that a supply of tickets equal to the full capacity of the hall of Lowell Institute was disposed of within three-quarters of an hour after the office was opened.

Those who know of Dr. Brown-Séquard's devotion to Prof. Agassiz in his last sickness need scarcely be reminded of the great affection they entertained for each other. The Doctor's tribute to the memory of his friend did not fail to awaken the sympathies of his audience. The lecture was as follows:

LADIES AND GENTLEMEN: I have no doubt you will excuse the emotion that is upon me at this time. Last year when I met you here, there was sitting there a man who certainly deserved the great admiration that has been bestowed upon him, and whose qualities of heart were so great, that although I admired him more than I admire any one, yet I loved him still more. His absence to-day justifies the feelings that are now upon me.

The lectures I have to deliver here are on a subject which is full of interest, and which deserves more study than it has obtained. The various effects produced by nervous force are certainly, even for persons who have nothing whatever to do with medicine, full of interest, and I may say of importance. I will go further. I have no doubt that persons who have not at all engaged in the medical profession could do more perhaps than physicians, in regard to discovering certain of the peculiarities of nervous force. Physicians unfortunately—I speak of myself as well as of others—are biased. Their bias prevents progress. They have received an education which has given them certain notions, and those notions prevent a free examination of certain questions. The unbiased minds of persons who have not studied medicine, or who, if they have studied the foundations of it, have not engaged in the practice of the profession, permit them to investigate and discover. Perhaps as a result of the lecture that I shall deliver here, it will be given to some of you to push forward discoveries in that line.

Before entering into the proper subject of this lecture it is essential to pass in review some of the elementary questions of physiology. I shall do it very rapidly. There are two elements in the nervous system which are united together, but which are, however, absolutely distinct, the one from the other. One consists in the nerve cell, which you see represented on the board. I have made it nearly round, but it is very rarely that it is so. That cell has starting from it a number of filaments. In the spinal cord and in the brain those cells generally have one element entirely different from the others, and that element is similar to the other element we find in the nervous system; that is, fibers. There are therefore two kinds of elements in the nervous system, the fibers and the cells, with their prolongations. What becomes of those prolongations is not known, and it may perhaps remain always unknown to us in this world. It is to be feared that the power of our microscopes will remain pretty nearly what it is, and if that be the case, then we shall never know much more as regards the ramification of those fibers. But the remarkable point of which I have not yet spoken, and which you ought to keep in mind, is that the fibers of the nervous system are united with those cells. Within the nervous centers, that is, the brain and spinal cord, there is but one of those fibers united with cells. In other parts of the body there are cells which have two real fibers starting from them besides the ramifications.

A DEATH-BLOW TO ANIMAL MAGNETISM.

Now the nervous force is produced in those elements of the nervous system. I have no need, of course, to give a definition of nervous force, or nerve force, as you will perhaps prefer to call it. It is that force which manifests itself in nervous actions. The nerve force belongs only to the elements I have described. Are there any instances in which we can find nervous force without the existence of those two elements? This question is now decided in this way. There are animals in which, and there are circumstances in man in which, the nervous tissue does not exist evidently in the way I have described, and still there is a nervous force; so that it appears that nervous force can exist without the nervous elements. There are conditions, especially in monsters, where the spinal cord, instead of being organized, is a fluid in which elements resembling those of the nervous system are not recognized, and still there is nervous action, and therefore, nervous force. In some low forms there are also tissues which do not represent at all the known elements of the nervous system, but in which, nevertheless, there is nervous action, and therefore nervous force. A professional friend in Paris has shown that there are certain instances of disease in man in which the nervous system is so transformed that it is hardly recognizable, and yet there is every probability that it acted, and that nervous force was manifested.

But the great question is not there. The great question is whether the boundaries of the nervous system are also the boundaries in health of that nervous force. In other words, can the nervous force spring out of the nervous system to produce some action? As regards this, I may say that there are no facts to prove it. You can easily understand that if I am right, this is a death-blow to what is called animal magnetism. But this is a point that we will debate more at length by and by. All I wish to say in this introductory lecture on this point is that there is no likelihood at all that nervous force can get away from the limits which are constituted by nervous tissue. There is no question, however, that nervous force can manifest itself outside of the boundaries of the nervous system; but it manifests itself often after having been transformed into another force. It is well known that nervous force is transformed into motor force. This I am doing at present. It is owing to motor force that I have any voice at present. This transformation into motor force takes place at every moment of our lives. Other transformations are also of great interest. You well know that there are fishes that possess an electric apparatus. In them the nerves which go to the electric apparatus are enormous. And those nerves convey nervous force, and not electricity. As soon as the nervous force is felt in that electric apparatus, electricity is evolved. Electricity is a transformation in that case of nervous force, just as we know that heat can be transformed into electricity or electricity into heat, heat into motion, and motion into heat, &c. There are animals which are phosphorescent, and which are so under an act of their wills, so far as we can judge, and under the influence of the nervous system; so that light also can be evolved as a transformation of nervous force. There are cases of consumption in which light has come from the lungs. The fact has been pointed out by Sir Henry Marsh and other physicians. The light appears not only at the head of the patient, but it may be radiated into the room. It has been considered that the light was only a peculiar effect of the mucus that came from the lungs of the patient. It is not likely that this is the case, because mucus in greater quantity is evolved, and all sorts of mucus, from the chests of people, every day, without any such phenomenon. I have read the history of each individual case of the kind so far as I have been able to get it, and in every one of the cases the patients, I find, were in a terrible state of nervousness, so that I cannot but believe that the production of light was, in a measure at least, owing to the transformation of nervous force.

HEAT, ELECTRICITY, AND NERVOUS FORCE.

There are great transformations also of another kind. You well know that nutrition, which implies chemical change in our system, as well as secretion, which also requires chemical change, may take place under the influence of the nervous system. I shall show this more fully in a subsequent lecture. When this transformation occurs, it is quite evident that it is the nervous force that has been transformed into a chemical agent.

Is nervous force ever transformed into heat? There is no doubt whatever that heat is evolved from our system, and in a great measure owing to the action of nervous force; but the question is whether that tranformation is an immediate one or whether it goes through other transformations. This is a point which it would be very interesting to determine, but which at the present state of our knowledge is not yet ascertained.

Now that we have passed in review all those facts showing that nervous force can be transformed into the other forces of nature that we know, almost all of them, the question arises, "Can all the forces of nature be transformed into nervous force?" This is one of the greatest questions that we could undertake to consider. Unfortunately, the elements we have for solving it are as yet very few. We do not know positively yet—at any rate I do not know, and I have read considerably to find if the question is solved—we do not know positively yet whether electricity can be transformed into nervous force. You can easily understand that if it were possible to have such a transformation, a great many weak people would receive manifest advantage in being galvanized. Therefore the question is of great importance. There is no doubt at all, for this has been established by a good many experimenters, that the elements of the nervous system benefit in their nutrition under the influence of electricity and galvanism; but a direct transformation of electricity into nervous force is not yet proved.

As regards light, very little is known. You well know that nervous disturbance will come from the action of light. There is no doubt whatever about it. Light is certainly a very powerful agent and a most useful one. Indeed, it is rather too much forgotten that light is almost essential to life; but we do not know if there is any direct transformation of light into nervous force. It seems to be so in the retina; but I cannot employ any other phrase than the phrase "it seems to be." It would not appear to be difficult to solve the question by experiment, and a solution would be of considerable importance.

There are other forces which certainly are transformed into nervous force. There is no doubt as regards motion. Motion increases nervous force in the limb without the least doubt. What the French call *massage*, which is shampooing, pounding or kneading of the flesh, increases nervous force without doubt. But there is still some little doubt whether it is not through an improvement of nutrition, through a chemical change, that the influence takes place.

There are other forces, heat, for instance, which perhaps are transformed into nervous force. The application of heat to children is exceedingly useful to help their development. If the air they breathe is cool, and heat is applied to their limbs, but not so much to the body, they certainly grow faster. There is no question that in northern climes, children who are not well clad, and are not well cared for in regard to the heat surrounding their body, do not grow so well as children who are submitted to the influence of heat. There is one thing which in this country especially is most hurtful and dangerous, and that is heat applied to the lungs. It is perfectly well known that the mortality of children in this country is enormous in the Summer months, and that chiefly through the influence of heat on the lungs and on the belly. Digestion and respiration are disturbed, and death comes, as you know, too frequently. More care could easily be attained in that respect, and it may be that I shall have a chance to speak of it in one of the last lectures of this course.

A DEAD OX KEPT FIFTY-SIX DAYS WITHOUT PUTREFACTION.

Some physiologists have considered that nerve force is nothing but that which many physiologists admit under the name of vital force. The theory which is most important in this respect has been put forward by M. Flourens. He considers that a spot in the medulla oblongata is the focus of vital force. There is, you know, a spot which is pierced by the matadors in Spain when they wish to kill a bull immediately. Death occurs instantly. This kind of death is a very interesting one. When we perform the experiment in the laboratory we find that the animal is so instantaneously and so effectually killed that there is no struggle whatever. The animal lies there, apparently having lost every vital power, and it is certainly a great question to know what becomes of the nervous force in those cases. It seems to have been lost altogether. I say it *seems*, for if we examine a little further we find that it is only dormant. It is accumulated in certain parts of the body in immense quantity. The nervous centers have lost it almost altogether, but the nerves are quite rich in nerve force, so much so that I have kept one of those animals for nearly 56 days in my laboratory without any trace of putrefaction, at a temperature which varied between 45 and 65°. The lack of putrefaction depended certainly on the long persistence of nerve force after death. There is in these cases a great mystery however. This nerve force we can detect very easily. If we galvanize a limb we find that there is a nerve force there, and that for a long time after death. But how is it that suddenly it disappears from the nervous centers, so much so that respiration, circulation, and all voluntary and involuntary movements cease? To answer this question would require no little study and investigation, and the person making it would have much to find that would be interesting. We find, however, in making these experiments that we can take away the part which has been considered as the focus of life, by employing certain simple precautions, without destroying life. At the College of Surgeons in London, in one of my lectures there, I had tried to show that death in the cases referred to is immediate. I had an animal—a guinea pig—on which the experiment was to be performed. In making the experiment my knife slipped and went all around the part, carrying away more than I had intended. The pig survived three or four days until my boy, trying to make the pig squeal, drowned it. [Laughter.] The vital focus, so called, does not deserve the name; for there are many cases in which it has been destroyed, and life persists. Therefore, we cannot look upon it as being a center for vital force or nervous force.

This leads me to examine now the question, What are the places of production of nervous force? Those places of production, I may say, are as extensive as the nervous system. For a long time physiologists had considered that the cells were the only parts that produced nerve force. But I have ascertained and proved, and I think most physiologists now admit, that nerve fibers can also produce nerve force. In experiments consisting in injecting blood into a limb which has been separated from the body for a long time, I have ascertained the nervous force which had disappeared has been reproduced. So that it is clear that nerve fibers can engender nerve force. If we separate a nervous center from the nerves we find that in four days the nerve has lost its power altogether. It seems, therefore, that something came from the nervous center which was useful in the production of forces there. But it is clear, too, that there are other forces reproduced in the part. If we allow the part to receive more blood the injection will reproduce nervous force again. I have kept a nerve alive apart from the body for 40 hours by injecting blood in it. The nerve force, even in the brain, can be reinvigorated when the brain has lost all power and is separated from the body. An injection of blood reproduces nerve force again and all the activity of the brain when in the animal is found to be manifested. In one case, that of a patient of mine who had had a dissection of a nerve, the nerve continued to act spontaneously for four days, and the muscles to which that nerve went were in contraction for the same length of time, owing to the persistence of life and action in that nerve separated from the brain. After four days the transformation which we know can take place in the nerve tissue had destroyed nervous activity, and the muscles then remained quiescent, completely deprived of action.

There is an organ in the body whose functions have been very much discussed. That organ is the cerebellum. In man it is a very large organ indeed. I shall not discuss its functions here, but I will say that there is no doubt that the cerebellum is one of the principal foci, one of the principal places where nervous force is produced. In many animals the principal place is the spinal marrow. But in man the cerebellum is the great focus of the production of nervous force.

POWER OF OXYGEN, STRYCHNINE, AND THE WILL.

What now is the agent of production of nervous force in our blood? It is clear that blood itself must be necessary to the production of nerve force. Still for a time the oxygen alone which is carried by the blood may suffice. Oxygen, even when the blood seems to have been taken away altogether from the part, can give some nerve force to the nervous system; but there is a medicinal agent which has immense power in producing nervous results. When the spinal cord of a frog has been washed of every drop of blood, when injections have been made of pure water so as to carry away every particle of blood, if strychnia is put on the spinal chord, in a very short time the amount of "reflex power," which is a manifestation of nerve force, is very much greater than it was before, showing that strychnia has increased that power. This is the only fact we know, which clearly proves that a medicine, putting aside oxygen, can have such a power, and a power, indeed, which is very great.

What is the power of our will on the nerve force? This is a question which a great many patients every day ask themselves. There is no doubt that nerve force is very little under our will. It may be an admirable provision of nature. It may be that we would spend it very foolishly, as we do spend many other things. Still there are many circumstances when the deficiency of will power is really painful, and in patients in whom the amount of nerve force is immense. I have tried to measure the amount of nerve force in a frog. I have ascertained that a frog could lift a weight of 20 grammes to a point which was about a line and a quarter, 600 or 700 times in an hour and a quarter. This is an immense amount of nervous force, and manifested, too, when the spinal cord was no more receiving blood, when there was no more circulation. In this case the frog was beheaded. Compare this with the case of a frog having its head. The frog with a head, after a very short time, could not move at all willfully; while still the reflex action, as we call it, an irritation of the skin, determined a strong movement. There may be, therefore, in certain circumstances, an immense amount of nerve force accumulated in the system. I would not say that there is no more production immediately after the cessation of circulation. I had not washed the vessels. There was blood left there; still there was not much of it, and it was not charged with oxygen after a time.

There is an immense difference as regards the amount of nervous force that remains in the system after death according to many circumstances, and especially according to temperature. If we have considerably diminished the temperature of animals having a great heat, such as we have, and we then kill them by means that will not bring on convulsions and an expenditure of force, we find that the amount of force that remains is considerable, and that it will remain there a very long time. In cold-blooded animals, when the temperature is very near freezing point, the amount of nerve force that remains in them for a very long time is also immense, while at a high temperature the transformation of nerve force into chemical force is very rapid, and then the expenditure of nerve force is total after a time, which is not long.

The principal question I have to examine in this lecture, however, is the one I shall now speak of; namely, is there unity of force or only one nerve force, or are there many in our system?

I have for a long time tried to prove that there is unity of nerve force. If we spend force, either in the way I am now doing, by mental more than by physical labor; if we spend force with the pen in hand, when we are studying quietly at a table, we find, after having been at work three or four or five hours, that the nerve force that remains for physical exercise is diminished. We have drawn force from a focus which is the same that gives it for mental action and for physical exertion. If, on the other hand, we walk 20 miles and find ourselves physically tired, we find then that very little nerve force remains for mental action. There are facts, however, which seem to be in opposition to this, and those facts will be fully explained in the last lecture, when I come to explain the laws of production and expenditure of nervous force. I may say this much, however, just here, that it is perfectly well known, contrary to what I have said, that we can do better with our brain if we have had some exercise than if we have had no exercise at all. But it is simply that a certain amount of exercise has led to the production of nervous force by improving the circulation, improving the secretions, improving respiration, and improving in fact all the great organic functions through which the secretion of nervous force takes place, so that we have become richer in our force because of the exercise we have taken physically. There is no doubt, therefore, that moderate exercise will lead to a production of nerve force and facilitate the exercise of our brain power; and there is no question that if we draw too much of the nerve force of our system, if we draw a great deal more of it than can be reproduced during a certain time; if we walk, for instance, very fast for five or six hours, we are then unfitted for mental work and for a good many other things. Our respiration becomes difficult. Our heart, after having beaten with much rapidity, comes to beat very slowly. We are weakened in every organ whose action depends on nervous force. There is no doubt therefore that there is a common focus of nerve force on which we draw for any of the activities of our system employing nerve force. Looking through a microscope for several hours, as micrographers know full well, is a cause of great fatigue, and renders mental work or physical labor thereafter more difficult.

THE UNITY OF NERVOUS FORCE.

There is one experiment that shows that nerve force is distributed as galvanism would be on a cylinder. Suppose a cylinder in the shape of my arm; suppose that this is charged with a certain amount of electricity, and suppose that this arm or cylinder is then cut in two just in the middle of its length; there would be in each half of the arm then an amount of electricity which would be just one-half of the amount that existed before. Suppose that the whole arm had manifested a force equal to twenty measures, the half of the arm would manifest a force equal to ten. So it seems to be with the nervous system. If we divide the cord across, as in a bird, behind the upper limbs, we find that the bird cannot make use of its limbs as before. The amount of force is not sufficient in the upper part of the nervous system. So it seems that nervous force is distributed all over the nervous system, and that if a cause operates to divide the nervous system into halves, each half has only the amount of nerve force which it had before.

There is one objection in appearance to the view that there is unity of nerve force, and that is that the brain is a double organ; that we have two brains instead of one. About that allow me to say that although we have two brains it is pretty much as if we had but one, as by the force of our education one only is raised to power The other is left with very little power indeed. It would be very easy, as I may hereafter show, to develop fully the power of the two brains by proper education. But if we have two brains there is no objection to the view that there is a unity for the nervous force. It is no objection because these two brains are united. There is communication. Every part of our nervous system is in communication with the other. We cannot touch a part of the skin or any other part of our system without producing a commotion all over the nervous system; in the same way that we cannot stamp our foot on the ground without shaking the whole world, and not only our world but the rest of the universe is shaken by such a simple thing as that. Of course, a very little shaken [laughter], but shaken nevertheless. There is no doubt that any action on any part of our system is felt everywhere through it. And that is the reason why many persons suffering in their nervous system cannot have an excitation brought on any part of the body, as it increases the trouble where it exists.

A few questions remain to be examined before closing the lecture. One is, how happens it that there are so many differences in sensation if there be but one kind of nerve force. This is not a great difficulty. The variety of sensations has an organic cause, of which I may have an opportunity to speak in another lecture. The nerve force is only an agent, most likely the vibration of a certain agent, and the vibration according to the location will produce one effect or another. The parts of the nervous system are not all alike; they certainly differ one from another, and the vibrations may be greater or less, so that we can easily be reconciled to the variety of sensation, although we admit but one kind of nerve power.

There is another question. That certain fibers seem to act on muscles, and others seem to restrain the nervous action. This is a point of such great importance that I shall give a whole lecture to that subject. When cells are active, either morbidly or naturally, an irritation coming from a nerve and acting certainly through nerve forces may be sufficient to stop the power of that nerve cell. That seems to be an act completely different from that by which a muscle, for instance, is put in action by the vibrations taking place; the transformations of nerve force taking place in the nerve, and also all the other actions that I spoke of—the emission of light and electricity. All these things may seem to imply some different action. But if you admit the great doctrine which exists now in science, and which has revolutionized natural philosophy as well as chemistry; if you admit that there is never a loss of force; that force is accumulated and that it is only transformed when it disappears, then you can easily admit that nerve force has been transformed in those various organs into some other force and that there lies the cause of the different actions of which I have spoken. But the difficulty exists, however, for that special case in which an action ceases in the cell. Suppose a person to have an attack of epilepsy. His head is thrown to one shoulder and he has not yet lost consciousness, and some one comes and draws the head to the other shoulder and the fit ceases. Well, there has been in that case an irritation starting from certain nerves when the head was moved, and this irritation goes to the cells of the gray matter that were active in producing the convulsions and stops the action of those cells. But the stopping of the action of cells is something different from the production of action. Therefore it may seem quite different. But we may admit, however,—and it would be most important indeed for chemists to make researches in that respect—we may admit that a chemical change is the result of that transformation; that the nerve force is transformed into a chemical force, and that chemical changes occur in the cell, very rapidly and in great quantity, just enough to replace the whole amount of nerve force that was acting before. Therefore, there is no reason *a priori* not to admit the possibility and the probability that nerve force is the same in every instance; that it affects cells of gray matter to stop them in the same way that it can put cells into activity; in the same way that it can put muscles into activity, and that it can put an organ into activity.

NERVOUS INFLUENCE—Second Lecture.

SOME OF THE FACTS THAT ARE DIFFICULT TO EXPLAIN—A NEGRO REDUCES CONVULSIONS BY PULLING AT THE GREAT TOE—MORE PERSISTENT VITALITY IN AMERICA THAN IN EUROPE, BOTH IN MEN AND ANIMALS—VARIOUS RELATIONS BETWEEN THE NERVOUS SYSTEM AND THE ACTION OF THE HEART—METHODS OF CHECKING CONVULSIVE EFFORTS, SUCH AS COUGHING, &C.

BOSTON, March 1.—Dr. Brown-Séquard delivered his second lecture to a large audience:

LADIES AND GENTLEMEN: In the last lecture I tried to show several points relating to the force which we know to exist in nerves. I particularly insisted on what I call the unity of force in the nervous system. I especially tried to show that every nervous action is the cause of an expenditure of nervous force. There are a few facts, however, which may be considered as constituting an objection to that. I will mention some of them. The principal one is, that we know full well that certain parts of the body may be extremely weak while others remain strong. But that certainly is no objection, since if we admit that the communication is obstructed between the part which is weakened and the rest, it is quite natural that there should be a diminution of force in that part. Besides this, there is something in the nervous system as well as in the muscles that permits a reaction after an irritation. There is a property of nervous tissue and muscles especially which we call excitability. The excitability of the nervous system is entirely and absolutely independent of the amount of nervous force. Perhaps it is wrong, however, to say as I have just done, that there is no dependence of one upon the other. There may be a dependence in this way, that the greater the amount of nervous force, the less excitability there is, and *vice versa*, the greater the amount of excitability the less amount of nervous force. People who have been ill; people who are naturally extremely weak, or those who have lost a good deal of blood and have been weakened in that way; in other words, people who have very little nerve force, are, as is well known, extremely excitable. They will jump at a noise and in other ways show nervousness. There is, therefore, something quite distinct in these two things—excitability and nerve force. This property of excitation is nothing but the power to receive an excitation. Persons who are extremely strong, will not generally be moved by excitation. They will, of course, appreciate the excitation; they will judge what it is; but they will remain calm under it. While, on the contrary, persons whose nervous system is weak, and who have little nerve force, will react under any excitation, however slight, without giving to the mind time to think of what the excitation is.

I said in my last lecture that the nervous force is quite different from electricity, that it is a force by itself; but I must add to this statement another one, that the nervous system is more or less charged with electricity all the time in health. The two forces, electricity and nerve power, are both present; but not always in proportion one to the other, as sometimes there may be an opposite condition. But certainly the nerve force is not electricity, as we well know that the speed of the nerve force is only from 80 to 300 feet in a second, while the speed of electricity as you know is thousands and thousands of times greater.

THE INFLUENCE THAT IS EXERTED UPON THE NERVES.

I now come to the principal object of this lecture, which introduces a subject that must extend to one or two more lectures—that is, the influence that the nervous system exerts upon itself by the force that we call nerve force. There are two kinds of such influence, which are absolutely distinct one from the other. One consists in the production of the activity, either normal or morbid; the other consists in the cessation of the morbid or normal activity. These two great influences of nerve force, acting upon parts at a distance more or less great, cover almost all the facts relating to the influence of the nervous system upon itself. I shall this evening enter more fully into the history of facts which show that the nervous system can stop the action of a part of its extent. All we know on this subject is of comparatively recent discovery, and the principal fact developed is that which relates to the heart. The brothers Webber discovered that the heart in a perfectly healthy man may be stopped suddenly in its action in a way which is quite different from that which regards muscles generally. If we galvanize a muscle that has been more or less in contraction by a current passing to and fro, stopping and passing again, so that the muscle is contracting and relaxing, as I show you now in this movement up and down exerted by the front of my arm—suppose that this is acting, and I pass a current into the nerves that goes to the muscles thus acting—immediately the movement stops; so that there is something similar to the cessation of the action of the heart. But the action stops, not because the muscles have stopped acting. On the contrary, the muscles are acting with a wonderful power, the greatest that they may have under the amount of electricity that is passing; and the contraction remains perfectly fixed so long as the current passes. This is the production of an active state in the muscle, and not the production of a passive state. According to the discovery of the brothers Webber, when the big nerve in the neck that goes to the heart, and which we call the *par vagum*, is thus influenced, the heart stops, passively, not actively, like the muscles of my arm. The walls of the heart remain perfectly flaccid, perfectly motionless from want of activity. During that time the heart is filled more and more by blood reaching it, and it becomes very much distended after a short time, as it does not reject the blood it is constantly receiving. There is, therefore, in that stoppage of the heart's action a phenomenon quite peculiar. And it is a phenomenon which implies a certain kind of activity. For although there is a passive effect obtained, a passivity produced in the heart, there is an activity in the nerves that go to the heart to produce that cessation. There is an influence upon certain parts of the heart belonging to the nervous system, and it is certainly an activity although it consists in stopping a movement. It is just as if you were to stop the wheel of a carriage by pushing a wedge under it forcibly.

ACTION OF THE NERVOUS SYSTEM ON THE HEART.

The great agents of the rhythmical movement of the heart are small ganglia, composed of cells of gray matter. They are suddenly rendered passive by the peculiar influence exerted upon them. Such an effect has been observed, first, by the galvanization of the nerve of the neck that I spoke of; and it was afterward found to appear when the medulla oblongata, or center from which that nerve starts, was galvanized. In experiments made by a French physiologist—Legallois—it was found that the crushing of the medulla oblongata produced an arrest of the heart. But he did not discriminate between that kind of cessation and death. He thought that death was caused by this crushing of the medulla oblongata, and that the heart had ceased because it had lost the source of its action. When I took up the question I found that a simple pricking of the medulla oblongata could produce an arrest of the heart's action. My friend, Prof. Charles Rouget, who took up the question of the mechanism of the phenomena by which an organ is arrested in its activity, considered that what takes place in the heart is similar to other phenomena which he noted at the time he published his paper. He established this law: that all such phenomena—which I shall call the phenomena of arrest, though in English they are generally called inhibitory phenomena—occurred always through the same mechanism. An irritation starts from a part which can convey nervous force, and the nervous force so conveyed after that irritation, reaches the cells of gray matter which were active, and those cells of gray matter are immediately stopped by that peculiar influence.

For another illustration of this mechanism we are indebted to the observation of a very intelligent negro, whose master was affected with a disease of the spinal cord which produced convulsions in the lower limbs. The most intense stiffness would manifest itself in the lower limbs. They were rigid like a bar of iron for a time; and after ten minutes of this extreme rigidity they began to have violent jerks. The jerks then disappeared and the rigidity returned. All day long the lower limbs were in this state of muscular contraction. His servant, the negro, having to dress him, found it very difficult to put on his pantaloons. One day, he by chance took hold of his big toe, and found as he pulled it that the limbs became perfectly soft and movable. The convulsions had disappeared altogether. The negro certainly had a natural genius for science. [Laughter.] He learned the meaning of the fact. He learned that whenever he wanted to push his master's pantaloons up, he had only to pull his big toe down. [Laughter and applause.] He succeeded every time. And as the master found the cessation of the convulsions useful at other times besides when he was dressing, the negro was asked very frequently to act on the big toe in order to effect it. [Laughter.] This fact is not a unique one. I have seen 14 such cases. Many of my medical friends have seen them also. In fact it seems somewhat a rule in cases where there is a certain disease of the spinal cord limited to a certain part, that this will be found. In this case you find exactly the same thing that exists in the heart when the *par vagum* is galvanized. In both instances there is a nerve that conveys irritation to the cells. In the case of the heart the nerve goes to the cells that are in the heart. In the case of the big toe, the nerve goes to the cells that were in a morbid state producing those convulsions. In the one case, that of the heart, the phenomena of movement were nominal; in the other, the phenomena were morbid. Still, it was the same mechanism in both. In both instances a cessation of activity was produced.

PRESSURE ON THE NECK TO CHECK THE HEART'S ACTION.

A friend of mine, Dr. Waller, a most intelligent man, a man of genius—although he was not a negro—found that by pressing on the neck he could produce the most interesting physiological phenomena. He has succeeded in that way in curing headaches, neuralgia of the face, and many other affections in which there was pain or great congestion of the head. An attack of epilepsy may be stopped in that way. Many physicians before him had produced some of those results, but they all thought it was from a pressure of the carotid artery. Dr. Waller has the merit of showing that it is chiefly—he thought it was only, but I have found that it is chiefly, not only—through an irritation of that nerve, the *par vagum*, that the motion of the heart is arrested in those cases, and that a diminution of the beating of the heart was followed by an amelioration in the circulation in the head, a cessation of an attack of epilepsy and of various other complaints. It was something, therefore, quite different from the mere pressure on the carotid artery. These views were not absolutely complete, as I have found that another nerve which goes to the blood vessels of the brain is also irritated by the process; and that the pressure exerted in the neck produces three effects: (1) It certainly diminishes the current in the carotid artery, and indeed stops that current altogether if the pressure is considerable; (2) it diminishes the circulation considerably, and may induce a profound state of syncope by acting on the *par vagum;* and (3) it also acts on the cervical sympathetic, and produces a contraction of the blood vessels in the head, by means of which a part of the good effect is obtained.

There are perhaps no parts of the nervous system which cannot under irritation have an influence on the heart to stop it. Even irritation of the nervous fibres of the brain may produce a cessation of the activity of the heart. Physicians in this room know perfectly well that sometimes a patient stricken down with apoplexy may have a great reduction in the action of the heart, and sometimes syncope may take place, resulting in death. In the spinal cord it is so also. There are indeed parts that cannot be pricked by the finest needle without some influence on the heart. Legallois, the French physiologist, of whom I have already spoken thought that all of the spinal cord was a center for the movements of the heart, and he had made experiments which seemed certainly to show that that was the case. He had passed a small bar of iron along a part of the spinal cord, and had found that that stopped the heart's action. But he made a mistake in considering that it was because he had destroyed the nerve center of the heart.

GREATER VITALITY IN AMERICA THAN IN EUROPE.

This experiment was the occasion, as perhaps some of you already know, of my finding that animals in this country can bear an injury far more easily than the same animals in Europe. I have ascertained that it is so for man also. And this is why so many medical writers in Europe consider that facts of this kind published here are mere inventions. There is a distrust among European physicians in the honesty and uprightness of American physicians, because the former cannot understand how man in this country can survive terrible injuries which would be fatal to him in Europe. I would not say that the truth is absolutely respected in this country or anywhere else, but still

There is no doubt that the facts which have been mentioned are perfectly true. Experimenting on a rabbit before a class in the University of New-York, I had announced to them that pushing the instrument as I was about to do, along the cord, would be quite enough to kill the animal immediately. Fortunately for me, I had said that death was due to the hemorrhage accompanying the instrument, and not to the lack of the influence of the spinal cord. After pushing the instrument in for some distance, I found the rabbit which had been operated upon, eating a carrot [laughter]. The class laughed more than you do now, and not at the rabbit but at me. [Laughter.] I could not understand at first what it was due to, and I then pushed the bar of iron its full length, or nearly one-half the extent of the spinal cord, but the rabbit continued to eat its carrot. Fortunately for me and for science, I found that there was no hemorrhage at all. I then took up the rabbit by its ears and showed that there was no bleeding, and explained in that way the persistence of life. What I had said, therefore, was verified by the fact that in Europe death takes place by hemorrhage. This tendency to hemorrhage in European animals is one of the differences between the animals of the two countries, and there are other important differences.

The heart can be stopped by a blow on the belly. Long ago Dr. Hunter had determined this. The fact was known before him, but he insisted on it. But the explanation was not what he thought. But it takes science a long while to move; progress is had slowly; and in this case it was a long time before the facts were generally received and a true explanation reached. Goltz, a physiologist in Germany, has made experiments on a frog, consisting in giving a blow of the finger on the ebly; he has repeated the experiment which had been made so many times on man. Only since his time has it been known that the sympathetic nerve there has the power of stopping the heart's action. I had published different researches showing how it is that in peritonitis, which is an inflammation of the thin membrane in the abdomen, death occurs from lack of action in the heart. It is owing to an irritation of the ramifications of the sympathetic nerve in the abdomen, that the heart's action stops. This is very important to know, as if we possess the means—and we do possess them—of diminishing the irritation that takes place in those cases in the abdomen, we may save the life of the patient. It is well known that the means which frequently save in peritonitis' that is, the use of opium, diminishes the excitability, and in that way prevents the influence on the heart. That influence goes up from the abdomen to the spinal cord, and rises there to the *medulla oblongata*, and then descends from the *medulla oblongata* by the *par vagum* to the heart.

A great many facts which you may observe at water-cure establishments, show the influence that cold possesses, by acting on the skin, in diminishing the action of the heart. There are a great many persons who are said to have no reaction after having been submitted to a cold douche or shower, and there are many who are in danger of dying from this treatment. Indeed, the person I know most intimately is absolutely unable to receive a douche of water without being in danger of dying from a cessation of the heart's action. In experiments made by two friends of mine, Dr. Dickinson and Dr. Bence Jones, they pushed so far the influence of cold water on the skin that they had actually had an arrest of the heart's action. It shows, therefore, that there is danger in the douche or shower-bath, and that persons who have not the proper reaction ought not to continue to expose themselves to such a cause.

There are many other causes that may stop the heart's action. It is perfectly well known that emotion can do it. In all such cases it is by pretty much the same mechanism. Chloroform kills in that way. One or two breathings of chloroform may be sufficient, by the influence exerted on the ramification of the *par vagum* in the lungs, the irritation going up to the *medulla oblongata* and then down to the heart and arresting its action. This is only to be feared, however, in persons whose nervous system is very excitable.

In the larynx we also find what an effect may be produced on the action of the heart. I have ascertained that by putting carbonic acid in the larynxes of animals, the heart's action may be stopped immediately. Still I am bold enough in many instances to push carbonic acid with great violence toward the larynx, when it acts at the same time on the mucous membrane of the mouth, and loses something of its bad effect which consists in the arrest of the heart.

DANGEROUS METHODS OF CURING HEADACHES.

In one instance I found that a mode of curing headaches which is now employed may be liable to fatal results. A friend of mine had a very bad headache. I thought that if I could galvanize the cervical sympathetis in the neck, which goes to the blood-vessels of the head, I should produce a cessation of the pain almost at once. I succeeded admirably, but I almost succeeded in killing my friend. The heart's action stopped, and he was in great danger of death from a galvanization of the *par vagum* which had taken place at the same time I was galvanizing the sympathetic. Since that, I have been more prudent, and have not repeated the experiment. Many physicians, however, galvanize the sympathetic. They do it, it is true, in a way which is different from the one I employed; they apply the currents with more care. Still, I cannot but confess that there is danger in the process.

I pass now to what relates to the arrest of respiration. There is no doubt that the respiratory movements are all due to an activity of cells of gray matter, just as the movements of the heart are; the cells of gray matter, as regards respiration, being placed on the base of the brain and in a part of the spinal cord. The same nerve, the *par vagum*, which goes to the heart, has a set of fibers which, instead of going down, go upward, and toward those cells of gray matter in the base of the brain and spinal cord. So that if you divide the *par vagum*, having one hand by which you can act on the heart and another by which you can act on the brain, you can at will, at one movement, stop the heart's action, and in another stop the respiratory movements. The stopping of the respiratory movement is very peculiar. I have unfortunately no time to enter into details about it. But there are two kinds of nerve fibers able to stop the respiratory movements. There is one kind, according to Rosenthal, going to the larynx, acting by the nerve which is called the superior laryngeal. This stops respiration by the cessation of the diaphragm, which is the muscle that dilates the chest. This is rendered soft and inactive first, as the heart is rendered soft and inactive by the galvanization of the nerve. The other part of the *par vagum* stops respiration by another mechanism quite different, which I shall not stop to describe.

But respiration can be stopped by a great many other means which are important to be known. It is important to know, for instance, that by passing a current of carbonic acid through the larynx, we can diminish the activity of the respiratory movements almost at once.

I have seen convulsions stopped immediately by the passage of carbonic acid in that way, and the respiratory movements themselves may be stopped altogether for a time; and as you are sure that they will return if you stop acting with the carbonic acid, you have there a means of diminishing the influence of a morbid state of respiration.

There are facts which I should have mentioned regarding the heart, which relate also to respiration. If we take a pair of bellows and insufflate air into the mouth of an animal, we find that the activity of the heart is diminished. If we do the same with a view of affecting the respiration, we find that the animal does not then take the trouble to breathe. It seemed to the physiologist that first made the experiment that, as he was giving the animals all the air they needed, they would be perfectly stupid to take the trouble to breathe. [Laughter.] The reality is that they do not think at all about it. I may say that they have no power of thinking, as in many cases the activity of the mind is lost for the time. But even if the mind remains, there is a cessation of the activity of the cells that serve respiration by the irritation of nerve-fibers in the bronchia. I have ascertained for instance that if you divide the *par vagum* in the neck so that the communication between the bronchia and the brain no longer exists, if you insufflate carbonic acid into the lungs there is no more stoppage of the activity. Therefore the stoppage took place through the influence that was propagated in the ramifications of the *par vagum* toward the brain. As Hering has insisted upon, there are many facts which show that the very effort of breathing brings with it a cause that stops breathing. The very fact of drawing in air is a cause which stops the action of drawing in air. He has gone a little farther than I should go in saying that the expulsion of air from the lungs is also a cause of stoppage of expiration. It seems in reality as if these three movements, the movements of the heart, of inspiration, and expiration, had associated with them a cause that diminished them. When that cause is deficient, in morbid states, then we find the movements of the heart becoming exceedingly rapid, and we find the movements of respiration becoming exceedingly rapid and tumultuous. The regulation of those movements belongs to the proper action of those powers of arrest which exist there. As regards the heart, in cases of palpitation, for instance, we have a simple means of diminishing the palpitation; it is breathing in rapidly and forcibly a good deal of air, dilating the chest as powerfully and quickly as we can. In that way an influence is developed which I have found to be the result of the association of the nerve force that goes to the muscles of the chest and the force which descends and stops the heart's action. At the same time that the current goes from the brain to the muscles of the chest to dilate it a current associated with that goes down the *par vagum* toward the heart to diminish its action. In health at every moment this thing takes place. It takes place in a very slight degree indeed. Every act of breathing is an act which moderates the action of the heart. So then there is an admirable provision of nature by which an excessive action finds a moderation in something which takes place usually along with it.

MEANS OF CHECKING COUGHING, SNEEZING, &C.

There are many facts which show that morbid phenomena of respiration can be also stopped by the influence of arrest. Coughing, for instance, can be stopped by pressing on the nerves on the lip in the neighborhood of the nose. A pressure there may prevent a cough when it is beginning. Sneezing may be stopped by the same mechanism. Pressing also in the neighborhood of the ear, right in front of the ear, may stop coughing. It is so also of hiccough, but much less so than for sneezing or coughing. Pressing very hard on the top of the mouth inside is also a means of stopping coughing. And I may say that the will has immense power there. There was a French soldier who used to say, whenever he entered the wards of his hospital, "The first patient who coughs here will be deprived of food to-day." It was exceedingly rare that a patient coughed then.

There are many other affections associated with breathing which can be stopped by the same mechanism that stops the heart's action. In spasm of the glottis, which is a terrible thing in children, as you well know, as it sometimes causes death, and also in whooping-cough, it is possible to afford relief by throwing cold water on the face, or by tickling the soles of the feet, which produces laughter and at the same time goes to the gray matter that is producing the spasm and arrests it almost at once. I would not say that these means are always successful. I would not say that we can always prevent cough by our will; but in many instances those things are possible, and if you remember that in bronchitis and pneumonia, or any other acute affection of the lungs, hacking or coughing greatly increases the trouble at times, you can easily see how important it is for the patient to try to avoid coughing as best he can.

There is also a series of other convulsive movements more or less associated with breathing, and it is very important in those cases to counteract the influence by action on certain parts. There is a form of epilepsy which consists almost exclusively in what Basil Hall has called laryngismus. He had an idea that it was essential to open the trachea and let the patient breathe through an opening there. But this is not at all necessary, even if it did good. Touching the larynx with a sponge charged with a solution of nitrate of silver will very frequently prevent laryngismus, when it has just begun and it has very little power. But in those cases of laryngeal epilepsy, in which the convulsions come from affections caused by a spasm of the larynx, there is no doubt that this device or expedient changes the activity in the muscles, and that activity is enough to produce a cure.

There are a good many other phenomena of arrest. The most interesting are those relating to the brain. I cannot in this lecture speak of more than one of them, and that is arrest of the cerebral activity, of thought, of consciousness. It is well known that in epilepsy cerebral activity is lost. It is well-known, also, that in certain cases of syncope it is lost. In cases of sleep, also, it is lost, except of course in great dreamers, and then there is hardly any consciousness, and in any case the condition is quite different from that of wakefulness. There is an evidence that a theory which I advanced long ago to explain the loss of activity in the brain is only partially true. It was that a contraction or spasm takes place in the blood vessels of the brain, that blood does not circulate there any more, and that, as I then supposed, the stoppage of the circulation causes a cessation of the activity of the brain. But there is another cause in these cases in which there cannot be a contraction of the blood vessels, because the principal nerve which produces these contractions has been divided; and even in those cases a loss of consciousness can take place suddenly. Pricking the base of the brain may cause a complete loss of consciousness in an animal after a division of the nerves that go to the base of the brain. We cannot attribute that loss of consciousness to want of circulation, for the blood may be circulating there. But there is another fact. If we galvanize the *par vagum* so as to arrest the heart's action, there then is no circulation at all in the brain; and if we have galvanized only the part of the nerve which goes to the heart after having divided it, so that there is no circulation at all in the brain, the animal remains conscious for eight or ten seconds. Therefore, when we find in some cases that certain irritation will produce a loss of consciousness immediately, we cannot look upon the loss of consciousness as being due to the cessation of circulation in the brain, as that cessation does not immediately cause the loss of consciousness. In cholera, too, the brain remains active sometimes, although there is no circulation in the brain, although the blood there is perfectly black. It shows that the brain may remain active when deprived of circulation, and even of oxygen. We must therefore admit that there is an active cause which produces the cessation of the activity of the brain in those cases in which it is produced by the cessation of the nervous system.

INDIRECT NERVE FORCE—Third Lecture.

CAUSES OF LOSS OF CONSCIOUSNESS—NO LIFE IN THE HEAD AFTER DECAPITATION—ENORMOUS DOSES OF STRYCHNINE—SUDDEN RECOVERY FROM PROTRACTED LETHARGY—VIOLENT REMEDIES FOR HYSTERIA.

Boston, March 5.—A large audience assembled to hear Dr. Brown-Séquard's third lecture on Nerve Force. He spoke as follows:

Ladies and Gentlemen: I tried in my last lecture to show that nerve power can stop a good many of the most important acts that take place in our system. I have shown that the heart's action can be stopped suddenly; that respiration can also be stopped suddenly, and I shall try to show that our consciousness may also be lost suddenly by an act similar to those which arrest circulation and respiration. Galvanization of a certain nerve in the neck, you know, stops the heart's action. As regards our consciousness there are a great many circumstances in which it may be lost. Those who are in good health know full well that every twenty-four hours they will lose consciousness for a time. Persons out of health may lose consciousness in a state which we call syncope; they will lose it in epilepsy, apoplexy, and in certain forms of asphyxia. In all these cases it is possible to admit that the loss of consciousness is due entirely or chiefly to the contraction of the blood vessels in the brain.

I stated in the last lecture certain facts in opposition to that view. I shall not repeat these; but there is one point of great importance to be noted. There is a nerve in the neck which goes to the blood vessels of the brain and has the power when it is excited to produce a contraction in those blood vessels, so that circulation is stopped in a good part of the brain. There is, therefore, according to the theories which we have admitted for a long time, a cause here for the cessation of the activity of consciousness. But that cause is not the only one at work in the beginning at least of loss of consciousness, either in epilepsy or apoplexy or sleep or in the other states in which we lose consciousness; because in certain experiments I divided that nerve (the sympathetic) so that it could not act normally and produce a contraction of the blood vessels of the brain. The brain necessarily, if the heart continued to beat, received the blood; and in some of those experiments not only that sympathetic nerve had been divided, so that the blood vessels in the brain were gorged with blood—because when that nerve is divided there is more blood in the parts of the brain to which it goes—but, on the other hand, the nerve of the *par vagum* was also divided, and if I applied a galvanic battery to that part of the *par vagum* going to the heart, and which you know, by the last lecture, will produce a cessation of the action of the heart—there was, under these circumstances, a cessation of the action of the heart without any trouble in the brain but that due to cessation of circulation. In that case there was a continuation of the activity of the mind of the animal for eight or ten seconds at least. In these cases the circulation, although improved in some parts of the brain, ceased altogether after two or three seconds, on account of the cessation of the action of the heart, and still there was activity of the brain. As noticed in my last lecture, the activity of the brain will persist in certain diseases—cholera, for instance—although there is hardly any circulation in the brain, and the blood is not at all charged with oxygen, but is dark and considerably altered.

THE PHENOMENA OF ARREST.

But now, if, having matters in the same way—that is, having divided the *par vagum* so that I can irritate the base of the brain without stopping the heart, and the sympathetic has been divided so that there is plenty of blood in the brain—if then, with a needle, I give but a touch to a certain part of the base of the brain, the poor animal, in some instances, though not always, immediately ceases to feel and loses consciousness completely. He loses consciousness, although circulation continues and the brain is full of blood. The loss of consciousness, in that instance at least, is not due to a lack of circulation in the brain. There must be another cause. And that other cause, substantiated by a great many facts which I have not time to mention, is something quite similar in nature to what takes place when the heart is stopped by the galvanization of the nerve that goes to the cells of gray matter within it. It is the same thing that takes place when, certain parts of the nervous system being irritated, respiration stops also. In other words, it is one of those phenomena which have been called inhibitory, or phenomena of arrest.

It is important to know that often very slight phenomena will act very powerfully. A partition of the muscles of the eye in a person with what is called hypnotism is often quite sufficient to change the condition of the things in the state of the brain so as to make the person lose consciousness. In that case there is a condition like that of sleep, with this difference, that, when called, the person will act like a somnambulist.

It has been a question whether there is life left in the head separated from the body. Well, the experiments that show that the irritation of the spinal cord near the *medulla oblongata* will produce a loss of consciousness independently of the loss of blood, which is also a cause of loss of consciousness. These experiments show that the cutting of the neck must also produce a state of unconsciousness. Philanthropists may thus feel assured that persons who are decapitated know nothing of their fate immediately after the blow.

SERIOUS EFFECTS OF SLIGHT IRRITATION OF THE NERVES.

I pass now to another kind of arrest or inhibitory influence. This part of my subject ought to have received the full and thorough investigation which its importance demands; but unfortunately the labor of research has been left to myself up to this time. Surgeons every day have to deal with such cases, and it is a great pity that more workers than an old man like myself do not study the subject. In many instances, under a prick or certain injuries of the nervous system, there is a cessation and sometimes a complete want of that interchange between tissues and blood which we call nutrition. The circulation, though diminished, may remain pretty active; but notwithstanding the persistence also of respiration, not so perfect as in health, though certainly quite enough, we might suppose, to produce a fair condition of the circulation. But notwithstanding the persistence of these two functions of circulation and respiration, we find that the blood in the veins is pretty much like the blood in the arteries. The change of color which we know to take place through nutrition, does not occur, and the blood returns to the heart pretty much as it has been sent out. It is red in the veins and the temperature of the body has sensibly diminished, owing to the lack of the production of heat. The interchange between tissues and blood has ceased. Is this owing, as the other phenomena of arrest of which I have spoken, to the cessation of the activity of certain cells? It is a question yet to be decided. It is very likely that it is. We find these cells of gray matter acting on the various parts in which there is a function for the persistence of life; they are pretty well scattered everywhere. My friend Prof. Lister of Glasgow has pointed out that almost everywhere, even in the walls of blood vessels, he has found cells of gray matter. We may suppose that the arrest of activity that takes place is due to a stoppage of the activity of those cells. Surgeons, as I have intimated, have very frequently to deal with conditions of arrest which are very serious. Under an emotion, or under a wound, under a physical or mental shock, a man may fall down, having the four kinds of arrest of which I have spoken. That is, an arrest or diminution of the heart's action; of respiration; of consciousness, and arrest of that interchange between tissues and blood constituting nutrition. Those kinds of arrest may and do co-exist generally. The degree in which they appear varies; but almost always in the state which we call collapse, those four things are to be observed. I may say that, strange as it may seem to the medical gentlemen present here this evening, one of the most dangerous of those is the cessation of that interchange between tissues and blood. Without any doubt, the cessation of the heart's action will kill after a time; but not so promptly as a cessation of what we call nutrition, which is really life. There are various facts relative to this.

CURIOUS EXPERIMENTS—HOW HORSES ARE QUIETED.

According to a discovery made by Prof. Schiff of Florence—a discovery which has been pushed beyond him by many others—we can very readily produce these conditions. He found that it was quite enough to touch the nostrils, as I do mine, simply passing the finger along the sides of the nose, to stop the activity of the heart and respiration, and stop consciousness in a measure. He did not find, but left another to find it, that interchange between tissues and blood is also stopped. It is well known now that most of those men who succeed in quieting violent horses, put their fingers to that part, and sometimes inside the nares. Merely touching these parts may produce some effect; pressing hard upon them has far more effect. It is not essential that the application be made there, as a pressure of the lip may produce the same thing. In some animals, rabbits and guinea pigs, if we pass needles into their chest and heart, so as to judge of respiration and circulation, we find that the needles stop altogether as we press the lips or part of the cheek. It is not that the poor creature is frightened, as when we have deprived them partly of their consciousness, or almost altogether, by the use of chloroform, the same phenomena occur. There is a very curious fact mentioned by Catlin, who traveled in the West, and wrote two volumes on the Indians. He states that the calves of the buffalo, if they are caught, and the air from the lungs of a man is strongly breathed into their nostrils, will become so fascinated by that peculiar influence that they will run after the horse of the hunter, and follow him five or six miles. It is said, and Mr. Catlin also affirms it, that in Texas, or in other parts of the country where there are wild horses taken by the lasso, if the hunter succeeds in taking hold of their nostrils, and then forcibly expels air from his lungs into the nostrils of the horse, he will follow him anywhere, and become perfectly tame. These facts deserve to be studied. I have heard that when Mr. Rarey acted so powerfully on very violent horses, both in this country and in Europe, he had something to do with their nostrils also. What he did, however, he kept in a great measure secret. That part of the system, at any rate, has a great deal to do in diminishing the activity of the principal organs. It is very natural, therefore, that such a power should be acquired by one who has done such a thing to an animal as intelligent as the horse.

There are other facts of very great importance. Those persons who did me the honor to follow the lectures I delivered here last year know somewhat of my views in regard to paralysis. I will not enter at length on that subject, but I may say that paralysis, anæsthesia, amaurosis, deafness, the loss of any of our senses, the loss of any of the powers of the mind or body, can be produced by a mechanism just similar to that which we know to exist when the *par vagum* is galvanized so as to arrest the heart's action. I will mention a number of facts which show that paralysis, which may appear suddenly, can also disappear suddenly; and if it can disappear suddenly after the cause of irritation has ceased, it is clear that it was that excitation which produced it. There are many cases on record showing that the muscles, of the eye, for instance, or the muscles of the face can lose power under neuralgia, but not a neuralgia at the very place where the muscle that is paralyzed is found. Sometimes the neuralgia is on the other side. Sometimes the neuralgia is in the arm, and it will be a muscle of the face that is paralyzed. But if you cure the neuralgia then the paralysis disappears. In the same way an irritation of the nerves of the teeth can be a cause of paralysis. There are instances of the paralysis of the two lower limbs, as Castle of New-York has shown, that were cured by the extraction of decayed teeth.

Many other cases of irritation of a nerve can produce paralysis. A small worm in the bowels, producing no pain, may cause paralysis. If the worm is expelled the paralysis may disappear in an instant. A worm may produce, as I have seen in two cases, a complete hemiplegia, or paralysis of the whole of one side of the body, and as soon as the worms were expelled the patients were well. Therefore what may seem a trifling cause of irritation of a nerve in any part of the system may produce a paralysis. In experiments on animals we find this better illustrated. The posterior columns of the spinal cord are perfectly well known now, not to serve either for voluntary motion or for the transmission of sensitive impressions to the sensoria. But if we lay bare the spinal cord and merely prick the posterior column, paralysis may be produced, which may disappear suddenly after a time.

An experiment I made in 1854 shows also that the irritation of certain nerves can produce forms of paralysis which are very singular, and which were observed only when the spinal cord or the base of the brain had been injured in a certain way. In those experiments the brain, the spinal cord, and the nerves going to the lower limbs were not at all interfered with. The nerves in the dorsal region that were not divided had nothing to do in a direct way with the lower limbs. Yet when this division was made there was a paralysis of voluntary motion in the lower limbs, a paralysis of blood vessels in the limb on the same side, and a paralysis of sensibility in the limb on the opposite side. This strange combination of effects occurred from a mere irritation of nerves which had nothing to do in a direct way either with motion or sensation, or the state of blood vessels in the lower limbs. Therefore it is quite clear that in these cases an irritation starting from a nerve has gone to distant cells of the gray matter and stopped their activity. Thus we have something similar here again to what takes place when the heart's action is stopped by galvanizing the nerves that go to it.

THE FACULTY OF SIGHT NOT SITUATED IN A SPECIFIC PART OF THE BRAIN.

As regards amaurosis, the facts are very striking. Amaurosis is a loss of sight. I find that in man an irritation of one side of the brain can produce amaurosis in the eye on the same side; it can produce amaurosis in the eye on the opposite side; it can produce amaurosis in both eyes. And it can do something more curious; it can produce a loss of power in one-half of one eye, and that may be the eye of the same side or the eye of the other; and it may be also in two eyes. Here are six kinds of facts which can be produced from an injury in a different part of the brain. We cannot, therefore, admit that an injury has been in a part of the brain serving for the functions of sight, because that would lead to an absurd conclusion; because we find that almost any part of the brain can produce that power, and that would be to locate a nerve center of sight in every part of the brain. In experiments on the *medulla oblongata*, we find also facts which cannot be explained by an injury done to the nerve that we are irritating. I find that almost always an injury to the spinal cord or *medulla oblongata* may produce amaurosis in the eye on the same side; an injury a little higher up in the *medulla oblongata* may produce amaurosis generally on the opposite side. And if we go a little more forward in a part called the *pons varolii*, then the amaurosis is invariably in the eye on the opposite side. All these facts show that an injury to the brain as well as an injury to the nerve anywhere in our system, can produce either paralysis, or anesthesia, or loss of sight, by a mechanism quite similar to that by which nerve cells are arrested in the heart and thereby the heart's action stopped. I pass now to some facts relating to the same question. It is perfectly well known that sometimes physicians have the happiness in the course of an organic disease of the brain to find that they have cured their patient of paralysis. It is a rare thing, but still does occur sometimes. In some of these cases the cure has been produced by simple motion; or caused by a remedy given at the time, which given to certain other patients would not affect them. In these cases strychnia is used with more effect. I will say that if homeopathy has any foundation at any time—though I most certainly believe it has not—it certainly has no value in these cases. Strychnia must be given in great doses to affect a paralysis. It must be given in doses that will produce stiffness in the limbs, and it is at the expense of some fright in the family—but no more; a fright without risk—that a cure is obtained in these cases. That state of stiffness must be persisted in for a given time. In this way you can understand that the view which I have not time to develop has sufficient grounds.

I can understand that when paralysis has been produced there has been an influence starting from the place where the disease is in the brain and acting on cells of gray matter in the spinal cord itself. We well know that strychnia will increase the power of cells in the spinal cord. Therefore it is easy to understand that a dose of strychnine may increase the power of those cells which had lost their force owing to the peculiar influence of nerve force coming from the brain. Now the problem for medical men is, I think, clearly stated. What is to be looked for is not only what I have tried myself to do and many of my medical friends have tried to do, namely, to cure the organic disease that existed in the brain, but it is also to try to break the communication between that part and the cells of gray matter affected, or to try to give to these cells a new activity. Of other remedies having a power in that respect equal to strychnia, I know but very few.

There are a good many other facts relating to the loss of power of the various senses which I had intended to mention, but I shall only state that what relates to deafness and loss of taste or of the power of olfaction is pretty much the same as what relates to the other parts I have mentioned. I can only say that all the functions of the brain can be lost for some time through a trifling influence, just as through a considerable influence they may be irremediably lost. If we can give new life to cells which are at a distance from the place of disease, we may obtain a cure or an amelioration. There is a very singular affection which has been called aphasia. This is a loss of the faculty of expressing ideas by speech. This aphasia may occur by attacks, just as epilepsy may occur by attacks; and it may occur from irritation, just as epilepsy does. That aphasia may disappear very suddenly. In fact, there are cases on record in which the mere cure of neuralgia has cured aphasia. There are cases on record in which the expelling of worms from the bowels has made the patient recover the faculty of speech immediately. Many remarkable instances I am obliged to pass without mentioning. I saw once in London a hysterical girl who had lost completely the power of speech and consciousness almost all the time, I may say, for ten days out of twelve. She was not asleep; her eyes were open. At times she seemed to sleep. She had also a considerable diminution of the power of the heart and the power of breathing. She had, in fact, a great many of the phenomena of arrest which we find to come through an irritation of certain parts of the spinal cord, and that irritation was increased whenever a pressure was made on the spine in the neck. Treating the spine was apparently the mode of cure. The disease was, however, cured one day suddenly. A slightly different irritation had been made, and she suddenly recovered and could not understand that she had been so ill. This is what we call lethargy. This condition is certainly a type of the state of lack of activity of cells, through the influence of irritation acting upon them and producing a cessation.

CAUSES THAT PRODUCE DISORDER OF THE NERVOUS SYSTEM.

My friend, Prof. Bernard of Paris, has made experiments which are very interesting. He shows that anæsthetics, ether, chloroform, &c., act, not by altering chemically or otherwise the properties of the brain, but by an irritation in certain parts. The irritation is propagated to others and stops the activity there. In his experiments chloroform did not reach any part of the spinal cord; but the spinal cord had, however, lost a great deal of its power. So that it was clear in these experiments that anæsthetics acted just as galvanization acted on the *par vagum* when it stops the heart. The irritation affects certain parts of the base of the brain and thus is extended to the cells all through the cerebro-spinal system, producing a cessation of activity. There is a power in us that seems to direct our movements. That power may be stopped by the irritation of certain parts. There are three parts which, so far as I know, are able to stop that power. It is a thing worth trying. If you try to stand on one foot with your eyes closed you will find that very soon you will totter. A state is produced very much like that of drunkenness. I would not say that it will be so with all of you. But I saw many white heads here, and I had these in my mind. It is very natural when a person has turned fifty that his power of directing movement is diminished, his power of balancing is diminished. When the eyes are closed it is very difficult to stand on one foot. That power is almost destroyed and sometimes completely so by an injury to certain parts. It is known that an injury to the cerebellum in animals destroys that power. In men it is very rarely so. Injuries in men are quite different, usually. I found that if a mere prick of the finest needle were made on the part of the spinal cord in birds where the gray matter in the center of the cord comes to the surface, that the prick immediately produced a disorder of movement. Animals affected this way go about as if they were intoxicated. Another part may be the cause of this, and this is very frequent, unfortunately, in this country. When the posterior columns of the spinal cord are diseased to a great extent, this is also what we call locomotorataxy. In all these cases, as my experiments on birds, and the experiments of others on the cerebellum have shown in all those cases, there is an influence or irritation starting from the cerebellum or posterior columns of the cord which goes toward those cells and stops their activity Of course we do not know the location of those parts that serve to balance our movements.

The phenomena of arrest have been very well studied. It is due to a Russian physician, Sekschenom, who studied the reflex power of the spinal cord to react and produce a movement after cessation has come to it, that we know that this power is destroyed or diminished through an influence coming from the brain. It is not rare in cases of paralysis in man that this reflex power is completely lost. In that case an influence is exerted by an irritation starting from the brain, on the cells of gray matter in the spinal cord, destroying their reflex action. This reflex power exists in a very great degree in the spinal cord and *medulla oblongata* in Guinea pigs, on which I have readily produced an attack of epilepsy by a simple process, consisting in appealing to the excessive excitability in these animals when the neck is touched. Sometimes a breath of air on this part is enough to produce a fit. This reflex action of the spinal cord, however, may disappear, and epilepsy be cured by cutting a portion of the skin of the neck. A cut of half an inch has been sufficient in a number of cases. A physiologist by the name of Goltz adds to this the assertion that the power the sympathetic nerve possesses to stop the heart's action, when it is irritated, may be lost.

CONVULSIONS, AND EXTRAORDINARY MEANS OF CHECKING THEM.

I pass now to a completely different kind of phenomena of arrest. That is, the stoppage of convulsions of various kinds. The first I will speak of is a kind of convulsions which we call eclampsia. Very frequently in this case, on irritation of the skin in children, may produce a cessation of the fit. Dipping a child in very hot water, or throwing very cold water on it, may stop convulsions. In other cases the introduction of acupuncture needles, —which the Japanese have employed for centuries, and which we unfortunately do not employ enough—may have an immense power on our nerves. By what mechanism they act is unknown. It is certainly not through chemical process, since they are of platinum, and have no chemical action. An irritation of the fauces or top of the palate by nitrate of silver may stop convulsions.

Ducros, a court physician for whom the Princess Adelida had a great fancy, was an ingenious man if he was not altogather honest. He succeeded in the presence of the physicians in stoping fits or convulsions in children or men, merely by pressing the skin in the neigborhood of the ear. A pressure in the neigborhood of the nostrils may do this. If we are seized with cramps, and can put one foot flat on a very cold floor, the cramps may disappear at once. Or a drawing of the muscles so affected may act on the nerve-cells or spinal cord and stop it.

Hysteria is one of the most singular affections we are subject to. I say we, because even men are so attacked sometimes. A remarkable and successful treatment of this, which I witnessed in Paris, is so peculiar and strange, that if it were not before such a trustful audience, bold and daring as I am, when I am sure of the truth, I should not dare to mention the fact. The daughter of a friend of mine was attacked with a fit of hysteria every morning. I succeeded for a time in breaking up the fit by the use of violent means for a half an hour before the paroxysm was due. But after a time the means I used completely failed. My friend then went to see a gymnast in Paris, named Triat, who was far more daring than I am, and was in the habit of treating hysteria in a very bold and unique way. He used to take his patients, as he did this lady, up a ladder, after having bandaged their eyes so that they could see nothing. After they had ascended to the height of about 20 feet, he made them walk very carefully on a plank that was about seven or eight inches in width. He, of course, was a gymnast, and accustomed to walk there, so that he could easily lead the person forward. When the young lady had reached the middle of the plank, which was pretty long—for it was a large gymnasium—he said to his patient, "Now, you are perfectly safe, and there is no possibility of your fit coming on again." He had previously assured her that this means was infallible; had referred to hundred of previous cases, and exaggerated his success in order to act on the mind of the patient. "Now," said he, "after I have left you, you will not try to lift up the piece of cotton-wool that is fixed on your eyes until one minute has elapsed." He started away and left the patient there in great danger, as you may imagine, of falling. After a minute had passed the patient removed the bandage and opened her eyes. Fortunately for Mr. Triat no accident has ever occurred there. How many patients he cured that way, I don't know; but I know the daughter of my friend was certainly cured. The next day there was no need of taking her up there. She had had enough of it. [Laughter.]

There are many other means that may cure an attack of hysteria. The great point to be remembered is, that faith in the patient in those cases is the principal medicine. Placing the arms in very hot water, as Dr. Cerise has found, will stop the fit. Other means, such as the application of ice on the back of the neck when the patient does not expect it, will also succeed. A ligature tied very tightly around the limb may stop the attack. All the means of counter-irritation may be tried also. But in those cases where it is not through the mind that the attack is begun, it must be through a direct influence exerted by the transmission of nerve force to the cells that were active, thus causing an arrest. Catalepsy may be stopped in the same way. Dr. King found that by drawing on the finger of one of his patients he always succeeded in stopping one of her fits. I have seen one case of the kind myself. Many other means may be successfully employed in catalepsy as well as hysteria.

NERVE DERANGEMENTS — FOURTH LECTURE.

EPILEPSY, INSANITY, PARALYSIS, AND HYSTERICAL AFFECTIONS—CUTTING THE HEAD OPEN NOT NECESSARY IN CASES OF BRAIN DISEASE—EXPERIMENTS ON DECAPITATED MEN—MOVEMENTS OF THE BODY HOURS AFTER DEATH—A CASE OF ECSTASY.

BOSTON, March 8.—Those who braved a night's violent storm to hear Dr. Brown-Séquard were disappointed if they expected a dry season at the Lowell Institute. The lecture was as instructive and as entertaining as those that preceded it.

LADIES AND GENTLEMEN: I tried last Wednesday night to show that a good many disorders in our system may result from the stoppage or arrest of the activity of certain cells of gray matter. I shall now conclude this part of my subject. Tetanus or lock-jaw is one of the convulsive affections which can be stopped immediately by certain influences coming from certain parts of the system. The kind of tetanus that strychnine will produce can be stopped at once, as Rosenthal has discovered, by insufflating air into the lungs. He thought that it was the oxygen that stopped the attack; but I have ascertained that carbonic acid will also stop the convulsions. In the same way other physiologists have ascertained that a current of galvanism applied in a peculiar manner will, in many instances, stop the tetanus excited by strychnine; not always saving the animal, but lengthening the life and giving a chance of recovery. Tetanus, which comes from wounds or injuries to nerves, may also be stopped. Chloroform, either applied along the spine or taken internally, in both cases may produce an irritation of nerves and act on the cells of gray matter in the spinal cord. So that the mechanism of the arrest of convulsions in tetanus is just the same as the mechanism of the arrest of the heart in the case of the galvanization of the *par vagum* in the neck. I have already mentioned that epilepsy can be stopped by a mechanism of that kind. And I may add that when an attack of epilepsy is to begin, when there are certain symptoms indicating it, a great many means, indeed, can be used to prevent it. An irritation of almost any part of the skin may be sufficient to stop an attack, and the irritation itself may be of a great many different kinds. Yet in each individual case it is impossible to say *a priori* that one method that has succeeded many times with other patients will succeed with the one you have to deal with.

TRUE THEORY OF LIGATURE IN EPILEPSY.

There are cases in which there is what is called an aura starting from a limb. From the time of Galen to our own, it has been shown a great many times that a ligature bound around the limb in which this influence takes place, will stop the fit. The supposed philosophy of these cases was that something started from the limb that went to the brain, and that the ligature being applied prevented that something from passing. I have shown that the process by which the attack is prevented is just the opposite of that. Instead of preventing something from passing, the ligature irritates the nerves in the skin and sends a current toward the brain changing the state of the cells there and preventing an attack. This has been shown very clearly indeed in a great many instances that I have seen, especially since 1860, when I was connected with the Hospital for Epilepsy, at London. At that hospital I had a very intelligent nurse, to whom I had given the proper directions. There were three or four patients there, who had this particular kind of symptom. In these cases, when the nurse was not far from the patient, or when she had time to be called to them, she invariably prevented the attack. In one of those cases, that of a clergyman's daughter, there was paralysis on one side of the body and convulsions, chiefly in the paralyzed limbs, extending to the feet; always beginning by the contraction of the foot on that side. As soon as the nurse heard that an attack was pending, she rushed to her patient, and immediately pinched her first on the foot or leg of the side which was to be convulsed, and afterward on the healthy side. In every case the patient was saved. Still, it is not a rule that the fit will be stopped when there is such an aura. Sometimes the ligature and the pinch will fail, and other means must be used. For instance, in patients having some trouble internally, the relief is found in giving at once something which will irritate the nerves of the stomach very powerfully: either brandy, or gin, or rum, or ammonia, or some similar medicine. And if the stomach be empty the chance of preventing an attack is greater. An immense number of facts show that it is almost always possible to save epileptic patients from an attack if there is time enough to apply the proper means. There are other facts which show that an attack may not only be prevented, but that epilepsy may be cured by means of irritation of certain nerves in the periphery of the body. Unfortunately, however, the means that I now mention, though they have been accidentally employed with great success, are too hazardous to be generally employed. There are many cases of epilepsy that have been cured by a mere accidental burning, by a fracture of the limb or by the wounding of a limb or part of the trunk. In fact, an irritation in any part of the system may sometimes be the means of curing. Unfortunately, we do not know when we deal with epileptic patients what chance there will be in irritating one part rather than another, and we cannot torment our poor patient to death by trying the whole surface of the body to see what will best serve to irritate the nervous centers.

CURING INSANITY BY IRRITATING THE NERVES.

Another kind of stoppage or arrest of the activity of cells consists in the arrest of the morbid activity of the brain. In treating of epilepsy I have spoken partly of this subject, but what I have to say now is distinct from what I have previously said. Take a patient who is insane. There are many cases published in the medical journals, relating to insanity, showing that a large number of patients have been cured suddenly by means of irritation of the skin, that was either accidental or employed by a physician. There are other means more curious and equally effective, as in the case I am about to mention. A patient in a lunatic asylum met another one, who struck his head and broke the cranium on the right side. The brain oozed out; a good deal of it was lost, and the patient was cured of his insanity and epilepsy. [Laughter.] This is rather a dangerous means of treatment, however, and of course I speak of it only to show that an irritation brought to the brain may often cure. It is in that way that bold surgeons—as many there were in this country in the period from 1825 to 1859—who have brought their instruments to the cranium and made an opening there, in cases of epilepsy, in search of a disease at that place that did not exist, have very frequently cured their patients. But not because they have taken away the disease that they supposed existed there, but because they have produced an irritation which has done it. But I may add that it is not necessary to open the cranium, though it has been done, to my own knowledge, more than fifty times in this country. All that is called for is an irritation of the skin of the cranium and of the fibrous band that covers the bone between the skin and brain. Irritation there has a very good chance of curing epilepsy in many very obstinate cases. There are many cases on record showing that an inflammation in almost any of the organs of the body is sufficient to check insanity. In the same way other affections of the brain, such as amaurosis or paralysis, may be cured suddenly sometimes without any cause that we can find, but with good ground certainly to believe that an irritation has acted which has produced a change in the cells of the brain and diminished their morbid activity. For there are clear cases in which those affections have been cured by such irritation. Those alterations of cells that were producing an arrest of the power of sight or paralysis, have been submitted to an irritation of parts of the skin or of some viscus, and this irritation going to the morbid part and producing a change in the activity of those cells, has cured the disease. So that a double mechanism of arrest may take place in all these cases. There is in the brain an irritation starting from the place where there is a disease. That we can see after death. That irritation goes to parts at a distance and acts on cells to stop their activity; but another irritation starting from some parts of the body goes to the parts that are diseased and there acts on the morbidly active cells and stops their activity, so that the effect that resulted from the disease ceased. So one phenomenon of arrest produced the cessation of another.

CAUSES AND CURES OF PARALYSIS.

In reference to paralysis a view is held which seems to be in opposition to what I have said here. Paralysis is considered to result from a cessation of activity of a part of the brain from disease. Let, for instance, a disease exist in that part of the brain that we call the anterior lobe. That part is considered as being in great measure the seat of the will. That part is destroyed by disease, and we find a paralysis; and the view is, as I have said, that the paralysis results from a cessation of the activity of that part. If we admit this view, then there is no need of accepting what I have taught here: that an irritation starts from a place that is diseased and goes elsewhere to produce an arrest of the activity of cells. But that view is entirely in opposition to facts. We see every day that a disease which is exceedingly limited in extent in the brain can produce the most complete paralysis, while, on the other hand, we see that disease which has destroyed an immense part of the brain may not produce a paralysis at all. It is impossible to conclude that paralysis proceeds in a direct way from the destruction of tissue that we see after death. There must be an intermediate agency between the seat of the disease and the paralysis. And that intermediate agency is what I have tried to make you understand in saying that the irritation starts from the place where the disease is, and goes to other parts of the brain, and also to the spinal cord, to stop the activity of those parts. It will be evident to persons here who know a little about anatomy, that it is impossible to admit the old view about paralysis. In the base of the brain there is an organ which is called the *pons varolii*. This is the only part by which communications take place between the brain and the spinal cord and the rest of the body for voluntary movements. There is also another part in front which is called the *crura cerebri*—legs of the brain. That part is composed of two halves, quite distinct one from another. Let us suppose that there is a disease either in one part of the *pons varolii* or of the *crura cerebri*, and that disease has destroyed a small part of one of these. What shall we say if the view that most all physiologists have is correct? Why, that the destruction of one part of the *crura cerebri* or *pons varolii* necessarily will produce a paralysis in some muscles of one-half of the body. But that is not what we see. In cases of disease there, the paralysis may exist in the same side of the body where the disease is or on the opposite side. It may be in one arm only or in one leg only. The facts are altogether in opposition to the admitted view. You may see also cases in which the *pons varolii* is destroyed without any paralysis at all. We should say also, according to the common view, that a disease that has destroyed only a few of the fibers would produce only a paralysis of some of the muscles. There are no such cases on record. It is essential to take another view of this matter. I have proposed this explanation: that paralysis appears only from an irritation which starts from the place where the disease is, and acts upon parts at a distance so as to modify them. All of you know that a tickling of the soles of the feet produces different effects in different people. So we can easily understand that an irritation in the brain which will produce a complete or a partial paralysis in one person will produce no paralysis in another, according to the excitability of different people. Take the facial nerve now. That nerve in almost all persons who have a chronic disease of the brain is partially paralyzed, perhaps only a few fibers of it. Well, as the disease which produced this paralysis is limited in every instance, and as the disease may occupy every part of the brain, if we conclude that paralysis comes because the nervous center of the facial nerve is destroyed, we would have to place that center in every part of the brain; in one individual in one part; in another individual in another part, and so on. And as we find cases in which a destruction of a considerable part of the brain does not result in that paralysis, we would have to conclude that some individuals do not receive that nerve in their brain. This is a *reductio ad absurdum*. We have therefore to throw overboard that theory.

HALF THE BRAIN EQUAL TO THE WHOLE.

There is one point about which I should like to deliver a whole lecture. I can only say now a few words in regard to it. It is a most important topic. A study of the facts relating to the brain has led me to conclude that each half of the brain—paradoxical as it may seem—is a whole brain. That is, that one-half of the brain is sufficient for all the functions of the two halves of the brain. If that is the case, I must mention a conclusion, although it may seem outside of my subject. It is that we are extremely neglectful in educating only one part of the body. We educate our right arm and make use of the right side of the body as much as possible, and leave the other side inactive, except in walking. We do not perform what is really needed if we have two brains. There is no question that it is our habit of making use of only one side of the body, that consigns to one-half of the brain—the right side—the faculty of expressing ideas by speech. If we developed both sides of our body equally, not only would there be the benefit that we could write or work with the left hand as well as with the right, but we should have two brains instead of one, and would not be deprived of the power of speech through disease of one side of the brain.

I pass now to quite another subject. You know that in the second lecture I said that I would examine two series of facts, one showing the power of arrest of activity that nerve force possesses, and the other having just the opposite object, that is, to produce an activity instead of an arrest. I now come, therefore, to the study of the production of the various kinds of activity that the nerve force possesses. The first question I have to examine is that which relates to the influence of nerve force in producing muscular contraction. It is essential first to say a few words on the power of muscular contraction and to see if that power is distinct and independent of nerve force. There have been a good many different views about this; but as I have little time I shall only say that the view is almost universal now that the nervous system is not essential to the existence of muscular contraction or irritability; that contraction can take place without any interference of the nervous system. My friend, Prof. Bernard of Paris, made some ingenious experiments on this subject. He found that the poison woorari affects the motor nerves in muscles, so that the conductors which unite the brain with the muscles become paralyzed, while the muscles remain active. He drew the conclusion that muscles remain connected with the brain as regards their activity. But there is an objection to this which I put forward long ago. It is not clear at all that in that case the muscular power in the fiber is lost. There is a state of things, anatomically and physiologically, inside of the sheath of the muscular fibers, which renders it very doubtful that the woorari acts upon those parts, and it may be that the nerve power remains inside of the sheath of the muscular fibers. The same objection can be made to the facts relating to the section of nerves.

A MAN STRONGER WHEN DEAD THAN ALIVE.

It is well-known that if a nerve has been divided, after four days it loses its power. The muscles, however, remain perfectly active, and we can produce contraction in them. Unfortunately, here, also, there is an element of nerve tissue, which is inside of the nerve sheath, and it is not known whether it has lost its power or not. In the case of two decapitated men, I made an experiment of cutting off the arms. I found, after thirteen and a half hours in one case and fourteen hours in the other case, that all signs of life in the limbs had disappeared. Up to that time, either galvanism or a shock produced by a blow with my arm or a paper-cutter, caused the muscles to respond to the irritation. I then injected the blood of a man into one of those arms, and the blood of a dog into another. In both cases local life was restored in those arms. The muscles became irritable again, and the strength of contraction was extremely powerful. Indeed, in the arm in which the blood of the man had been injected, the power was immense. It was greater certainly than during life. There was therefore a return of muscular irritability after it had disappeared, and nervous excitability had not come. The nerves remained quite dead. Therefore it seemed quite clear that the muscular irritability depended upon nutrition by blood and the oxygen in it. The blood injected was richly charged with oxygen and that was the reason why the muscular irritation became so great. There was more oxygen than usual. As the nerves had not regained any power at all, it was not through any influence of the nerves on the muscles that the part had re-acquired life. There also we find, however, that same objection, that we do not know whether the elements of the nervous tissue which are inside of the sheath of muscles had lost their power or not.

But there are other facts more decisive. Professor Simpson of Edinburgh examined the power of contraction in the umbilical cord—the cord which unites the fœtus to its mother. In that cord the contraction by galvanism was made with great intensity. Some physiologists have thought that there are no nervous centers there. If there are any, they are very small. In the iris of an eye I have found a singular fact. Long ago I had discovered that light can affect the iris of the eye, even when it has been removed from the body. The eye of the eel had been removed from the body for sixteen days and kept at a temperature of about 36° to 40° Fah. But I found that although the eye was in almost complete putrefaction, the light still acted as an irritant of muscular fibers. There it was impossible to admit that there was nervous action. The muscular fibers themselves were considerably altered. Still they acted.

But there is a fact which is more decisive to show that muscular irritability is independent of the nervous system for its existence. It is that if we strike a muscle that is dying away, we produce a ridge at the place we strike. All the fibers in the muscle contract at that place. And as it is impossible to admit that in those cases there has been a nervous action in every elementary fiber, because the parts I spoke of, which are inside of the sheath, are generally in the middle of the length of the fiber, and any part of the muscle may react in that way, it is, therefore, impossible to admit that there is any nervous action in those cases. Therefore, they show that muscles are independent of nerves for their action.

I pass now to a class of movements which we call rhythmical. It is well known that the heart performs them. It has been questioned whether these movements depended on the nervous system. There is no question indeed that in a normal state—I do not say in every state—the rhythmical movements of the heart depend upon cells of gray matter which are inside of the heart itself. The diaphragm, the most important of the muscles of respiration, possesses, like the heart, the power of contracting rhythmically quite independent of the brain, the spinal cord, and the *medulla oblongata*. In almost all experiments we find that when we destroy the brain or *medulla oblongata* we destroy the movement also of the diaphragm; but that is by the phenomena of arrest. We arrest the movements of the diaphragm there as we arrest the movements of the heart when we galvanize the *par vagum*. But if we operate in a certain way we may succeed in separating the diaphragm completely from the spinal cord by the dissection of the diaphragmatic nerves, and we may see the diaphragm continuing to act perfectly in a rhythmical way. We see it even when we have rendered the warm blooded animal on which we operate almost cold-blooded by diminishing the temperature constantly. The diaphragm, therefore, possesses the power in itself of rhythmical movements.

MUSCULAR MOVEMENTS AFTER DEATH.

What is the duration of those rhythmical movements when the parts are separated from the body? It has been found that 48 hours after the heart has been separated from the chest of a dog it continued to beat. There is recorded the case of a man at Rouen in whom the heart was found to beat for 36 hours after the death of the body by decapitation. There is therefore a possibility of long persistence of life in those organs. And I dare say that the great cause why we see those organs stop at death so quickly, is that the phenomena of arrest of their activity have taken place at the time of death.

There are many other parts that possess rhythmical movements; the great vessels near the heart; the arteries of the heart in certain animals, as Prof. Shiff has discovered; the vessels of the wings of the bat, as Wharton Jones has discovered, and the excretory canals of either the liver, or the pancreas, or kidneys in some animals. Then also certain parts of the digestive apparatus of birds, separated from the body, may continue to act rhythmically. Indeed, I have found that every muscle in our system, as well as in animals, can in certain circumstances, have perfect rhythmical movements; so that these regular movements do not depend on a peculiar organization belonging either to the heart or to the diaphragm. It is a property which every contractile tissue possesses, and which shows itself only in certain circumstances different from the ordinary circumstances of life.

The next point I shall mention is that movements voluntary in appearance can exist without nerve force. In that respect a very singular fact has come to my knowledge in a positive way. I was called once to see a patient who was indeed no more a patient; he had died before I reached him. I was told that he was making certain movements, and his family and friends all thought he was alive. I examined him and found that he was certainly dead without any chance of returning to life, at least according to our very limited knowledge. I found that he was performing slowly movements that he had been performing with great vigor before I came. He would lift up his two arms at full length above his face, knit the fingers together as in the attitude of prayer, then drop the arms again and separate them. The movements were repeated a good many times with less and less force, until at last they ceased. These singular movements, to persons not knowing what may take place in the human body after death, must certainly have looked as if the will-power had been directing them. Evidently there was no such thing there. The heart had stopped beating; the respiration had ceased for a long time. The appearance of the eyes and of the other parts of the body were those that we observe in death. There was no trace of sensibility anywhere; no reaction to the operation of galvanism or burning anywhere, as I had to make use of these means to satisfy the family. A needle was pushed into the heart, as there was no danger from this experiment, a certain physiologist having, for the mere sake of showing what the Japanese had done that way, introduced one many times into his heart. The needle introduced showed that the heart of my cholera patient did not beat. But what I did not do, the proof I did not have in this case, Dr. Bennett Dowler of New-Orleans has given. From patients who died of yellow fever or cholera—and it is chiefly in those cases that involuntary movements resembling voluntary ones occur after death—Dr. Dowler has amputated limbs. It was a bold undertaking; but Dr. Dowler has done it, and the limbs amputated continued to move after having been separated from the nervous centers; so that if there was nerve force acting, then it was nerve force existing in trunks or nerves and not the nerve force that comes from the will. Those movements, I repeat, resemble voluntary movements.

EXTRAORDINARY FEATS CAUSED BY DISEASE.

There are movements which of course require more force, but which resemble those movements in not being directed by the will. The field of pathology is indeed very rich in cases in which all sorts of movements resembling voluntary movements are made by patients who, however, are not trying to perform those movements. There is one case especially of a young lady in Paris who was attacked with ecstacies every Sunday, and who performed a feat the thousandth part of which not one among you could perform unless you were diseased like her. Every Sunday at 10 o'clock the young lady ascended a bed, and putting her feet on the top of the edge or border of the bed, took an attitude of prayer and began to address prayers to the Virgin Mary. She continued in that attitude, fixed like a statue, except that her chest continued to move and her heart to beat, and the lips were giving utterance to sound. All the other parts of the body were absolutely motionless. This was a feat that you could not perform on level ground. Standing rigidly on tip-toe, even without shoes, is an utter impossibility, beyond a short time. I ventured to try my own power on the border of that bed, and fell immediately. [Laughter.] I was not ready to try it again, as there was no doubt that the thing was impossible. I had been called by the agent of police to see whether there was disease there, or whether it was a false pretense to make money, as the family of the girl was poor, and many came and paid for the privilege of witnessing her attitude in prayer. It was clear that there was disease. I made an experiment which proved it.

There are other movements which are performed without the will. Some of these are very singular. Sometimes it is a movement forward, sometimes it is a movement backward as fast as possible; then movements sideways, or a movement like a horse in a circus, or a simple rotation executed on the same place on the feet. What may surprise many persons, there are two cases to my knowledge in which these rotary movements, instead of being performed as I just performed them, were performed with the head on the ground. [Laughter.] The feet were against the wall, without which, of course, this action would be impossible. The patient turned with a rapidity that was wonderful. No person with will-power could have done it. The head spun around as if it were a top.

In another case, I saw a most beautiful Irish girl who had a blow on the head and who had a rotary movement on that account. She knew well what was the matter with her, and had come to be able to prevent any bad effect of it. If she wanted to go in a contrary direction she turned herself in a direction almost at right angles to it, and the irregularity of her movement brought her to the right place. [Laughter.] She knew the amount of her rotation, her deviation from a straight line, and calculated accordingly. So when she went along the stree she executed a series of half-circles and in that way succeeded in going forward. She was in perfect health otherwise. She could not help this. There was an irresistible power pushing her so. Her will force could not overcome it.

The most singular of these rotary movements are those that the ear will produce. An injection of cold water in the ear will produce a very great change sometimes. In a curious book of a Frenchman of Alsace—perhaps he is a German now [great laughter]—there are, I dare say, more than three or four hundred of those strange cases of rotary movements or change of direction by something acting against the will. These diseases are particularly common in women, and a great many of the cases are allied to hysteria; but they exist from an organic cause in man sometimes also.

SUMNER'S SUFFERINGS—Fifth Lecture.

PROFOUND EMOTION OF THE LECTURER—CONSEQUENCES OF IRRITATING PARTICULAR NERVES—PEOPLE SAYING THINGS THEY DON'T WANT TO SAY—SNEEZING 50,000 TIMES IN 82 HOURS—TREATMENT ADOPTED IN SUMNER'S CASE—WHY AND HOW HE ENDURED THE TORTURE.

Boston, March 15.—Dr. Brown-Séquard's fifth lecture on Nervous Force would regularly have been delivered on March 11, but a summons to Washington to attend Mr. Sumner postponed the delivery until last evening.

It was evident when the lecturer appeared on the platform that he was suffering much agitation. Some moments elapsed before he could obtain possession of his voice, and when he did speak there was a tremulousness in the utterance which showed the deep emotion that swayed him. His allusion to Mr. Sumner in opening his lecture was more affecting than a simple report of his words can indicate. When, after talking a half hour, his subject led him once more to return to Mr. Sumner's case, the Doctor broke down completely, and was obliged to ask the audience to excuse him for the remainder of the evening.

Ladies and Gentlemen: For the second time in lecturing here I have to beg your forgiveness for being moved in the way that I am. Since 1857 the eminent man that has left us has been under my care, and has been also a very dear friend. I sympathized with him in every one of the generous impulses that led him to occupy such a high rank in the history of this country. And therefore it is easy for you to understand that I am now hardly able to say more about his greatness, and the blow that our country and you in this city, and I, as his friend, have received. In a few minutes, when a little more master of my nerves, I shall have to say something about him professionally; something which I have never mentioned but to a few friends, as so long as he lived I knew that a modesty by far greater in him than anybody knew, would have been wounded if I had spoken it aloud as I shall to-night.

EXTRAORDINARY CONSEQUENCES OF IRRITATING THE AUDITORY NERVE.

I now come to the subject of this lecture. You remember that in the last lecture I gave facts to show that the greatest disorders may occur repeatedly and almost constantly under the influence of the irritation of the nervous system. I shall now mention a few more of these facts. When we inject cold water in our ears, we remark that peculiarly disorderly movements come at once. In certain animals, if we prick a certain nerve—the auditory nerve—we find that a number of strange phenomena will occur immediately. In the first place, when the poor creature tries to move, it turns around and around. It is hardly in its power to walk straight forward. It turns around like a horse in a circus. But what is more surprising, what answers in the animal to the left arm, on the opposite side to that where the injury was made, is drawn backward in what we call torsion; that is, the thumb, or what represents it, is turned outside, and this connection remains always the same as long as the animal exists. Besides, there is a considerable increase in the susceptibility of the skin. Frogs, as you well know, very rarely produce a sound of the voice, but they shriek under this treatment very frequently.

In superior animals, and in the mammals particularly, an injury to that nerve produces also very frequently great disorderly movements. Those phenomena have been considered as depending on something else than the irritation of the nerve; there are semi-circular canals in the ear which have been considered as having peculiar power. But I think the question is clearly decided, for in frogs we can reach the nerve without touching at all these semi-circular canals, and we produce these phenomena I have mentioned. It is thus certain that the nerve of audition has a power in that way to produce very disorderly movements.

In man an affection of this nerve is frequently followed by the greatest disorder. I have been called more than once to see patients who have been considered as afflicted with a serious affection of the brain, but who had nothing but an affection of the auditory nerve, more or less quickly controlled, and at any rate not threatening a fatal termination as the supposed disease would have done. In one of those cases an abscess in the mastoid bone, behind the ear, was the cause of all the trouble. The abscess was opened and the patient got well. I saw the patient at Elmira, and the able physician who performed the operation, and the cure was perfect.

INABILITY TO BRIDLE THE UNRULY MEMBER.

There are some other cases which consist not merely in a disorder in movement, but also in some disorder of the mind associated with it. There are cases in which, through some irritation, a patient will utter certain words and not always the most desirable words. A most eminent mathematician—one of the four or five most able and ingenious mathematicians of the age—is suffering from this affection. He is certainly, as regards power of mind, above most men with whom I am acquainted. But very frequently, under this affection, a word, and often one which no man in society ought to utter, will come to his lips. He has sometimes the power of contracting his lips before the sound comes out, so that he may be saved from the mortification of being heard. But sometimes it occurs with such rapidity that it is uttered fully, and the poor man has the mortification of saying something that very few educated men would say. [Laughter.] My friend Dr. E. C. Seguin related the case of a clergyman who was troubled in this way, and whose affection took a peculiar form. Immediately after having begun the Lord's Prayer, after having said, "Our Father which art in Heaven," he invariably exclaimed, "Let Him stay there." [Great laughter.] Of course he had to give up preaching.

A lady of the highest nobility in England had to leave court for a similar reason. She gave utterance to the most unpleasant things for people to hear: "You are very stupid:" or, "This is a madness in you." And she said those things to the Queen or to anybody else, and that quite suddenly, frequently interrupting a conversation for the purpose. In two of those cases, that of the mathematician and the lady, both of whom I have seen, I have ascertained that the affection was dependent on the irritation of certain parts of the stomach and bowels.

Once a patient, a young lady, was brought to me by her father. My office was up stairs at the time. I happened to be down stairs when the gentleman came. I asked him to go up, and told him I would follow in a few minutes. The father turned to me and said, "Please pay attention." I did not know what he meant, but I said, "Is your daughter so very ill?" "Oh, no, but just listen." I listened, and just then the lady called out, "Hoo! hoo! hoo! hoo!" (imitating a peculiar unreportable tone, in which the sound was uttered.) His daughter was afflicted with that peculiar trouble which has no name in science, which consists in the ejaculation of the sound of a word. Some of those patients, especially those who are hysterical, bark like dogs; which has given rise to the name hysterical barking.

There are many other facts which show that even attacks of the great convulsive affections may be brought on by a mere touch, or mere tickling. When I was lecturing in St. Bartholomew's Hospital in 1858, a young patient came to consult me, who was an epileptic, and who could not be touched in the back part of his head without having an attack. He committed suicide soon after. His fellow-students there had the cruelty to press on the back of his head very frequently. As he had no chance in life, he thought, except in the study of medicine, and as he could not endure the treatment he received there, he was thrown into despair, and so committed suicide.

CONVULSIONS AT A TOUCH—NERVES GOVERNING BLOOD-VESSELS.

My very able friend, Prof. Edward H. Clarke, has found in one of his patients that the touching of the breast brings on a fit of epilepsy. I have seen a number of cases in practice, in which the irritation of one part of the skin produced an attack immediately. In Guinea pigs, as I have said, it is quite enough to tickle the neck, or sometimes it is apparent to blow upon the neck to have an attack appear. Tetanus may be excited in the same way. It is so frequently in hydrophobia, the touch of the wound produced by the bite of the dog being enough to occasion an attack.

A friend of mine, Dr. Bastian of Paris, has seen a case of hysteria in a man who had a tumor in the ear which could hardly be touched without some convulsive phenomena occurring. The tumor was removed and the patient recovered. Catalepsy is of the same category. It can be produced in some persons by merely striking the body. I had one case of that kind in London. The patient was the daughter of a physician there. A simple touch of a part of the spine was sufficient to produce an attack. Chorea and a good many other affections may be thus produced. In one case, sneezing was performed 50,000 times, according to the record of a physician, in 82 hours, owing to the simple irritation of the auditory nerve. When that was cured, the patient ceased to sneeze.

The next series of facts I have to speak of consists of alterations of nutrition excited by nerve force. For many years, before a great discovery was made as regards the action of a certain class of nerves on blood-vessels, there were physiologists who admitted that blood-vessels were controlled by nerves; but facts had not been brought forward proving it positively. I had an opportunity with a friend of mine, Dr. Tholozan, who is now the eminent physician of the Shah of Persia, to see how nervous influences can be exerted on blood-vessels from dipping one hand into cold water. If one hand is dipped into water at nearly freezing point, we find that the blood-vessels of the other hand are contracted, and as a consequence of that, there is a diminution of temperature. In one case this diminution of temperature was so great, owing to the lack of circulation there, that my friend lost 21° Fah. in ten minutes, the temperature of the air being very low that day. We found that on certain days we were more excitable than others. The mechanism was simply this: The irritation of nerves in one arm, when dipped into water, is propagated by the spinal cord and goes to the blood-vessels in the other hand and produces a contraction there, which remains, so that no blood reaches the part. Such an effect we sometimes see in people from an exposure to cold air, which may produce what Marshall Hall calls *digitis semi mortuis;* that is, fingers half dead. The fingers seem to be dead, and really there is no circulation in the part. How life can be maintained there is a mystery. It may last sometimes for days without gangrene. Most likely there is some serum there which receives oxygen, just as the serum in the cornea receives oxygen when that part is wounded. But at any rate it seems mysterious that there is no decay when there is such an absence of circulation. When we galvanize the cervical sympathetic in the back of the neck we produce a contraction of the blood-vessels of the face immediately, and all the consequences that I have noted as following such a contraction. There is a diminution of the temperature, a diminution of the sensibility, a diminution also of the vital property. If the reverse is done, if the nerve is divided instead of galvanized, then we have an opposite effect. The blood-vessels are paralyzed; they dilate considerably. There is more blood because the channel is more open. The heart sends blood with the same force everywhere; but if one part of the system is more free it receives more blood, and in consequence of the greater influx of blood there is an increased temperature, an increased sensibility, and an increase in the vital property of the part.

When I made my first experiments on the galvanization of the sympathetic, I came to the conclusion at once that those nerves most likely came in a measure at least from the cerebro-spinal system, although they belong to what we call the sympathetic nerve. I was led to this conclusion by facts which I have no time to mention. But the great point is this: I ascertained by a few experiments that it is chiefly from some nerves there, the first, second, and third dorsal nerves in the spine, that the sympathetic receive those branches. This fact was put in a more clear and forcible way by two other physiologists, Dr. Budge and Dr. Waller.

THE TREATMENT OF CHARLES SUMNER.

When, in 1857, I saw Mr. Charles Sumner for the first time, he presented to me at once symptoms which I could not but recognize as dependent upon an irritation of some fibers of that sympathetic nerve, and a paralysis of others. As you know, he received a terrible blow upon the head. His spine as he was sitting had been bent in two places, the cranium fortunately resisting. This bending of the spine in two places had produced there the effects of a sprain. When I saw him in Paris he had recovered altogether from the first effects of the blow. He suffered only from the two sprains of the spine and perhaps a slight irritation of the spinal cord itself. He had two troubles at that time. One was that he could not make use of his brain at all. He could not read a newspaper; could not write a letter. He was in a frightful state as regards the activity of the mind, as every effort there was most painful to him. It seemed to him at times as if his head would burst; there seemed to be some great force within pushing the pieces away from one another. Any emotion was painful to him. Even in conversation, anything that called for depth of thought or feeling caused him suffering, so that we had to be very careful with him. He had another trouble resulting from the sprain which was at the level of the lowest dorsal vertebra. The irritation produced was intense and the result very painful. When he tried to move forward he was compelled to push one foot slowly and gently forward but a few inches, and then drag the other foot to a level with the first, holding his back at the same time to diminish the pain that he had there. It had been thought that he was paralyzed in the lower limbs, and that he had disease of the brain, and the disease of the brain was construed as being the cause of this paralysis of the lower limbs.

Fortunately the discovery made of what we call the vasa-motor nervous system, led me at once to the conclusion that he had no disease of the brain and had no paralysis. He had only an irritation of those vasa-motor nerves, resulting from the upper sprain in the spine. That irritation was the cause of the whole mischief as regards the function of the brain. The other sprain caused the pain which gave the appearance of paralysis. When I asked him if he was conscious of any weakness in his lower limbs, he said, "Certainly not; I have never understood that my physicians considered me paralyzed. I only cannot walk on account of the pain."

What was to be done was to apply counter-irritants to those two sprains. That was done. I told him that the best plan of treatment would consist in the application of moxas, and that they produced the most painful kind of irritation of the skin that we knew. I urged him then to allow me to give him chloroform to diminish the pain, if not take it away altogether. I well remember his impressive accent when he replied: "If you can say positively that I shall derive as much benefit if I take chloroform as if I do not, then of course I will take it; but if there is to be any degree whatever of amelioration in case I do not take it, then I shall not take it."

I did not find courage enough to deceive him. I told him the truth—that there would be more effect, as I thought, if he did not take chloroform. And so I had to submit him to the martyrdom of the greatest suffering that can be inflicted on mortal man. I burned him with the first moxa. I had the hope that after the first application he would submit to the use of chloroform; but for five times after that he was burned in the same way, and refused to take chloroform. I have never seen a patient who submitted to such treatment in that way.

I cannot conceive that it was from mere heroism that he did it. The real explanation was this: Heaps of abuse had been thrown upon him. He was considered as amusing himself in Paris; as pretending to be ill. In fact, he wanted to get well and go home as quickly as possible. A few days were of great importance to him. And so he passed through that terrible suffering, the greatest that I have ever inflicted upon any being, man or animal.

I mention this only to show what the man was, and I shall only add that since that I have always found him ready to submit to anything for the sake of what he thought to be right; and in other spheres you know that such was his character. [Applause.]

At this point Dr. Brown-Séquard was so much affected that he found himself unable to proceed, and so stopped the lecture, after having spoken one-half of the usual time.

WHAT NERVES MAY DO—Sixth and Last Lecture.

UNITY OF THE NERVOUS SYSTEM—GRAFTING A CAT'S TAIL ON A COCK'S COMB—THEORY OF CATCHING COLD—INSTANCES OF POWER OF IMAGINATION—LIMITS OF NERVE FORCE—RULES FOR HEALTH.

Boston, March 19.—Dr. Brown-Séquard delivered on March 18, the final lecture in his course before the Lowell Institute. The audience was large, and although the lecturer, having a half hour due him from the last lecture, ventured to add about 20 minutes of it to the regulation hour of the Institute, yet attention or interest did not flag from beginning to end, and there were not a few regrets expressed at the close that the course of lectures was terminated.

Ladies and Gentlemen: I began in the last lecture to speak of the vaso-motor nervous system. That nervous system supplies the blood vessels and keeps them in a state of activity. When paralyzed, the blood vessels, not having any stimulus to contract, yield to the power of the heart and become very much larger. That nervous system exists in all parts of the body where blood is present, so that a direct influence can be exerted by the central organs of the nervous system on all parts of the body. But the question is, whether this nervous system is the only one that acts on circulation. My friend Prof. Bernard has insisted upon the view that there is another nervous system acting on circulation and serving to dilate blood vessels. This view, however, you will see in a moment, has no real foundation. The facts on which it has been grounded can be explained by quite another supposition. The second nervous system, which Bernard, and Schiff and others suppose to exist, has been presumed to act on peculiar muscular fibers in the blood vessels, so as to produce their dilatation. The ground for the view is, that by irritating certain parts of the nervous system we find blood vessels dilating instead of contracting. But it is clear, from many facts indeed, that the dilatation comes from quite another mechanism than that which is supposed by the physiologists I have named. There is evidently a number of nerve fibers transmitting nerve force to the cellular tissues, and indeed to the neighborhood of tissues, not going into any of them, but terminating between the elements of tissue; the discharge of nerve force which these fibers produce s transformed into chemical force; and owing to the activity of chemical phenomena following that discharge or transformation of force, there is any attraction of blood.

THE HEART NOT ESSENTIAL TO CIRCULATION.

As you well know, the blood circulates from the arteries to the veins, and Prof. Draper of New York has perfectly well proved that the chemical changes occurring in tissues must be a cause of activity of the circulation. But there are many other facts besides those he knew, which show that when we irritate a nerve, if there is more blood in the part where that nerve goes, it is not because that nerve goes to blood vessels, and affects them by dilating them, but because of the direct transformation of nerve force into chemical force producing an attraction of blood. A great many facts indeed show us that circulation will go on without an impulse from the heart. In plants the circulation proceeds from chemical changes without any heart at all, without any power that pushes the liquids forward. In fœtal monsters in our own species, there are cases in which the monster had no heart, and in which the communication of its circulatory system with that of the almost half child with which it was connected, was too slight for the circulation to go on if we were to look upon the heart as the only organ producing circulation. Besides, in embryos, in animals at a certain degree of their development form the ovum, circulation takes place while the heart is not yet formed. And we may say that instead of the heart being the only organ that serves for circulation, that, on the contrary, the heart is formed by circulation. The circulation helps to give it a form of organization, and helps to give it a function when it has accomplished its organization.

I long ago made an experiment with frogs, consisting in making a section of the ventricle of the heart, dividing it so as to do away with more than two-thirds of the length of that part. After a time a clot is formed there which unites the lips of the cut, and the circulation goes on with a part of the ventricle, which is so small indeed that there is hardly an impulse coming from it. There is a passage, however, for the blood there, and that is all that is necessary, that the great cause of circulation, which is attraction, may be accomplished in every tissue through life. Even in our own species it has been my lot to see one case, that of a lady, in which the heart was almost entirely destroyed by fatty deposition. The heart in this case had very little action, if any, but still life persisted for some time. In appearance there was a state of health, until suddenly one day death occurred. There is on record the case of a man who for three days had had no beating whatever of the heart and who, nevertheless, had had a circulation. He had had no pulse—the beating of the pulse depending on the heart—but the blood was circulating, and life was maintained all the time. Therefore, although I would not say certainly that the heart is a useless organ [laughter], it is certainly by far less important than it was considered to be, a great deal of the work of circulation being due to the attraction that tissues exert on the blood. That attraction is increased by certain nerves, and thereby circulation is considerably increased, sometimes locally to a most wonderful extent, by an irritation of the nervous system. In cases of inflammation we see this very plainly. Where the inflammation exists inside of the cranium, we find that the carotid artery beats with tremendous violence. Sometimes we find an enormous increase of pulsation in the arteries of the temple. As we find in such cases that the heart, as indicated by the pulse in the wrist, is not beating with much more force than usual, we must conclude that there is considerable irritation and an inflammation in the membrane of the brain or the brain itself.

A CAT'S TAIL ON A ROOSTER.

If we put an organ taken from a living animal inside of another animal, very frequently this organ will be engrafted there. The infused serum becomes the object of chemical changes, the blood is attracted and the organ receives circulation. I once engrafted the tail of a cat on a cock's comb. A few days after it was evident by pricking the tail that blood was circulating in it, and it certainly would have stayed there had not the cock had a fight and lost its tail. [Laughter.] Other cases of grafting leave no doubt in this respect. It is shown by the fact that *ova* in animals when they are implanted on a mucuous membrane take hold of it, blood is attracted there and circulation takes place.

Now, the question is, does the nervous system which acts so powerfully on nutrition, as you will see in a moment, act only through blood vessels and through that peculiar influence which I had named an attraction of blood? Certainly not. Whatever be the suppositions we may make as regards the mechanism by which the alterations I will speak of are produced, it is quite certain that we cannot explain all the facts on the supposition that the nervous system affects nutrition only through the blood vessels. There must be other influences. And the variety of facts I shall mention, although not so great as I should like to present, will be sufficient, I think, to show that we cannot accept that position.

The mere division of a nerve is followed by a good many alterations, often producing atrophy not only of the muscles but also of the cellular tissue of the blood vessels, and also of the bones themselves. All the parts that were animated by the nerve are more or less atrophied after division. Dr. John Read made an experiment to ascertain whether it was because the nervous system has an influence on the nutrition, which is essential, or whether it was simply the lack of action, the perfect rest in which the part was thrown, that occasioned this wasting away or atrophy. He allowed atrophy to take place, and then galvanized the limb very frequently, and found it improved. But the principal experiment consisted in preventing atrophy by galvanization. He galvanized every day, and found that the limb did not become atrophied. I pushed the experiment further. I waited until atrophy had become considerable in the limb, and then I applied galvanism. I then learned that although the nerve had lost nerve force altogether—as they lose it four days after dissection—yet there was soon a manifest increase in size, and after a time the limb was brought to the normal size that it had before the operation.

Even in man we frequently see cases of that kind. I once had a patient who from rheumatism had been without any exercise in one of his legs for a long time and atrophy was considerable in the thigh. When the pain had diminished considerably he began to apply galvanism. I observed day after day a change for the better, and at the end of a week he had gained at the upper part of the thigh five centimeters, or nearly two inches in circumference. This implied a rapid transformation for the better. It is evident, therefore, that in a great measure it is owing to rest or inactivity of a part that want of nerve action and consequently atrophy is due.

CONSEQUENCES OF IRRITATION TO NERVES.

There is a great variety of results, as I have said, when any part of the nervous system is irritated. The irritation may come in a direct way; that is, it may, if it exist in the brain or part of the spinal cord, go direct to the muscles or skin or bones or glands or part with which it is connected. But there is another way. An irritation may start from a part of the skin or mucous membrance and go up to the brain or spinal cord and be sent back by the brain or spinal cord toward other organs which become atrophied. There are a number of cases which show that an irritation in the bowels or elsewhere, in the skin, for instance, from a cut, has produced an atrophy at a distance in other parts of the body. The variety of effect produced is considerable.

On the skin a great many alterations may be observed. A bulla, which is a rising like a blister on the epidermis, a liquid being between the epidermis and the skin may be formed, or what we call pemphygus, or papules, which is the rising of a part of the skin with redness, or what is known under the name of herpes—all these may be due to an irritation of the nervous system. The treatment in herpes is to be that of simple neuralgia.

A gangrene may also be produced by a nervous affection. It is well known that insane patients, especially those having a peculiar inflammation of the gray matter of the brain and the *medulla oblongata*, and those attacked with what is known as general paralysis of the insane, have a slight effusion of blood in the ear and sometimes gangrene. It used to be thought that the nurses, who are unfortunately often very violent to insane patients, had been abusing them. But it is certain, also, that the trouble is frequently due to an inflammation. For there is no reason why nurses should always and especially strike them on the ear. Again, they may have had trouble in that organ when attacked; and thirdly, I have actually found that an injury of a certain part of the base of the brain produces almost invariably a hemorrhage of the ear and gangrene after it. It occurs in several species of animals, especially in Guinea pigs. So that there is no doubt whatever in my mind that the affection of the ear in insane patients is produced by a morbid irritation of the nervous system. Great changes may also occur in the hair, in the nails, and even the color of the iris may be changed from the same cause. The nails cease to grow, as Dr. Mitchell of Philadelphia has shown, in many cases by disease of the brain. They become altered in shape, and show a series of lines, depressions, and protrusions, or ridges and canals. So that a morbid influence takes place on those parts which are only secreted from the blood. The hair may change color from one day to another under a morbid influence. It may be changed not only in color but in density and thickness, and become dry or oily. There is a morbid alteration of the skin and the cellular tissue, which is not rarely observed in cases of disease of the brain or spinal cord. It is the sloughing of a part due to injury of the nervous system. It was perfectly well known that such sloughing might appear after an injury to the nervous system, yet people often called these appearances "bed sores." But we know that pressure in people who have not an irritation of the nervous system will not produce bed sores. In cases of fracture of the limbs, for instance, the patient lying in the position to have a pressure of the nates will not have these sores. But on the other hand—and these has led me to the view I propounded long ago, and which is now being accepted—in animals, in dogs, for instance, when lesion is produced, which causes an inflammation of the spinal cord and an inflammation of the nerves arising from it, we find a sloughing coming from a part of the sacrum, which is just the same as in man. In dogs, instead of lying down as we do on the back, the lying down is on the front part of the belly and on the thigh, while the sloughing, nevertheless, appears just where it does in man, on the nates. Therefore, it cannot be construed as being caused by pressure. Besides, I have seen a sloughing appear within three days after an injury, so that even if we imagined that the poor creature had turned and pressed on the part for a time, yet the length of time would not be sufficient to produce the trouble there. Neither is the explanation that the sloughing is due from decomposed water from the patient a satisfactory one. Undoubtedly this is a powerful cause of increase of the sloughing, but not the original cause, as in those animals I refer to there was not a drop of that water irritating the back.

INTERNAL ORGANS SUFFER FROM EXTERNAL IRRITATION.

All sorts of inflammation in the viscera can be produced from an irritation of the nervous system. Inflammation of the lungs is extremely common in certain cases of diseases of the brain. And inflammation of the kidneys or bladder, or bowels, may come from an inflammation of the spinal cord. Burns will produce also phenomena of that kind. A burn on the skin will frequently prove fatal by producing an inflammation of that part of the bowels called the duodenum; the inflammation may be so rapid as to produce an ulceration in a few days.

The eyes are the theater of considerable alteration from the nervous system. It is almost useless to go into a demonstration of the influence which an irritation on the nerve of one eye may produce on the other eye, because it is generally admitted now that an injury to one eye can injuriously affect the other. When I first upheld that theory I was alone in it, and it was necessary to pile up my facts; now everybody has found it out. It is quite certain that an injury to the frontal nerve then, will produce disease in the corresponding eye, and the best thing to do in those cases is to divide the nerve between the part which has been injured and the brain, so as to prevent the transmission of the injury to the brain, from which it is reflected to the other eye. In the same way an irritation of one eye may produce inflammation in the other. And if a patient who has one eye very much altered and irritated, so that it is sure to be lost, if the patient begins to have inflammation in the other eye, it is now a common thing for surgeons to take away the eye first injured to save the other. That of course acts in dividing the nerves which connect the eye first injured with the brain, and prevents a propagation of the irritation from the brain to the second eye. Even cataract and glaucoma can be produced by a nervous influence.

But more than this, all the inflammation of viscera that we suffer from may and does come from an irritation of the skin. Of the persons in this room now who suffer from coughing I dare say that nine out of ten—yes, 19 out of 20—owe their cough to an irritation which was brought to other parts than the part which, being inflamed, causes the cough. An irritation of the neck by cold, an irritation of the feet, or arms, or any other part of the body by cold, especially by damp or wet cold, may bring on inflammation of some organ. When persons have an inflammation of the lungs, almost invariably—I was on the point of saying in all cases—this inflammation has its origin, in great measure, if not entirely, in some irritation of the skin, or of the mucous membranes in the neighborhood of the skin, in the nostrils or in the throat.

POWER OF THE NERVES OVER NUTRITION.

There is a question which now arises, after having shown you how various and how great is the action of the nervous system on nutrition. It is, Are we to consider the nervous system as essential to nutrition? It is certainly not essential to nutrition, but without doubt also it is most useful to nutrition. But, unfortunately, beside being most useful to nutrition, it is in a morbid state most detrimental to nutrition. So that these three points are now particularly established: (1.) In the first place the nervous system is not essential to nutrition, which can and does go on without it, as you well know it goes on in plants and fœtuses before the nervous system is formed, and as it goes on also in completely developed animals after the destruction of certain parts of the nervous system. For instance, the destruction of a great part of the spinal cord in cats, allows the development of the lower limbs. There is an atrophy or wasting in size or girth of the limb, but the development in length takes place. (2.) The second point is that the nervous system has, however, a great usefulness in improving nutrition. (3.) And thirdly; it has a great power in disturbing nutrition, especially under certain influences, prominent among which is the application of cold to the skin. I may say here that the great danger comes from the fact that we do not expose ourselves sufficiently to cold. If we accustomed our skin to the influence of cold, then we should be in very much less danger of having any of the morbid influences that cold acting on the skin can produce.

I now approach a broad subject, about which, unfortunately, I shall not have time to say as much as I should like. In fact, it would take a large number of lectures to develop it completely. It is the power of the mind over the body through nervous force. That power of the mind over the body is much greater than most of you imagine. Indeed, I do not think that any one among you, however exalted may be his or her idea of the strength and variety of their power, has an adequate conception of its magnitude within the bounds which I will mention. You all know what mesmerizers have tried to establish. You all know what persons believing in animal magnetism profess and declare. You have heard of what is called the "od force;" and you have heard of a peculiar process which originated in New-England, and which we know under the name of Perkin's Tractors. All these views that I have mentioned have a ground in nature, and I may say there is hardly any folly in mankind of any importance that has not some ground, some degree of truth.

THE POWER OF IMAGINATION.

But though there may be some ground for it, there may not be enough to establish the truth of a certain view. The ground here is simply that the power of imagination on the body is immense, and that what is done by persons in a state of what is called mesmerism, or in any of the instances I have mentioned, which is apparently due to those odd forces—this time it has two dees—[laughter], is due to the imagination of the person under these influences. John Hunter long ago having to deal with a mesmerizer, showed very clearly what occurs in these cases. He said that he had observed of himself that by thinking of any part of the body he could very soon produce a sensation there, and if he thought of a certain kind of sensation that kind of sensation was produced. Having been urged strongly to go to a mesmerizer's, he tells us that he was very reluctant to do so because he was troubled with that serious affection known as *angina pectoris* and feared for his health. Finally he made up his mind to go, and determined to call some sensation from a part remote from that on which the mesmerizer was trying to fix his mind; so that when the mesmerizer was trying to act on his hand, saying, "Don't you feel this or that sensation when this instrument is put in your hands?" Hunter at that time was trying to give himself the gout in the big toe. [Laughter.] Hunter unfortunately knew by experience what the gout was, for he was careless of his health, and had that complaint in other and worse parts than the big toe. But this time he thought he would divert it to that member, and succeeded in doing it so well that all the attempts of the mesmerizer to produce a sensation in the fingers failed. Hunter had the true view about this, when he attributed it to the imagination. Another man of immense genius, although at times, according to my notion, he was carried away by hallucinations and illusions from a disorder in his mind; that man, Swedenborg, had also a very clear view of what John Hunter has expressed. He lived before Hunter, and therefore preceded him in this view, and he expressed it in his usual way, somewhat mystically but very forcibly, for he said that the brain had the power of conveying various sensations in it of other things to any part of the nervous system. And this is what imagination may do. But the real discoverer of this influence, the man who has established on most solid grounds the agency of the imagination in this matter is Thomas Braid of Manchester, the real introducer of hypnotism, although some three or four Americans had had a good deal of his thought mixed up with notions more or less incorrect. The influence of the mind on sensations especially is exceedingly great. Prof. Bennett of Edinburgh related the case of a butcher who was once trying to hang a piece of meat on a hook. He found suddenly that he has suspended himself to the hook instead of the meat. His agony of pain, when he discovered it, was terrible, but an examination showed that the hook had only passed through his sleeve and had hardly touched his skin. [Laughter.] The exaltation of the senses that we see, especially in mesmerized persons, may go to a most wonderful extent. Indeed, the power of the sense of hearing especially is such that it would be dangerous, if you wanted to reach the truth about mesmerism, to talk in a room adjoining the one in which was the mesmerized person, about that which the mesmerized person was to find. The mesmerized person would have a good chance of hearing what you say. All the senses indeed are exceedingly delicate then.

KNOWLEDGE OF TIME WHILE UNCONSCIOUS.

Still there is another thing than an increase of the senses. Prof. Laycock of Edinburgh has insisted on a point of great importance. If you put a watch on the back part of the head of a mesmerized person—I have not seen it, but it seems well attested—that person will know what time it is exactly to the minute, although some hours may have elapsed since the person had the opportunity to consult the time. In that case Prof. Laycock suggests that we all know that during sleep we have a power of judging of time. There is no doubt that there is such a power of knowing the time, so much so that some people can wake themselves up within a minute of a fixed time. So it is quite easy to admit that the mesmerized person knew the time by that power, whatever it is. Therefore, the power of knowing the time did not come from the fact that the watch was there; or that the hands of the watch were seen by the hair or the skin, or the bones, it was that there was a knowledge within of the real time. The way to ascertain if the person sees would be to put there a watch which gives the wrong time.

I could give a good many facts to show that even in health, in persons of imagination, a great deal of pain can be produced when there is no organic cause for it. I could show also that lack of sensation may be produced to such an extent by the imagination that pain may scarcely be felt, as in the case of the Convulsionaires of St. Médard. These men and women were trampled under foot in the most violent manner, and never showed the least sensibility under pain. They had come to imagine that they could bear almost anything, and did do it. There is a story of one of these poor Sisters of Charity who was struck and beaten all over the body, and trampled on by some 10 or 12 persons over her limbs and belly and chest, and still bore it all without any sign of pain whatever.

As regards the power of producing anæsthesia, it seems to me unfortunate that the discovery of ether was made just when it was. It was, as you well know, in 1846 or 1847 that the use of ether as an anæsthetic was begun. It started from this city. At that time in England Dr. Forbes was trying to show from facts observed in England, and especially in India, from the practice of Dr. Esdaile, that something which was called mesmerism, but which, after all, was nothing but a peculiar state of somnambulism induced in patients, gave to them the idea that they were deprived of feeling; so that they were in reality under the influence of their imagination, and operations were performed that were quite painless. I say it was a pity that ether was introduced just then, as it prevented the progress of our knowledge as to this method of producing anæsthesia. My friend, Prof. Broca, took it up in 1857-8, and pushed it very far; and for a time it was the fashion in Paris to have amputations performed after having been anæsthetized by the influence of Braidism or hypnotism. A great many operations were performed in that way which were quite painless. But it was a process which was long and tedious, and surgeons were in a hurry and gave it up. I regret it very much, as there never has been a case of death from that method of producing anæsthesia, while you well know that a great many cases of death have been produced by other methods.

EFFECTS THAT BORDER ON THE MIRACULOUS.

Not only anæsthesis may be produced, but the secretions may be very powerfully affected by the influence of the mind over the body. Here we find facts of great importance indeed. There are many facts which show that the secretions of milk may become poisonous for a child from a mere emotion in the mother, and especially from anger. And if it were not the duty of every one to avoid anger it would certainly be the duty of a young mother who has to nurse a child. There are cases, although they are not common, in which death has resulted; and alterations of health in children from this cause are very frequent. A great many men who have reached an adult age owe their ill health to such an influence in childhood.

Every one knows, also, that the secretion of bile, the secretion of tears, and the secretion of saliva are very much under the influence of the nervous system. The purging of the bowels, which depends on a secretion there, or a secretion in the liver, is also much dependent on the influence of the imagination. The Emperor Nicholas tried to see what power there is in the imagination in that respect. Bread-crumb pills were given to a great many patients, and, as a result, most of them were purged. In one case a student, not of medicine but of theology, having the idea that the word pill meant a purgative, looked for "pill" in the dictionary; and the first kind of pills that he found there was one composed mainly of opium and henbane, both astringents, and capable of producing great constipation. He wanted to be purged, and took a certain number of these pills, and instead of becoming constipated he was purged just as he wished to be. [Laughter.]

Vomiting may be produced in the same way. Du Cros, a French physiologist, tells of a trial made in a hospital by a nurse who went around and gave to all the patients a very harmless kind of medicine, and then told them that she was sorry that she had by mistake given them all very powerful emetics. Out of 100 patients, 80 were affected as if they had taken the most violent emetic and vomited for a long time.

This we see on a very large scale on seaboard every Summer. I have no doubt whatever that sea-sickness is in a great measure due to that, and if you could go on board of a steamer with the idea that you would not vomit I am well satisfied, from experiments I have made, that you would escape a great deal of sea-sickness, if you did not escape it altogether. One fact I recall is very interesting. A person had crossed, on one occasion, a small bay when it was very rough. There was a man playing the violin on the boat. The person I refer to was terribly sea-sick and vomited a great deal. He had not, of course, made up his mind that he could not be sick. However, the point is that after that he could never hear a violin without vomiting. [Laughter and applause.]

To pass to something more serious: You have all heard of what are called the *stigmata*—marks representing the wounds on the limbs of Christ. Those marks have appeared in persons who have dreamed or imagined that they were crucified and suffering the pains of Christ, having invoked the goodness of God to let them have that suffering to punish them for their faults. The most remarkable fact of that kind is that concerning St. Francis of Assisi. There is no doubt that he had the mark as clear as possible. If you compare with this fact one which is related by Dr. Carter you will have the explanation of it. Dr. Carter says that while a mother was looking at her child who was standing at a window with the fingers on the border of the window just under the lifted sash, she saw the sash come down with great force and crush the three fingers of the poor child. The mother remained unable to move, feeling immediately a pain on the three fingers at the very place where the child had been injured. Her fingers swelled, an effusion of blood took place and ulceration followed and she was a long time in being cured. If in the case of this mother the imagination could produce such results, you will see in the case of the stigmata the imagination may have been equally powerful.

PERFORMANCES OF RELIGIOUS DEVOTEES.

The mind in a state of emotion has also great power on the heart, the breathing apparatus, and several other organs. The most important of the facts here—which I must say I committed the fault of denying for a long time—are those which relate to the fakirs of India. You know that they may remain dead to all appearance for a number of days, and it is even said for months, without any change occurring in their body, without any change in their weight, without their receiving any food. They show neither circulation nor respiration, as their temperature had diminished very considerably, and altogether present a series of effects which are certainly very marvelous. But marvelous as it is, the testimony of some officers in the British army who are men of perfect veracity leaves no doubt as to the possibility of the fact. But in the light of the fact that I mentioned in my first lecture, that I had a dead animal in my laboratory lying for several months without any sign of decomposition, in a temperature varying from 40° to 60° during day and night, we can understand that these fakirs may remain able to live although they do not live—that is, do not have actual and active life. But why, you will say, do they come out? Admit that there is in us a power which is quite distinct from our ordinary power of mind, which is quite distinct from what we call consciousness, which during our sleep is awake and watches; with this admission and the facts I have mentioned before, we have all the elements, I think, for an explanation of what has been said about the fakirs.

I find, unfortunately, that the time presses so that I shall be obliged to pass over a good many facts and come to the miracles of La Salette and to the miracles accomplished at the tomb of Father Matthew, and also what has been said of a great many other instances of recovery from illness. I cannot but believe that there is no need of appealing to any other power than what we know of imagination for the explanation of what takes place in those miracles. They are very curious, but hardly more curious than what we see when we know without doubt that imagination is the cause of such a change. The cure of any illness which does not consist in any disorganization of the tissues can often be accomplished when the person thinks that it can be done. If we physicians, who treat patients every day, had the power to make them believe that they are to be cured, we certainly would obtain less fees than we do, and I must say that the best of us would rejoice at it. There is no doubt at all that if we could give to patients the idea that they are to be cured they would often be cured, especially if we could name a time for it, which is a great element in success. I have succeeded in this way sometimes, and I may say that I succeed more now than formerly, because I have myself the faith that I can in giving faith obtain a cure. I wish, indeed, that physicians who are younger men than myself, and who will have more time to study this question than I have, would take it up, especially in those cases in which there is a functional nervous affection only to deal with, as it is particularly, though not only, in those cases that a cure can be obtained. Indeed a cure may thus be obtained in certain organic affections; even in dropsy it may lead to a cure. You know that it will stop pain; that going to a dentist is often quite enough to make a toothache disappear. [Laughter.] I have seen patients come to me with a terrible neuralgia, who dreaded the operation I was about to perform, and, just at the time I was to undertake it, ceased to suffer. [Laughter.]

LIMITS OF NERVE FORCE—LAWS OF HEALTH.

I think I have shown that the power of nerve force is exceedingly various; that nerve force can be transformed into chemical force, into motion, into electricity, into heat, into light, and so on. But what are the limits of the action of nerve force? I may say that the limits of the action of nerve force, except after it has been transformed into other forces, are our own body. Those persons who think that by an imagination, or by an act of will, or by the action of a mesmerizer, we can send in any part of our body an influence that can modify it, those persons make a great mistake if they think that this can take place by forces distinct from nerve force in the subject in which the action takes place. If we divide a nerve going to a part, never mind how much we may imagine that we can move the muscles to which it goes; never mind where we go to be the object of a muscle, we shall not have the least action in the muscles to which that nerve went. That nerve is absolutely outside of our control. Nerve force cannot be propagated to parts that are not in connection with the nervous centres. This fact is a death blow to the view that there are other forces acting in us than mere nerve force. To continue the illustration of this fact: If the spinal cord, which establishes communication between the brain and the various parts of the body, is divided, the parts of the body that are below that section are separated absolutely from any act of will, any act of imagination, any act coming from emotion, in fact, from anything that comes from the brain. There is, I repeat, no force in our system other than mere nerve force for the transmissions that may come from the brain, as the seat of the imagination, the seat of emotion and the seat of the will.

I shall now add but a few words on the production and expenditure of nerve force. Nerve force is produced as you know through blood. It is a chemical force which is transformed there into nerve force. This nerve force accumulates in the various organs of the nervous system in which it is formed during rest. But if rest is prolonged, then it ceases to be produced. Alteration takes place in the part which is not put to work. On the other hand, action which is so essential to the production of nerve force, if prolonged will exhaust force also, but produce a state distinct from that of rest. Rest will produce a lack of blood, while over-action may produce congestion. The great thing, therefore, is to have sufficient but not excessive action.

There is another law which is that we should not exercise alone one, two, or three of the great parts of the nervous system; since thus we draw blood to those parts only, and the other parts of the body suffer. In the due exercise of all our organs lies the principal rules of hygiene. This view, you know, comes from a physician. It is not in agreement with what the poet Churchill wrote:

> "The surest road to health, say what you will,
> Is never to suppose we shall be ill.
> Most of those evils we poor mortals know,
> From doctors and imagination flow."

Unfortunately Churchill died a victim to this view that doctors were murderers. He died of a fever at the age of 34, and that because he had been too careless about calling in a doctor to help him. But it is certainly true that the great rule of health is not to lay imagination aside, and this is why I have quoted these verses. Imagination, on the contrary, is to be appealed to far more than we do, and this is one of the great conclusions that I hope young physicians will keep in mind.

To conclude with these great rules of hygiene, I should say that we should not spend more than our means allow us. Many commit this fault. As before said, we should make an equal use of all our organs, and of the various parts of the nervous system. Those who employ the brain suffer a great deal from inattention to this law.

Lastly, there should be regularity as regards the time of meals, the time and amount of action, the time and amount of sleep—regularity in everything. It is very difficult indeed to obtain it. But there is in our nature more power than we know, and if we conform ourselves to the law of habit things will soon go on without our meddling with them, and we come to be perfectly regular, although we perhaps had naturally a tendency not to be.

In conclusion, I have to thank the audience that has listened to me so patiently through these long and disconnected lectures. [Loud applause.]

ERRATA.

Page 14, col. 1, line 18: for "days," read *years*.

Page 33, col. 2, lines 10, 11: for "had the power of conveying various sensations in it of other things," read *is portrayed in the nerves and that they carry with them its animus.*

Page 33, col. 2, line 15: for "Thomas," read *James*.

Page 34, col. 1, line 60: for "both astringents," read *and an astringent substance*.

Page 34, col. 1, line 66: for "Du Cros," read *Durand de Gros*.

Page 34, col. 2, line 10: for "recall," read *have heard stated*.

MR. PROCTOR'S NEW LECTURES.

Mr. Richard A. Proctor, the distinguished English astronomer, began on the afternoon of April 3, at Association Hall, another series of lectures supplemental to those delivered some time ago in the same hall, and which many persons—ladies especially—were unable to attend on account of the limited accommodations of this usually adequate hall. The first of this series was upon the Past and Future of Our Earth, and the lecture was profusely illustrated with stereopticon views. His audience, which was composed mainly of ladies, was very sympathetic with, and deeply attentive to, the line of thought pursued by the lecturer, and approbation was frequently manifested.

EARTH'S PAST AND FUTURE—First Lecture.

TEACHINGS OF ASTRONOMY—PARALLEL BETWEEN THE SUN AND EARTH—DOWNFALL OF METEORS—THE EARTH MADE FIT FOR MAN BY GRADUAL PROCESSES—NO PARALLEL IN THE MOON'S CASE—THE INFINITE CYCLES OF THE FUTURE.

LADIES AND GENTLEMEN: In the year 1837, on March 23, the French astronomer, Arago, addressed to the French Senate a statement having reference to the wonderful value of the study of astronomy as teaching true thoughts of the Creator. He related how a certain clergyman had come to him and complained that he found his people wanting in attention. Said he, "I repeated to my people all that I had hitherto been teaching about the wonderful power of God, but they would not fix their attention. They seem to look upon these matters as false." Arago said to him, "Pass from those older teachings and take what astronomy teaches;" and then Arago related to him the wonders of astronomy, and the minister went away rejoicing. When the time came at which he knew the minister was to employ those teachings, he waited with impatience to hear the result. The minister came back to him, but he was not rejoicing as Arago had hoped. With despair pictured on his face he said: "When I brought those wonders before my audience they had forgotten the sacred nature of the place they were in, and rose up and applauded me to the echo."

VARIOUS VIEWS OF THE VALUE OF ASTRONOMY.

It appears to me there are in the teaching of astronomy several ways of viewing the science. The study of astronomy is interesting and important, whether it be considered either as an aid to the memory or an exercise of the mind; but we pass to a higher value of astronomy when we come to consider it in its theoretical aspect, the study it presents of various problems of interest, and the way it replies to observation and experiment. Perhaps in the minds of many, a higher value of astronomy will be found in its utilitarian aspect, as a means of ascertaining the laws that guide the seaman in his course over the ocean, or the traveler in his journey through the desert, thus working out a useful purpose. But all these, noble as they may be, seem to me insignificant compared with what astronomy does—and what every other science does—in bringing us into the presence of the great questions which affect all of us and are of such vital interest. The question what we are, what this earth is, what all this is going on around us and in which we are taking part, seems to me to bring astronomy before us in its noblest aspect.

This may be illustrated by considering the study of human nature. The doctor who teaches us the way in which the human frame may be guarded from ill, and the anatomist who conveys to us knowledge of the wonderful structure of the human frame, do well. But "man does not live by bread alone, but by every word that proceedeth out of the mouth of God." His voice is all around us. He speaks in all the works of science; and what we wish to deal with now, in the particular course of lectures I am to give, is to forget, as it were, the intellectual aspect of astronomy, to forget even—or rather only to take the results of—the theoretical aspects, and to consider those questions of which I have been speaking—the questions of the past and future of this earth, the prospect of life in other worlds and the presence of infinities into which we are brought, infinities of space, infinities of time, infinities of matter, infinities in the occurrence of events, and the great infinity—the Almighty God.

HYPOTHESES OF THE FORMATION OF THE SYSTEM.

I don't suppose any one can hope from the teachings of science to learn anything clear or distinct of the reality of the Almighty. That always lies infinitely beyond our conceptions, but it is well for us to find, and this astronomy especially does, that all things, even material things, are not within our power to understand; that by the mere study of scientific facts we are brought into the presence of Inconceivables. And therefore if it shall be shown, as some men of science say it is, if it shall be shown that the idea of a personal God is inconceivable, we are not therefore to reject it. We are to remember that it is only one of many inconceivables that lie around us.

To-day I take the subject of the past and future of this earth. I remind you that in the course I gave before I dealt with certain preliminary considerations. I spoke, for instance, of the two theories of the universe and the general facts on which both of those theories are based. I told you then how the various planets circling in one direction round the sun, the sun also rotating in the same direction, and the satellite family turning in the same direction, seem to point in a manner which there is no mistaking to a process by which the solar system reached its present condition. One of these theories was that it had contracted from a great nebulous mass; and another theory was that the solar system, instead of contracting, had grown to its present condition by the in-drawing of great flights of comets. [Here Prof. Proctor illustrated the two theories upon the screen.]

The picture shows you the nebulous matter—what the star depths afford us in answer to the theory. There you have a picture where you see a number of stars surrounded by nebulous matter, and this picture suggests a certain amount of evidence in favor of the attraction theory, the attraction toward the various centers of light. The next picture shows the way in which nebulous matter sometimes extends over enormous regions of space. This picture illustrates the wonderful nebula in Orion. There you see it spread over enormous regions of space, and suggests that, as regards quantity, there is an ample amount of this matter from which schemes like the solar system may be formed. I am passing down from the earliest condition toward which we can trace back the past condition of our earth. This nebula has been shown to be constituted of great quantities of glowing gas, hydrogen and nitrogen being present in an elementary condition. In other words, they fail to give the lines usually given by these gases, but only in each case a single line; and the idea has been suggested by a physician of your own that all the elements may have been produced from these elementary stages of hydrogen and nitrogen. I hope to show you that there is no possibility of arriving at the real beginning of the earth, but I shall pass back to that first stage of which we can hope to have any information.

INSTANCES OF FORMATION IN NEBULOUS MASSES.

I shall show you the great southern nebula in Argo, although rather faintly. It looks as if motions were taking place in the star spaces—as if some progress were actually making under the very eyes of astronomers, toward the beginning of a new solar system. We see these great masses moving, changing in place, and we may imagine that evolution is there beginning. Another picture shows the central part of that nebula in somewhat enlarged space, and that contains a sun which, as it were, is immersed in that nebula. This was formerly of the first magnitude, but it has now been ranked in the fourth magnitude. It has become scarcely visible to the naked eye on the darkest night. May it not be the first of a process by which a sun is being formed, or the last? We may see it tending toward an end, and find that there we have a sun which is gradually flickering out, like a candle just before it expires. So we see we may have a system either beginning or gradually dying out.

Here is another picture showing the changes this nebula has actually experienced, and we will now have a series of illustrations of various classes of nebulæ, in order that we may have a choice between the various orders of nebulæ, from which we may imagine our solar system arose. There you have great quantities of nebulous matter in great variety of shape. Here is one of these nebulæ where you seem to see various centers of light, as if the nebulous matter were gathered in toward some centers.

After dealing with these primary states we must pass to the condition of our earth as a center. Here is the other theory, that our solar system sprang from a gradual drawing in toward the center of great masses of glowing matter. Instead of being contracted, masses of glowing matter, hard or liquid, were drawn in toward the center, which led in the first place to the formation of the center of our system, and afterward to subordinate centers of aggregation. Here you have one of the great circular clusters, a cluster tending toward a single center. Above you have also one somewhat tending toward the center, all suggesting the possibility that centers of aggregation may be formed.

SIMILARITIES TO THE SOLAR SYSTEM.

Now we will have an enlarged view of that great spiral. Here you see the central part of its true proportionate dimensions, and you seem to feel that that great center of aggregation will grow until it becomes a fitting sun. Over here, in this next picture, you see the first subordinate aggregation, and you see in that system that a planet, that will occupy the same position as Jupiter does in our system, is being formed. Here is a picture showing the process of formation. Here you see the spiral branches are more distinct, one from another, and you see beside the central aggregation, one of the first subordinate aggregations—the Jupiter of that system—and another which we may regard as the Saturn of that system. And so we may perceive that the other branches, not perceptible by us, may lead to aggregations, out of which the smaller planets of that system are to be formed.

In the next picture you will see one of these spirals turned edgewise, so that you can notice the flatness of its nature. We know that our system is, as it were, a flat system, and if these spirals were not flat we should not find in them the true analogue of our system. You can see our spiral has something the shape of the great whirlpool spirals, precisely as a cloud near the horizon looks long and straight, although its shape, viewed from below, would be probably round.

Another series of photographs was thrown upon the screen, and the lecturer continued: I told you that we might recognize in the signs of the star depths, the past probable condition of our solar system. It may possibly be that in this ring of nebula we have a prior condition; that it is from this ring of nebula that these spirals are to be formed by a process of breaking up. I want to call special attention to the fact that these rings, like the spirals, are almost flat. When they are seen edgewise they have that elongated shape.

PROCESSES OF AGGREGATION.

Here is another nebula having only one center of aggregation. Here, you see, is one center, and toward that center various branches seem to tend. That seems to me instructive as tending to show that these great spirals are not at rest. If they had been originally at rest, then there would always have been the appearance here shown—that is, a great center, and all around that center branches would be seen tending inward; but if they were traveling in some cases forward with great rapidity, then there would be a tendency toward an occasional eccentric. In other words, the supply of matter to the central aggregation would be greater at one stage than at the other, if the nebulous mass were traveling from a poorer to a richer region, or vice versa.

And now in order to show that we have evidence of a prior condition of our solar system in that stage of nebulous matter, though not necessarily as a great rotating nebula, we will have a picture brought on illustrating the spectrum of a comet. Here we seem to see the prior condition of matter, but we find in the comets other signs of the existence of great nebulous masses. Here you see bands of comets which correspond to the glowing vapor of carbon, and you seem to see the sign that comets contain the glowing vapor of that element—carbon. We have these comets traveling to us out of the star depths and bringing information as to these great masses.

Here is another picture of a comet, and I wish here to remind you of the enormous extent of these bodies and the great quantities of glowing matter which we have to believe in as soon as we recognize the fact that these comets are made of such gases. The breadth of Halley's comet—the head of it—is 70,000 miles. You see the enormous quantity of glowing gas presented before you. Nor was that comet of Halley's by any means the largest of known comets, but was in fact comparatively small. The comet of 1811 had an estimated diameter, not of 70,000 miles, but of 700,000 miles, and its tail was over 12,000,000 miles long. No matter what degree of variety we give to the material of these comets, we yet have immense quantities of glowing gas. In those glowing gases we recognize the first condition of our earth to which we can carry back our thoughts.

THE CHILDHOOD OF THE EARTH.

I hope to show you that there is no limit, either in the beginning or the end, to the processes of change, but we must stop somewhere, and it will be convenient to stop on either side at some point. I don't know how we can go further back than to this nebulous condition. We have carried back our earth to this nebulous state, when it gathered in from its earliest childhood, so to speak, masses of nebulous matter from without, capturing those portions that came near enough to it, and growing, as it were, by all those indrawn portions of matter. That was the mere beginning, and during the whole time of its history until we come to the appearance of life upon its surface, it has been gathering matter in that way. Everything that there is in this room, our bodies, our brains, have been formed by the gathering in of matter, not from one part of space, but the great force of gravity has been engaged in drawing in matter; so that this hand [here Prof. Proctor raised his hand before his audience] contains particles from regions far away in the Northern heavens, and particles from the distant South as well; particles drawn in by processes continuing millions upon millions of ages until by the chapter of accidents they have been combined, formed into the earth, drawn from this plant and from that plant to form the nutriment of my own body and the hand before you.

There is the first wonderful thought we have—that not merely our earth, but everything we take or touch or handle or see, has been once spreading throughout the immensity of space. And now we pass to another picture to show you the relation between comets and meteors. There is a representation of what you might well take to be a comet. It is in reality one of the starry cloudlets in space.

A SECOND STAGE OF EARTH GROWTH.

Now to the next stage of our earth's condition. Beginning as a great mass of glowing gas, it gradually contracted and changed from a flattened condition to a globular form, becoming more and more globular in appearance until at last it presented a form perfectly globular, or nearly so, having only such an amount of flattening as corresponded to its rotation, and having most of the qualities that we recognize in the sun.

This picture of the sun shows what was probably the former condition of our earth. We can scarcely fail to recognize the fact that it must have once been a sun. It may have been that at that time the moon was a satellite, and that the earth then afforded the supplies of heat and light necessary for the existence of life upon the moon; but whatever view we form we feel that in the time when it first contracted from a state of glowing gas, first began to have some liquid matter, or solid matter, in its constitution the earth must then have been a sun.

Here is another picture showing the sun's surface. It may be that this earth on which we live was not only a sun, but showed all those phenomena of spots. And yet I must point out here a difficulty to be considered. We must not be carried away too much by analogy, and say this earth has passed through, or will pass through, all the stages that the other members of the solar system have passed through; that once it was like the sun; that still later it presented the appearance Jupiter now does, and so on, until at last it became like the moon. We must remember that the question of the original quantity of matter comes in as a very important consideration, and it may be that no two orbs of the universe were ever exactly alike, and no one ever had any change corresponding to any single change in the appearance of any other orb.

There is this point to be remembered: that volume and surface are related together in such a way that the proportions of the different materials that form the surface of a planet will be different according to the size of the planet. The surface of a planet, after all, is the most important relation, so far at least as the nature of life is concerned. Life exists, for the most part, on the surface. It is but a very small section of the earth's crust, and a very small portion of the depth of the atmosphere, that is occupied by life. Surface, after all, is the great question, and surface and volume are not similarly connected. If a planet has twice the diameter of another, it has four times the surface, eight times the weight, and eight times the volume of that other. And that would make a very great difference in the constitution of its atmosphere and of its oceans. There would be eight times the quantity of water, eight times the quantity of oxygen, eight times the quantity of nitrogen, with a surface only four times as great; and that is the former condition of our planet as I proceed to consider it. So, with eight times the quantity of matter being spread over a surface only four times as great, there would be twice the quantity of matter—twice the amount of water and atmosphere for each square mile of surface. And that would produce differences that would be very marked indeed. Then from the very beginning of a planet's existence it has only a certain quantity of heat, depending upon its size and the might that resides in it. So the sun at the beginning of its existence had more heat than this earth has ever had. So again with the planets Jupiter and Saturn. I mention these facts not to negative any instruction we may derive from the analogies before us, but to prevent too much stress being laid on those analogies. I shall have occasion, probably, to say that Jupiter represents the earth as it was in its former state of existence; but there are essential points of difference.

SIMILARITY OF THE SUN TO THE EARTH.

Now we will have another picture of the sun brought on the screen, and then we will proceed to consider the nature of the sun's surface and the probability that the earth's surface corresponded in some degree to that of the sun. There we have a more spotted picture of the sun, and you see at the border, the signs of the existence of a deep atmosphere, and, as it were, the floating over the surface of the sun of something very much like slag floating upon the surface of liquid, molten metal. We have this theory of the sun to consider, related, as it probably must be, to the past of our earth—the theory that the sun is at present merely a bubble of matter, as it were. You are aware that Prof. Young of Dartmouth has advanced this theory, and there is much in the appearance of the sun to suggest it—to suggest that that great center of our system, while there are cold spots upon it, is always radiating its heat, so that there is a continuous transition of viscous substance into liquid globules, and that the boiling down of those globules produces continual showers of meteoric rays. They descend again, and keep gathering as they descend; but after a time as they approach the great heat center they again become vapor, and so there is a continual down-fall.

Another picture will be brought on the screen, illustrating, on a large scale, the nature of the sun's surface. There you have that appearance resembling slag, of which I spoke. You see the mottled appearance; the roughest of the phenomena presented by the sun.

We will now have another picture, showing every minute detail as revealed by the telescope, with the hope that we may possibly recognize something there that will suggest the former condition of the surface of our own earth. You see all these comparatively small bright points, and the bright matter in which the bright points seem to be floating. We shall now have another picture, showing what Prof. Langley of Pittsburgh has discovered. He resolved these bright points into still smaller points, and then he has found that in the neighborhood of the spots there is that wonderful appearance you there see. It is in some sense confirmatory of the theory of Young, that there are continual showers taking place. You see the upper part of the dense matter, and here you have side views of the showers; and owing to some great eruption—possibly of gas from the sun's interior—you see those showers spread. Nor need we be deterred from accepting that theory of Young's from the fact that the long streaks of bright lines assume a curved appearance, because we know by direct telescopic observation that great cyclonic disturbances are constantly taking place there. I wish you to remember all the time that we are dealing with the possible or probable past condition of our own earth. The appearance of the sun may probably have had its analogue in the past history of this earth on which we live.

Now that picture will be passed on and another brought on showing the cyclonic action of which I have been speaking. At the present time the sun is in this condition. Gradually parting with its heat, forming these great showers, and gradually contracting, as we believe, the sun will contract, the showers will attain a greater depth, as it were, the crust of the shell becoming thicker, the sides of the shell becoming less, the whole contracting towards the first condition of our earth, regarded as a liquid or solid globe. When the time came that the whole mass of the earth was liquid, what changes would then have taken place? We are in the habit of judging what would take place from the behavior of water when it freezes. We know that ice forms on the surface of frozen water and that below there is liquid. We are so in the habit of dealing with analogy that we suppose the earth must have formed a solid crust. But I conceive that Dr. T. Sterry Hunt and those who follow him are right in assuming that there would be a formation of solid matter in the interior of the earth in the first place, and the heavier matter would all sink down, gathering toward the center, and that for a long time the outer part of the earth's crust would be liquid. Then, at last, there would come another change. The center would become solid. The liquid matter would become more and more dense, more viscous, less plastic, and at last it would be so dense that the solid matter so formed would no longer sink, and then at last the crust would begin to be formed. It would be separated from the great solid mass of the interior by a sort of internal shell of viscous and partly liquid matter. And that, I conceive, was not merely the state of the earth at the first formation of the earth's crust, but is probably the present condition of the earth.

THE FORMATION OF THE EARTH'S CRUST.

We find that William Hopkins and many others have adopted that view. And there is one very strange possible confirmation of the theory that the interior of the earth is of this nature, a great solid mass, separated from the solid crust by a viscous, plastic ocean. Terrestrial magnetism, carefully studied, shows such a change in position of the magnetic poles of the earth as can only be explained by the theory, advanced by certain astronomers, that there is an interior solid globe rotating under the outer shell, but not at the same time with it. Thus, there are four magnetic poles, two poles of the interior globe and two poles of the outer shell, and the continual change of the relative position of the great internal solid or liquid mass, and the outer shell, produces a corresponding change in the position of what may be regarded as the mean magnetic poles of the earth. At any rate, we find in this theory an explanation of these irregularities upon the earth's surface. We should have the surface contracting, and it would contract more rapidly than the liquid matter underneath, and the result of that would be that it would force out that liquid matter, and thus oceans would be formed of glowing liquid matter, outside of the crust. And we find traces—so the best geologists tell us—of just such processes. We must either take that view, or else we must take the view that was adopted as to the nature of all the change by the German, Meyer, namely, that in past ages there were such great downfalls of meteors that, when they fell, they were converted into liquid or gaseous matter, which spread itself over the earth, and thus produced those great extensive regions which were originally in an igneous fluid state.

And here I remark—to show how one may be led to a theory and imagine it to be original with him when it is not—that the very theory which I advanced, and which I supposed was a novel and startling one, viz., that our moon's surface had been rent open by great meteors and that the signs of such violent contact could be recognized in the multitudinous craters of the moon, was the old theory of Meyer as to the former condition of our earth.

We will now have a change made in the pictorial illustrations. One remaining feature of the sun is to be mentioned—its colored prominences—in order that I may remind you of that epoch of the earth's surface when the whole surface was surrounded by glowing flames. Then after the first formation of the solid crust there forced itself out from beneath, from time to time, the liquid matter, not unaccompanied, we may be sure, with great flame. So that at that time, if the inhabitants of the moon had studied the earth, they would have found existing all around the solid crust of the earth great flames such as now exist around the surface of the sun.

THE RAIN OF METEORS.

You now have before you a picture representing the meteoric downfall. We find much in the appearance of the earth now which shows that that was taking place all the time the mass of the earth was being formed, changing from the gaseous to the liquid condition, forming a solid interior and then subsequently forming a crust. All that time there was a continual pouring down on the whole surface of the earth of meteoric matter. Then we have clear signs that some of this matter must have existed in large globes. Nay, we may go further. I speak of these globes as large, which they were in reality, but they were very small in comparison to the earth. I have spoken to Dr. T. Sterry Hunt upon the subject and he feels satisfied that it is the true theory that those meteors which fell upon the earth, and which, when carefully examined, show signs of the existence of certain forms of metals that we associate on the earth with vegetation, were once covered with vegetation, that they were, so to speak, first the orbs of real vegetable life, and then, that animal life may have existed upon them. We know that those meteors fell in such masses that there are whole strata of earth that correspond in structure with meteoric masses. And the strange thought is suggested that there has gone toward the formation of those strata myriads of former meteoric orbs once surrounded or covered with vegetation. So that the startling thought of Sir William Thompson—which was deemed almost too wild even to be seriously discussed—the thought that life upon our earth may have commenced from the downfall of meteoric masses, is a thought that seems to have a scientific basis.

THE EARTH WITH A GLOWING CRUST.

We will have another picture brought on while I proceed to consider the next stage of the earth's existence. At this stage it was surrounded by a glowing crust, which must at that time have had a deep atmosphere. The whole of the water that forms our oceans must have been present in the form of steam. All this steam upon the surface of the earth would be raised into the atmosphere, and thus there would be an atmosphere exerting a most enormous pressure upon the surface of the earth. Quite apart from the intense heat that must naturally have existed at that stage, quite apart from that intense heat, we know very well that under that enormous pressure the boiling point would be very high indeed; and therefore the whole surface of the earth, the whole of that glowing crust to which we have now brought the earth, would have continually falling upon it great streams of water, boiling at a very intense heat—boiling at a much greater heat than our ordinary water. But that would not be all. Hydrochloric acid would be formed, and sulphuric acid—those gases that we recognize as the great resolvers in which all the noblest metals are resolved—hydrochloric acid and sulphuric acid would be continually pouring upon the whole surface of the earth. They would, as it were, form the matter which we find in our present oceans, but which, in the oceans of past time, must have been present in greater quantities. We have signs of this under what was left by those oceans, some of those saline or chalybeate springs. We find that precisely as the atmosphere of old times was much more dense and complex than the present atmosphere, the same is true of the oceans. With these changes taking place, the time would come when the chlorine was removed from the atmosphere and then sulphur, and nothing would be left but carbonic acid, aside, of course, from the atmosphere we now breathe; that carbonic acid must have existed in much greater quantities to make the material out of which the strata of the earth have been formed. It is true that some of those strata indicate having been formed by living creatures—that they are the mere shells of innumerable quantities of creatures that were once alive. But, also, we find certain of these strata that must have been formed by the direct action of carbonic acid upon the crystalline rocks of the earth, but which were thus changed into clay. Thus changes went on; carbonic acid actually became withdrawn from the atmosphere, and then probably came the time when this process of withdrawing the carbonic acid was helped by the process of vegetation.

THE ADVENT OF VEGETATION.

Vegetation, as we know, withdraws carbonic acid gas from the air and replaces it with oxygen. Then we come to the time when vegetation was first introduced upon the earth, and we are brought before the solemn question as to the beginning of life on the earth, because vegetable life is undoubtedly is the beginning of life. May it be that spontaneous generation was possible in that former state of the earth? I must confess that I find myself not in the least hampered with the religious questions associated with that matter. A man of science must set those questions quite apart from their religious aspect, quite apart from the interpretations which have been placed upon the Word of God. We may be perfectly satisfied that the works of God will not teach us wrong. We must deal with this matter quite apart from the preconceived interpretations. Over and over again it has been ascertained that our interpretations are wrong, and it may well be so in this matter of the creation of life. For instance, it is absolutely undemonstrable that the descriptions given in the Bible may not have referred to such processes of evolution as this I am now following; and where it is said that the Almighty made this or that kind of creature, it may be that it means that he then gave laws to the universe under which they were subsequently formed. It seems to me that we can form no idea of the Almighty God as consistent as to suppose continual processes of creation. Any way, whatever view we form, we find that vegetation was introduced at a stage not prior to the existence of animal life on the earth, and it appears manifest that the vegetation of those days was much richer than the vegetation of our own time. It was then that those forest masses were formed from which the supplies of coal that we are now using were derived; and in those times trees existed on a scale so great that all of our large forest trees would seem dwarfed into bushes by comparison.

THE FIRST ANIMALS FITTED TO A DENSE ATMOSPHERE.

It would appear that the time at last arrived when animal life became possible. The first creatures that lived we have proved to have breathed an atmosphere such as in our time we could not respire. That atmosphere contained much more carbonic acid. They seem to have been fitted for life under those conditions.

Then there was a stage when the aspect of the earth was strange indeed. The whole earth was surrounded at that time by an enormously deep atmosphere, continually laden with clouds such as we recognize in the planet Jupiter. Volcanic disturbances were then taking place to a far greater extent than at the present time, and thus its atmosphere was having continually poured upon it fresh supplies of carbonic acid gas. We may well conceive that the aspect presented by the earth to the inhabitants, if there were any, of the moon, must have corresponded with some degree of closeness to that which we have now in the planet Jupiter.

We here have a representation of the planet Jupiter. It is supposed to be a picture of our earth at the time when its atmosphere was laden with enormous clouds, and when underneath those clouds those operations of abundant vegetation were taking place; when strange animals existed, such as geology gives us the record of: the enormous saurian, with long neck stretched above those oceans, as the imaginary sea serpent has been conceived to do to-day; peculiar animals on land, and the startling dactylian creature, with enormous bat-like wings, floating in the dense atmosphere at that time—those creatures that we find provided with enormous eyes so that through the darkness of the cloud-laden atmosphere they were enabled to search after prey.

THE SURFACE GRADUALLY FITTED FOR MAN.

We shall now have another picture of Jupiter, with the appearance that the earth may at that time have presented. Now at last came the time when the animals began to improve in their quality and character. We may conceive that the processes of evolution went on, and the animals at present existing on the earth began to appear. Whether that process of evolution led to the introduction of man upon the scene is a point I need not venture upon, for my views on that matter would be worth very little, and it must be left to the geologist. At last there came the stage when man did arise, and now we find a stage when certain new processes are coming to be applied. Animals are going gradually to consume vegetable matter, and man is come. He is to exhaust supplies garnered up in former ages, to use the forests for his purposes, and the land is gradually to be denuded of its covering, and losses are to take place that can never be replaced. If you consider, in looking back at the former stages, you will find that each new stage used up, as it were, the materials that had been provided by the former stage. In the gradual using up of carbonic acid we find that the materials previously forming the surface of the earth were gradually undergoing a change. Then came the time when vegetation used up the abundant supplies of carbonic acid gas. And then comes the time when animals are to use up the vegetable supplies. Is it to be believed that the process can continue for an indefinite period? It seems to me that the way in which man is consuming the vegetable supplies of the earth is such as to show that there must be an end. When man, the inventor of so many machines which are using up the supplies of coal—when man insists upon using the materials of the earth at such a rapid rate, we begin to see our way toward the end. By that means it seems to me animal life will come to an end long before those material physical processes by which astronomers see that the earth is passing toward its end. We see that the earth is parting with its internal heat; that the great central sun must, in the long run, draw down to the stage when he will no longer have that great supply of heat which he now possesses.

SOURCE AND CHARACTERISTICS OF ENERGY.

There will be a loss of force, a loss of energy, using these terms as they are beginning to be applied by men of science. Force is unchangeable. One form of force changes into another. All energy—working energy—may be consumed; for instance, if you raise a great mass of matter to a great hight, you have a certain quantity of force available from the position of that body, and in the falling down of that body it may be made to do work. In falling down it gives out its heat and has no longer available energy. It gives out energy according to the position of the body before it fell, but it is too much spread to be useful. It becomes part of that heat that the earth will eventually radiate into space. So with the sun's heat which, being at a high degree, is a source of energy, but finally, when it will have parted with that heat, there will no longer be energy, although the force will be spread throughout space and still be in existence.

We find then the earth gradually tending toward the end. Is the end apart from that which will result from the consuming powers of man? Does it resemble the end we recognize in the case of the moon? We see in the moon an orb gradually dying out. Is the earth tending toward such an end as that? It seems to me that here we have introduced again the point to which I called your attention. Here then again we have introduced that question of the prior condition of all the different orbs of the solar system, the larger orbs existing with much greater original heat and much greater relative quantities of atmosphere, and therefore in a condition which does not tend to reproduce orbs in any stage, in any of the stages, that the smaller orbs pass through. In this picture of the moon you see quite enough of the aspect of it to say that the earth will not pass to such a condition. The moon may be looked upon truly enough as an orb that is dying out and no longer fit to subserve the purposes of life. In the fullness of time it shall fall perhaps on the central sun or earth, in some way to give out new supplies of heat and energy; but at present it is in a dead state, and there is nothing in its appearance to show that the earth will ever have this aspect.

NO PROBABILITY OF THE EARTH BEING LIKE THE MOON.

There is the moon with its surface covered over with these marks. Here is a place [pointing to the picture upon the screen] where the meteoric missiles have fallen into the moon, corresponding in a certain sense to the stage when missiles of the same kind were falling on the earth, but whereas the earth at that stage of its existence had abundant materials out of which oceans and atmospheres were to be formed, it would appear as if the moon, by virtue of its smaller size, had not; and therefore all these small signs of disturbance on the surface of the moon have been unchanged. There have been none of these processes, of which the signs on the face of the earth have not been swept away, or if they exist at all exist far down below the strata of earth which have been formed by denudation. Here you have again that wonderful scene of barrenness, and I conceive there is nothing in what we know of the earth to show it will ever arrive at this condition. Again I say that this earth seems very unlikely indeed to present such an appearance as that. I don't say, indeed, that the atmosphere of the earth can never fail to continue to clothe it. We have seen that parts of the atmosphere have been withdrawn. It seems conceivable that other parts of the atmosphere will gradually be withdrawn by chemical processes, and that then a time will come when the earth will no longer have an atmosphere. Then there will be nothing to cover the earth with those signs of volcanic action. Therefore, I say the final stage of the earth will be very different from the final stage of the moon.

Here is a larger picture showing the proportion of the moon's surface and the kind of aspect which the earth might have presented in past ages if the atmosphere had been removed from it. There you see the signs of that process of aggregation. It must have resulted from having an outside solid crust. It would seem as if in that respect the moon might have resembled the earth. Here is a picture showing a portion of the moon's surface, which corresponds to what might have been the appearance of the earth in former ages.

NO ATMOSPHERIC ACTION ON THE MOON.

You see there is much to show us that at any rate no two orbs of different sizes pass through identically the same stages. Here is the earth on which we live which was passing through these stages when in a very different condition from the present condition of the moon. The moon now has no atmosphere, and cannot have had any atmosphere of any appreciable extent. If it had, those markings on its surface would have been swept away in great part, and the moon would be reduced to the condition of our earth when the heat had passed away from it. But our earth will never have the appearance of the surface of the moon, because those marks that might originally have been seen have been removed by the downfall of hydro-chloric and sulphuric acids in the first place, and after that by the processes of denudation, rain showers, snowfalls, and especially the grinding action of glaciers.

Now we have traced the earth towards its final condition. We look to the solar system, and find also a tendency towards a final condition. The sun at least will gradually part with its internal heat, and we may look forward to a long period during which the surface of the sun will be fit for habitation, simply because it retains and will retain enough of its former heat to be in a habitable condition. Thus can we look forward to see more distant changes, to see the solar system, as it were, traveling around some distant center, and see change after change and cycle after cycle, until, we may believe, the day when, in the words of the poet,

> "Drawn on by power of never-ending duty,
> The world's eternity begun,
> Absorbed in an eternal beauty,
> At rest on the heart of the great central Sun."

THE UNENDING CYCLES OF THE FUTURE.

On the contrary, inconceivable as the notion is to us, we find series on series of matter, series after series of time-changes. We are, indeed, in the condition of a creature not knowing the fact that it was one of a race—that before its time others of the same race had existed, that after it had passed away others of the same race would come into being.

It seems to me that these cycles are unending, and, although they are inconceivable by us, we must believe in their continual progression, precisely as we believe in the infinity of space, although we cannot form any conception of that; precisely as we believe in a continual progress of time, not believing, as I have seen recently stated in a serial in this country, that progress implies a beginning, because it implies nothing of the kind. It may be infinite in some cases, and we know in some cases it must be. Time and space can have no limits. The space the mind tells us of is without limit—in the star depths—and so here science brings before us what I conceive to be the true teaching; not the materialistic, which tells us that we may know everything and may form an opinion as to the wisdom and power of the Almighty, but the teaching which, after all, is expressed in the Scriptures, "Canst thou by searching find out God? Canst thou find out His wisdom unto perfection? It is as high as heaven, what canst thou do? as deep as hell, what canst thou know?" And again, those other words of Job when, speaking of the wonders of creation, he says: "Lo! these are but a portion of God's ways; they utter but a whisper of His glory. The thunder of His power who can understand?"

LIFE IN OTHER WORLDS—SECOND LECTURE.

NONE OF THE PLANETS FITTED FOR EXISTENCE—MERCURY, VENUS, JUPITER, AND SATURN TOO HOT—MARS AND THE MOON TOO COLD—SOME SATELLITES OF JUPITER OR SATURN POSSIBLY HABITABLE—SPACE AND TIME EQUALLY BARREN OF LIFE.

Prof. Richard A. Proctor gave the second of his supplemental series of lectures at Association Hall on the afternoon of April 4. As at the preceding lecture, the audience which gathered was very large and appreciative, consisting largely of ladies. The lecture treated of the probability and possibility of "Life in Other Worlds," and the conclusion arrived at by the lecturer, as the result of scientific inquiry, was adverse to the popular theory that the other planets of the solar system, especially the major planets, are at present habitable.

LADIES AND GENTLEMEN: I have received several letters calling my attention to the fact that many of the audience who have collected to hear the present course of lectures were not able to attend the former course, and that, therefore, I ought not to refer to matter in the former lectures as though they had been heard. Of these letters one invites me to mention, in the course of these lectures, the general facts relative to the transit of Venus. These letters I would like to answer. In the first place, it will not be just to repeat simply to-day, for instance, that which I gave before, on the sun's family of planets; having given a prospectus and lectures indicating that there would be a certain novelty. It might be a pleasant but not a just thing to do, and all I can say in reference to the request, is to touch on those matters which are necessary to make my subject complete, and to touch them sufficiently to demonstrate the facts necessary, but to make the subject, so far as possible, new. In regard to the transit of Venus, I think you have had enough of it. It is not a subject which is perhaps specially inviting, and therefore I do not think I shall devote any portion of these lectures to the treatment of it.

FUTURE MEANS FOR MAN'S EXISTENCE ON EARTH.

Now I pass to the special subject of to-day's lecture, in which I am dealing with the subject of other worlds than ours, need I hardly say, the sun's family of planets, and I propose to-day, instead of giving my consideration to the distinction which exists between the two parts of the two families, to discuss that subject with special reference to the new theory to which I have been led. Brewster's theory was composed upon the idea that other worlds, the planets and the satellites, and possibly the suns themselves, are the abode of life, and were intended to be the abode of life, not merely for a portion of their existence, but for all time. That is Brewster's theory, and it may be considered a theory of the plurality of worlds carried to its utmost possibility. Then there is the theory of Whewell. I shall hardly speak of it as if I believed he really had any theory on the subject, but he wrote a book to show what there was on the other side of the subject. Still it is a theory which is associated with his name, but he really wrote the book on the Plurality of Worlds to show that our world is the only inhabited world, and that there are just reasons for so regarding our earth. The view to which I have been led is this. I take the analogy of our earth, and looking back through its past history, I find that long before life began on the earth, even if we take the lowest forms of life, that long before then, the earth existed as a globe, glowing with intense heat, and for many millions of years, a much longer time than she has been the abode of life. Preceding that time there was a much longer period when the earth was a mere mass of vaporous matter. Then looking forward to the future, we seem to see the time approaching when the earth will cease to be fit for the abode of life. We cannot tell when that time will be. It may be that the higher forms of life will first suffer; that the quality given to man by which he has the power of exhausting the supplies garnered in the earth, that quality in which man differs from the brute creature who lives on what the earth produces—that quality may enable a man, to his misfortune perhaps, to consume these substances; that at last life will be impossible to the human race. It may be then that man will first perish from the face of the earth; after that there will be a time when animal life will continue and vegetable life may remain as the last form, as it was the first form of life on the earth, and with these will follow more changes, spoken of in the books of astronomy—the changes material and physical, by which the earth will be rendered unfit as an abode of life; or it may be that life will cease first through the fact of these changes. Now in regard to the future of the earth as an abode of life, we can form no satisfactory opinion. We find, as the opinion of the geologists, that the interval of between one million and ten millions of years is the probable time during which animal life will continue on the earth. Looking forward to the future we have no satisfactory means for our guidance. We might even say a few thousand years was the limit of time in which the human race could exist with anything like comfort. We do not know, however, what powers man may have to employ the means garnered upon earth. He may by some contrivance, as Ericsson has suggested, be able to use those parts of the sun's heat which are at present wasted and lost by radiation. He may construct instruments so as to garner up these supplies. One way of Ericsson's is this: There is a possibility that you might have the sun's heat gathered, that falls on some desert place, and the whole of it employed in lifting up great bodies, and these might be the means of driving machinery. It might be gathered together in what we may call sun machines, and so employed to drive engines and do that work for which coal is now used. It may be that is the future to which man's ingenuity tends.

THE EARTH'S CONTRACTION BALANCING ITS RETARDATION.

It seems to us to lie within our range, seeing certain physical and natural processes, to say that the earth will one day be the scene of death and desolation. One of these corresponds with the moon's change in rotation by which it was worked down until its period was a lunar month. The earth has a tidal wave, which is acting as a sort of brake, and slowly but continually reducing the earth's rotation. You will remember that in the former course of lectures I dwelt on that fact. I have since heard news which will be gratifying news for all those who may be terrified with the idea that in a few millions of years that state of affairs would be brought about. Prof. Newcomb tells me that recent observations on the moon, since 1863, show that the moon is running away from her calculated place. Some change is taking place in the moon's motion. Astronomers have too thoroughly mastered the lunar theory to be in doubt about that. It must be that a certain change is taking place in the earth's rotation, and not of the kind I have spoken of—not retardation. It is increasing in rate. Here is a strange piece of information, not the first brought to us, by the companion of the earth, its satellite, the moon. It seems to show a retardation in the moon, and we know from that that the earth is accelerating her motion. It is shown, too, that it is not uniform. We can understand the retardation of the earth, the great tidal wave being opposed to it; but what are the changes which are leading to this acceleration? It seems to me in this way. It is a process of cooling. The earth is gradually contracting, and that leads to a hastening of the rotation, and that hastening is to be regarded as counterbalancing the brake action of the tidal wave. Now it seems as if it more than counterbalances a portion of that, but for some reason or other that change is taking place more rapidly than any other. The irregularity is then a process in the interior of that plastic ocean that lies beneath. It is a curious law, but we must accept facts as they are presented to us. We thought the earth was losing in its rotation, and now we find it is gaining with a variable rate of gain, and there is no clear evidence that it is going to lose its rotation in any measurable manner.

There is another change by which the earth must gradually be drawn in near to the sun, that the ether must compel the earth to travel more and more inward, until at last it must fall into the sun; but the period is so long that to our conception it is an infinity of time, if we only recollect the extreme rarity of the ether that occupies space. Prof. Whewell studied Encke's comet, and was led to this result: a man drawing a full breath takes in as much air as would form a globe three inches in diameter; in order to take in as much air at the pressure on Encke's comet he would be required to draw in a globe 6,000 miles in diameter. If the earth is to be checked by an atmosphere like that it must be in a period of millions of millions of years, and we can hardly doubt that before that this earth will have ceased to be the abode of life, so that whenever the earth falls into the sun there will be no destruction of life on the surface.

MERCURY NOT THE ABODE OF LIFE.

Now we will have the room darkened while we apply these considerations to the various planets. I shall have to mention a few facts from my former lectures, but I shall take them for granted and so proceed to apply them.

The planet Mercury is not studied under favorable circumstances. When it is nearest to us it presents a crescent shape, and when its full front is toward the earth, it is smaller on account of its greater distance. But we feel quite satisfied that it can hardly be the abode of life such as we are acquainted with. The sun pours upon it with from four to ten times as much heat as we have. In this picture you see the sun in the various sizes as seen from the different planets. The upper picture shows it as seen from Mercury; here as seen from the earth, from which the comparison can be made. Here we have illustrated before us the enormous supply of heat poured on Mercury. Upon Venus also it is greater than upon the earth. Another picture shows us the appearance of the sun as seen from Mars. Another shows the appearance from the asteroids. But I want to call your special attention to the sun as seen from Jupiter Saturn, and Neptune. I shall show that the sun is not the cause of the changes there, and when you see the smallness of the sun as seen there, comparing it with the sun we see, you will see that both in Jupiter and Saturn that tiny sun cannot produce the effects that are ordinarily ascribed to it—changes of great activity that we cannot believe to be brought about there by the insignificant sun that would be seen there if those were inhabited worlds.

VENUS NOT YET HABITABLE—CONDITION OF THE MOON.

I pass from the planets Mercury and Venus rapidly because we have so little telescopic information of them. It will probably dispose us to regard them as intended to be the abode of life but not that yet. Only when the sun has lost the fourth part of his heat in the case of Mercury, and in the case of Venus one half, will they be inhabitable. When the sun has lost half of his heat, the time will come when Venus will be inhabitable. It will then be with her as with us now. So we look forward for millions of years when she will be inhabited as this earth is. It may be that the planets are inhabited only for a short period, and not necessarily cotemporaneously. Here is Venus. You will see that there are certain markings. I would call your attention to the great benefit of the clear atmosphere of America in observing these marks. In England they say they can watch them and see them in the periods of the rotation. The large telescope at Harvard and the other fine ones of Alvin Clark and others fail to show them. The subject seems to me very much as if it were an optical delusion; that she shines with so much light that the eye is deceived. Three other pictures of Venus will be shown, indicating on a more correct plan the delicacy of these markings. We see some signs here of an atmosphere, which is so necessary to life. There you see the twilight circle. Here it becomes more marked, and you see there is a possibility of life, as it depends upon the existence of an atmosphere.

Now we will pass to the planet we are able to study to the best advantage, our moon, which we are so used to regard as a mere satellite, but which is a planet having the same path around the sun as we have. We are so accustomed to regard the earth as the center of the solar system, that we forget that she is a planet like our own. She is a planet circling round the sun, having nearly the same path as we have. We will now have a picture of the moon brought on the screen, showing the relative size of the earth. Now let this be remembered. You consider the diameter of this lesser orb, and it is about the fourth part of the earth. The surface of the moon is about the thirteenth part, but the volume does not bear so great a proportion. It is a little more than the fiftieth part. If we assume that the same quantity of matter existed, of the same character as on the earth, there will not be the same amount for each square portion. So the oceans would have been less relatively. We don't find enough traces of atmosphere on the moon to suggest that theory. In my last lecture I spoke of the changes in our atmosphere. That at first there was chlorine, sulphuric acid, and carbonic acid, with some steam. We know that the steam formed the oceans. We know that the chlorine and sulphuric acid were gradually used up in forming chemical combinations and then the carbonic acid was withdrawn by the processes of vegetable growth. These changes show how the atmosphere may be gradually reduced in amount. I mentioned that it probably had greater density than now. It was withdrawn and reduced in quantity, and it may come to an end. There may a time come when it will gradually have been consumed in some chemical processes, combining with the various earthy substances—those that form the surface of the earth. In the case of the moon that process may have been performed, and so in it the atmosphere has been reduced to its present small amount.

THE MOON'S SURFACE VASTLY DIFFERENT FROM THE EARTH'S.

This is a picture of the moon in its first quarter, and you see it is covered with craters. We find here much to teach us that we are not to think of other worlds from our own case. We see that the moon could never have passed through the stages that we have. It must have been unfitted for the abode of life. Life would have been endangered by the continued downfall of meteoric matter, suggesting the idea that the higher forms of life could not have existed there. There we have the moon tending toward the full, and we recognize nothing of those things that are recognized as necessary to life here, at any rate to the higher forms of life. We see, then, that the moon has passed through the stage when life was possible. We are not to regard all the planets of the solar system as at present the abode of life. We pass from our earth to the next in order of distance, and we find signs that there is no life. If that analogy be extended, the statement may be made that life upon any planet is not at present existing, or the time is past or is yet to come.

There is much to show that the time life lasted upon the moon was very much shorter than the time life may last upon the earth. We find, also, in the case of the small orbs, that a small orb radiating its heat into space, having a volume not correspondingly large, parted with its heat more readily, and I think we are led to the inference that the smaller orbs like our moon only remained for a very short time the abodes of life. The theory of Dr. T. Sterry Hunt was that the meteors traveling around the sun were the abodes of life. The metals in those meteors indicate a former condition when vegetable life must have been present. Then, again, he finds hydro-carbon, and, therefore, he conceives the strange thought that in the first stage of their existence they were covered with vegetable growth.

THE QUESTION OF SPONTANEOUS GENERATION.

But if we assume that then the smaller orbs must have existed only for a short time in that condition which was favorable to life upon its surface, this other thought is suggested that that vegetable life must have been produced spontaneously. It seems to me if only Dr. T. Sterry Hunt can establish this view, that vegetable life existed, we have forced upon us the conclusion that spontaneous generation is the true law in those cases, and the controversy between Bastian and Huxley must be settled eventually in favor of the believers in spontaneous generation. It would almost seem as if there were a stage in the existence of any orb when vital force was present in the orb itself; and thus spontaneous vegetation must have been produced. This would correspond to what we know about the chemical elements, which immediately after being separated from chemical association, possess a curious power of affinity by which they tend to proceed directly toward a higher stage than of the elementary condition, the animal condition; and it would suggest the possibility that there is yet another stage when vegetable matter is ready to pass to the form of animal life, when spontaneous generation is possible. Before that it is impossible; afterward it is impossible. At a certain stage, however, it appears to be possible.

Now we will pass from this picture to another which tends to show the evidence on which some astronomers were disposed to believe that some creatures existed on the moon who possessed the power of making fortifications, and they point to the fact that owing to the small gravitating power of the moon it would be possible for creatures of the same size as man to erect much larger buildings, and so large, indeed, that the signs of those buildings might be recognizable from the enormous distance at which we view the moon. But we know that theory is disproved, and we can hardly conceive how creatures otherwise constructed than we could have the reasoning power to build those.

APPEARANCE OF THE MOON'S SURFACE.

Now we will have a picture illustrating that point. There you have the great black shadows which we find thrown, there you have the minor shadows, and there we find the evidence of the absence of atmosphere, and we recognize the fact that if there be inhabitants of the moon they would have, even at the time when the sun's rays were poured on the surface of the moon, a perfectly black sky. There you have a picture showing the moon as her surface probably exists at the present time, those enormous craters indicating the action and downfall of meteoric masses, and very little to suggest the idea that life at present exists.

We will have now two pictures brought on in rapid succession, illustrating the way in which artists have endeavored to picture the moon, with enormous circular craters. Suppose the case of this crater (pointing it out), remembering that it would have a diameter of five or six miles—the great crater, Copernicus it is called—do you not feel that the outbursting of so small an orb as the moon could never require such a great orifice in which to manifest the outlet? It seems to me that there were downfalls of meteors, and that those great masses falling down, as Myers conceived, upon the moon, produced these enormous craters.

The artist has made a slight mistake here. You will see that the floor here upon which these smaller craters are shown lies quite high from the surface of the moon, but it appears from a careful study that the floors lie rather below the surface. Instead of being, like Ætna and Vesuvius, above the ground, they are probably depressed below the general level, precisely what we would expect if great meteoric bodies forced their way down, and the place where they had fallen had been covered over with a slow filling up of plastic matter.

PROF. MORTON'S LUNAR PICTURE.

I wish to correct a remark made in my former course of lectures about these pictures. You have one here drawn by James Hamilton of Philadelphia. In my former course I told you these pictures were drawn by him, and then I showed another picture, remarking that it was drawn with much less artistic skill. The real fact is this. Just before I gave the lecture, a letter from Prof. Morton was placed in my hands and while I was still arranging the pictures, glancing over the letter, I found this statement made, that the pictures were drawn by James Hamilton, except one, which was drawn "with much less artistic skill." I forgot the natural interpretation I ought to have put upon that letter, for, knowing Prof. Morton's disintereste 'ness and modesty, I might have known that he was the artist of inferior artistic skill, and that it was a little mere self-abnegation. Reading the letter and stating the facts I simply brought them out as in the letter; and there was Prof. Morton present all the time and allowing me to state it. [Laughter.] We shall have this picture brought on the screen. I think there is much in it indicating great artistic skill, and not only so, but there is a clear recognition on Prof. Morton's part of the way in which the craters must have appeared.

[With these delicate words of compliment the picture was exhibited.] I think this is the real appearance the craters must have presented on the moon—saucer-shaped. Here is a little work of imagination—a little village with a church, corresponding to the suggestion made about requesting Sir John Herschel to advise some means by which religious instruction might be conveyed to the benighted inhabitants of the moon. [Laughter and applause.]

I have another remark to make about this picture. I laughed about this picture, saying that it was a mere fancy of the artist. But it would appear that some gentleman has constructed a picture of this sort, and assuming this was a photograph taken from his picture, he grew highly indignant and wrote to THE TRIBUNE, saying that he had good reason for placing upon his picture that little village and that little church. His letter abused me in round terms for taking that little village to task. The fact is, I did not borrow from that artist, did not even know his name, and the picture I really used was this one of Prof. Morton's, and I am sure *he* would not be angry were I to suggest the probability that villages do not at the present time exist on the moon.

THE CONDITION OF MARS.

I shall now pass to the consideration of the planet Mars, introducing a picture showing that this one planet is the only one which gives signs of being the abode of life. Here we have learned that these rugged regions are continents, and these dark regions are oceans. We know certainly that they are oceans, and that the familiar water, such as we drink, exists in the planet Mars. We know it as certainly as if we had sent some one there to bring us back a pint of it to analyze, and, therefore, when we see great wide regions hiding over these well-known marks on Mars, we know that they are clouds, and therefore we know that storms, rain, sun and clouds exist there. Then recognizing the fact that there are continents above the general level of the ocean, we know those rains must find their way down to the ocean, and can only do so along brooks and rivers, gradually growing larger until they pour their waters upon the ocean. We have then all the terrestrial signs, so to speak, that we recognize as in the case of our earth, marking the latter as the abode of life.

It may be thought at the first view, that we have a planet which we can hardly dismiss from the list of habitable worlds. But, first of all, Mars is a much smaller planet and must have had much less inherent heat, and, therefore, on that account alone be a much colder planet. I reminded you of the apparent size of the sun as seen from the planet Mars, and how much smaller it appeared than the sun we see. Then the probability is that Mars, being relatively smaller, the atmosphere would be rarer relatively, and cold would result from that also. All the facts about Mars suggest an intense cold, which would render life impossible to creatures constituted as we are.

Here is another picture showing the planet Mars and the extent of its polar snows. The extent of these polar snows is not so much greater than those on the earth as to force us to believe that there is a much greater degree of cold. There (pointing to the picture) are the polar snows in the Winter time of that planet, and here you have the polar snow in much smaller extent in the Summer time. But you must recollect that if the quantity of water is less than on our earth the vapor would be less and the quantity of snow or rain fall would be less, and therefore less than on our earth. Here is another picture showing you these same polar snows more perfectly. Here you see they extend to a degree of altitude corresponding in Mars to that of New-York, and showing that in the Winter time an exceeding bitterness of cold must prevail. But I think we must not apply that question of snow to the ordinary analogies that we have in the earth. We must take into consideration that a great intensity of cold must there prevail, and if Mars was intended to be the abode of life the time has now passed when life could have existed. The conclusion forced upon us is that the relatively small extent of the oceans, and therefore the relatively small atmosphere of Mars, precludes the idea of that planet being the abode of life.

Here is a map of Mars, and you see the way in which oceans and seas are mixed up together, with no excess of ocean, as in the case of our earth. Another curious fact about Mars is the way in which travel would be possible from any one part of the planet to another without leaving any particular element that a person most desired to remain on. He may go on land or water, just as he likes. He may go all over the planet on land, and visit any part of it, or he may travel all over it by water, and visit every river, bay, ocean, and lake.

THE ASTEROIDS—DOES NATURE WASTE?

And now we pass from these planets with the thought, as I conceive, that we have not yet found any one of them that can at present be the abode of life. In the case of the moon and Mars we seem to see that life has passed away, that those planets have become refrigerated and life no longer exists upon them. Of the five worlds around the sun two are too much heated and two are too cold. Why should we insist upon regarding the present time as that to which our reasoning should apply? It is, of course, the great time for ourselves, but it is not necessarily the special time to which our reasoning should apply. We should regard the past time when Mars was inhabited or the future time when Venus and Mercury will be the abode of life. There is no special reason for regarding the present time, any more than any man has in regarding his own time as necessarily the most important so far as the earth is concerned. So the existence of this earth is the most important time for the inhabitants of it, and there is an end of the matter. It is not, however, the most important time for other worlds, and we have no reason for taking this time as the proper time in which to say that this or that orb must be inhabited at the present time.

Now we will pass to the curious family of planets which travels between Mars and Jupiter. Here you have, in the first picture, the scale on which those planets are formed—Pallas, Juno, Vesta, and Ceres. The whole mass of these planets combined is very much less than Mars. Many yet remain to be discovered, and thus we recognize a scheme of millions of orbs. If they follow the same law as the other planets, then, being much smaller than the earth on which we live, it must have been very long ago when they possessed inherent heat enough to be the abode of life. They must have had it but a very short time, as they would have parted with it very quickly. Thus we have presented for contemplation the strange fact that millions of millions of years ago these planets were the abodes of life, each for its own brief period.

Is there, indeed, a waste? Are we to regard those little orbs as indicative of an enormous waste in nature? Waste seems to be the law of nature. We judge of waste because all our ideas are limited, so far as time and space are concerned. But we cannot apply our ideas to infinity, and where there is an infinity of matter and of space we can hardly say there is a waste. Suppose a hundred years, or a thousand, or a year or two, or a few days only, to be the time during which life has lasted on those small orbs. The earth brings to our knowledge the fact that of the number of seeds falling from a tree—perhaps only one in a year—in many years often may produce a tree. So it seems to us waste. The idea of waste is continually brought before us. So it is with the planets of the solar system. As we measure them by human analogy there seems to be an immense waste, but as there is an infinity of time and space, there can be no waste.

And before we pass from these smaller planets I would remind you of one great sign of waste in our own earth. The only part inhabited is the surface. All the central mass seems to be waste, so far as we apply our mode of measurement, so long as we regard human life as the great test and measure of the Almighty. When we consider that enormous number of millions of cubic miles of matter which have no living creatures existing within them, we are amazed at the apparently enormous waste. Only a thin crust of the earth is inhabited.

Here are pictures of the planets suggesting curious thoughts as to how these planets may pass each other within hailing distance, and, therefore, during the long past time when those planets were the abodes of life, the living creatures upon them might have exchanged ideas with the creatures of other planets that traveled millions and millions of miles away from them.

THE GREATER PLANETS.

We will now pass to Jupiter and Saturn. We have the clearest possible evidence that these planets are not the abodes of life. I showed you how that tiny sun poured on Jupiter. Here is Jupiter marked in this strange way. Here are great streaks showing signs of great disturbances taking place in those belts. This slanting streak shows signs of great forces being at work; this streak—which had, be it remembered, an enormous surface—for you must keep in mind that when you are dealing with Jupiter you are dealing with a planet whose diameter is ten times that of the earth. The whole surface of the earth would not be more than this portion of the belt which I now indicate; and a surface equal, probably, to the whole of our continent was perceptible in an opening through which the dark surface below could be seen. Now this streak changed from its present position until it was slanted right across one of these belts, and corresponded to the motion in that atmosphere at the rate of 200 miles per hour. That motion continued upwards of six weeks, and we must accept the inference that a great hurricane was blowing, shifting this great open space in the cloud layer gradually, so far as the facts are concerned, but shifting it with enormous rapidity, so far as the planet itself is concerned. That is a disturbance which, if it took place upon our earth, would sweep life away. It was not merely the streak that was disturbed, but the whole surrounding matter. The whole of that region was swept by a tremendous storm blowing at a rate twice as great as all the storms on the earth—competent to destroy the buildings and the ships, and to tear down the forests. It went on blowing, not as our hurricanes do, with a certain obedience to the sun. We know our hurricanes gain and lose force with a change corresponding to the progress of the day. But here was a difference indeed. It was carried around and around for six weeks without showing the slightest effects of the sun's influence.

It seems manifest, then, that in the case of Jupiter we have a planet full of inherent energy, competent to load its atmosphere with enormous cloud masses. We find that the shape of the planet changes so that the planet is sometimes drawn inward in such a way that the satellite passes across the planet, and is in ten minutes outside the planet, as if the planet had shrunk in. So here is an atmosphere so dense that the density would be greater than that of the heaviest metals, and we know nevertheless the true weight of Jupiter, and we know its density is only one-fourth that of the earth. We find in Jupiter the same reason for a small density as in the earth, or in other words a great heat. That great planet—the first subordinate aggregation in the solar system, and containing more matter than all the other planets put together—must in the first processes of its construction have engendered an enormous heat, and that would not pass away so quickly as that of the earth, and the planet would remain much more heated than this earth; and doubtless, we still see in the planet a condition where life is utterly impossible.

POSSIBILITY OF LIFE ON JUPITER'S SATELLITES.

But I told you we found reason to suppose that the planets around Jupiter are the abodes of life. We find those satellites have a surface large enough to enable them to be fit abodes for living creatures.

The largest one of them is larger than the moon, and the others are about the same size. We find in dealing with them the same fact that we found in the moon, that, being smaller bodies, the heat would pass rapidly away and the time fitting for life would be smaller. So the chances we have to find life on them is smaller. Upon the earth we find millions of years that life was possible, and millions of years before and after. In the satellites perhaps we have only to deal with thousands of years. Therefore, taking the present time, we find the chances very much reduced, because the interval when life is possible is very much smaller proportionately than here. You see the larger of Jupiter's moons is a large body. Still you recognize that those small orbs could not remain so long the abode of life. Even if supplemented with the heat of Jupiter, only one of them can possibly be inhabited at the present time, and probably not even one of them is so. You see you must go back into the past or into the future to find the time. Here is a curious relation of the satellites of Jupiter which is well worth noting. In the uppermost picture you will see all the three satellites in a straight line. The lower picture shows them in a different arrangement. You see they must circle around like the hour hand, the minute hand, and the second hand of a clock; so they have a certain orderly motion that brings them time and again into a straight line. They are so adjusted that they will continue this forever.

THE SATURNIAN SYSTEM.

Now that picture will pass, and we shall have a picture of the planet Saturn. There you have a picture of the planet Saturn. I conceive that this planet is doubtless intended to support life, and afterward to be a scene where life will exist; but still I feel that it is not so now. We have these enormous belts, with signs that the atmosphere changes in shape. It seems to flatten at the poles and bulge out at the equator, and these must be of such enormous extent as to render life impossible on the ring planet. It is an orb still too active to be the abode of life. Another picture will show you the changes, in which also you will notice how large a portion is hidden from the sun's rays by the belt. That dark mark is the shadow cast by the belt, and on all the planet that is behind it there is this great dark shadow. Let us inquire whether that arrangement is such as to accommodate the wants of living inhabitants. On this part of the planet where there is Summer, there is no shadow of the ring, but where the Winter is there is no sun. Therefore the cold, if there is no inherent heat, of that Winter, instead of being moderated by some effect of the ring, or heat reflected from it, is enhanced by it.

If we are to believe that all the orbs have been intended to support life, in this ring we have a family of orbs. It is made up of a multitude of minute satellites. No astronomer has seen them, but this dark portion has been said to be due to the fact that there we see through the ring between a number of small satellites. That view might be accepted if that was the case. Peirce and Bond of your country and Maxwell of my own country have shown that if it was a solid, it would have been broken up and been thrown in fragments on the surface of the planet. Now a ring made up of small satellites could possibly exist, and the thought is suggested that they are intended to be the abode of life. If we take Dr. T. Sterry Hunt's view, we can hardly refuse them to be the abode of life, of animal life and vegetation. Then there would be accidents all the time, a series of collisions, producing a widening of the ring. So you seem to see these multitudinous collisions may result in a constant destruction of life.

Here you will see disturbances in the equatorial belt. You will see with the aid of the great power of the telescope, great cloud-like masses. Changes of color have been recognized in them. A milky white color had changed to a ruddy color, to different shades of ruddiness, and again back to the original white. We seem to see signs of internal activity of the planet; that the surface below is of a red heat; that the planet below the cloud layer is glowing with a red heat. I think we may safely say that both the planets Jupiter and Saturn are still glowing with ruddy surfaces. This picture shows the length of the Saturnian year. These are the shapes shown when the planet is looked at through the telescope. It gradually opens and closes in this manner and these changes require for their completion 29 years, or thereabouts. I think there again we have the thought that the planet cannot be the abode of life. We know that behind the ring, in that portion on which that black shadow rests, we should find the coldness of death. Now we will have a picture of the planet with the ring withdrawn and the great shadow shown. It grows wider and wider, spreading out, not with a rapid change, but taking seven and a half years to pass to this last appearance. Then it slowly passes back into its former state, taking nearly seven and a half years to do so. It takes nearly 15 years to go through these changes. When you consider this enormous shadow you must think there is not the adaptation to living creatures which we recognize as necessary. Here, on this earth, we find the most perfect adaptation between the requirements of living creatures and the planet itself. What creatures are there living here who could exist on that planet in this long Winter? I have calculated that in some places in the latitude of this part of America, of Madrid and Rome in that latitude, there would be an eclipse lasting seven of our years. Therefore we seem forced to the theory that Saturn is not now the abode of life, nor intended to be for millions of years, but among its satellites there may possibly be a different condition. But there again we find bodies so small that the chances are very small that this is the time when life is existing there.

BARRENNESS OF TIME COMPARED WITH THAT OF SPACE.

These views may appear at first sight somewhat new and startling, and the thought especially of the enormous waste that exists may occur to many, but it must be remembered that one of the great results which science teaches us is that we are over and over again misled by the want of knowledge. If then we look at the whole of the solar system and find nothing to lead to the belief that any one of these great orbs is inhabited, there is nothing in that which reflects upon the wisdom of the Creator. When we pass from our earth and the solar system to other systems in the infinity of space, what opinion are we to form? I think the same general opinion: Our solar system is the abode of life, because our earth is inhabited. A question arises here: Has our solar system been continuously the abode of life? When it began on earth, had there been life in any other planet? When it ceases on earth, will any other planet cease to be inhabited? This earth is passing to its end, and when life has passed away from it the solar system will be a scene of desolation, with no life upon it, and then will come the time when the next satellite will be the abode of life, and so on for the future as in the past.

The time during which life has existed on the solar system, has only been this short time or that short time, separated by enormous intervals when there was no life. I think if we take the analogy of space, compare space with time, the analogy will be a true one. As one is inconceivable, so is the other. And what do we learn about space?—that the occupied parts of space are infinitely small compared with the unoccupied parts. If you take the solar system, the distances between the planets comprised in it and the occupied parts are inconceivably small, comparatively. If we take the distances of our solar system from other solar systems, we still find the occupied spaces inconceivably small compared with the vacant spaces. So I think we may justly take the analogy of space and time, and believe that the occupied parts of time are inconceivably small compared with the duration of the time when no life has existed. It may appear to our conceptions that in taking this view of our universe we are calling up a scene of great barrenness and desolation. After all it is the same with space, and we must take these matters as we find them. Let us take the evidence that is brought before us and not insist upon this or that theory according as it seems natural to our conceptions. If we find great depths of space we may well believe that the infinite duration of time is only broken into at inconceivably great intervals by the periods during which life has existed. At any rate science has brought that before us, and it seems the most probable view of the matter.

We are led to recognize the finiteness of our conceptions, and we must be continually misled in applying finite conclusions to infinite matters.

OTHER SUNS THAN OURS—Third Lecture.

ANALOGY BETWEEN OUR SUN AND THE FIXED STARS —PROSPECT OF EXHAUSTION OF THE SUN—STARS THAT ARE UNFIT TO SUPPORT LIFE IN PLANETS —THE GLORIES OF COLORED SUNS—VARIETY RATHER THAN UNIFORMITY THE RULE OF THE UNIVERSE.

Mr. Proctor delivered his last matinée lecture, the third of his farewell series, at Association Hall April 6. The subject, "Other Suns than Ours," required an illustrated description of almost the entire heavens, as well as specific remarks upon the brightness, colors, and motions of the stars, the nature of the Milky Way, and the hypotheses of the lecturer and other astronomers as to the constitution and extent of the starry hosts. The audience was large, and, as in the previous lectures, mainly composed of ladies. The arrangements for darkening the hall were perfect, and enabled the numerous and beautiful illustrations to be exhibited to great advantage.

Ladies and Gentlemen: In the last lecture I dealt with the question of life in other worlds, considering the state of the various planets, and taking the analogy of our own earth as the guide. In my lecture to-day I shall consider the probability that the various stars that we see, are at present the centers of schemes of worlds, and that in those worlds there may be life; and shall touch also on some of the conditions under which life may exist in those worlds; but before I proceed to the subject I would remind you that in dealing as I have done with the theory of life in other worlds, I have not been guided by mere fancy. It has not been merely the expression of an opinion that this or that theory has been better than some other theory, but I have presented the subject as modern knowledge affords us the light. We have true analogies to deal with, and not false analogies, and as knowledge increases we are able to prove our estimate of what this earth teaches us.

THE BASIS OF ANALOGY.

For example, when Brewster was advancing the theory that all the orbs in space are the abodes of life, he took the analogy in this way: He pointed out that all the parts of the earth are inhabited, that it seemed the purpose of the Creator to supply life most abundantly, on land, in sea, in temperate zone, in torrid zone, and in arctic zone, maintaining it at all hights above the sea level, and at all depths below the surface of the earth. Every part of the earth seemed to be intended to be the abode of life. That was a true analogy; but then that shows us only in what way a world is inhabited when it is passing through the special stage of time intended for its habitability. We must not overlook the other analogy of the past condition of the earth that shows us so clearly those long intervals of time when no life at all existed, and we are bound to take this analogy, and to accept, not as a mere fancy, but as a probable theory, the view that the various orbs forming the solar system are only intended to be for a short time the abode of life. Then we may proceed to inquire whether this or that member of the solar system seems to be at the present time likely to be the abode of life. It seems to me it is the just way to view the matter. We are to form our idea of the solar system from the knowledge of our earth, which is a member of it; and so in the case of suns, we must take what we know of our "bright, particular star"—the sun—and from that knowledge infer whether the sun is intended to be for the greater part of its existence the center of the planetary system, and then what are the conditions under which the various planets traveling around other suns may probably exist. We will now have the room darkened and a view of the sun placed upon the screen.

PERIOD WHEN THE SUN'S HEAT SUPPORTS LIFE.

We have in our sun a scene of continual activity, and we have there the same argument that is derived from the earth. Activity implies life, implies a certain definite period during which life exists. We know the activity of the earth has had a beginning and will have an end. We infer that the activity of our sun has had a beginning and will have an end. We recognize in the past history of the sun that it was then intended to sway the various members of the solar system, and to supply them with the requisite quantities of light and heat.

It was only when the sun had contracted that the system, properly so called, began to exist. Now we see all these wonderful processes, how its face becomes covered over with spots, and we know that they indicate enormous disturbances, eruptions from below, with all the cyclonic disturbances which sweep over the sun, and then with that glory of light now depicted before you. Not that we always see it, but we know it is there, that the glorious corona spreads around, and so we have a picture of what our sun is.

But you are to consider whether it is possible for the sun to supply in the future, light and heat for the worlds around it. All the theories we have, point clearly to a definite period when exhaustion must supervene. Whether we regard the downfall of meteoric matter, or the contraction of the sun, or chemical processes, in respect to all such processes as are connected with the supply of the sun's heat, we see that every one of these processes must have an end, and the time will come that the sun will not have that high temperature which he sheds upon the worlds around him. Even though we know there is no real loss of force, there is a loss of energy.

LIMIT OF THE SUN'S ENERGY.

We shall have another picture to show that these disturbances, all these great spots, sometimes cover even a vast surface. We have to consider that there is the sun giving out his life to the worlds circling around him. And thus coming to view the sun, as one having a definite period, we have to derive the same argument that we derive from the earth; and as we judge from the comparative shortness of the time that the earth is to be the abode of life, and that other worlds are not at present passing through that short period of life, so we derive from the sun the knowledge that the period is comparatively short. So when you take the millions of stars revealed by the telescope, the chances are small that it will always be as it is now, and it is only the great number of these suns that leads us to believe that they are the centers of schemes of worlds. We will now have a picture of the sun as painted by himself. The two last were the productions of an artist. This is one of those wonderful photographs taken by your countryman, Dr. Rutherfurd. The diameter of that orb is 840,000 miles. There is the great central machine of the solar system working with an energy so immense as to force us to view the probability of exhaustion.

It seems almost as if we could not consider those enormous outflows, as it were, of light and heat, without recognizing the possibility of existence; and this reminds you of that strange thought of waste apparently taking place in the universe, since we see that of those immense supplies of heat from the sun only one part in 230,000,000 is employed by being received upon the planets. Again, if we look upon our earth as the only planet which is the abode of life, then see what a proportion is waste. The heat falling upon Jupiter is waste, and all on Saturn is waste, and only the heat received by the earth subserves a useful purpose; but after all we cannot be sure that the support of life is the only useful purpose in the pouring out of the solar rays. At any rate we have that result, that only one part in these many millions is poured upon the earth. Again and again when we study nature we find what appears to be waste.

Now we shall have another picture, painted by the object itself, of the solar corona. There you recognize signs of the intense activity of the central orb, and those signs will be more clearly indicated in the next picture, where the fainter parts are depicted, and where the signs of tremendous energy exerted in the sun are well brought out. And now we know that the whole mass of the sun is constituted of elements with which we are familiar.

CONSTITUENTS OF THE SUN.

By analysis we can see the sun's light spread out into a rainbow streak, crossed by a number of lines, which indicates that the sun's great central mass consists of liquid or solid matter glowing with intense heat, but relatively cool vapors cut off a portion of the light. The spectrum before you shows the lines of Fraunhöfer. The pictures of the stars I am about to show you, were not used in my former lectures on the stars, but they have been specially prepared. Multitudinous as these lines appear before you they are but few of the number that really exist. The spectrum is covered by myriads of these lines. In order that here, as in the two former cases, we may have something to satisfy us that we are not merely dealing with the work of the artist, we shall have another picture brought on the screen, in which you will find what the sun has himself done in photographing his spectrum. The upper part shows the picture as drawn by Kirchoff; but the other shows the lines photographed simply by their own action, and you know it truly indicates the nature of the solar spectrum.

And now when we pass to the stars we find there is a resemblance generally in their character to the solar substance, and here we are led to the thought of the wonderful variety in the system, the lines indicating the presence of the gas hydrogen, existing with various degrees of density, seeming to imply various degrees of size in the stars; because if we assume that one of these suns is made of all these various elements familiar to ourselves, in a quantity proportionate to its mass, then those of less specific gravity will extend above the others, and the larger stars will have the lines of those elements more strongly shown. Here is another picture showing the characteristic differences. In the uppermost picture you will see the lines of hydrogen strongly shown, and that spectrum belongs to what I call the kingly order of stars. Here is Sirius, 5,000 times the size of our sun, and probably having, therefore, the various elements in its substance in corresponding proportion. We cannot wonder, then, that that star and others show the lines of hydrogen strongly marked, as they are here indicated. In the next spectrum are exhibited stars showing, apparently, a resemblance to our sun in constitution. The third picture shows us stars probably resembling our sun in having spots upon them, and spots so much larger that the light of those suns would seem to vary greatly. Our own sun, be it remembered, is a variable star. If he were watched from some distant point, he would be found to vary in brightness during those 11 years that the spots seem to wax and wane over its surface. We are forced to believe that certain suns are not sufficient to supply light and heat steadily to worlds like ours.

UNFITNESS OF CERTAIN STARS TO SUSTAIN LIFE IN PLANETS.

There before you is the star Betelgeux, and there is that other and wonderful star which has received the name of "Myra," in the Whale, which changes in brightness. We can hardly conceive that life could exist in a world circling around such a star. Imagine what it would be if our sun varied constantly in brightness, and sometimes only had a brightness one-hundredth part of that which it now has! We begin to find among the stars signs that they are not at present—and perhaps some of them may never have been—fit to be the central luminaries of circling worlds.

Here is another picture, showing how Dr. Huggins and Miller studied the constitution of the sun. There you see the lines of the solar spectrum, and the various lines of the elements compared by Dr. Huggins with those existing in the atmosphere of that star. Dr. Huggins found in the star Aldebaran, nine of our familiar elements, with the probability that many others existed. He found mercury, iron, sodium, calcium, antimony, &c., and here then we find that lesson which seems to teach us that although any particular star may not have life in the worlds circling around it, yet we seem to see the purpose. Here it contains the elements with which we are familiar. We know our sun contains the same elements which the earth does, and thus we infer that a world circling around a central sun is constituted in the same way. Looking at the star Aldebaran, we infer that these elements exist in the worlds circling around it.

After all so long as we fail to believe that there are in other worlds reasoning creatures, we find, as I conceive, very little interest in the question of life at all. The great point of interest to us is whether there be living creatures, reasoning as we do, capable of appreciating the wonders around them, and recognizing the nature of the various changes which I shall have presently to describe; for I shall describe to you the condition of life in the world circling around the colored stars. We know that the existence of man upon the earth is much shorter than the existence of animal life, and still shorter than animal and vegetable life combined, and so we intensify the argument in view of this fact.

This picture illustrates the way in which the colors of the double stars are brought about. The uppermost picture shows the leading lines in the solar spectrum. Below it are the two spectrums of the double star, Beta in Cygnus, a double star having one component orange and the other blue, and this spectral analysis shows why these colors exist, that it is not inherent in the light of those stars, but that their atmosphere cuts off certain waves of the light, and leaves the rest of certain colors.

In the third spectrum you see many bands or lines over the yellow and orange part, and therefore a great part of the yellow and orange is cut off, and the blue and violet lights show so that the star shines as a blue star. In others there is a superabundance of orange and yellow, and that star shines as an orange star. There is one peculiarity about the double stars in the fact that we very seldom see the larger component of two stars showing the blue color. You see here the central sun is orange, and the two companion stars are green. That is the star Gamma, of the constellation Andromeda. Then you see the next two stars, both blue. The third star on the upper row is one of considerable interest, and is star 61 of the Swan.

LIFE ON A PLANET OF A DOUBLE STAR.

Now, let us inquire what must be the nature of the life on worlds circling around one of those double stars. In the first place, there are many ways in which the worlds circle about them. Suppose, in the case of our own solar system, that at some distant epoch our solar system consisted of a Sun and Jupiter as a subordinate or second sun, glowing with heat, and forming, with the Sun, a double star. Now, if you consider the other orbs of the solar system divided into three classes—Uranus, Neptune, and Saturn, circling outside both the suns, then Mars, the Earth, Venus, and Mercury circling around the central sun, looked upon as the special family of the central sun himself, then a family of worlds circling around Jupiter—it is evident how in the double stars three families may exist. There is a little family of the orange star, another family circling around the blue star, and yet another circling around both the stars. That is to say, circling around the common orb of the stars. Now, according to those various conditions, different states would exist. There would be different portions of light received by those stars.

Again, take the illustration drawn from Jupiter, because it simplifies the matter. Suppose, instead of Jupiter shining as he does, he has a considerable amount of brightness as a blue star, while the sun is an orange star. Then we shall have illustrated the state of affairs in the world circling around the orange star, and having the blue star traveling around it. When the earth is midway between the sun and this blue Jupiter, then one half of the earth would be illuminated by the blue star and the other half by the orange, and there would be no night. There would be a continual change between orange day and blue day. Suppose the blue sun to travel onward as Jupiter does, there would gradually come the change that Jupiter, after shining at his highest at night, gradually would become a fainter star. Then there would be the orange day, and after the orange sun had set, the blue sun would still remain in view, and the orange day would be followed by a short blue day. Then the blue day would set, and then would be twilight of a strange character, twilight produced by the blue and orange, a state of things altogether different from any we can imagine. Then that change would gradually go on until the blue and orange stars would be in the same part of the sky, and there would probably be white sunlight.

Again let us take the effect of seasonal changes. Suppose the day to be as it is at the equinox, equal day and equal night, but suppose the orange sun on the one side and the blue on the other. Then according as the earth was turned over toward the orange or the blue sun it would be orange Summer and blue Winter, or blue Summer and orange Winter. The two would be strangely combined. There might be a long orange day in the arctic regions, and no night. Then as you pass gradually from the arctic parts toward the equator you would find the orange day getting gradually shorter, though still remaining, and the blue day would be getting longer. There is another possible circumstance. Suppose the earth placed in those circumstances had a companion orb like our moon. Then that moon, instead of showing merely the changes which our moon passes through, would show some peculiarities. At the time when the earth was half lit by the orange and blue suns, the same would be true of the moon. It would pass through its phases, only instead of being white and black the two parts would be orange and blue. Then the earth traveling onward would get one-quarter of the way around, when the quarter of the moon would be orange. There would be an orange and blue hemisphere of the moon, but the hemispheres would overlap, so that the moon's surface would be divided into four parts, as if to divide an orange into four segments, one part orange, the opposite part blue. Where the two combined it would be white, and the other portions would be black.

Thus again the planets, as observed from the earth, would show wonderful changes in color. At one time they would be lit up by an orange and again by a blue sun. Then again the landscape would be very strangely colored; to those parts that were concealed from the blue sun, there would be an orange shadow; to those that were concealed from the orange sun, there would be a blue shadow, and a black shadow would be cast on those parts where the blended light of the orange and the blue suns was obstructed. Those shadows themselves instead of being neutral would be colored. We can hardly conceive of the wonderfully enhanced beauty of the sky at sunset under these circumstances. We recognize in these worlds very curious and varied relations. But we may be satisfied that precisely such relations as I have been speaking of undoubtedly existed.

DIFFERENT STARS REGARDED AS SUNS.

We shall now pass on to Eta Argûs, a star, which, as you well remember from one of my former lectures, was once of great magnitude, but is now almost invisible. In the year 1846 it was shining more brightly than any other star in the heavens except the star Sirius; at the present time it is barely visible on the darkest night. Now this picture will pass away and we shall introduce you to a new one. You have in the upper row there, one of those wonderful clusters of stars. You see how large some of them are and can imagine how brightly they shine. You can scarcely fail to admit the probability that circling around those orbs there are worlds in which life may exist. We can easily calculate how much light the various stars of that cluster are capable of giving to these orbs that circle around them. The sky of those worlds must be covered, not as our sky is with stars, but with suns. There is a wonderful display of their power to the inhabitants of such a world. [Prof. Proctor here quoted that passage from the poet White, in which these lines occur:

> Why should we thus shun death with ceaseless strife;
> If light may thus deceive, why may not life?]

Now we shall have another picture of star clusters, showing the enormous variety that they represent.

This picture will give place to another, showing the nature of one of these great clusters.

As we find in our solar system orbs of different character, as we find all these forms and variety in this one system, so in each one of these infinitely varied systems—to say nothing of the infinite varieties, as in the colored, double, and variable stars—there is a variety corresponding to that in our own system. Now we will have a picture showing a much greater scene of glory. There you have the great nebula of Andromeda, which has been considered as made of multitudinous suns, and where the glory of the scene must be so enhanced that the gazers must turn away from those suns, unable to endure their brilliancy.

Now I propose to present to you as clearly and succinctly as I can, the views I have been led to with regard to the distribution of the stars in space and the rules I would suggest as to their observation. Sir William Herschel said it was the great object of his ambition to ascertain the constitution of the stellar heavens. Here we have a picture representing the northern stars of the Milky Way. I think that their aspect, that the appearance of the Milky Way forces us to the conclusion that it is not made out of stars, spreading further and further out into space, and by the combined luster making that appearance, but that it is a complicated system of stars, and that when we come to analyze it we may expect to find there varieties corresponding to those which are exhibited in all parts of the universe; that we are not to look there for uniformity or to assume that there is a uniformity where all the stars have been marked by variety, but that we are to find in these that there is a great variety. We shall have the picture of the southern heavens brought on the screen and there you will see other evidences of that variety. There you see the Magellanic clouds of light, with great openings in them and a great rift in them in the lower part. That great rift will be shown better in the next picture. There you see the two branches, extremities of the Milky Way, branching out into space, and between the two that great space.

STARS OF DIFFERENT SIZES MIXED IN SPACE.

I must remind you of the utter incorrectness of the common account of the Milky Way that it is divided into two branches. I may say that the ordinary textbook account is not more incorrect than the description of the lad who said that the Milky Way was a kind of cloud in the heavens called the trade winds or the aurora borealis. The book says the Milky Way goes right around the heavens and is divided into two parts along half its extent. This division is not along half its extent, but there are multitudinous nodules of light.

The principles on which my application depends are very simple. Suppose you were traveling on an open flat surface, and perceived a number of trees along the horizon, all of the same size. Suppose you took an opera-glass and found a number of smaller objects resembling the other trees. Now there are two theories which you might form in explanation of that appearance. You might conceive that these smaller trees were really as large as the others but at a much greater distance; or you might suppose that these smaller trees were really smaller—were young trees. You might test it in this way. If you found in looking around the horizon that they were more thickly clustered in some parts than in others, then you would find much to show whether they belonged to the same clumps as the smaller ones. If you were traveling at random it would be a very astonishing thing if just behind each clump of large trees there should be another clump much smaller and lying in the same line. If you find this appearance repeated several times, there would be no doubt of it. You would so have learned this fact, although it would not be particularly interesting, you would have learned the fact that each clump of trees was made up of different kinds of objects. Now apply that to the case of the stars. If you look at the star depths, you see the stars clustered together in clusters of large stars. If you find others that are much smaller, and if you find that those which look much smaller are as richly spread as the others, you can make the same inference; not that the smaller stars are lying further away, but that they are really mixed up with the large stars in the same clump. You cannot suppose that, placed as the earth is, at random in the heart of the star system, that one cluster of large stars would have just behind it, but at an enormous distance another cluster of smaller ones. You are bound to believe that stars that are different in size are mixed in space.

AN INVESTIGATION INTO THE DEPTHS OF SPACE.

We shall have another picture brought on the screen, and there you will see how I map the stars visible to the eye. You will see that there are clusterings there, and you will notice that they form a festoon of light, which corresponds to the Milky Way. I was able to apply to this map, having a map of an equal surface, a plan by which equal parts of the heavens are represented in equal space on the map. In order to know what proportion any part will bear in the number of stars, I take a portion of this map, say where the stars are thickly spread, and weigh it, so as to know what proportion it bears to the map of the whole heavens, and then count the stars on it. Then I know what the proportion of stars is there.

Now, if you take the Milky Way and weigh it and count the stars on it, you find that the stars are so thickly spread there that it would require 5,000 more stars to make certain other parts appear equal to it. Then again there are spaces where the stars are spread so poorly that 4,000 stars would have to be obliterated from the parts just shown, to make those other parts equal.

Here the southern stars are brought into view. There you recognize a much greater peculiarity of the distribution of stars. That cloud is the great Magellanic cloud. It seems as if that bore the same relation to that section that the sun does to our planets. I would not for a moment think of that for a theory, but then it has more to say in its favor than that of Madler, which is that one star in the Pleiades is the center of the whole stellar system. There you see the upper rich region and the lower rich region, and you see also this comparatively poverty-stricken region. The old theory of Sir William Herschel was that the Milky Way was made up of stars lying in a long train, going further and further away. Remembering my plan, you will see that all I had to do was to take these regions where the stars were rich. and, if I found they agreed with these other regions, then I should be safe to adopt the safe inference as in the case of the imaginary traveler, and so should be led to believe that the large and small stars of the Milky Way are in the same region, differing in size, not merely by distance.

We shall have the central part of a map of 324,000 stars. In the center you see two bright stars. These are the guardians of the Pole. You are looking at that part of the heavens as seen with a telescope not over two inches in diameter, and yet you will see particularly at that part of the heavens, at the Little Bear, that there are countless stars. How much more is shown by large telescopes in the richest places! It leads us to consider what would be the result if the power of the eye were increased gradually to the power of the telescope, and should then go on increasing until at last it had the power of one of Herschel's gauging telescopes, revealing 21,000,000 stars, and then still more increased to the power of the Rosse telescope. Imagine the power of the eye increasing to the power of a telescope 20 or more inches in aperture, and think of the heaven's glory with this myriad of suns! To the Almighty these wonders exist, and it is only the feebleness of our senses, it is only the small opening of the eye, which renders us blind to these wonders existing around us.

A SURVEY OF THE HEAVENS.

Now a picture will be shown in which you will see indicated the result of this investigation. You will see that in the upper part the stars are thicker than in the lower. The upper part is where the Milky Way crosses Cassiopea's chair. All that light between that and Andromeda is produced by the multitude of stars which are visible through a telescope of 2½ inches in diameter. We cannot fail to see that the same mode of reasoning is applicable here, and the result is that the Milky Way is a stream of large and small stars mixed together.

Here you have a still more peculiar arrangement of the stars. Here you see the head of the Bull in the direction toward the constellation Orion, and between the Pleiades and the head of the Bull you see a curious dark opening. We notice regions in various parts of the heavens where very few stars are seen. I find that that opening is continued by a more powerful telescope, and still there is the same poverty of stars. I am going to try with Lord Lindsay's telescope, when I reach England, to see if it still continues. Another picture will show that we are gradually returning to the same rich region.

Then it is that we reach the Milky Way. The three brighter stars of the Little Dog may be recognized which lie in the border of the Milky Way. Herschel's theory was that these clouds of light were produced by the stars brought into view by the large telescopes, but here we see that these represent the end of the Milky Way. In this next map you may recognize stars familiar to us. You may see these stars of the Wagon, or as you call it, the Dipper.

Now this map will pass on and another will appear where we are tending toward the Milky Way on the left. That will pass on and the last of these separate pictures will be shown, and that will show how the cloud of light is there brought into view by these greatest of our stars. That is precisely the part of the heavens—in the Swan—that appears like a cloud on a dark night. The old theory of the stars must be abandoned, for not indicating the much greater variety of that cluster. Another picture will be cast on the screen illustrating the star distribution. It shows the multitudinous stars which are included with the stars of Argonauta. We will pass from this map to another showing the star cloudlets. You see the curious manner in which they are fitted into the Milky Way. Here we have some of the very reasons for that kind of arrangement of which I was speaking when I referred to clumps of trees. We recognize a certain definite arrangement throughout the whole and see that they form a part of one system. We find a real connection between the star cloudlets and the stars. We are shown that all those cloudlets are part and parcel of one system.

THE EXTREME VARIETY OF STELLAR SYSTEMS.

Now we shall have that picture which is intended to indicate another astronomer's theory. I call your attention to it, because I want to show that there is no evidence in its favor. The center of the stellar system, if it has a center, will be in the plane of the Milky Way. He extended the argument in this way: As you go nearer and nearer toward a central sun you will find the stars travel more and more slowly. Now that is not true. The nearer you come to a great cluster of stars the slower they move. They have a drift in one direction, and the stars which lie over the central sun would seem to lag behind, so he reasoned that as we approach the sun, we shall find the stars drifting in another direction. Another map will now be brought on the screen, and there you will see how I jotted down all the stars of the northern heavens, and how I jotted down by them little arrows that indicate the direction in which each is traveling. You will see that the arrows are of different lengths; each one indicates by its length the distance the star with which it is connected will travel in 36,000 years. Here are the stars of the southern heavens, with their little arrows attached to them. I conceive that no such regular arrangement, after what is shown in this new map, can be believed in. There you have the theory of Sir William Herschel; but I repeat I conceive that no such regularity of arrangement can be believed in for a moment. The next picture, which will now be brought on, shows what I take to be the variety of constitution in the stellar stream. With all those there are varieties of star cloudlets and varieties of arrangement which we can never reduce to uniformity. We ought no longer to adopt those uniform rules, but be ready to admit those views which seem most varied rather than those which appear most uniform. We see in the star depths the most wonderful exhibition of vitality—a vitality so great that no imagination can form any conception of it. We find, in the words of the psalmist: "When I consider Thy heavens, the work of Thy fingers, the moon and the stars, which Thou hast ordained; what is man, that Thou art mindful of him, and the son of man, that Thou visitest him?"

THE INFINITIES AROUND US—Farewell Lecture.

EVIDENCE OF THE INFINITE IN SPACE—THE INFINITY OF MATTER—EVIDENCES WHICH POINT TO AN INFINITE GOD—THE LIMITS OF OUR SENSES—THE VARIETY OF THE UNIVERSE—RESOLUTIONS OF THANKS—ADDRESSES FROM PROFS. HITCHCOCK AND NEWBERRY—PARTING WORDS OF MR. PROCTOR.

The 101st and farewell lecture in this country of Prof. Richard A. Proctor, the eminent English astronomer, who was to leave for his home across the water in the Cuba, April 8, was made the occasion of a very pleasant gathering. The usual crowded audience was present to hear the Professor's views on the subject of "The Infinities Around Us," and many warm admirers lingered after the lecture to shake hands with the scientist and wish him Godspeed on his voyage. The use of the stereopticon was dispensed with, no pictures being exhibited. A pleasant programme to follow the lecture having been arranged previously, the stage was filled with prominent gentlemen, among them the Rev. Dr. S. Irenæus Prime, the Rev. James Waters, W. H. Fogg, W. Oliver Stone, Seabury Brewster, the Rev. Dr. Vincent, the Rev. Dr. Chessire, H. B. Sands, M. D.; R. W. Weir, M. D.; the Rev. Thomas Armitage, D. D.; A. F. Hastings, Theo. Roosevelt, Robert L. Stuart, Norman White, James B. Colgate, Samuel B. Schieffelin, J. W. Pirsson, S. A. Bunce, John Taylor Johnston, S. S. Constant, Nathan Bishop, the Rev. Dr. Seymour, the Rev. Dr. Roswell D. Hitchcock, Prof. Newberry, Prof. Peaslee, the Rev. Dr. Sawyer, the Rev. Dr. Holme, and John R. Ludlam.

Ladies and Gentlemen: I have to-night to speak on a subject not astronomical in itself, but one of those to which the study of astronomy naturally leads us. I suppose that there is no thought more common or which has been more ordinarily entertained than this—that space must necessarily be infinite. Utterly inconceivable, though, the idea of infinity is. Every one must have had the thought that if you take a line, as it were, a line through space, in any direction, there is no boundary; the line may be carried onward and onward, forever and ever, and whether it meets a solid substance, whether it arrives at a void space, still it may be carried onward and onward, and so forever; but that this space in that direction must be infinite. To a student of astronomy this idea is, perhaps, more naturally presented than to any other, because he is in the habit of considering telescopic power, which carries the mind's eye, as it were, further and further into the depths of space, still without any limit. Thus the idea of the infinity of space is the one with which the student of astronomy naturally has to deal.

We begin, then, with this subject of the infinity of space first of all, because it is the one we are best able to deal with, the one about which we feel the most certain. We may entertain doubts as to infinity of time, in past or in future; although, as I shall presently show, infinity of time as an idea has not near as much force upon us as that of infinity of space. In infinity of space we recognize a view that we must hold. We have, then, something that is inconceivable, and that yet must be admitted. And I want, this evening, to bring before you the idea that that which is inconceivable may necessarily be that which is true. So, inconceivable is this idea of infinity of space, the idea that all around us there are immensities of space, not merely as Sir John Herschel has said, practical infinity, but real infinity, absolute infinity, going on forever and forever.

OTHER DIMENSIONS THAN LENGTH, BREADTH, AND THICKNESS.

The idea seemed so inconceivable that men in our time, great mathematicians, of most powerful minds, have endeavored to escape from it, by this strange conception, that our idea of space may be limited by certain imperfections. They begin by conceiving the possibility that there might be a kind of creature having only length, living always as it were, having for its body an infinite straight line without any breadth, only length. And then they pass from that idea to the idea of a creature living always in space of two dimensions — in thickness and breadth—and show how to creatures of that kind the idea of space of three dimensions would be inconceivable; and they say, therefore, that we may be limited by some such want of conception in our powers, and that there may be space of four dimensions; in other words, something else than length, breadth and thickness may be a possibility. Now, if you consider you will find that you can thus get over the difficulty, although the explanation is not a whit more conceivable than the difficulty it is intended to meet. For instance, if there were creatures living in space, of one dimension, having only length, then instead of living on a straight line, as the first supposition was, it might have for its body, or rather its conceptions might be limited to, a perfect circular ring; then the conception of that creature would be that length measured with the circular ring was infinite, yet we know the circular ring would have a certain measurable size. Prof. Clifford, the great mathematician of England, one of the leading mathematicians, one of the rising mathematicians of our day, has pictured the case of a creature having only length and breadth, living on the surface of a sphere. Then to creatures of that kind the idea would be presented that surface was infinite, just as to us the idea is presented that space is infinite, and yet their surface would be the surface of a sphere; and, although it would have no limits, as we know that the surface of a sphere has no limits, yet it would not be infinite in dimension. So says Prof. Clifford and so say the German mathematicians, from whom that idea has been borrowed; so it may be possible that it is only our limited conception which gives us the idea that space is infinite.

IS MATTER AS INFINITE AS SPACE?

Well, I pass from these conceptions with the remark that to me they seem not a whit less inconceivable than the absolute infinity of space. And it appears to me that so far from high mathematical power forcing upon us the possibility of such conceptions, that as soon as we take the *rationale* of the matter, the ordinary, simple explanation of facts, we are bound to admit that space of three dimensions includes the whole of possible space. You will have length and breadth, and you will have everything that lies above it or below it. In other words, if you have added to length and breadth the conception of thickness, you have the whole of space. We have then infinite space. We have brought before us, as I conceive, that which is utterly beyond our powers of conception. Then arises the thought: If space is infinite, may it not be that matter is not so, that the matter which occupies space is limited, that the region of space occupied by matter has its boundaries? And you will all remember the reasoning that was applied by Aristotle to that matter. He said: If you take in all material particles in space, a line drawn from one to the other is limited; it has its two ends, and no space can be without limits of which that is true; that every part of it be at the two ends of a limited line. Yet after all, so soon as we apply to this matter ordinary reasoning, we find ourselves led to a contradiction. And why should we wonder at that when we recognize the certainty that there is here something contrary to our powers of conception? You will see that is the idea—to insist upon the fact that as we deal with these infinities we have continually enforced upon us the knowledge of the fact that there is something far beyond our powers of conception. And you will presently see that I propose to apply that to the problem full of interest for us all.

But then comes in an astronomical view of this question of the infinity of matter. It has been shown that if there were spread throughout the universe an infinite number of suns like the stars, spread uniformly through the space, then it can readily be shown that the whole of the heavens ought to glow with the same brightness as the sun's surface. It does not matter how far apart those suns may be, or how small their dimensions might be, compared with the distance separating them, still you would have the whole of the heavens glowing with the glory of sunlight unless light were gradually extinguished as it travels through space. For let this be remembered. Any group of stars of limited extent would look as bright, wherever it were placed. If you carried it away—if it lay at a certain distance—the stars composing it would gather at a certain portion apparently occupied by that group. Now, suppose the group carried twice as far away, then the stars would only cover a part of the apparent dimensions that they properly covered; but then also, the group would only look one-hundredth part of the size. And therefore although the quantity of light would be reduced in proportion to the distance, the brightness would remain unaltered. Therefore it follows if you conceive space filled with an infinite number of stars, separated by any average distance, however great, any certain inclosed part of that space would have a certain brightness; the portion next beyond it of the same size would have the same brightness, and a similar portion next beyond that the same. Now suppose that that brightness of which I have been speaking was a millionth part of the same size. In other words, the space that the sun occupies in one of those groups covers but the one-millionth part of the space that the whole group appears to occupy; then the next group covers another millionth, and the next another millionth, and if you go on infinitely, you only require to take a million of those groups to have a million times the millionth part of sunlight; therefore you have the whole of that region glowing with the glow of sunlight. And so we come to the conclusion, if stars are spread infinitely through space, the whole heavens ought to shine with a glow of sunlight. If that is not the case, then we are forced to the conclusion that light must be extinguished as it travels through space.

A METHOD OF EVADING THE ASTRONOMICAL OBJECTIONS TO INFINITY OF MATTER.

And yet there is a way to get over that which I had thought of, but which was originated by Sir John Herschel. He points to the fact that the dimensions of the several component parts of any system are very small compared with the distance that separates one from the other. And when you pass to a system of a higher order, you find the dimensions of the first system are very small compared with those of the next. For instance, take the solar system. The dimensions of the earth and other parts of the solar system are very small, infinitely small, compared with the distances that separate the various parts of the system from each other. Then again, the distances that separate parts of the solar system from each other are small compared with the distances that separate our solar system from its neighboring systems in space. Proceed to a higher order and you will see that the dimensions of the solar universe are very small compared with the distances that separate it from its neighboring universe. Go on in that way; carry up the order of systems higher and higher without limit; and then if you apply to systems of that kind—if you apply to them a process of calculation—you find that no longer have you that result of heavens that glow with the glory of sunlight, but instead of that you may have any order of brightness you please, according to the relations you may suppose to exist between the parts of a system and the distances that separate one from the other. And thus we have this curious conception of the infinity of matter occupying space. If we are to believe in that infinity of matter we have this conception, that it may be compared to a tree. Begin with a lower twig, and travel along that twig until you come to where it joins the next twig, and so on until you come to where it joins the next twig, and you have a gradual enlargement; you come to a new order of twig at this point; you come to a branch, and then to a larger branch, and so you go on from that larger order, and then you have the whole tree at last, and there an end. But if you believe in the infinity of matter, and if you choose to feel that there is a continual passage from one system to another upwards gradually increasing, or downwards gradually diminishing, then you no longer have the difficulty of which I speak, and it appears to me if we accept infinite space we are almost bound to accept the infinity of matter. Otherwise see the difficulty in which we land ourselves. Suppose that occupied space has a certain finite extent, let that extent be what it may, there lies outside of it an infinitely greater region, so that again you have what appears incongruous, that you have occupied space which is infinitely small in proportion to the unoccupied space. The idea of the infinite occupied space is beyond our powers of conception; but not a whit less beyond our powers of conception is the idea of an infinite unoccupied space; and thus we are led to believe that matter is infinite, and that an infinite quantity of matter occupies space.

INFINITY OF TIME AS WELL AS OF SPACE AND MATTER.

And thus we are led to the next point that we have to deal with, an infinity of time. We are very naturally led to pass from the infinity of space to the infinity of time, in this way, that the only way the human mind can become acquainted with the character of matter is by the flight of light. And then we recognize this, that every part of space we have not yet become acquainted with, and that therefore time is occupied in conveying light messages that we know not of. We are immediately led from the infinity of space to the infinity of time. Let us make this comparison. As we take in space an infinite line, a quantity which extends in every direction, so let us take an infinite line in time. Let us carry back our thoughts infinitely, an infinite progress backward. Do we come to an end? Is it not a thing that can have no end? You come to the beginning of all things on that side, the beginning of all created matter. Beyond all that is the infinite void of time. Suppose you come to the end of all things; beyond all that is the infinity of time, the infinite void of time. We have on either side of us infinity; the idea that the whole of time has been and is to be expended, in the past and future; the idea that the whole of time has been occupied by the occurrences of events, or the idea that there has been some part of time unoccupied. Both ideas are equally impossible to our conceptions. Since both are equally inconceivable, we would naturally take that which is most congruous, the idea that the whole of time has been occupied. We are led again to the utterly inconceivable idea that there can be no beginning and no end. One need not be repelled there by the words of Scripture. The words of Scripture are, "in the beginning;" but they don't say that there was a beginning of time, but a beginning of forces, as far as we are concerned. It has been said that the very idea of the progress of time implies a beginning. It has been said that the very idea of space implies a limit, but we know it has not a limit. So we find ourselves, whether we consider space or time, led to inconceivables.

EVENTS AND MATTER OCCUPYING TIME AND SPACE.

Now let us consider that as far as we know they are occupied by events and matter. What are the events that have occupied time and the matters which have occupied space? The matters that have occupied space are those which astronomers have brought to our mind—worlds, systems, systems of systems, universes in stars, collections of universes—and the mind is carried on to yet higher ideas of what occupies space. But as to what occupies time, we recognize continual action in those parts of space, one upon another. We recognize a sun gathering in all around it, deriving power from the indraft, and spreading out that supply of power over the creatures that live upon the worlds around. We recognize all the progress of time, and in the regions of space we recognize the continual action of power. There is continual force and continual energy. We are told by science that so far as our knowledge goes there is an end to all that energy. The earth, for instance, was once an orb like the sun, which gradually parted with its inherent heat until it reached its present stage; and looking into the future of the earth we trace the time when it will be like the moon, when it will have dismissed its inherent heat and no longer be fit to be the abode of life. Passing on the other side, we come to orbs like Jupiter in a longer state than this earth, still instinct with their inherent fire; and still higher than that we come to orbs like our sun, fit to be the center of schemes of circling worlds. We find these various orders, and recognize the fact that the orbs of our order are passing rapidly down to the next order. The sun is gradually parting with its inherent heat, and will unquestionably assume one day or another the state of the planet Jupiter.

Then again the planets Jupiter and Saturn are passing down to a lower order. Our earth is passing down to the order the moon presents; the moon may be still further parting with its inherent heat, and so there is a continual progression from the higher to the lower orders. But is there an end to that progress? Does it imply on one hand a beginning from which all these orbs arrive at this state, or, on the other hand, an end to which they are all tending, and to an end when all the orbs in the universe will be equal in point of heat, and then, although the force in the universe will remain unchanged, the real acting energy, depending, as we know it does, on temperature, will have passed away. That is the view to which we seem tending.

WILL THE UNIVERSE BE RENEWED?

I have heard the view insisted upon by a philosopher of this country, for whom I have high respect, as tending to show that astronomy is the one science teaching us that there was a beginning and that there will be an end. Here again it seems to me the finiteness of our conceptions has led us astray, and when we view the matter rightly we recognize in this progress a progression which neither implies a beginning nor an end. We find ourselves merely members existing through a long series of ages, and it appears to me that we may look back into the infinite past through which these changes had a present state. It is as though persons reasoning about a tree, for instance, springing, as we know it does, from a seed, were not aware of the fact that the tree, after it was dead, would give birth to other trees, and so there would be a continual progression. In the same way we can understand—it is quite conceivable—that the state of things which now appears tending toward an end is really tending toward a condition where there will be a new beginning, and evidences of energy will continue forever, and thus there is neither a real beginning nor a real end. At any rate, we see that the universe, having infinity of space, and infinity of material occupying that space, has also infinite power. The quantity of material matter would not imply power, but material matter separated by enormous distances at least implies power. Take our sun, for instance; grant him his present enormous mass, let all the matter be gathered in upon his surface, and power is not implied, but let that matter be restored to its original distance, and give the sun his in-drawing power, and then in the sun resides power making him fit to be the center from which are to be dispensed endless supplies of life and energy. Since this distance of matter implies power, and since matter is infinite and distances are infinite, and matter occupies infinite space, according to our assumptions power in the universe is infinite also.

And thus we come to the conception that there is in the universe, quite apart from all ideas of God, infinite power. We have been led then from the thought of infinite occupied space, to the thought of infinite time occupied by events, and now to the thought of infinite power; and yet all these ideas are utterly beyond our powers of conception. Why, then, dismiss the idea of a God merely because He is beyond our powers of conception? The materialist is right when he says this or that doctrine is inconceivable, but he is wrong when he says I will not admit it; the idea of space is inconceivable, that we must admit; the idea of infinite time is inconceivable, that we must admit; the idea of infinite power is inconceivable; but, taking the view that infinite space and infinite time are brought to our knowledge, we must admit the idea of infinite power.

THE ATTRIBUTES OF DEITY DEDUCED FROM ASTRONOMY.

Why, then, stop short of the idea of infinite wisdom and beneficence of the design of the Creator merely because it is something that is inconceivable to us? It seems to me, then, we may fairly turn from this to the consideration of the possible attributes of Deity without being disturbed by the thought that the very notion of the Deity—of a being infinite in existence, infinite in space, infinite in time, infinite in power, is inconceivable to us. Why, those very attributes that have been ascribed to Deity are the things we have been forced to see. We began with infinity of space, and it is infinity of space we attribute to the Almighty. We are led from that to infinity of time; thence to an infinity of power; and it is by that we are led to the mere physical consideration of the qualities of the universe. Thus, then, naturally we may turn to the thought of possible qualities on the part of the Deity and the way in which, in some sense, His authority may be exercised over the dominions of the universe. Take, for instance, the senses by which we became acquainted with the nature of the universe, and let us remember how utterly feeble those senses are; on how narrow a basis we form all our conceptions of the universe. There are five feeble senses; only one of those senses, the sense of sight, brings to us any knowledge of outlying space; and that sense existing only in two small pupils which are to tell us of the universe. We may, indeed, extend the powers of the eyesight by means of the telescope; but then we, in point of fact (I do not use the word in jest), see as through a glass darkly, because we have only a small part, a small portion of the heavens brought out into view; and it is only by combining the views thus formed, combining them in the imagination, that we can form an estimate of the real wonders which appear; so we can imagine what might be seen if the power of the eye was increased to that of the largest telescope, and we can conceive what would be seen if the power of the eye was increased a million fold beyond that of the largest telescope; the wonderful displays of the dark clouds and masses of matter gathering in various portions of space, the power of recognizing their motions as the telescope enables the astronomer to do, learning the harmony existing in their motions. That is something that the feeble sense of sight only adequately extended might bring before us.

THE LIMITS IMPOSED BY OUR SENSES.

Nay, there is another thought connected with this subject, which is dwelt upon in a little book called "The Stars and Earth," which you may have seen—the author of that book is unfortunately unknown—that wonderful thought that everything that has gone on in the universe, everything that has occurred, is at the present moment conveying its message into the depths of space; the time when life began on this earth, although it may have been a million of years away, all that has happened upon the earth, is at this very moment conveying its message into the depths of space; all that was happening during the millions and millions of years in which the earth was forming, is conveying its record into space. Nay, further back, when the world was a nebulous mass, and when the solar system was beginning, as we understand, that message is still being conveyed into the depths of space. Now if we admit the idea of a Deity, infinite in the power of sense and in the power of perception, then to Him all those records are being at this very moment conveyed. But after all the sense of sight affords but one of the feeblest methods of ascertaining what is going on. Our conceptions are feeble; but we can conceive more powerful means of learning what is going on. Light takes a certain time in traveling; it travels with enormous velocity; but still our sense of sight is not a cotemporaneous one. We have information about a star at one time, while another star is presented to us at another time. The scene is not that which exists at the time it is presented to us. We turn to another force, the message of gravity, which, according to our present modes of measurement, acts instantaneously, and conceive the possibility of a creature perceiving by it, as we see, at the moment. We cannot doubt but that all the information that will be conveyed to such senses must be, as it were, possessed by the infinite and inconceivable Being occupying all space and existing for all time. If we have these various conceptions presented before us, we can think as to what is possible on the part of the Almighty; but we have to remember that we too must be an absolute part, as it were, of His existence. The whole universe is at this very moment conveying information not only and not merely about its present state, but about its past state. Every part of the universe at this present moment is conveying its message, as it were, to the Almighty. Nor can we doubt that a being of infinite power, of infinite future existence is indicated by the present state of matters on this earth, for precisely the same reason that the present state of things throughout the universe indicates what is past, it also indicates what will follow. We have then a new conception brought before us, or at least a new idea, which is utterly inconceivable; and added to the ideas of infinite space and infinite time and infinite power, we have an idea of an infinite knowledge of the Almighty. You see, then, we have been gradually led by the study of these various orders of inconceivable ideas—we have been gradually led to those ideas about the Almighty which form so great a subject of dispute. It seems to me to dispute this matter is hopeless and must be endless, because it is based upon that which is inconceivable.

THE VAST VARIETY OF THE UNIVERSE.

But now let us consider the field through which the action of the Almighty is extended. And here we have the teachings of astronomy before us. We have thought of the wonderful power displayed, but have not considered the wonderful variety. We have in our solar system, for instance, the great central orb that controls the system, an orb swept by cyclonic storms, surrounded by the zodiacal light, circled by various planets, these planets differing from each other in kind; there is the terrestrial order of small planets and giant planets, the asteroids and the multitudes of satellites and the meteoric systems. All are traveling around the sun. We must recognize the fact not merely of variety, but that these varieties must extend through infinity. We see that the various suns, for instance, are not alike. Some are double and others are single; some are variable and others are fixed. Then we come to these wonderful star clusters, changing like clouds before the Summer breeze. We see all these processes taking place which indicate a variety of existence in worlds circling around these suns. Then we are led to the question of life, life in other worlds and of infinite life. I have brought it before you with more detail in this, the conclusion of this course of lectures, because in the theory of life in other worlds we have a theory which, as such, seems to limit the domain of life. According to it our world is probably the only inhabited world of the solar system; according to it, probably in not more than two members of that system is there any life at all. But then when we remember that the systems are numbered by millions, and that there is an infinity of suns, it seems to me such a conception is incorrect, and that, in answer to another class of thinkers, from the infinity of numbers we have no right to say that life does not exist where there are no creatures to study them.

It seems to me as unreasonable, as these philosophers do, to deny existence except in relation to life, as it would be unreasonable to deny existence in this earth before there were creatures living upon it to admire the works of God seen from its surface. And after that the great point is that by the study of astronomy chiefly we have brought before us various forms of infinity and various forms of inconceivableness, and that this inconceivableness teaches us that religious ideas are not in any way to be dealt with merely as they affect our powers of conception, and it is no answer to any form of religious belief to say that it is inconceivable. We may say it is inconceivable that there should be a miracle,but here we have science teaching us the infinite and the inconceivable. Why then should we consider the mere argument that such and such a work is inconceivable, when after all, it is only inconceivable to us because it is beyond our experience.

Why should we say it is inconceivable as overthrowing any religious form of belief? It seems to me, then, the instructive part which astronomy brings before us are these inconceivablenesses, for there are other studies which lead us down in an opposite direction, an infinite smallness, an inconceivable infinity of division and subdivision, and it may well be there are no limits in that direction also. There are other thoughts. We are apt to limit our conceptions with the view which is brought before us. It may seem a strange and startling thought that the very reason we possess may be merely a lower form, as it were, of possible modes of existence.

THE SHORTNESS OF LIFE COMPARED WITH THE LENGTH OF TIME.

We see different modes of existence—the existence of the mineral, the yet higher one of the vegetable, and the yet higher one of the animal—and we may separate the animal from the human in this sense—the higher existence of the living creature. But may there not be higher orders of existence, orders as inconceivable to us as the sense of sight is to the blind man? It seems to me these thoughts would well bear our study, and that it would be well to remember that what we know is not the measure of that which is possible.

Now, in astronomy after all—and I must leave these subjects, which do not belong to my domain, although I think it not unworthy of the student of one science to show how his science throws light on subjects belonging to another—in astronomy after all we have to deal with space, we have to deal with the way in which space is occupied. And the great infinity that is brought before the student of astronomy is the infinity of space, is the infinity of unoccupied space. We pass from this earth on which we live, an orb that seems to us the emblem of all that is stable, all that is important and magnificent, and we find ourselves led step upwards to the higher orders of existence. We pass to orbs, in the first place, like the planets Jupiter and Saturn, orbs compared with which this earth is a mere point. Then we are led to the sun, and there we recognize not merely dimension, but powers so great that those other orbs from which we have passed sink by comparison into utter insignificance. Then we are led to the stellar distances, distances that separate one part from the other, and there is suggested to us one thought that is well worth the considering. If we take the analogues of one infinity and infer from this the analogues of another, we may well believe that the theory I have advanced about the time in which life exists is the true one. For be it noted, in space we find that occupied space bears what may be regarded as an infinitely small proportion to unoccupied space. In other words, throughout space we find the dimensions of each orb are infinitely small as compared with the distance separating it from its neighbors. And may it not be that in time the same law holds—that as the dimensions of an orb of matter are infinitely small as compared with the void around it, so the length of time occupied may be infinitely small as compared to the unoccupied time on either side. That corresponds, as you will see, with my theory that life on this earth will last but an infinitely short time compared to the void that has passed before and the void to be passed thereafter, and that this is true of the other worlds constituting occupied space. So with this idea that the present condition of the sun, which is the center of circling worlds, is infinitely short as compared with its future and its past existence.

To return to the analogues of space, we pass from the solar system to the distances that separate that system from its neighbors in space. We pass from one orb to another. We pass to the star-clusters to which our system belongs, to the stellar cluster of which, again, that is only a portion, and then we find ourselves brought face to face with infinity—with infinity of space, for that phase of infinity is all that I can venture to deal with. Yet I can remind you that we are led up from nature unto Nature's God; and when I say infinity of space, I cannot fail to recognize infinity of power and goodness also. Seeing, then, infinity of space, finding ourselves in presence of the Almighty, we are led to those feelings that the poet Richter ascribed to the man in that wonderful dream that he describes, and which De Quincy has translated. This dream I repeated in one of my former lectures, but I know of no words more fitting in which to bring my lectures in this country to a close.

PROCEEDINGS AFTER THE CLOSE OF THE LECTURE.

At the conclusion of the lecture, the Rev. Dr. S. Irenæus Prime addressed the audience as follows:

As this is the last lecture Prof. Proctor will give in this country, and as this is the last time his voice will be heard here, it gives me great pleasure to comply with the request of the Committee who have had this course of lectures in charge, and present to Prof. Proctor a minute showing of feelings with regard to the course of lectures he has given to us.

Having listened with the highest satisfaction and delight to the lectures of Prof. Richard A. Proctor, whose fame had long preceded his visit to our land, we desire on his departure from us to return to his own, to give a faint but sincere expression of our gratitude to this illustrious scholar for the instructions we have received from his eloquent lips. He has led us with reverent steps through the sublimest paths of the heavenly worlds; and while he has brought down the suns and stars that we may study them with him, their study, with his genius and learning as our guide, has taught us not to admire only, but also to adore.

In parting with Prof. Proctor we give him the assurance of our grateful appreciation of his labors in the United States, our hearty congratulations on the success which has attended him through the 103 lectures he has delivered in his journey of six months, and regretting that he is constrained to leave us (for a season only, we trust), we wish him a pleasant voyage, under propitious skies, an unclouded sun and favoring stars, and bid him to-night a respectful and affectionate farewell. [Applause.]

I shall now have the pleasure to say that the audience will listen to a few remarks from Prof. Newberry, to be followed by Prof. Hitchcock.

Prof. J. S. Newberry of the School of Mines of Columbia College, in accordance with this introduction, spoke as follows:

REMARKS BY PROF. NEWBERRY.

LADIES AND GENTLEMEN: In consenting to say a word in support of the resolutions which have been laid before you, I felt at first that I had committed myself to a great impropriety; for if you look over the whole list of sciences, you will know that the one I am devoted to is at the other extreme, and that it has been far from the theme of Prof. Proctor's lectures, which have been showing to you the wonders of the heavens, and carrying you from sun to sun and from star to star, while I am chained to the earth, and not only so, but am compelled to delve deep down into the mines that are sunk in its substance. And so while I could not refuse to say the word that was asked of me, and thought that the choice was one not fitting to be made, I think that perhaps in another sense it is not unfitting in its propriety; for at the infinite remove I am from the subjects which have been brought before you, knowing that I have derived pleasure and light from the interesting lectures I have been permitted to listen to, I might take it for granted that the interest extends through all the ranks of scientific men, as if from some dark and remote corner of this audience there should come to you some echo of this appreciation and interest. [Applause.] So I take extreme pleasure in saying that I have listened not only with interest but with great profit, and that I am greatly indebted to Prof. Proctor for giving me so clearly and lucidly the last word upon the structure of the universe, the last word of what we know of the structure of the universe; and it would require no great stretch of imagination to say that I can weave into my studies of the structure of the earth what he tells us about the structure of the far distant orbs, inasmuch as he has shown that one plan pervades the whole, and that nearly the same substances are in them, and that they are controlled by the same forces. Therefore individually, as a geologist to him as an astronomer, and as a member of the audiences which have listened to him, I am sure that I only express your feelings when I echo the gratitude which has been expressed, and the good wishes for his safe return home and also for his speedy return to us. [Applause.]

REMARKS OF PROF. HITCHCOCK.

The Rev. Dr. Hitchcock then added a few words. I am not sure, said he, but I shall learn wisdom by and by, and decline invitations to meet the gentlemen in that side room. [Laughter.] I came here to-night without the slightest idea of being called upon to say a word. I represent, without preparation, the science which the eloquent lecturer of the evening will admit to be the mysterious queen of all the sciences. I have been reminded this evening, as I sat listening, of that striking remark of Emanuel Kant, the great metaphysical philosopher, to this effect: "There are two things that I stand in awe of—the starry depths, and the sense of responsibility in man." It has been a dictum of philosophy: "I think, therefore, I am"—*cogito ergo sum*. What follows from the fact that we think infinitely? The infinite thought pledges infinity of being to us in the time to come.

A word has been said by Prof. Newberry about the science that is beneath our feet, so to speak, in contrast with the science which is above our heads—the science of the microscope in contrast with the science of the telescope. That reminded me of the teaching of the Great Augustin of the Fifth Century, who, speaking of God, said: "Great in great things (*magnus in magnis*); greatest in the littlest (*in minimis maximus*)." Those who have heard Prof. Proctor will be only too glad to welcome his return to this land, and we shall all give him a hearty goodby, and shall follow him in imagination, not to the May-poles, I suppose, of Merrie England, but to greener grass and a softer sky than he leaves behind him. God bless him on his voyage. [Long applause.]

MR. PROCTOR'S PARTING WORDS.

Prof. Proctor then rose and advanced to the front of the platform, and was received with great applause. He said: Ladies and gentlemen, I do not remember ever to have felt feelings so strangely blended as those that I recognize at the present time. I cannot say that I am sorry to go home. You can conceive that after an absence of six months from my own house, quite apart from all questions, all thoughts of revisiting England—and I am an Englishman at the heart—quite apart from all those thoughts, the very thought of going home again to my wife and children would be one that naturally must make me feel glad. [Applause.] But, on the other hand, I can say unaffectedly that I feel a true feeling of sorrow at the thought of parting with the American friends that I have made, or rather that have welcomed me as friends on this side of the Atlantic. To say that I have made friends would be to indicate qualities in me that I do not possess; but I have experienced friendship; that is rather the way in which I would put it. I have experienced friendship on all hands and kindness from every one the whole time I have been here. It has seemed to be the common thought of all I met, not merely to show kindness, to help, but from one and the other I have had kindness and help, as though my plans and purposes were the very object in existence of those gentlemen who assisted me. Then Profs. Morton, Youmans, and—but why should I mention names, why make invidious distinctions? Everywhere throughout the length and breadth—I was going to say of the land; but I did not visit the whole; I visited the length and breadth of a large section, but do not speak of the distance from the West to California, or from St. Louis to New-Orleans and Florida, for those regions still remain unvisited, but all the other sections of the land that I visited—throughout the length and breadth of it, I have had nothing but kindness.

Then again, I have had an opportunity of seeing the way in which science is progressing in this country; and to the student of science there is something peculiarly hopeful as to the manner in which science is pursued in this country. The The present condition of this land, its advancing condition, and the absolute necessity there is that in this large country its inhabitants should devote a large portion of their time to material interests, that is to be considered. But in the way in which science is undertaken, the generous way in which men give their time to it, the ingenuity with which they endeavor to advance science, the fresh thoughts they take, and the plans they employ—there is in all this something hopeful to one who has learned to look with regret on the fondness shown on the other side of the Atlantic for following old paths and not trying fresh modes of research. Before I sit down let me say that in one sense I find myself more comfortable in speaking to you now than I was on the former occasion when I spoke in this hall. Then I was, although not at the beginning of my labors in America, I was at the beginning of the most important part of those labors. You doubtless know that in the three months before that time I gave but 29 lectures; in the three months following I gave 73; and, therefore, if I spoke at that time highly of this country, it might be in the thoughts of some that my expressions of respect for American science might be perhaps a little exaggerated in presence of the approaching visits I was about to make to the centers of science in this country, and that the gratitude I then expressed for the kindness I received might be that form of gratitude that has been described as "a lively sense of favors to come." [Laughter.] But there is one thing I feel it desirable to mention at this time—that my admiration for American science has not dated from my visit to this country, but preceded it, and has been expressed more strongly than expressed here, in books written before I ever thought of visiting this country. With these thoughts, with this remembrance of the kindness of this country, with these hopes as to the future of science in this country, as to the great advance science is to make under the labors of men in this country, I return to England; and I can assure you that I shall convey to England with me a sense of the warmest possible gratitude toward this country, and a sense that I return to England with much that I have learned. Lastly, ladies and gentlemen, to the persons who are here present I have only to convey again my warmest, my sincerest, my most unaffected thanks. [Great applause, during which the speaker retired.]

Dr. Prime then said: If there is no objection, we will consider the resolutions as unanimously adopted. The audience then, after a hearty round of applause, slowly dispersed.

THE GERM THEORY OF DISEASE.

A LECTURE BY PROF. C. F. CHANDLER.

GERMS DEVELOPED IN FERMENTATION AND PUTREFACTION—THE THEORY THAT DISEASES ARE DUE TO THE ABSORPTION OF GERMS INTO THE HUMAN SYSTEM.

Prof. Chandler of Columbia College delivered a lecture, March 31, at the Stevens Institute of Technology, Hoboken, on the subject of Fermentation and the Germ Theory of Disease. The first part of the lecture was devoted to elucidating the changes which take place in organic bodies during fermentation and putrefactive processes.

In 1680 Leuwenhoeck discovered with his new microscope the yeast globules. In 1787 Fabrioni advanced the doctrine that the yeast was an acid which acted upon the sugar as a base, saturating with carbonic acid and alcohol just as hydro-chloric acid acts upon chalk to form carbonic acid and chloride of calcium. In 1803 Thénard advanced the idea that the yeast eats a little of the sugar; assimilates a portion and rejects the rest, as alcohol and carbonic acid. Stahl suggested catalectic action, and Liebig advanced that idea and long defended it. He thought that the oxygen of the air starts the decomposition of the albumenized matter, and that the activity developed in this way is simply communicated by contact with the sugar, which is literally broken to pieces by the forces at work in the yeast. In 1837 De La Tour suggested the true explanation of fermentation, namely, that it is an effect of the vegetative active action of the yeast. This theory received no attention at the time. In 1843 Helmholz experimented in solutions of sugar, in which the yeast was limited to a portion of the solution by a membrane, and proved that the action was limited to the yeast globules. Pasteur finally established the doctrine that the growth and reproduction of yeast fungus only takes place in fermentible liquids, and that alcoholic fermentation only occurs when the yeast plant is present in a state of active development.

This discussion necessarily involves to some extent the question of spontaneous generation—a doctrine which was received without question by the early Greeks, and which only disappeared within the last two centuries, and has been recently revived, to the great horror of many very good people, who think that any idea that is contrary to their prejudices is necessarily very wicked. Aristotle supposed that oysters and all shell-fish, many insects, and even eels, were generated spontaneously in the mud; that maggots grew spontaneously in putrefying flesh. The story of the bees found in the carcase of a dead lion by Samson was supposed later to furnish a Scriptural foundation for the doctrine of spontaneous generation. Redi was the first to prove that maggots were simply the young of flies. He advanced the doctrine *Omne vivum ex vivo*: no life without antecedent life; a doctrine which we now call biogenesis. Considerable discussion took place, and numerous experiments were made to throw light on this subject. These the lecturer described in some detail. For a while the idea of spontaneous generation was pretty effectually disposed of, and it came to be generally believed that all life was derived from previous life, but the introduction of the microscope and the discovery of infusoria revived the question, and a new discussion started, which has been going on for the last 20 years. In the case of almost every living form it is found that what appears to be the spontaneous development of animals and vegetables is simply the development of spores or germs that are constantly floating in the atmosphere. These find their way into liquids and moist substances which furnish the proper soil for their development.

The analogy between fermentation and the development of infectious diseases was then pointed out, and numerous instances in which disease has been directly traced to parasites through animals or plants were cited. Among these were the internal parasites, the *tænium solium*, or the pork tape-worm, which appears in the measles of pork in the form of quiescent *crysticercus*, and which develops, when eaten as human food, into the tape-worm; the similar tape-worm contained in the measles of beef and veal; the dog tape-worm, which produces in its younger form the hytadid tumors in man. The last is the worst of all tape-worms; 500 persons are supposed to die annually from it in Great Britain. Another frightful internal parasite which attacks man is the *trichina spiralis;* it appears in the hog in the encysted condition, is eaten in pork, and secretes itself in the alimentary canal of man. The little worms being set free, attach themselves to the walls and develop with frightful rapidity in five or six days. Each family produces from 500 to 1,000 worms. As one ounce of pork sometimes contains a quarter of a million worms, it is no wonder that a meal of raw pork should prove a very serious indulgence. As soon as the young worms are born they eat their way all over the body, get into the blood-vessels, and are carried everywhere. Death generally ensues in from 15 to 50 days.

Several cutaneous diseases are known to be caused by the growth of fungi; the ring-worm and similar affections, for example. The development of internal vegetable parasites in both plants and animals was the next subject of discussion. The potato-rot, the *muscardine* of the silk-worm and house-fly, and the *pebrine* of the silk-worm were described as examples. The latter disease, said the Professor, cost France by the damage inflicted upon the silk crop more than $200,000,000.

The development of bacteria in the blood of animals, and the production thereby of most fatal and malignant diseases, has been the subject of interesting experiments. Instances of the effect of inoculating infected blood were cited, and the fact was stated that the bacteria are invariably found in the blood of persons suffering from typhoid fever, small-pox, scarlet fever, puerperal fever, and other diseases. The investigations upon vaccine virus bring this contagion into the same category with the other fungoid diseases. It was thus shown that but little is needed to establish fully the germ theory; that many of the most fatal diseases known to man, such as cholera, typhoid, typhus, yellow fever, etc., were generated in this way. The analogy in the mode of development, the introduction and the course of the symptoms, and the production of the contagion, was clearly pointed out.

Dr. Beale's theory supposes that these diseases are not developed by special germs, but that the white corpuscles of the blood, which in their normal or regular development are produced in the ordinary course of life, may develop, under special circumstances, abnormally into bodies—germs we may call them—of diseases which not only produce this disease in the person in whom they are developed, but which may pass out as do the spores of the fungi, and, entering the bodies of other persons, produce a similar disease.

The lecturer closed with a discussion of the means of prevention, which depend upon the prevention of the development of the diseased germs, the greatest protection being afforded by cleanliness.

TRIBUNE POPULAR SCIENCE.

PART III.

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THE ACADEMY OF SCIENCES.

SESSION AT WASHINGTON — FIRST DAY.

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[FROM THE SPECIAL CORRESPONDENT OF THE TRIBUNE.]

WASHINGTON, April 21. — The National Academy of Sciences is obliged by the terms of its charter from Congress to hold a meeting in April of each year at Washington. It usually happens that the accumulation of papers which the members are anxious to put on record is too great to wait for the annual opportunity, and that a meeting is called some time during the Fall to throw off the superfluous load. This was the case last year, and led to the meeting in New York in October, which was fully reported at that time in THE TRIBUNE. But the Washington meeting is always regarded as the one of greater consequence; and as the National Academy is the highest scientific body in the country, this session must be considered as of the utmost importance. To it the most eminent men in their special pursuits whom America possesses, contribute the fruit of their painstaking researches, not unfrequently embodying in a single paper the labors, not to say the aspirations, of months or even years.

The meeting was held at the Smithsonian Institution, a temple of science which is the fitting repository where from all lands and seas curious and valuable things have been collected, till now it takes high rank among the few great museums of the world. The venerable Prof. Henry, Secretary of the Institution, presided over the deliberations of the Academy. The limited number who by the system of election can be joined to our "immortals" were more largely in attendance than last year at Columbia College. There was a sprinkling of curious visitors, but the Academy makes no bid for popularity.

Prof. Le Conte was called upon for the opening paper, which was a delicate compliment to a rival institution, as he is the President elect of the American Association for the Advancement of Science, a body which has a larger hold on the popular heart than the Academy.

CLASSIFICATION OF THE RHYNCHOPHOROUS COLEOPTERA.

BY JOHN L. LE CONTE, M.D.

Dr. Le Conte's paper began with an allusion to the fact that at the January meeting of the Academy of Sciences in 1867 he had opened the subject now under consideration. The group of insects referred to are exceedingly complex in their characteristics, and good European entomologists had made frequent efforts to settle their classification. These attempts were reviewed historically, and the methods and systems were detailed of Schonherr in 1833–34 and Prof. Lacordaire in 1863, the latter being somewhat supplementary; of Mr. H. Jekel in 1860; the remarks of Mr. Suffrain in 1847, and of the work of Prof. C. G. Thompson in 1865, and the careful studies of Dr. George H. Horn, 1873 From the last-named work Dr. Le Conte selects a statement concerning the males of some genera having eight and the females seven dorsal abdominal segments, and calls attention to the importance and wide extent of this characteristic. He has made a series of dissections of Rhynchophorous insects, and makes a division of them into three series: (1.) Haplogastra, having abdomen alike in both sexes; ventral segments not prolonged upward into a sharp edge. (2.) Allogastra, abdomen dissimilar in the two sexes; ventral segments prolonged upward, forming a sharp edge. (3.) Heterogastra, abdomen alike in both sexes; ventral segments prolonged upward to fit into the elytral groove. Many other distinctive characteristics were given, with a detailed description of the very numerous genera belonging to each of the series.

Although principally devoted to classification, Prof. Le Conte's paper gave many points respecting the habits of some of these destructive insects. The Attelabidæ and some Rynchitidæ provide for their progeny in the Spring. The females roll up the leaves of trees and deposit in each roll an egg, the inside of the leaf furnishing food to the larva when hatched. Other Rinchites deposit their eggs in young fruit, the kernel of which is eaten by the larvæ; others in undeveloped buds of trees, which are thus destroyed. A European species of the Rhinomaceridæ deposits eggs in the male flowers of the *Pinus maritimus*, the development of which is thus prevented. The results of years of laborious dissections and study seem to have been compressed in this paper of Dr. Le Conte, and the exact anatomy and characteristics of a vast number of insects, many of them the pests of the husbandman or fruit-raiser, were given at great length; but the paper was far too technical for the average reader.

AN AUTOMATON TO PLAY TIT-TAT-TOO.

BY PROF. FAIRMAN ROGERS OF PHILADELPHIA.

This paper described combinations of mechanism for imitating mental processes, illustrated by means of diagrams showing the peculiar requirements of an automaton which should play the game of tit-tat-too against an opponent; the play of the automaton to be a resultant effect of the play of his opponent.

Among the various classes into which machines may be divided, we find those which have for their object the mere transformation of motion according to various sequences, as is the case in clocks, certain portions of moving machinery, and especially calculating machines. In all these the apparatus being constructed according to a certain law, goes through operations automatically, which resemble to a greater or less extent the operations of the human mind. In the case of the calculating machine it reproduces and extends in a regular sequence the form with which it starts.

Babbage, in speaking of his analytical engine, has suggested that a machine might be made which would play a game of combination such as draughts, provided the maker of the machine himself could work out perfectly the sequences of the game. He does not appear to have published anything further on this subject, except to suggest that the child's game of tit-tat-too is the simplest of all the games of combination, and therefore possible to be played by an automaton.

The author of this paper finds that the sequences of this game being readily tabulated, it is possible to arrange a machine which will follow them, and which will have the power of apparently selecting the course which will lead to success when there are two ways open to it. It differs from the calculating machine in so far that it not only follows out a regular sequence as the result of its construction, but it is able to follow out the principle of the game when modified by the varying and unexpected moves of its antagonist. The manner in which this is done is briefly as follows: The opponent to the automaton makes the first move in the game, and in so doing causes a certain cylinder or equivalent device to change its position. This, from the construction of the apparatus, causes the automaton to make that play which the proper sequence of the game requires, and at the same time moves the corresponding cylinder into position. The next play of the opponent moves the third cylinder, and the combination of the three cylinders determines the action of the automaton for the fourth; and so on throughout the sequence. If the player plays perfectly, the game will be drawn, as the automaton's play is mathematically correct. If the opponent makes a mistake, the automaton, by a simple device, takes advantage of it, and makes such a play as to win the game. Illustrations were then given on the blackboard, showing that there were three general conditions of the problem, the third being much more complicated than the other two.

The application of this mechanism to a game of this kind is intended to illustrate its character, and to show that its addition to apparatus for registering physical phenomena, or for performing geometrical or mathematical operations, may enable such mechanical devices to have a use much more extended than heretofore.

The paper of Prof. Rogers excited much interest, and the practicable character of the proposed automaton was very clearly demonstrated. Prof. Hilgard inquired how many pieces of machinery were necessary. Mr. Rogers said that in the first of the three cases involved by the problem, there were 18 levers required; in the second case, 32; in the third, 48. As many cylinders were required as there are units in the game; as many levers as there are combinations. To economize machinery, the board itself turned round a half or more.

Prof. Hilgard asked whether we do not really think very much as the automaton acts—whether the mental process was not similar to the mechanical. Prof. Henry said that the question was transcendental in its character. Mr. Rogers mentioned that several solitaire games could be played by an automaton, and that the machinery for this was very simple, but it had not the same interest as a machine which could take advantage of an opponent's mistakes.

Three papers by Prof. A. M. Mayer of the Stevens Institute of Technology, Hoboken, in the absence of their author, were read by the Secretary of the Academy.

FUNCTIONS AND MECHANISM OF AUDITION.

BY PROF. A. M. MAYER.

This paper was entitled Suggestions as to the Functions of the Spiral Scalæ of the Cochlea, leading to an Hypothesis of the Mechanism of Audition. It opened by a reference to the paucity of investigations on the form and functions of the cochlea, and mentioned as the principal if not the only contribution to the subject the statements and suggestions of Dr. J. W. Draper in his work on physiology in 1853. Prof. Mayer dissents, however, from the view taken by Dr. Draper respecting the action of the auditory apparatus, basing his objections on a measurement of the wave-lengths of the assumed vibrations and a comparison of those lengths with the lengths of the spiral scalæ which were believed by Dr. Draper to be the subjects of these vibrations. Prof. Mayer shows that the scalæ are too short to fulfill the requirement.

Prof. Mayer's paper then gives a careful, detailed, technical review of the anatomy of the ear. He then undertakes to show that the significance of these anatomical relations is to bring the sound vibrations to act with the greatest advantage on the co-vibrating parts of the ear, and to cause these parts to make one-half as many vibrations in a given time as the tympanic or basiolar membranes. This is demonstrated by an extended review of the functions and possibilities of different portions of the auditory apparatus. In the course of this train of argument Prof. Mayer advances the view that what are known as the hair-cell cords, having swellings in the middle of their lengths which cause them to act like loaded strings, are probably so constituted that each hair-cell cord is adapted to co-vibrate with only one special sound. He mentions, referring to one of his own discoveries reported in THE TRIBUNE last October, that these hair-cell cords are placed in reference to the pulses striking them, somewhat in the relation which the external fibrils of the musketo bear to a wave-surface to which their lengths are perpendicular. If his view be correct, these cords bear to the membrane to which they are attached, the same relation as stretched strings bear to the vibrating tuning-forks in Melde's experiments, and therefore a cord in the ductus of the ear will vibrate only half as often in a second as the basilar membrane to which it is fastened.

Prof. Mayer was able to illustrate this theory by an apparatus devised for the purpose. But perhaps the most convincing experiment in support of the hypothesis was this: a tuning fork held near the ear causes a sensation corresponding to the designated pitch of the fork. But the vibrations of this fork can be sent to the inner ear through the bones of the head. Now if we first hold the fork near to the ear and note its pitch, and then press it firmly against the temporal bone, we perceive a marked difference; we hear the simple sound of the fork accompanied by its octave. By a variety of modifications this effect was clearly brought out, the sound communicated only to the internal ear always having the higher octave of the fork singing along with its usual note. If the external ear be now closed, the higher octave sounds as loud as the original note. Prof. Mayer has the testimony of an accomplished musician to the success of this remarkable experiment.

DURATION OF THE SENSATION OF SOUND.

BY PROF. A. M. MAYER.

This paper was headed Abstract of a Research in the determination of the Law connecting the pitch of a sound with the duration of its residual sensation, and on the determination of the numbers of beats—throughout the range of musical sounds—which produce the most dissonant sensations; with applications of these laws to the fundamental facts of musical harmony, and to various phenomena in the physiology of audition. Prof. Mayer gave the particulars of a series of experiements by which it was ascertained what must be the frequency of successive sounds to have them blend indistinguishably together. Worked out mathematically, the data indicated that the residual sensation only occupied one five-hundredth of a second in the case of 40,000 vibrations per second; but in the case of 40 vibrations to a second the residual vibration was one-eleventh of a second. He concludes that the whole ear vibrates as one mass, and the durations of these oscillations of the whole ear are far too short to remain one-thirtieth of a second. He thinks that this explains our inability to distinguish the actual pitch of sound when that pitch exceeds certain well-known limits. One of the most remarkable deductions was that the duration of the sensation depends upon pitch rather than upon intensity. A considerable difference in intensity has very little effect upon the duration.

Among the inferences which he draws from this investigation is that the timbre of a composite sound begins to change at the instant the vibrations causing it cease, and the residual sensation becomes more and more simple till at last only the simple sound of the fundamental harmonic remains in the ear. There are analogous phenomena in respect to the sensation of light to the eyes. Another deduction is that a composite sound can be analyzed by means of a revolving disc with sectors cut out of it, interposed before the ear. Already this line of research has cleared up many obscure points in the theory of audition, and it bids fair to correct many grave errors into which previous investigators have fallen.

REFLECTION OF SOUND FROM FLAMES AND HEATED GASES.

BY PROF. A. M. MAYER.

This was a series of experiments showing that flames, heated gases, and cold gases of densities differing from that of the atmosphere, can reflect sonorous aerial vibrations, and the experiments have also given a measure of the reflecting power of flat gas flame. Prof. Mayer was incited to this investigation by reading the exceedingly interesting experiments of Prof. Tyndall on the stoppage of sound in a non-homogeneous atmosphere, and the description of an apparatus devised by Mr. Cottrell to illustrate this, and also a paper by that gentleman on "The Division of a Sound Wave by a layer of Flame or heated gas into a reflected and transmitted Wave."

Prof. Mayer's method of illustration is simple and easy of performance. He takes two similar resonators and places the planes of their mouths at right angles to each other. Then in this angle he firmly fixes the tuning-fork corresponding to the resonators, so that the broad face of one of its prongs faces the mouth of one resonator, while the space between the prongs faces the mouth of the other. Complete interference of the sounds issuing from their mouths is obtained, and the only sound that reaches the ear is the faint sound given by the fork's action on the air outside the angle included by the mouths of the resonators. If in these circumstances we close the mouth of either one of the resonators with a piece of cardboard, the open resonator will strongly reënforce the sound of the forks. If we now cover the mouth of this resonator with card-board, we shall again have silence.

Now substitute for card-board, when both resonators are open, the flame of a bat's wing gas-burner, with one resonator, and use something more permeable to sound than the card-board with the other. By trying a series of more and more permeable diaphragms, it was found that tracing paper just equaled the effect of the gas-flame in guarding the mouth of the resonator from the entrance of sound. A sheet of heated air above the gas-burner was found to be exactly equivalent to the gas-flame. The passage of a sheet of cold coal gas over the mouth of the resonator produced a similar effect; and so also did carbonic acid gas, though in less degree; but cold, dry hydrogen closed the mouth of the resonator more effectively than either of the above gases, though not equal in this respect to the heated air above the bat's wing flame. Among other curious results, Prof. Mayer has ascertained that there is an absorption of sound in the bat's wing flame; that the flame is heated by the sonorous vibrations which enter it as such, and issue as heat vibrations. He has endeavored to obtain a quantitative mathematical analysis of this absorption and hopes for exact results.

TESTS OF THE STRENGTH OF PINE.

BY PROF. W. A. NORTON OF YALE COLLEGE.

This paper was exceedingly elaborate, and gave the results of a series of experiments on the sets or residual deflections of pine sticks after having been subjected to a transverse stress. In 1869 Prof. Norton demonstrated that the received theoretical formula for the deflection of rectangular beams under stress required the addition of another term, varying directly as the length and inversely as the breadth and depth of the beam. Since then he has been more recently experimenting upon residual sets or deflections. The apparatus for testing was described at length and with great detail. Great care was taken to guard against incidental errors, especially in respect to consequences of changing temperature during the stress. There was evidence that after repeated strains a molecular change took place in the wood, and the effect of strain, after an interval of rest, to a great extent not only passed away, but even left the stick with less set than it had a short time before. A great number of curious and seemingly contradictory results were obtained in the course of these very numerous and varied experiments. As one of the results obtained it appears that a load equal to one-fourth of the breaking weight produces a permanent set, and that repeated applications of this load from day to day are attended with a continually increasing set. It results that such wood should never be subjected in any structure to one-fourth of its breaking strain.

Prof. Hilgard suggested that it was desirable to use material for these experiments that could be examined optically, such for instance as glass. He also suggested the extreme similarity of Prof. Thurston's experiments upon the torsion of pine sticks. Prof. Norton was not inclined wholly to accept Prof. Thurston's method of explaining the phenomena. Prof. Hilgard mentioned that glass rods took a set under torsion; Prof. Henry urged the use of homogeneous material in these experiments, and Prof. Rogers suggested brass as a suitable substance; he agreed with Prof. Hilgard in regarding the pine stick as a mere collection of fibers with more or less rosin between them.

The proceedings of the day were closed with the reading of a biographical sketch of Prof. Henry James Clarke.

THREE NOTABLE ESSAYS—Second Day.

DR. BROWN-SEQUARD'S THEORY OF THE OPERATION OF THE NERVES AND BRAIN—PROF. NEWCOMB TELLS OF WHAT AMERICA IS DOING FOR THE COMING TRANSIT OF VENUS—MAJOR POWELL'S EXPLORATION OF THE CAÑONS OF COLORADO.

Washington, April 22.—The session of this day far exceeded its predecessor in interest. It is rather unfortunate that the Academy makes no announcement in advance of the programme for the day, but this is of a piece with its general indifference to public attention. Not only is no programme published, but scarcely any is arranged in advance. Only a few of its members knew that Dr. Brown-Séquard was to deliver an address; still fewer knew that Prof. Newcomb was to speak, and there was an element of uncertainty even as to Major Powell. Had it been generally known that Dr. Brown-Séquard would tell us something about our brains, there would have been no difficulty in packing the long hall of the Smithsonian with an eager audience. A master of a subject with which few are acquainted, he brings to every utterance upon it the rare results of his own inquiries coupled with a freedom from prejudice in favor of antiquated views that is rare in his profession. In this address he gave a clearer expression than ever before to his own views of the structure and functions of the brain and nervous system. Hitherto his lectures seem to have been too much confined to tearing down the edifices of theory which his predecessors have so laboriously reared. The present address is not open to that objection, though it does good service in exposing the fallacy of views recently advanced by Dr. Ferrier of England, formed on a narrow circle of experiments, which have threatened to lead us back into the mists of error from which we were gradually emerging.

The address of Prof. Simon Newcomb, the eminent astronomer of the Washington Observatory, has an immediate interest. Very recently *The London Times*, in a very long article describing the preparations making for observations on the transit of Venus, dismissed those of America in a sentence of almost contemptuous brevity, to the effect that little or nothing was known about them. It is a fact that our preparations are of the most thorough character, that they embrace novel and ingenious modes of procedure, that they are worthy both in their scale and character of the nation and of American science, and that they bid fair to accomplish excellent results. It was to tell of this that Prof. Newcomb emerged from the seclusion of his watch-tower in the skies—a man of bashful and retiring manner, plain and thoughtful in his words, and giving his facts with simple directness of expression. Both Prof. Newcomb and Dr. Brown-Séquard speak without notes, and do not prepare their communications in manuscript.

Major Powell's description of the Cañons of Colorado brings freshly before us the wild features of that strange Western country which he has done so much to explore. His expedition seems to have penetrated regions hitherto deemed almost inaccessible, and he has brought back a large amount of information of value from a scientific point of view, as well as an exceedingly entertaining narrative of adventure.

Notwithstanding the fact that so few knew what was in store for them, there was a considerable popular audience present at the session, including a number of ladies.

FUNCTIONS OF THE BRAIN AND NERVES.

BY DR. C. E. BROWN-SEQUARD.

The title of this address was "On the Pretended Localization of the Mental and the Sensorial Functions of the Brain." Dr. Brown-Séquard began by saying that the subject has been rendered more difficult by assumptions of physiologists upon insufficient data. Among the views which have been recently put forward upon the localization of nervous power in certain parts of the brain, there are two of importance: One relates to the seat of power actuating muscles, and the other is as to the seat of sensation for different nerves. In the latter particular, I shall review especially the assumption in respect to the seat of power for speech. The following are some of the old views respecting the localization in the brain of the various faculties. There was a theory put forward by Müller of Berlin which for a time had great popularity. It was, however, absolutely wrong. It assumed that as regards the power of the action of the will on the muscles, the brain must be considered as the keys of a piano. When the soul or the will acted to produce a movement, it was supposed to act upon the nerves as the fingers upon the keys of a piano. As regards sensation, the mechanism was supposed to be equally simple; it was supposed that there were elements by which the sensations were transmitted through the whole system, without any break, through the spinal cord to the brain.

DEFECTS OF THE MECHANICAL THEORY OF THE NERVES.

This theory assumed that sensation was conveyed through the body by the nerves, as the bells rung in any part of a hotel have the sound conveyed along wires to a central office, where the fact is recognized from where the call may come. But this assumption was just as false as it was simple. There is no such compact continuity. Pathology shows that there is no foundation for such views. In the first place, the spinal cord (which is the organ through which all the nerve fibers or conductors coming through the brain have to pass, and also all the conductors coming from the periphery to the brain have to pass) can be destroyed in great part without destroying either the power of motion or the power of receiving sensations. There are facts respecting the *medulla oblongata*, which as you know is between the brain and the spinal cord, which place this beyond the reach of question, and prevent Müller's theory of mechanism from having our permanent acceptance.

There are other facts relating to this question which are certainly quite clear. There are animals utterly without brain, which still exercise the functions that are supposed to be located in that organ, such for instance as the *Amphioxus lanceolatus*. In others we find the part that answers to the brain is hardly large enough to meet the requirements of such an organ. Now if you hold your arm upon a table and try to make dots with a pencil in your fingers without changing the position of your arm, you will be able to make perhaps 1,000 points. Well, if such a power as that exists—and, indeed, the number which I have given is not too large, as I have counted 792 points made by myself, and I am a miserable draughtsman—if such a power exists with so little movement, you can easily understand what an immense number of fibers it would require to establish communication between the brain and the periphery, were all the fibers continuous from the brain to the periphery, or vice versa. Again, if we divide a portion of the spinal cord we may find a diminution of sensation and voluntary movement, or both, below the point of division; but the communication is not utterly severed; there is not always complete paralysis, as there should be to satisfy the conditions of the bell-wire theory.

In fact there is no necessity of more than a very few fibers to establish communication between the brain and the spinal cord. It is more like a telegraphic communication than a movement along a wire, by which sensation is conveyed from the periphery to the brain, or the brain transmits its orders to the periphery. Let me give an instance of what I mean. If a piece of ice is laid upon my foot, I have at once, the sensation of a contact, sensation of a temperature, the sensation of the extent of the surface of the ice that touches me, the sensation of the weight of the ice, and, if it is left upon my foot, the sensation of pain, and the sensation of the skin to which the ice is applied. All those forms of knowledge are communicated at once. I believe that all these impressions are communicated to the spinal cord, which as a single wire transmits it to the brain.

PERTINACIOUS ADHESION TO EXPLODED THEORIES.

Now, as to the two sides of the brain, the old view was that the left side of the brain governs the movements of the right side of the body, and the right side governs the movements of the left side of the body; and that there is a similar arrangement respecting perception and sensation. Facts oppose this view. I am sorry to say that physicians adhere too pertinaciously to old views like this, without regarding more recent discoveries. We are constantly holding on to our old clothing, wearing it when it is worn out. I am sorry to speak thus severely of a profession which is my own, but the discoveries of the last ten years seem scarcely to be recognized by the medical faculty. Younger members of the profession should seize opportunities to make themselves familiar with the advances of modern discovery. Take such facts as this for instance: One-third of one-half the brain may be utterly destroyed without any symptom of the injury; then one-third of the other half, and still no symptom. Still another third of either half may be destroyed without any indication of ill-health. There are hundreds of the first-named cases; I know of eleven or twelve of the latter. But Abercrombie and Spicer relate still more remarkable cases. A lady of refinement had had very slight symptoms of any trouble with the brain. She had gone to a tea party and enjoyed herself there; had walked about and talked as if in her usual health. Nothing in her sensations indicated any serious trouble. She was found dead in her bed the next morning. The autopsy revealed that one half of her brain was entirely destroyed, and moreover that this destruction had been of long standing. The account of this is to be found in Abercrombie, page 177, 4th edition.

Let us now consider the question of the locality of the intelligence of the brain. Most physiologists are agreed that this is the gray matter of the upper parts of the brain. But the method of communication is still open to research. Here the lecturer went to the blackboard and drew a figure somewhat like a sheaf of wheat without a band around it; the stalks representing the nerves, the heads of wheat representing the cells. Now you may subtract from this, by disease or otherwise, say the upper third, and still you have the nerves and the nerve cells and the processes can be carried on; but in the progress of such destruction downward there would eventually be reached a point where the functions of the brain could no longer exist. This view would explain the facts as we find them. But there is no case on record where the gray matter on both sides of the brain has been destroyed without the loss of intelligence, and we must regard that gray matter as the seat of the intelligence. But vast portions may be removed before the loss of intelligence becomes apparent. This I have myself tested and proved by vivisection of the lower animals.

Now, in respect to the locality of the power of speech. It has been said that the loss of brain power to express ideas in speech was located in a certain part of the brain. This affection is called aphonia or aphasia. There are three modes of expressing ideas—by speech, by gestures, and by writing. It is with the first only that we are concerned. Some very bold theorists have tried to locate all these powers in a particular part of the brain. Let us confine ourselves to facts. Dr. Broca of Paris has advanced the view that a certain small portion of some of the convolutions of the brain held the power of speech. I admit that facts seemed to favor this view. But we find that there is no relation between the degree of aphasia and the extent of the disease in that part, and there are cases where the destruction of those convolutions is very great and the injury to speech very little. Secondly, we find that disease may have overtaken the anterior, the posterior and the middle lobes of the brain, the particular convolution supposed to involve speech not being affected, and yet there is marked aphasia. Now is some one of these lobes the locality of the power of speech? Such would be the reasoning of my opponents. We should be obliged to concede that in some persons the faculty of speech existed in one part of the brain; in some in another; in others another, and so on *ad infinitum*. This is a *reductio ad absurdum*.

There is the case of the paralysis of the insane, where the gray matter may be diseased on both sides of the brain. In these cases the power of speech does not seem to be involved. There are cases of aphasia where the diseased person has had the power of speech restored during delirium. The speech is coherent, though the sense may not be. It is evident then that the faculty of speech is not actually lost in such cases; and yet we find that the third frontal convolution is actually diseased in these aphasiacs who talk in their delirium. But the most decisive argument is found in the cases that I have seen, where the third frontal convolution, the alleged organ of speech, has been destroyed, and yet the patients have not lost the power of speech. Therefore the theory is itself destroyed. There are fifty cases on record to show that the question of right-handedness or left-handedness does not apply in these considerations. The lecturer here cited cases in the practice of Jacmet of Montpelier and Mr. Prescott-Hewitt of London. In the latter case the patient had suffered a destruction of that part of the brain for 20 years, and yet for 20 years had spoken.

THE LOCALIZATION OF CENTERS OF MOTION IN THE BRAIN.

We shall now take up the question of the localization of motion in certain parts of the brain. I am surprised at the avidity with which a certain series of facts have been accepted as proof of this theory in England. A very eminent man, of whom I should not like to say anything severe, my friend Prof. Carpenter, has accepted those views. I may say that all England has accepted them. Prof. Huxley indeed has written me that he only accepted this view in part; but I cannot see how he can accept a part without accepting the whole, where even the part is incorrect. The famous experiments of Dr. Ferrier of Guy's Hospital must here be considered. As you will see, they are not, however, conclusive. By the application of galvanism to certain parts of the brain of animals, he produced certain movements. When we do not stop to think, this would seem to prove that there are in the brain certain centers of movement governing certain parts. But it is only a semblance. A part of the facts are taken for the whole, We should know all the series before we adopt the conclusions. Let us examine the other facts.

It is perfectly well known that the cutting away of a large portion of the brain does not produce the least alteration of voluntary movement anywhere. Suppose that part of the brain—say the anterior lobe, being excited by galvanism, produces a movement in the anterior limb. Now suppose that part of the brain is cut away—then the anterior limb should be paralyzed, for its voluntary movement is gone. Admitting that the other half of the brain should supply the place of the missing part; let us take that away also. Then certainly there should be a paralysis of the anterior limbs. But there is not. This should be sufficient to invalidate the conclusions of Dr. Ferrier. But there are abundant pathological facts of this nature, proving the fact beyond question. And then there are the cases of recovery from paralysis. There is no such localization of power as Dr. Ferrier has assumed. If galvanism be applied to the severed leg of the frog, the leg will jump, though there is no brain power in the question.

What should have been done was to have cut the connection of parts, so that a general effect should not have been propagated throughtout the brain by the application of galvanism to a part. This would be the *experimentum crucis.* My friend Dr. Dupré of Paris has made this experiment. I made it also, before he did, but he published his before mine. But there are many other facts almost equally impressive in their character which may be cited. We find many cases where the lesion of part of the brain produces paralysis on the same side of the body, and not on the opposite side as in the majority of cases is the rule. There is a case where a ball passed directly through the brain and it produced paralysis on the right side instead of the opposite side. Here Dr. Brown-Séquard objected to having a certain class of brain affections named after him; stating that diseases should be named from their distinctive features and not after physicians.

Dr. Brown-Séquard then applied a similar course of reasoning to the localization of sensation in specific parts of the brain, using, among other happy illustrations, this fact: An intestinal worm will occasion sometimes convulsive movements, sometimes paralysis, sometimes deficient sensation; are we therefore to conclude that in these cases the center of power was in the abdomen? He attacked the view of Gall, saying that we do not know the locality of these affections, and have no reason to suppose that they originate in a limited area of the brain. We now know that only a few fibers are necessary to make the connection between the spinal column and the brain. The brain, like the rest of the body, receives nerve fibers coming from other nervous centers, some along the blood-vessels, for there are a great number of fibers starting along the blood vessels and going into the cellular tissue of the brain; some fibers coming from the sympathetic nerve; others coming from various sources. We find, for instance, that the prick of an exceedingly fine needle at the *crux cerebelli* will produce rotary movements, the animal whirling around with a rapidity impossible in a normal condition. The activity of the heart may be stopped by the prick of a needle point; convulsions may be similarly stopped by the action of carbonic acid on the mucous membrane of the throat. With these facts under consideration we may see the vast field of research that yet lies before us, the mere questions arising from the activity of nerve cells affording an almost boundless subject for inquiry. But it is evident that we cannot locate the centers of either sensation or motion in specific parts of the nervous system.

OBSERVING THE TRANSIT OF VENUS.

BY PROF. SIMON NEWCOMB OF THE WASHINGTON OBSERVATORY.

This was a description of the preparations in this country for the great astronomical event of next December. The first steps in respect to the observations on the Transit of Venus were taken in Washington four years ago. The plan adopted divided itself into three parts; the nature of the observations; the stations to be chosen, and the organization of the parties of observers. The fundamental idea of the methods adopted was then stated. The two classes of determinations were, on the one hand, observations of interior and exterior contact, and on the other, measurements between the centers of the bodies observed. There are also the visual method and the photographic method.

Hitherto the visual method, however employed, has proved very uncertain. It is now about 200 years since Halley observed a transit of Venus at the Island of St. Helena. The absolute accuracy of his observations cannot now be accepted. The difficulty is in knowing the exact moment of the ingress or egress of the planet from the sun's disk. The approach of the two points of light when the planet cuts the disk of the sun is a matter not only of the most delicate observation, it is a point in which an intrinsic uncertainty is involved. Even at the last transit of Mercury, observers differed enormously in noting the time of disappearance of the dark line of sky which separated that planet from the sun.

DIFFICULTIES IN OBSERVING A TRANSIT.

The best way to ascertain the conditions of this phenomenon is by the observation of the transit of an artificial Venus over an artificial sun. This was done, rather more than a year ago, at the high point visible from the Observatory. The artificial sun and planet were placed on Wilder's building, at a distance of 3,300 feet, in order that full effect might be given to atmospheric vapors and softenings of the outline. The apparent dimensions of the artificial sun and planet were those that will be presented by the real bodies at the time of the transit. It is found that the sun looks a little larger and the planet a little smaller than their true magnitudes. When the light of the sun is close to the planet the space between is apparently filled by a ligament known as the black drop. It is commonly supposed that the moment of disappearance of the black drop is the moment of contact; but the uncertainty thus occasioned is of serious moment. It is not due merely to a bad atmosphere; it is an absolute effect independent of this cause. In observing the artificial Venus the same difficulty is more or less encountered. Even in a fairer atmosphere than we hope for at the time of the transit we must expect this phenomenon.

In moving toward the edge of the sun, before reaching it, there is again a similar source of error. A cloud seems to pass through the thread of light between the planet and the edge of the sun; the bright line grows darker and darker, and at last disappears—that being the moment of true contact. No ordinary observer can fix this time with accuracy. Another method has been suggested—observation by photography; but the difficulty here is that the photograph is dependent upon the comparative actinic power of the thread of light, and every photographer knows that the slightest haze will make a difference in the impression on the sensitive plate. The light thrown on one plate may be five or even ten times greater than on another without any corresponding difference in the facts. I think we shall not attempt the photographing of the interior contact.

It was supposed that the movement of Venus into the sun's atmosphere could be observed by means of the spectroscope with great accuracy; but a committee in Germany, including Zowlner and Awers, came to the conclusion that this was after all one of the most uncertain methods, and it was finally given up entirely. It has been found, however, that the moment when the planet first makes a notch on the sun is a well defined occasion, and the experiments of Strübner of St. Petersburg agree with ours on the artificial Venus in this particular. Another method of determining this problem consists in observing the distances of the centers of the two bodies. The Germans thought of doing this by means of heliometers; but the use of the necessary number of these instruments is impracticable, as they are cumbrous and expensive. I believe there is not a heliometer in this country.

The American method of photographing the transit has been already published: this is the method of Prof. Winlock, and experiments have shown that it is likely to be eminently successful. The photograph is taken by means of a horizontal telescope into which the image is deflected. It was at first supposed that the measures could be taken direct upon the photograph; but this has elements of inaccuracy, except by the method of photography devised by Prof. Winlock. The other methods of photography will not give a closer approximation, according to M. Delarue, than one minute of arc; but we have already much closer measurements of the solar parallax than this would provide. Our present uncertainty does not exceed thirty-four hundredths of a second. Such photographs would be of no value. The method of Prof. Winlock was then described.

STATIONS AND ORGANIZATION.

Let us now consider the matter of stations. Suppose for instance that we had four stations, two northern and two southern. If these were divided into two classes of observations, A and B at the north and A and B at the south, as A is not comparable with B, the failure of either A at the north and B at the south, or B at the north and A at the south, would render all the four observations valueless. Therefore, all the observations will be of the same character. The chief element in selecting stations has been their meteorology, the question at issue being their liability to bad weather at the time of the transit. About two years ago circulars were sent to American Consuls in almost every part of the world where the transit is visible, to ascertain the condition of the weather at those points in November and December, and every other source of similar information was utilized. We had thought of selecting from a number of others Hurd's Islands in the Southern Indian Ocean as being one among the best stations. Northern stations with probabilities of good weather are easily to be had. Especially favorable in this view is Peking in China and Vladivostok in Siberia. In Japan the weather is scarcely as favorable. Hakodadi was very objectionable in respect to weather; Yokohama was just as bad; Nagasaki was rather better.

The only satisfactory station in the southern hemisphere in respect to weather was found to be Hobart Town, in Tasmania. New-Zealand is nearly as favorable. But from all the other proposed Southern stations the accounts were very bad; notably at the proposed station at Hurd's Islands the almost uniform report was "clouds, rain, tempests, and snow;" the chances of observation there did not exceed two-tenths; this station was therefore given up. The most favorable station left at the South was Kerguelen Island, though somewhat neighboring to Hurd's Islands, and that was selected. A party will also be landed, if practicable, at Crozet's Island. Instead of sending four parties to each hemisphere, we shall send three to the north and five to the south, to equalize the chances as to weather. We hope to get complete results from two parties in each hemisphere.

The following is a list of the chiefs of parties and their stations: Northern stations, Wladivostock, Siberia, Prof. A. Hall, U. S. N.; Nagasaki, Japan, Geo. Davidson, U. S. Coast Survey; Peking, China, Prof. James C. Watson of Ann Arbor, Mich. Southern stations, Crozet's Island, South Indian Ocean, Capt. Raymond, U. S. A.; Kerguelen Island, South Indian Ocean, Lieut.-Commander George P. Ryan, U. S. N.; Hobart Town, Tasmania, Prof. Wm. Harkness, U. S. N.; New Zealand, Prof. C. H. Peters of Clinton, N. Y.; Chatham Island, South Pacific, Edwin Smith, U. S. Coast Survey. The constitution of each party is such that in case of disability on the part of its chief, the second officer can take his place. Each party will have three photographers—a chief photographer, who must have been of long experience in the business; an assistant that has had practice, and a second assistant trained only for the occasion. Nearly all the second assistants' positions have been filled by students or graduates of various schools and technological colleges throughout the country. The parties for the southern station will sail, we expect, about June 1. These are all ready; the photographers are to be in full practice here next week. The northern parties will go later and not all together. The Navy Department has furnished a ship, the Swatara, to go to the southern stations. The longitudes of the stations will be determined by occultations wherever telegraph communication is impracticable; but already there is such communication between Vladivostok and Hobart Town. Arrangements are made with the Governments for exchanging longitude signals, and the prospect of the extension of cables to New Zealand and other points gives fair hope that there will be only a few points where the method of occultations will be the sole resort.

THE COLORADO CAÑONS.

BY MAJOR J. W. POWELL.

This was an elaborate descriptive essay, an account of the progress made in the survey of the Colorado and its tributaries by parties under direction of the Smithsonian Institution. The following extracts show the character of the country:

The whole region embraced in the survey is a cañon country. At the very beginning we have a series of cañons through the Uintah Mountains, as the channel of Green River. Flaming Gorge, King-fisher Cañon, Red Cañon, the Cañon of Lodore, Whirlpool Cañon, and Split Mountain Cañons. Then Yampa Cañon, the cañon along the lower course of the river of the same name, and many other tributary cañons. Then below, in descending the river, the Cañon of Desolation, Gray Cañon, Labyrinth Cañon, and Stillwater Cañon, with their laterals; then Cataract Cañon, a profound chasm below the junction of the Grand and Green, then Narrow Cañon, which terminates at the mouth of the Dirty Devil River; many cañons lateral in all these have also been explored.

Along all the streams mentioned we have series of cañons, and yet all of these represent but a part of the cañons explored and mapped, for there are many profound chasms, the channels of intermittent streams, dry during the greater part of the season, that are hundreds of feet deep, and that never have a continuous stream for their entire length. But I cannot stop to enumerate all of these dry gorges.

Then Glen Cañon, a beautiful chasm carved by the river, in the bright-red homogeneous sandstone of Triassic age. From the mouth of the Paria River to the mouth of the Colorado Chiquito is the beautiful gorge to which we have given the name of Marble Cañon. The walls are of limestone, and near the foot are of a crystalline structure which receives a beautiful polish; white, gray, slate-color, pink, brown, and saffron-colored marbles are here found, carved and fretted by the waves of the river, and polished by the floods of sand which are poured over the walls during the seasons of showers, giving to the walls of the cañons, which have assumed architectural forms on a giant scale, an appearance of great beauty and grandeur.

Then we have the Grand Cañon, the most profound chasm known on the globe. Were a hundred mountains, each as large as Mount Washington, plucked up by the roots to the level of the sea and tumbled into the gorge, they would not fill it.

Perhaps the most wonderful of the topographic features of this country are the lines of cliffs, escarpments of rock separating upper from lower regions by bold, often vertical and impassable barriers, hundred or thousands of feet high and scores or hundreds of miles in length. I will enumerate some of the more important. First, we have the Brown cliffs, an escarpment which forms the southern boundary of the plateau through which the Cañon of Desolation is carved; then the Azure cliffs, the southern escarpment of the plateau through which Gray Cañon is cut; then the Orange cliffs, a broken escarpment, which commences at the foot of the Sierra La Sal, on the eastern side of Grand River, past the Grand, then across the Green River, and then down in a south-westerly direction parallel to the Colorado River about fifty miles, and then turns again to the south-east and crosses the Colorado, terminating in the slope of the Sierra La Sal, two or three scores of miles south of the initial point. Thus the head of the Colorado, the junction of the Grand and Green, is encompassed by a towering wall—the Sierra La Sal—on the east; on the north, west, and south the Orange Cliffs; on every side a facade of storm-carved rocks is presented. The Indian name for this basin is *Tum-pin wu-neir tu-weap*, the land of standing rocks. Buttes, towers, pinnacles, thousands and tens of thousands strange forms of rock, naked rock of many different colors are here seen; so that before we had learned the Indian name we thought of calling it the Stone Forest or Painted Stone Forest; and these rocks are not fragments or piles of irregular masses, but standing forms, carved by the rain drops from the solid massive beds. Weird, strange and grand is the *Tum-pin wu-neir tu-weap*.

Passing by many others, let us speak of three more only. The Hurricane ledge is an escarpment due to a fault having a northerly and southerly direction, starting away to the North of Tokerville, in Utah Territory, and running South across the Colorado River. It probably continues in this direction as a fault or a fold for 400 miles.

The Vermillion cliffs have an easterly and westerly trend; this line then crosses, in an irregular way, the head waters of the Rio Virgin, still on the east crossing the head waters of the Kanab and the folds around the northern extremity of the Kaibab plateau, then crosses the Colorado and turns in a southerly direction across the Little Colorado by a monoclinal fold. This escarpment presents a wall of triassic red sand-stone, and is due to erosion; the beds below have been stripped away by the rains and rivers.

White cliffs are approximately parallel to these; the line is a broken angular escarpment in jurassic limestone and homogeneous gray sandstone, capped by beds of limestone.

To the knowledge of the geography of this country we have given a great number of plateaus. Those along the course of the Green and Upper Colorado I may not stop to mention. Geographers and geologists have heretofore spoken of a great Colorado plateau, referring to the district of country through which Marble and Grand cañons are cut, for so it appeared to the observer standing on the south-west margin of this great district of country; but it has proved, in fact, to be a complex system of plateaus, bounded by walls of faults, escarpments or cliffs of erosion, and cañon gorges. Chief among these are the Mark-a-gunt, Paguns-a-gunt, Aquarius, and Kai-por-o-wits plateaus, lying to the north in the surveyed district, and in which head the Dirty Devil, the Escalante, the Paria, the Kanab, and the Rio Virgin Rivers. The upper beds of which these plateaus are composed are of tertiary age, but they carry on their backs extensive outflows of lava and numbers of dead volcanoes. The numerous plateaus, mesas, and terraces to the south of these are composed of beds of cretaceous and jurassic age, but I pass them by without further mention. The Paria plateau, on the south side of the river of the same name, is a great table of trias. On the north side of the grand cañon we have the Kaibab, the Kanab, the Vin-karet and Shevwitz plateaus. These are extensive tables of carboniferous age with many eruptive masses and volcanic cones. For the great plateau to the south of the Colorado River, bounded on the north by the grand cañon, on the south-west by an escarpment, which is the continuation of the Hurricane ledge, but which in this locality has received the name of Aubrey cliffs, and on the north-east by a great escarpment which faces the Little Colorado, and whose eastern boundary is not determined, I propose to retain the name originally given to the whole series of plateaus—Colorado plateau.

These plateaus can be thrown into classes on geological grounds, as follows: The tertiary plateaus to the north, cretaceous plateaus immediately south, triassic plateaus next in order, and carboniferous on the south. The geological classification serves well, also, for geographic purposes, as each group has peculiar topographic features, depending on the texture and structure of the rocks of which they are composed.

A VARIETY OF SUBJECTS—THIRD DAY.

AN INSTANCE WHERE SOLAR TIDES EXCEED THOSE CAUSED BY THE MOON—A NOVELTY IN INORGANIC CHEMISTRY—THE THEORY OF CYCLONES—NEARLY ALL THE ATMOSPHERE OF THE EARTH TWO HUGE CYCLONIC WHIRLS.

WASHINGTON, April 23.—Disagreeable weather tended to reduce the audience of April 23 at the Smithsonian Institution. The subjects discussed did not equal in general interest those of the previous day, but they had at least the merit of bringing forward some novelties in scientific discovery. The statements of Prof. Ferrel respecting the tides of Tahiti were curious rather than important. The discoveries of Prof. Gibbs of Harvard, who is equally noted as an original investigator, and as an editor of *The American Journal of Science and Arts*, of compounds in inorganic chemistry having the characteristic of metamerism that has hitherto been unknown except among organic substances, seems to open a new field of research. Prof. Gibbs mentioned that he had given no name to his new compounds; for which we may be truly thankful, since names that chemists are apt to indulge in when making discoveries in organic chemistry, are rarely limited by six or seven syllables and sometimes reach a dozen.

The communication from Prof. Alexander, the distinguished astronomer of Princeton, suggests a very interesting though difficult inquiry. Prof. Hayden gave a glowing and rapid sketch of the explorations in which he has been engaged, and of the work accomplished and under way. He was warmly greeted by several of the professors, who evidently held his work in high esteem. Prof. Silliman told of the localities of the American ores of tellurium—that curious substance which once on a time a bold experimenter swallowed, the result being that his friends dropped off gradually. He noticed after a few days that everybody seemed to avoid him. Finally he cornered one of them and begged an explanation. "Why, the fact is," said his friend, with his nose in his handkerchief as he spoke, "you must be aware that you have a horrible smell." The experimenter was obliged to retire into obscurity for some weeks, till the tellurium was out of his system. Prof. Ferrel's theory of the law of cyclones was exceedingly interesting to the meteorologists present.

THE TIDES OF TAHITI.

BY PROF. WM. FERREL OF THE U. S. COAST SURVEY.

In 1856 the U. S. Coast Survey took advantage of the surveying expedition under charge of Capt. (now Commodore) John Rodgers to obtain a series of tidal observations at the Island of Tahiti in the Pacific. A self-registering tide gauge was sent by the Coast Survey, and left by the expedition in the hands of a French soldier at the town of Papeetee on that island. By this means a series of observations nearly complete was obtained from June 1 to Oct. 1. These were reduced by the Coast Survey and published in the report of 1864. The great peculiarity of these tides is that the solar tide is for the most part greater than the lunar tide, although the force producing the latter is more than double that producing the former. There is only one other case of the sort in the world—at Courtown, Ireland. It is not, however, due to any exception in the general theory of the tides. Certain constants in the tidal expressions, which have to be determined by observations, are unusually large in this case. It is yet impossible to specify, however, what are the irregularities of ocean bottom and of coast outline which occasion the phenomena in this particular instance.

A representation was here given by diagrams of the solitidal intervals; *i. e.*, a mean of the curves for morning and evening tides, as furnished in the Coast Survey Report. The small diurnal tide was eliminated from the representation, which only gave the semi-diurnal tides. The solitidal intervals were given instead of the lunitidal, because the former were the larger. In June, however, at the time of the quadratures, when the solar and lunar forces are in opposition, the sun has its greatest declination, and the moon is near the equator, and hence the solar tide is smaller and the lunar greater than usual. Hence also, in June and July, the times of high water at the quadratures follow the moon, and the range of the solitidal interval is from 0 to 12 hours. But toward September, at the quadratures, the moon is near its maximum declination and the sun near the equator, and hence the solar tide is larger than usual and the lunar smaller; and the times of high water follow the sun rather than the moon, and occur within a range of three or four hours near noon and midnight.

From theoretical considerations applied to the observations, it was, however, shown that the observed times of high water in the small tides, affected by abnormal disturbances of the winds and changes of barometric pressure, necessarily differ considerably from the theoretical calculation, which merely depends on the forces exercised by the sun and moon.

METAMERISM IN INORGANIC CHEMISTRY.

BY PROF. WOLCOTT GIBBS OF HARVARD UNIVERSITY.

Although this paper was of a technical character, and its greatest value is of course to those who are interested directly in chemical researches, it presents a discovery so novel in its character that it can scarcely be without interest even to the non-professional student. Hitherto what has been denominated metamerism has never been observed except in organic substances. Bodies are said to be metameric when they are of the same composition and atomic weight, but differing entirely in their properties, in consequence of different molecular constitution. Prof. Gibbs has discovered six such bodies bearing such a relation to one another and to a seventh which was not of his discovery.

That is, if you were to take these seven substances and separate each into its ultimate constituents, you would find each giving not only the same materials to ultimate analysis, but weight for weight the same amounts of these materials; and yet each of the seven substances is intrinsically different from the other in its character, appearance, and chemical reactions; and no one of them can be transformed into the other. In the whole realm of inorganic chemistry there has been no similar instance recorded, although among organic bodies there are not a few such cases.

The substance with which the series begins was discovered by Dr. Erdmann. It is an exceedingly stable compound. Its constituents are two parts of cobalt, six of ammonia, and six of nitric oxide. Its chemical formula is:

$$Co_2 (NH_3)_6 (NO_2)_6.$$

The six other bodies metameric with it, were obtained by Prof. Gibbs by making the compounds and combining them when made, in the manner indicated in the notation which follows. It will be observed by the chemist that the combination of the compounds is that of an acid with a base, in each instance making a true salt, obtained in crystalline form. For the sake of abridgement in notation, in what follows, the ammonia (N H 3) is represented by A and the nitric aeid by X. Oa account of the difference in their atomic constitution, Dr. Gibbs divides the seven substances into three series.

First series—Eidmann's discovery:

$$\ldots\ldots\ldots\ldots\ldots\ldots Co_2 A_6 X_6$$

Second series—Dr. Gibbs's discovery:

$$(\overset{II}{Co}_2 A_4 X_8) \quad (\overset{II}{Co}_2 A_8 X_4) = 2.\ Co_2 A_6 X_6$$

$$(\overset{II}{Co}_2 A_4 X_8)_2 \quad (\overset{IV}{Co}_2 A_{10} X_2) = 3.\ Co_2 A_6 X_6$$

$$(\overset{II}{Co}_2 A_4 X_8)_3 \quad (\overset{IV}{Co}_2 A_{12}) = 4.\ Co_2 A_6 X_6$$

Third series—Dr. Gibbs's discovery:

$$(\overset{VI}{Co}_2 X_{12}) \quad (\overset{VI}{Co}_2 A_{12}) = 2.\ Co_2 A_6 X_6$$

$$(\overset{VI}{Co}_2 X_{12}) \quad (Co_2 A_8 X_4)_3 = 4.\ Co_2 A_6 X_6$$

$$(\overset{VI}{Co}_2 X_{12})_2 \quad (Co_2 A_{10} X_2)_3 = 5.\ Co_2 A_6 X_6$$

As each of the salts thus obtained is beautifully crystalline and perfectly well defined, and each salt of the second and third groups gives the reactions of each constituent with perfect distinctness, no doubt can exist as to their real chemical structure.

COMPARATIVE VELOCITY OF LIGHT IN AIR AND IN VACUO.

BY PROF. STEPHEN ALEXANDER OF PRINCETON COLLEGE.

This brief paper merely contained a few interesting suggestions on a small correction of the velocity of light as deduced from experiment.

In accordance with the undulatory theory the velocity of light must be less in atmospheric air than in vacuo, in the inverse ratio of the index of refraction of atmospheric air to 1; that is, as 1 to 1.000294. The velocity then as ascertained by experiment under the air should be increased by just about 0.000294 of itself to be equal to that in vacuo; *i. e.*, to the extent, almost exactly, of 55 miles per second; a very small quantity indeed in comparison with the whole velocity of 185,000 miles per second; and yet small as it is—and so small as to be below the limits of error of the experiments in question—it is yet very closely equal to three times the velocity of the earth in its orbit.

It is an outstanding excess, and no more, with which we often have to do, as, for example, in the measurement of temperature; but the scale on which those differences sometimes present themselves makes them, small as they may be in their original comparison, grand in comparison with ordinary standards. Prof. Alexander was not aware that anything has yet been put forward elsewhere on this subject.

Prof. Hilgard remarked that the postulate of this paper that the undulatory theory required that light must move more slowly in air than in vacuo, was not by any means settled. There had been an approximate experiment—on aberration, by Prof. Airy, who filled a telescope with water and sent light through it—but no deviation was observed after the most careful observations. We are not sufficiently acquainted with the character and properties of the luminiferous ether to speak with certainty on these subjects, but the investigation is well worthy of the highest effort. Prof. Henry spoke a few words of merited praise about the communication.

RECENT WORK OF PROF. HAYDEN.

SUPPLEMENTARY TO TRIBUNE ACCOUNTS OF EXPLORING EXPEDITIONS AT THE WEST.

Prof. F. V. Hayden appeared before the Academy to give a general account of the scientific explorations and survey at the West in which he has been engaged. As full accounts of these explorations have appeared in THE TRIBUNE it will be unnecessary to reproduce the details with which our readers are already familiar. The following particulars are concerning more recent work and bring the story of these explorations from the accounts in THE TRIBUNE Extra of Dec. 30th to the date of the meeting.

The party returned from the field-work in Colorado in October and at once commenced the preparation of the annual report and the construction of the maps. The seventh annual report, containing the preliminary results of the survey for 1873, will be ready for presentation to Congress in May, and will form an octavo volume of about 800 pages, with over 300 illustrations, sections, profiles, maps, &c. The geological and mineralogical, as well as topographical, structure of the remarkable mountain region of Colorado has been worked out with care; sections of all the mines have been made with the utmost attainable accuracy, showing the connection of the mineral lode with the country rock, so that the light which will be thrown upon the origin and history of these formations will be of great value to science. Two classes of maps, on a scale of four miles to one inch, have been prepared. The first class are in contour lines of 200 feet, upon which to represent the various geological formations in the areas explored, with suitable colors. On the second class the peculiar mountain forms will be delineated, in excellent relief, by a peculiar kind of brush-work. These are the topographical maps. When the survey of Colorado is completed the great features of the physical history of that Territory will be summed up in one volume, with an atlas of maps and sections. Prof. Hayden regarded this work as a contribution from the General Government to its ward, the Territory, toward the development of its resources. It will also form the basis upon which more detailed surveys can be carried on by the community itself. Dr. Hayden closed with an appeal to the members of the National Academy to spare no effort to enlist the continued sympathy of Congress in the great work of making known to the world the unexplored portions of our public domain.

Prof. Henry said that we are inviting thousands of foreigners to come here, and we ought to be able to tell them what we have to offer them. For this purpose a survey of the whole United States ought to be made. We have three organizations for this purpose—the Coast Survey, the Engineers' Survey, and this Civilians' Survey. It is very desirable that there should be no wrangling between these organizations; that their work be brought into coördination and unity. He recommended that the Academy take this matter into consideration, and perhaps suggest the formation of a commission.

Prof. J. Lawrence Smith of Louisville, Kentucky, followed up this observation with one on the lack of unity in the State surveys. His own State suffered much from the need of correct surveys from fixed points determined by the Coast Survey. It is exceedingly desirable that the method and system of all surveys be placed under one head and conducted with uniformity.

Col. Forshey of Louisiana enforced the foregoing views by his experience in that State and remarked also on the value and interest of Prof. Hayden's work. In the matter of hydrographic surveys there was almost an equal deficiency of unity of plan and useful results.

Gen. Barnard of Washington referred to the extreme difficulty that was found in conducting the operations of the war without maps of a topographical character. He considered that much of the delay which characterized our undertakings in the war was principally due to our ignorance of the country where they were carried on—an ignorance of topographical details paralleled in no European country.

He also alluded to the difficulties which ordinary civil engineering operations find in our deficient surveys. The opening of a water supply, for instance, where a canal or railroad was being constructed, could not be predicated with any certainty when the geological and topographical features of a section of country were almost unknown.

Col. Forshey was glad to hear the proposition (suggested by Prof. Henry) that a Commission be appointed to unify the surveys throughout the United States.

Prof. Henry mentioned, in the absence of Dr. Bessel, that the entire scientific operations of the Polaris were under his management, and that his report of the work effected during the voyage of that vessel would be presented to the Academy, in accordance with the provisions of the acts of Congress concerning that expedition.

MINERALOGICAL NOTES.

BY PROF. B. SILLIMAN OF NEW-HAVEN.

The subject which he proposed to treat was the telluric ores of Colorado. The rocks are principally gneissic, and granite with excess of feldspar or quartz. At the place where the mineral is found there is a remarkable dyke of 50 feet in thickness. It is on the side of this dyke that the mineral containing the little-known substance tellurium is found. Prof. Silliman showed the evidence that the tellurium was introduced by the plutonic invasion of this dyke. He had found in many instances that telluric ores were associated with gold, and the association was very unfortunate for the gold miner, as in one instance $3,000 worth of gold thus associated was thrown away (through ignorance), while the yield of the rest of the ore was only $40 or $50 to the ton. Prof. Silliman asked Prof. Endlich to perform an experiment, showing the presence of tellurium by using concentrated sulphuric acid. A bright purple color was rapidly obtained when the ore was thus treated with heat, in a test tube. In one specimen of these telluric ores there was $55,000 extracted from a ton. Specimens of telluric ores were exhibited, and Prof. Silliman mentioned that these and many other very valuable specimens, now the property of the Smithsonian Institution, were procured in Prof. Hayden's surveys.

ON THE LAWS OF CYCLONES.

BY PROF. WILLIAM FERREL OF THE COAST SURVEY.

There were at one time two rival theories with regard to the motions of the atmosphere in cyclones. According to Espy's theory, called the radial theory, the atmosphere flowed in from all sides toward the center in the direction of the radius, and ascended in the middle of the cyclone and flowed out above. According to Redfield, Reid, and others, the motion of the atmosphere above and below was that of a circular gyration around the center of the cyclone, and there was no motion either to or from the center.

In the year 1859 in a paper published in *Runkle's Mathematical Monthly*, Prof. Ferrel first demonstrated the effect of the earth's rotation upon any body moving upon its surface, which was to cause a deflecting force at right angles to the direction of motion, to the right hand in the northern hemisphere, but to the left in the southern. It was also shown that the effect of this deflecting force upon air tending from all sides toward a center, was to cause it also to gyrate around this center, and that consequently Espy's theory could not be true. If the atmosphere has a circular gyration, the deflecting force arising from the earth's rotation is in the direction of the radius from the center, and causes a depression and low barometer in the center; but there is no force to overcome the resistance to the gyration, and hence the atmosphere is soon brought to a state of rest. There must, therefore, in all cases be some motion below, toward the center of the cyclone, so that the deflecting force—depending upon the earth's rotation—arising from this component of the motion, may overcome the resistance to gyrations; else the gyration soon ceases. The resultant of the gyratory motion and the motion toward the center gives a motion, the direction of which makes an angle with the isobar, or line of equal barometric pressure. (Here Prof. Ferrel drew a circle on the blackboard, showing the line of the isobar in a perfect cyclone.) The greater the resistances, the greater this angle must be, and hence, since resistance is as the square to the velocity, all other things being the same, the more rapid the motions of the atmosphere in the cyclone, the greater must be this angle. (The angle was shown on the blackboard as formed by a tangent to the circular isobar.)

On the open sea, where the amount of resistance is small, especially when the velocities are not very great, this angle must be small, and the gyrations nearly circular, as Redfield's theory requires. In violent tornadoes on land, where the resistances are very great, this angle is large, and the directions of the motions at the surface do not differ much from those of the radii, and hence there is an approximation to Espy's theory. As Espy took his observations mostly from tornadoes on land, and Redfield took his mostly from large cyclones at sea, each one had observations which, with a little bias in its favor, seemed to verify his theory. Until recently, no considerable number of observations have been discussed to determine from observation the truth of the preceding laws adduced from theory. The Rev. Clement Ley recently, from a great number of observations made by the signal service of England, France, and Holland at 15 stations, has determined that the average for the angle between the direction of motion and the isobar for all the stations is nearly 21 degrees, and hence has verified the theoretical law above. By taking the average, also, for five stations on the coast, where the resistances, since part of the gyration is on the sea, are less, he found the value of this angle only 13°, while for five other stations entirely inland, where the resistances are greater, the average gave 29° for the value of this angle. This verifies another part of the theory above, namely, that the greater the resistances the more must the directions of motion deviate from that of the isobar, and consequently the more must the gyrations deviate from the circular gyrations of Redfield's theory.

When Mr. Ley considered the observations separately from the different quarters from which the wind blew, he obtained for the angle of deviation from the isobar 51 degrees on the N. E. side of the cyclone, 18 degrees on the west side, 9 degrees on the S. W. side, and 20 degrees on the S. E. side. He also states that the average directions in which the cyclones move is toward the N. E. Hence the angle between the direction of motion and the isobar for the front part of the cyclone seems to be much greater than that for the rear. For this no very plausible reason is apparent, but several probable explanations might be given.

It is commonly supposed that the gyrations of a cyclone in all parts are the same way, that is, from right to left in the northern hemisphere, and the contrary in the southern hemisphere; but this is not the case. In every cyclone in the northern hemisphere the gyrations are from right to left in the interior part, while they are from left to right in the external part, but the gyrations in the interior are much the more rapid, the motions of the exterior gyrations amounting usually to only gentle winds. The highest barometric pressure is on the dividing line between the two systems of gyrations.

As the motion toward the center in the lower part of the cyclone causes the direction of the wind to deviate from the isobar on the side toward the center, so the outward motion in the upper part of the cyclone must cause the direction of the wind to deviate on the side from the center, and there must be a certain median plane where there is no motion either toward or from the center, and where the direction of the wind must coincide with that of the isobar, that is, where the gyrations are entirely circular. If, therefore, an observer stands with his face exactly toward the wind below, the clouds in the upper strata, moving with the directions of the wind there, must always come from a direction a little to the right of the observer, and the higher the clouds in general, the greater must be the difference in the directions.

Beside the ordinary cyclone of which we have treated, there is also what is called an anti-cyclone. In this kind of cyclone the denser and heavier part of the atmosphere is in the center, and hence the air descends there and flows out on all sides below, and in from all sides above, and hence the motions in a vertical plane are just the reverse of those of an ordinary cyclone. For this reason it is generally supposed that the horizontal gyrations are also reversed in an anti-cyclone; but this is a mistake. The gyrations in both cyclones are precisely the same, and such as have been given for the ordinary cyclone. Anti-cyclones are always stationary; having their centers in the interior of a continent or larger island where the atmosphere in Winter is colder and consequently heavier than over the surrounding sea; and hence it descends in the middle and flows out at all sides below, and the deflecting force already explained gives rise to a stationary cyclone.

Each hemisphere of the earth contains one grand anti-cyclone, with the cold Pole in the center and the one-half of the torrid zone for its external warmer part, and in these anti-cyclones we have a verification of what is stated above, since in the northern hemisphere the gyrations nearest the Pole are from right to left, giving rise to the eastward current in the middle and higher latitudes, while toward the external border at the equator the gyrations are the contrary way, giving rise to the general westward motion of the air in the torrid zone. In this case, also, as in ordinary cyclones, the barometer stands the highest at the dividing parallel of latitude of about 35 degrees, which separates the two systems of gyrations or winds.

At the business session, Prof. F. A. P. Barnard, President of Columbia College, New-York, was elected Foreign Secretary, vice Prof. Agassiz, deceased. The constitution and rules limit the number of members to be elected annually to five. The following individuals were honored by election April 23: Prof. C. F. Chandler of New-York, chemist; Geo. Davidson of San Francisco, mathematician and astronomer; Prof. O. C. Marsh of New-Haven, Conn., geologist; George W. Hill of Nyack, N. Y., mathematician; Prof. Henry Morton of the Stevens Institute, Hoboken, N. J., physicist.

LAST DAY OF THE MEETING—Haste for the Sake of Adjournment.

SCIENTIFIC VALUE OF THE POLARIS VOYAGE—AN INTERESTING DEBATE ON THE FORMATION OF THE NORTHERN PART OF THE CONTINENT—THE GREAT TELESCOPE A GREAT SUCCESS—OTHER SATELLITES LIKE OUR MOON—LAWS OF STORMS—SILURIAN FOSSILS.

Washington, April 24.—It was evident when the session of the day began, that the Secretary, Prof. J. E. Hilgard, was pushing matters with unusual rapidity. There were many papers of interest and value that had been under consideration, which were either declined, read by title (that is, not read at all, except the title) or hurried through with little ceremony. Two or three times a rising debate on the subjects presented was brought to a close by an appeal from the Secretary urging haste. And, to the surprise of most of the members and all of the audience, the Academy did actually finish its proceedings and finally adjourn at the usual hour of closing the session for the day.

If those who imagine that the work of Polar expeditions is a mere useless expenditure of enthusiasm could have been present at this meeting, and seen the deep interest taken by all the members of the Academy in the scientific results of the expedition of the Polaris, they might have found cause for changing their opinion. In this memoir and the debate which followed nothing was more evident than that in order to obtain a satisfactory answer to the many unsolved questions of the history of the earth an immense number of facts is yet to be amassed, which can only be procured by new expeditions to the higher latitudes. In the interest of science alone, Polar expeditions are of the highest order of value.

Everybody that takes the least interest in astronomical science is anxious to know whether the great telescope in Washington, with the largest achromatic lens ever constructed, is really a good instrument, and whether it has met the sanguine hopes entertained during its construction. To such inquirers, Prof. Newcomb has given a most interesting and a categorical reply that is perfectly satisfactory. The astronomical paper furnished by Prof. Alexander seemed to tear away the last hope of habitability in any part of the solar system except the earth. Prof. Proctor has shown that none of the primary planets were fit to be the abodes of life; and Prof. Alexander now disposes similarly of the satellites. Those interested in meteorology found much of interest in the calculations of Prof. Loomis concerning the law of storms; and Prof. Newberry gave information of scientific value respecting fossil plants of the Silurian age.

RESULTS OF THE POLARIS EXPEDITION.

BY DR. E. BESSELS.

This manuscript was entitled the History of Smith's Sound from a Geographical and Geological Point of View, and some other General Results of the Polaris Expedition.

It is probable that Smith's Sound must be regarded as the best of the three gateways to the pole. A channel of almost 300 nautical miles long, and in some places scarcely 25 miles wide, separates Greenland from Grinnell Land and the archipelago south of it. Connecting it with Baffin's Bay and Davis's Straits, we can regard this channel as one having for its geographical homologue only the Red Sea. It was discovered in July, 1616, when Bylot and Baffin, in smacks of 36 and 50 tons, sailed through Davis's Straits to 77° N., when Baffin discovered Smith's Sound and described it as a deep bay. For more than 200 years the east and west capes of the Sound were the northern Pillars of Hercules.

John Ross in 1818, nearing the Sound, described it as bounded by a range of elevations, which he named Dulcina Mountains. Inglefield, in 1852, searching for the survivors of the Franklin Expedition, sailed over the locality of these imaginary mountains, and reached 78° 28′ N., which has been passed only twice since. The most northerly points determined by him are Pelham Point of the east and Cape Sabine of the west coast. Kane followed on the heels of Inglefield the next year, and reached with his ship latitude 78° 37′. One of his sledge parties traveled to Cape Constitution, 80° 25′ N., sighting land beyond on the west coast in 82°. He supposed erroneously that Cape Constitution was the northernmost point of Greenland. Thirteen years ago Hayes reached the boundary of navigable water in the Sound at latitude 78° 18′, and could penetrate no further. The Polaris, under Capt. Hall, was more fortunate, and reached 82° 16′, the highest latitude a ship has ever reached.

The land found between 81° and 82° seems to me to be of great importance in demonstrating that Greenland has been separated from the continent in a south-north direction. That entire tract of land, and probably the whole coast north of Humboldt Glacier, shows Siberian limestone, having at times almost perpendicular cliffs of an average hight of 1,500 feet, with occasionally lower elevations covered with irregularly distributed hills, and mountains not systematically disposed in ranges. Garnets collected in this locality were found identical with some at Fiskernesset, in lat. 62° N., and a very characteristic white quartzite was identical with that of Cape Alexander. Besides these there were collected hornblende rock, gneissic granite, sandstone, and other specimens of rocks found in position considerably south of Polaris Bay—even labradorite like that of the coast of Labrador. The identity of these specimens with rocks near Ita was recognized by several Esquimaux from that place, to whom Dr. Bessels showed them. From these observations he concludes that the direction of the geological drift is from south to north.

On the North American continent in general the main drift of erratic material has been southward from northerly latitudes, a fact paralleled in the North German plain in erratic blocks and débris of Scandinavian origin; in Sweden and Lapland by drift from Spitzbergen; in Iceland by débris from both Spitzbergen and North-Eastern Greenland. Smith's Sound seems therefore an exception to the general rule, and we must conclude that its drift was transported by floating ice-fields and icebergs, and not by glaciers. Among many specimens which Dr. Bessels examined between the degrees of latitude named, he only found one piece showing glacial scratches. This was silurian limestone, identical with and not to be mistaken as other than that of the immediate vicinity. He sought in vain for erratic blocks of this limestone further south than the original deposit. None of it was to be found between 76° and 78°.

Palæontological researches, as well as the fauna and flora of the region, point to the determination that the continent and Greenland were formerly connected. Greenland is now known to be an island. It is a rule in the formation of islands by separation from main land that the sea between will be shallow, especially if its width be inconsiderable. The soundings of Davis's Straits and Baffin's Bay are deeper than would be expected, Dr. Schott having some time ago computed the average depth, by Airy's method, at 250 fathoms. By the kindness of Baron von Otter, Dr. Bessels was supplied with soundings for 6° of latitude, showing a greatest depth at 67° 25′ N. of 930 fathoms, and an average in 28 soundings between 67° 25′ and 74° 04′ of 290 fathoms, corroborating Dr. Schott's computation. With these we may take into account the sounding of Ross at 76° N. and 71° W., giving 250 fathoms, and a sounding probably by the Advance, at 65° N. and 59° W., giving a depth of 288 fathoms.

Along the east coast of Davis's Strait, and its northern continuation, a narrow, warm current flows, moving from south to north at a mean velocity of 0.2 miles per hour, turning to the west off Jones's Sound, and there deflected to the southward by the cold Arctic current. The velocity of the latter differs according to locality and season, but never exceeds 12 miles per day. At Smith's Sound and Kennedy's and Robeson's Channels, the expodition observed a northerly current with a velocity of 8—12 miles per 24 hours. The current spoken of by Ingelfield as setting north 72 miles per day, near Cape Saumarez, must have been a local eddy near the coast—an eddy into which the Polaris was once drawn and carried rapidly to the northward. At all other localities the current flows to the south. That this current cannot carry any drift material from south to north is evident.

Still, we find between 81° and 82° minerals and rocks that doubtless had their origin in South Greenland, indicating that the current must at some time have had the opposite direction. This condition could only have been produced by the fact that the separation of Greenland from America must have occurred in the same direction that the current flowed. The outlines and form of Davis's Strait tend to strengthen this view. That the southern end of the strait is the older is apparent from the fact that the southern portion of it is evidently broader than the northern; and also the fiords on the south-west coast of Greenland are by far more numerous and deeper than further north. Let us construct an ideal current chart of that period, when both countries were yet united. According to the theory, a warm current must have moved along the east coast of America, and must have entered Baffin's Bay, having the full strength of an unweakened current in washing the end of that bay. Thereby considerable atmospheric precipitation as rain was occasioned, accelerating the growth of the glaciers, which moved on toward the valleys, and there formed spurs. The fiords we must consider as the former beds of these spurs.

What was the agency which caused the separation, we can only surmise. There are two probabilities; either the channel is a fissure which gradually widened because of the influence of the current, or it has been eroded by the action of a glacier, the south end of which gradually melted down. The latter hypothesis seems the more probable of the two, and we may regard the channel itself as formerly an immense fiord. But we know that the soundings of fiords are usually shallower at the mouth than at the head; while with Davis's Strait and its continuation exactly the reverse is true: the greatest depths are found at its entrance.

In reality nothing else could be expected. We know that the bottom of the North Atlantic is slowly but continually sinking, and has been ever since the miocene period. Among other evidences is the fact that the Bermudas rest on a coral foundation. This motion reaches far north and includes a part of Greenland. At Disco, for instance, the colonial store-house had to be removed from a small island to the main land because its site was inundated by almost every high water.

Further north the land rises. Kane and Hayes saw terrace-like formations, which Herschel regarded as old sea-beaches. The Polaris expedition detected similar appearances. There was decided proof of the rise of the land north of Humboldt's Glacier, and many terraces were seen, though too much weight must not be given to this appearance, as similar terraces can be formed by the melting of snow. In the case of Hall's land, there was evidence of its rise in the discovery of crustacea in fresh-water ponds more than thirty feet above sea level, which could not be reached by the highest Spring tides of 5½ feet. Also, at elevations of 1,800 feet above sea-level, the expedition found marine shells and the balanus, identical with those of animals at present living in the neighboring sea. Later, mixed with these numerous remains were found numerous pieces of drift-wood. The expedition also discovered a fine, limy mud, 1,200 feet above sea-level, showing by aid of the microscope, specimens of *Polythalamiæ*.

These facts as to the rise and sinking of the land must be regarded as important factors in the change of level of the bottom of the seas. It seems probable that the former conditions of depths underwent change, they becoming gradually obliterated, because many icebergs melt in the middle of Davis's Strait and Baffin's Bay, dropping the debris they carry, and gradually producing shoals. That the separation of Greenland from America must have occurred from south to north, seems more than probable. How this took place is as yet an open question, needing for its solution many additional observations.

Dr. Bessels read from the report of the Polaris examination the results of the scientific work of the expedition. This was published some months ago in THE TRIBUNE.

Prof. Newberry made the following remarks in respect to the expedition in which Dr. Bessels had borne so prominent a part:

Some of us will remember how, a few years ago, the matter of the organization of the Polaris party came before us, and the duty devolved upon us of prescribing a formula of observations. Instructions for observing in some directions of science were delegated to the Academy by the Government. Part of that duty fell to my charge; and it became my duty to write out some views which I wished to submit to Dr. Bessels when he left us. That paper was transmitted to him just about the time of the departure of the expedition, and members of the Academy will remember with what sympathy and concern we saw these men take their lives in their hands and go off to the Far North to execute this scientific commission; and nothing is more proper than that we should recognize the importance of the contributions that have been made to science; that we should welcome back those who have gone upon such a dangerous mission, and that we should express our regret that the chief of the party has fallen a victim to his devotion to science.

I shall limit myself simply to the expression of the degree of satisfaction I feel as to the accuracy of the statement that Dr. Bessels has made here, and has made to me personally, in regard to the evidences that are furnished there [pointing to map] of the great changes of level. It may be a matter of a little time and needing a great extent of observation to connect those with the changes we have found in lower latitudes, and in that way to work out plans that can give the physical history of the northern portion of the continent, running through that remarkable period, the glacial, and to connect that with the miocene before, when the temperature was so very different.

This change of elevation to which he has referred I have received notice of with great interest. You will remember that Dr. Bessels mentioned that in the cliffs of Hall's Land there were found, 1,800 feet above the present level, mollusks such as are living in the sea at the present time. We find them all the way down to Lake Champlain, and I have myself collected them there, evidently indicating the effect of the same general depression. We find these rocks with many recognizable shells upon the shores of an ocean perhaps that has prevailed over the far north, presenting an ancient coast line that at times has been washed by the sea waters and at other times was elevated by the erosion that has cut up that great system of fiords. The matter of the transportation of the drift from south to north is of great importance, and can be certainly known if we could find larger amounts of bowlders with grooved surfaces. In the gradual elevation of temperature, and a diminution of the magnitude of glaciers, there came a time when the glaciers there were local, carrying with them the material by which it passed this coast, and very probably have left those striated bowlders which could hardly have had any other route than such as I have referred to.

I cannot express my own immediate degree of satisfaction in welcoming back Dr. Bessels, who has so faithfully executed the commission we committed to him.

Dr. Bessels replied: I should like to make another remark on the raising of the land. I thought I might find some clue in collecting some specimens of the stems of old willows that grew on that land, and on examining those different willow stems, I found that there was not a single one of them older than 196 years. That is indicated by the number of rings, although I do not think that such a rise as 1,600 or 1,800 feet could have been produced in 196 or 200 years.

Dr. Guyot asked: Will Dr. Bessels please tell us what the diameter of that tree is, which is 196 years old?

Dr. Bessels—These willow stems were a little larger than my finger.

Dr. Guyot—Might I ask Dr. Bessels how he would explain in the transportation to the North the coming of the bowlders from Labrador. It seems that the sea ought to have come as low down as Labrador.

The Chairman (Prof. Henry)—Where would be the point of separation between Greenland and the continent?

Dr. Bessels—The point of separation would probably be in the vicinity of Newfoundland, because in tracing such a line following the coast of Greenland would just exactly give us the shape of the continent required. You will remember that Burckraeister was the first to point out that such a triangle with the points to the south was the shape of the continent. [Dr. Bessels here drew an imaginary triangle on the blackboard.] The apex of the triangle is pointing toward the south, and in tracing the line from the south cape of Greenland to the eastern cape of Newfoundland that would just give the triangular shape required by the theory.

Dr Guyot—That is true; but all that space from Smith's Sound ought to be open, in order to give the drift from Labrador.

Dr. Bessels—Most likely, but that is what I wanted to find out, though we did not find soundings greater than those in the low fiords, and we found the lesser depths toward the north, the greater toward the south.

Dr. Guyot—And the separation would be still in existence on the northern part.

Dr. Bessels—We find the same motion of the earth is existing still in Australia. The little continent Australia is tilting just like a boat under a heavy pressure of sea.

Dr. Guyot—What I want to know is where was the connection between Greeland and the continent. That is the point, and I think that could not be anywhere than just in the southern part.

Dr. Bessels—Well, I think the last connection must have been somewhere in the latitude of Labrador.

Dr. Guyot—Anyhow, this transportation of drift northward is very interesting. All or a part of Buering's Strait would be open at that time, and the change of separation would interrupt the currents from the Pacific, and change the whole circulation from the Pacific Sea.

Prof. Newberry—We think the circulation of the sea must have changed, because we find that the amount of atmospheric saturation from existing currents is not enough to form glaciers.

Dr. Bessels—It is so very small that the region under consideration could not have been so affected.

The Chairman—Would not the abnormal appearance of the drift be explained by simply supposing that the sea of the North is not coincident with the pole of the earth?

Dr. Guyot—Certainly.

Prof. Newberry—I venture to refer to the fact admitted, that we have traces of the lower Silurian rock stretching through to the utmost point reached north, and the upper silurian, also. The elevation of these series of later deposits has come lower this way, as you know. In the mouth of the St. Lawrence we have these same deposits 500 feet deep in the sea, and down about New-York on the Hudson, 200 or 250. The depression seems to be greater toward the north.

The Chairman then announced that the photographer of the Smithsonian Institution desired to take a photograph of the audience. Thereupon everybody turned about and faced toward the opposite end of the hall. Grave professors ran their fingers through their hair and struck an attitude. A solemn rigidity crept over the spell-bound group, at last to be interrupted by a sigh of relief as the black cloth was finally replaced on the camera.

The next address was an account of the new instrument at the Observatory.

THE GREAT TELESCOPE AT WASHINGTON.

BY PROF. SIMON NEWCOMB.

The initiatory movement in the construction of the great telescope was early in July, 1870, when Congress authorized for it an appropriation of $50,000. The contract was made with Alvan Clark & Sons of Cambridge, Mass., to manufacture it. The price agreed upon for the entire telescope was $46,000. Chance & Co. of England agreed to furnish the glass, they being the only makers of achromatic glass suitable for large refractors. There were many failures in casting the glass disks, and fully a year elapsed before Chance & Co. delivered the glass to the Messrs. Clark; but even this was more expeditious than has been the case in other instances, as at least one order given about the same time had not at last accounts been filled. Alvan Clark & Sons finished the great telescope in October, 1872. It is not too much to say that the glass fully met the high hopes that had been entertained concerning it.

The telescope is mounted on what is known as the German, or rather the Munich plan; but this has not been rigidly adhered to where improvement was possible. Certain important modifications have been made in the machinery by which the instrument is operated; some of these were devised by the Messrs. Clark, and one was adopted from Mr. Cooke's great telescope at Gateshead. As a result of these improvements, the observer can point the telescope by means of the circles alone so nearly that an object shall be in the field of view of the finder without the observer having been required to leave the floor or to look at the object.

The question is frequently asked, How does the new instrument compare with other telescopes? This is difficult to answer, since there are no refracting telescopes in this country of comparable dimensions. The question as to the comparative efficiency of refracting and reflecting telescopes is frequently raised. It must be admitted that great reflecting telescopes give very variable results and are very apt to prove unsatisfactory As an instance of this, if we examine the record of Herschel's work, we find that nearly the whole of it was done with his two-foot reflector; we shall almost arrive at the conclusion that all the work accomplished with the four-foot reflector might have been done with the smaller instrument. The same comparison of results leads us to a similar conclusion with regard to the four-foot reflector of Lassell—probably the largest ever constructed. He had under the clear skies of Malta made many important observations; but when he took his four-foot reflector there, hoping with it to verify his discoveries, it does not distinctly appear that he succeeded. Struvé, after looking through the four-foot telescope, wrote that it was not in any remarkable degree more powerful than his own 15-inch instrument at Pulkova. The only exception to this generalization is the fact that the four-foot instrument of Lassell did really discover the two inner satellites of Uranus. Prof. Newcomb having rediscovered these with the new instrument, and thus verified Lassell's discovery, thinks that they could never be seen with a 15-inch refractor. In the new telescope the outer satellites of Uranus look as if of about the size that d, *Ursæ minoris* appears to the naked eye. The smaller satellites, strange to say, have been best seen when the moon was shining, and its light was plainly apparent in the telescope; the first of those appears about half as bright, and the second about one-third as bright, as Titania.

It must be admitted that it is impossible to make a refracting telescope perfectly achromatic. The secondary spectrum which is obtained is for certain kinds of observations a serious objection to this class of lenses. This is especially the case where an extremely faint object has to be observed alongside a very bright one. In investigating the working of all ordinary telescopes, if we confine ourselves to the yellow and green rays, we shall find the rays to be brought to very nearly the same focus; but on examining the other rays we find that the red and the blue rays come to a longer focus, while the focus for the extreme indigo and violet rays is so much longer that they form a halo around the star's image. Possibly this can be avoided by adopting a device of the earlier astronomers—by having telescopes of one or two hundred feet in length, and by making changes in the curves of the glass.

The difficulty in a refracting telescope is a theoretical one; it is inherent in the instrument, and can never be entirely avoided; that of a reflecting telescope is mechanical in its nature, but has hitherto proved the more baffling of the two. On the whole, for regular work of almost every kind the refractor is better than the reflector.

Our friends have asked whether there is difficulty in the Washington telescope on account of spherical aberration. This proves to be a very small factor; its total amount is less than that produced in the lens by ordinary atmospheric variations of temperature—an effect which is noticed when work is first begun with the instrument of an evening, but which rapidly wears away as the glass acquires the uniform temperature of the rest of the instrument. It seems to be only the rays near the edge of the glass which are thus affected. Prof. Newcomb has looked through many other refracting telescopes, by way of comparison, and after full consideration he gives it as his unhesitating opinion that the new instrument must be regarded as a great success.

The following paper, in the absence of its author, was read by the Secretary:

THREE OF JUPITER'S SATELLITES.

BY PROF. S. ALEXANDER OF PRINCETON, N. J.

It is claimed that the other satellites of the planetary system resemble our moon in the coincidence of their times of rotation and revolution; and that in consequence every satellite presents always nearly the same side to its primary. One occasion for this belief is found on observing the special vicissitudes which the light of the satellites exhibits, each specified change recurring when they have again arrived at the same position in their orbits around their respective primaries. Another evidence is found in the remarkable phenomena of their apparent loss of light on certain occasions. All Jupiter's satellites, except the second, have at times been seen when in transit on the disk of the planet, appearing in whole or in part as dark instead of bright spots; and sometimes after at first appearing bright they seemed to become dusky. This, as Prof. Alexander has intimated in previous publications, would seem to be due to the absorption of, and possibly also, to the interference of light; *i.e.*, of the light reflected from Jupiter meeting that of the satellite; and all this on a scale such as is only seen in astronomical observations.

The extent of the undulations of light coming from the planet should, it would seem, be greatest where the penetration through its atmosphere and the return are most nearly in a vertical direction, *i. e.*, near the middle of the disk; while near its edges those undulations traversing the atmosphere (both going and returning) with great obliquity, would be more restrained. Accordingly a satellite may sometimes—as it does—appear bright, possibly unusually bright, at its first entrance on the disk of the planet. As it advances, under the partial effect of absorption, &c., it becomes dusky. Near the middle of the transit it seems relatively black, continuing so sometimes to the end of the transit, the passage of the disk being, very possibly, in the region of a bright belt. It is not strange, under these circumstances, that the dark spot should not always be round.

Aside from all this, however, the phenomena in question would seem to be consistent with the theory of a coincidence in the times of rotation and revolution, for the appearance of the satellite in the course of its transit as a black spot has within moderate intervals of succession recurred when the satellite had returned to a like position in its orbit around its primary. Admitting the absorption already indicated, then, instructed by the revelations of the spectroscope, we may regard it as possible that the satellite may be colder than its primary. This would happen—indeed we would have a reason for it—if the satellite, like the moon, had little or no atmosphere. All these analogies would be quite consistent with the hypothesis that all the satellites (including the moon) had been similarly condensed from the nebulous state, and then subjected to the stringent conditions which prevail in satellite systems.

The loss of atmosphere is one of the supposable consequences of those stringent conditions, as indeed M. Laplace has intimated, when, after stating the distance at which the attractive force of the earth is in equilibrium with that of the moon, he adds: "If at this distance the primitive atmosphere of the moon had not been deprived of all elasticity, it would be carried to the earth, which would thus draw to itself (*l'aspirer*). This is perhaps the reason why the moon's atmosphere is nearly insensible."

Système du Monde), (Book IV., chapter 10, conclusion: We may fairly inquire whether this has not been the case with all the satellites and their common experience.

THE LAWS OF STORMS.

BY PROF. ELIAS LOOMIS.

This memoir was entitled Results Derived from an Examination of the United States Weather Maps for 1872 and 1873. It was a continuation of the researches concerning which Prof. Loomis presented a memoir at the Academy's meeting last October, which was at that time reported in THE TRIBUNE. The material employed in these investigations is the United States weather maps for the years above named, one map daily at 7½ a. m. being selected. The method employed is to plot out the line of storms on skeleton maps month by month, reduce the paths to tabular forms by means of a protractor, measuring with reference to a meridian, and thus ascertain the progress of each storm on a scale of inches. Reduced thus to tabular form, the highest velocity is found in February, 31 miles per hour; the lowest in August, 17.7 miles per hour; the average for the year, 25.6 miles per hour. The average direction of the storm paths for the year is N. 82° E., and is found to be 23° more northerly in October than in July; the velocity in February is 75 per cent greater than in August.

The diversity of the direction and velocity of particular storms much exceeds these averages. On Oct. 20, 1873, a storm traveled N. 44° W.; on Oct. 25, 1872, N. 18° W.; on May 10, 1873, N. 160° E., or S. 20° E., showing a range of storm paths of over 180°. The velocities have a range from 0 to 57.5 miles per hour. As the mean values of the storm paths would thus form a very uncertain guide in predicting their velocity and direction, Prof. Loomis undertook an investigation of the disturbances accompanying the storms, using the material afforded by the weather maps. There seems to be a direct connection between the fall of rain and the course of a storm path. The rainfall of each storm was therefore collated, and the distance on each side of the path to which the rain extended. The whole number of storm paths was then divided into four classes, according to their respective velocities, with the following results in 152 cases:

Velocity in miles per hour.	Extent of rain area in miles.	Velocity in miles per hour.	Extent of rain area in miles.
38.8	590	21.6	503
28.5	548	14.5	365

These numbers indicate that the rain area generally extends 500 miles eastward of the storm center; that when the rain area exceeds that extent the storm advances with a velocity greater than the mean, and when the rain area is less, the velocity is below the mean. The comparative acceleration or diminution of velocity can be deduced from the table.

A similar class of comparisons to ascertain the connection of rainfall with the direction of the storm gave the following results:

Course of the Storm.	Axis of rain area.
N. 40° E.	N. 53° E.
N. 116° E.	N. 118° E.

The average course of the storm paths for 24 hours coincides very closely with the portion of the axis of the rain and for the preceding eight hours.

By dividing the paths of 79 storms into quadrants the following table of the prevailing winds was obtained:

N. quadrant.	S. quadrant.	E. quadrant.	W. quadrant.
7.6	8.8	8.3	10.1

By further comparisons of extremes of velocity of storms and prevailing winds, the following result was determined:

Velocity of storm in miles per hour.	Velocity of wind in E. quadrant.	Velocity of wind in W. quadrant.
32.1	8.8	9.0
18.1	7.8	11.3

These numbers show that the stronger the wind on the west side of the storm, the less is the velocity of the storm's progress. When the velocity in the east quadrant is equal to that in the west quadrant, the velocity of the storm is seven miles greater than the mean; but when the velocity of the wind in the west quadrant exceeds that in the east by 45 per cent, the velocity of the storm's progress is seven miles per hour less than the mean.

A comparison of barometric observations showed that when the barometer after a storm has passed rises 50 per cent more rapidly than usual, the storm-center advances 21 miles per hour more rapidly than the mean; but when the mercury afterward rises 50 per cent less than usual, the storm is one that has traveled 13 miles per hour less than the mean. The barometric pressure at the center of the storm does not afford an index to its progress. When the barometer rises rapidly as the storm passes by, the pressure at the center is increasing, but when at the rear of the storm the barometer rises slowly, the pressure at the center is diminishing or the storm is increasing in intensity. If the rise of the barometer is 22 per cent greater than usual, the central pressure increases one-tenth of an inch in 24 hours; if 22 per cent less than usual, the central pressure decreases a tenth of an inch in 24 hours. When the winds on the western quarter of a storm are stronger than those on the eastern, the storm is increasing in intensity; the reverse is true when the winds on the eastern quarter are strongest. But this rule is subject to numerous exceptions.

Prof. Loomis then explained the process by which he applied similar computations of the relative velocities of the winds, &c., at high altitudes, such as that of the Signal Service stations at Mount Washington; coming to the conclusion that at the hight of 6,000 feet in the western quadrant of a storm, the velocity of the wind is more than double that of the storm. By another series of computations he obtained the forms of the isobaric curves in at least 200 cases. In 55 per cent of the whole number of cases the major axis of the isobar exceeded its minor axis by half its length; in 30 per cent the major was double the minor; in 3 per cent the major axis was at least four times the minor. The storms of the United States are mostly of an oval form, with the longer axis most frequently in a direction about N. 40 E. About three-quarters of the great storms originate in the extreme West. In a case of which the details were particularly reviewed it seemed probable that the first development of magnitude in a storm began with the collision of moist air from the Pacific Ocean against the peaks of mountains in Oregon, resulting in heavy rainfall. But the most remarkable fact elicited was that the storm, once originated and organized, traveled over the highest mountain ranges without indicating sensible obstruction, proceeding eastward across the whole continent of North America.

LOWER SILURIAN FOSSILS.

BY PROF. J. S. NEWBERRY OF COLUMBIA COLLEGE, NEW-YORK.

This was a memoir on the so-called Land Plants of the Lower Silurian in Ohio. In the January number of *The American Journal of Science* Mr. Leo Lesquereux describes two fossils found in the upper portion of the Cincinnati group, near Lebanon, Ohio. These he considers as the remains of land plants, and refers them to the genus *Sigillaria;* and this case is cited as the first instance where plants so highly organized have been met with in Lower Silurian rocks. Through the kindness of the Rev. H. Hertzer, to whom the specimens in question belong, they had been in my possession some time before the publication of Mr. Lesquereux's notice, and I had examined them with some care for the purpose of determining, if possible, their botanical relations. I had also made careful drawings of them, of which copies are herewith submitted. As the result of my examination I am compelled to say that I fail to find either in the external characters or internal structure of these specimens any satisfactory evidence that they represent land plants; still less that they form species of the genus *Sigillaria.* Their external markings are fairly represented in the accompanying figures, and I am compelled to say that they exhibit no internal organic structure whatever. They are simply casts in earthy limestone without carbonaceous matter, or any traces of woody tissue. The smaller specimen is a discoid section of a cylindrical trunk of which the external surface is very smooth, but is marked by a reticutation not unlike that of one section of the genus *Sigillaria.* I fail to find, however, any dots or tubercles in the centers of the meshes, such as are referred to by Mr. Lesquereux, and which were they present might be supposed to represent the place of the nutrient vessels of the leaves. Taken by itself I should say that this specimen might be considered to represent a sponge or some other low form of marine life, quite as well as *Sigillaria.* Since the specimen is so small and forms so little of the original organism I think it would be unsafe to make it the base of any general and important conclusion.

The layer specimen is represented, like the other, of the natural size. This is also a cast of a nearly cylindrical trunk of which the external surface is roughened by irregularly disposed and unequally sized lenticular prominences. These recall, in a rude way, the leaf scars borne by the trunks of some Lycopodiaceous or Cycadaceous plants, but they do not exhibit the spiral arrangement, nor the details of structure which the leaf-scars of such plants almost universally retain in the fossil state. In the interior of this trunk are seen a few irregularly scattered points of carbonaceous matter, but they are not continous fibers, and to my eye show no traces of cell structure.

Taking all the characters of these interesting fossils into consideration, I am disposed to regard them as casts of the stems of fucoids. Had they been land plants they would almost certainly exhibit more distinctness and regularity of surface marking, some coating of carbonaceous matter, and some traces of organic structure. A large number of specimens of sea-floated land plants, which we have found in the Devonian limestones of Ohio, all assert their botanical affinities by these characters. The remains of fucoids, on the contrary, consist almost universally of mere casts of their external surface, carbonaceous matter and internal structure having both entirely disappeared. For these reasons, therefore, I should hesitate to hang upon these specimens so important a conclusion as that promulgated by Mr. Lesquereux. I would not be understood, however, to assert positively that they are not the remains of land plants, for they are too imperfect to be decisive of that question, but only this, that they do not afford characters which permit one to accept them as evidence of the existence of land plants, and certainly not of *Sigillaria,* in Ohio, during the Lower Silurian age. The remains of what have been called land plants are found in the Lower Cambrian sandstones of Sweden, and two species have been described (*Eophyton Lennarsonum,* Torell, and *E. Torelli,* Lenarson). These plants are pronounced by algologists not to be algæ, but are referred to vascular cryptogams and monocotyledons. It is not certain, however, that they are not thallogens, as all traces of structure are lost, and nothing is left but the cast or impression of the external surface. (*Geological Magazine,* September, 1869.)

Land plants of Gaspè have also been found in the Upper Silurian strata, Canada, by Prof. Dawson. Here, with a large number of fucoids, a few specimens have been found, which he refers to his genus *Psiloplayton.* In these the scalariform axis, and the outer fibrous back both remain and serve as satisfactory guides in their classification. (*Dawson's Precarboniferous Plants of Canada,* p. 66.)

With these exceptions no land plants are reported below the Devonian. On this point, however, the evidence is all negative, and highly organized land plants may be at any time found in the Lower Silurian rocks. Indeed, the variety and high rank of the Devonian flora prepares us to expect such a result. Strict accuracy compels us to state, however, that up to the present time positive proof of the existence of land plants in the Lower Silurian has not been met with in other countries, nor is it furnished by the specimens under consideration. What we know of the physical condition of the region about Cincinnati during the Lower Silurian age strengthens the conclusion that the specimens before us are the remains of marine and not terrestrial vegetation. As I have shown in the Geological Report of Ohio, the Cincinnati axis was raised above the sea at the close of the Lower Silurian age, and when the Cincinnati group was deposited an open sea occupied all that region. The shores of this sea were formed by the Eozoic highlands about Lake Superior, in Canada, in the Adirondacks, and along the Blue Ridge; nowhere less than 500 miles away from the locality where these fossils were found. It becomes, therefore, extremely improbable that two distinct species of terrestrial plants should be wafted from those distant shores and deposited in the calcareous sediment of the sea at this point. The remains of fucoids are, however, not uncommon in the Cincinnati group, and the only objection to grouping these fossils with *Buthotrephis* and the other Silurian algæ must be found in their somewhat peculiar surface-markings. These are, however, not unlike the markings on the stems of many recent and fossil fucoids. The summit of the stem of the giant kelp *Macrocystis* is marked with irregular rings left by the removal of their great fronds, and the stems of many fossil fucoids are scaled or tuberculated more regularly and distinctly than are these specimens. Among such I will only cite *Arthrophycus Hallii* of the Medina, the tuberculated fucoid called *Halymenitis* of the Cretaceous, and the scaled *Phytoderma* of the Jurassic.

HOW THE EARTH WAS FORMED.

BY CAPT. C. E. DUTTON, U. S. A.

This paper was entitled A Criticism upon the Contractional Hypothesis.

The hypotheses that have been put forward to explain the operation of forces beneath the earth's surface in producing its characteristic features are here referred to two types: (1) those attributing the surface features to contraction from loss of heat, which may be called the contractional hypothesis, and (2) the arguments which attribute them more or less to disturbances produced by external changes, which may be called the reactional hypothesis.

The contractional hypothesis assumes that the earth may be regarded as of two portions—a cooled exterior and a hot nucleus. The secular loss of heat is supposed to be greater from the latter than from the former, and by a consequent contraction of the nucleus it is assumed that the shell would tend to collapse. Owing to the unequal ability of certain portions of the shell to bear the tangential strains thus occasioned, the yielding taking place along the lines of least resistance would be manifested in the production of table lands, or mountains, or disturbed stratification. The smaller conductivity of materials underlying the land is held to account for the primary division into land and water, the land having been left behind in a general convergence of material toward the center.

There can be no reasonable doubt that the earth mass consists of a cooled exterior inclosing a hot nucleus, and secular cooling and contraction are necessary corollaries. As the process was of immense duration, we may take some starting point, and assuming the loss of temperature to have been continuous, may arrive at a period when the whole mass was fluid. As was pointed out by Sir William Thompson, this was a period of homogeneity, both as to material and heat. The first result of loss of heat would apparently be consolidation, and the argument of Hopkins is here accepted that consolidation would begin at the center, where pressure would enable congelation to be effected at high temperatures. Materials solidifying at the surface would sink by their increased density, until the surface was so far reached by solidification proceeding from the interior as to leave only an imperfectly liquid mass, where such movements, gradually retarded, at length ceased. The result would be a solid globe with perhaps isolated reservoirs of liquid that might consist of matter having a higher melting point.

MATHEMATICAL BASIS OF THE ARGUMENT.

Here follows in Capt. Dutton's memoir a summary of Fourier's solution of the problem of secular cooling. It is based upon certain factors, which are represented thus:

V, denotes half the difference of the two initial temperatures.
r, half their sum.
t, the time.
x, the distance of any point from the plane.
T, the temperature of the point x at the time t.
k, the conductivity of the material in terms of its own thermal capacity.

With these data a formula is computed. To obtain the coefficient of k, Messrs. Thompson and Forbes made experiments on rock material with thermometers imbedded at distances of from three to 25 feet during a period of 14 years. V, representing the maximum temperature of the interior of the earth at the beginning of cooling, must be hypothetical; for our purposes we may take it as the melting point of the more refractory material forming the chief bulk of the nucleus, and assume it to be that of the anhydrous silicates and that they are 500 to 800 miles in depth. Allowing for the effect of pressure upon the congealing point we may accept Sir William Thompson's estimate of this temperature as, at a maximum, 7,000° F. A course of mathematical reasoning then is put forward by Capt. Dutton, which shows that if it be possible to determine a true mean rate of increase of temperature per foot of descent at any point near the surface, the time required to elapse from the epoch of the establishment of the cooling to the present time can be deduced. This mean is placed by some investigators at 1-50 of a degree of Fahrenheit per foot, by others at 1-60; the former would give about 100,000,000, and the latter about 130,000,000 years.

The correctness of the mathematical deductions cannot be questioned, but the data on which they proceed are open to doubt. The coefficient of k may not be an invariable constant, as it seems probable from experiment that the conductivity of material increases as fluidity is approached. The time required to establish an increase which may be represented by 1° Fah., divided by 50.6, would thus probably be largely augmented. This would also reduce the basis of the contractional hypothesis by reducing the total dissipation of heat and the contraction inferred from it. Again, as to k, if porous rocks are saturated with water they are much worse conductors than those on which Sir William Thompson experimented; this value, now represented at 400, might then be put at 250. The effect of this would be to extend the duration of the cooling. Another factor open to question is the rate of increase of temperature per foot of descent. Its value, varying widely with locality, is found in some places one-fifteenth and in others one one-hundred-and-tenth. Proximity to igneous masses may vitiate any average based on such observations, as these cases may be extreme, and aqueous circulation below the surface may equally vitiate other observations.

RESULTS AS TO THE AGE OF THE EARTH.

(1.) Let us assume that the earth, when first ceasing to be fluid, had a temperature of 7,000° F., and now exhibits an increase of one one-hundredth of a degree for each foot of descent near the surface. The period between would then be about 625,000,000 years. At a depth of 300 miles the increase of temperature would be about a fifty-six hundred and fortieth of a degree per foot of descent; thence inward the total amount of cooling would be inconsiderable; outward it would augment at an increasing rate to the mean temperature at the surface.

(2.) Take the present surface rate of increase of temperature at, per foot, one degree Fah. divided by 50.6. The epoch would be about 160,000,000 years, and below 140 miles the rate of increase of heat would be inconsiderable.

(3.) Take the valuation of k at 400 instead of 250, and of the surface rate at 1 divided by 50.6, the epoch becomes about 98,000,000 years, and below 150 miles the rate of increase would be less than 1 divided by 2,700.

(4.) Take k at 250 and the surface rate at 1 divided by 200, the epoch would be 2,500,000,000 years, and at a depth of 600 miles the cooling might be disregarded.

But in general the application of this theorem is fatal to the contraction hypothesis, as it shows that after 200 or 300 miles the cooling has been comparatively little; were it otherwise the present rate of increase of heat per foot would be lower than the lowest reasonable estimate with our present knowledge. Our acquaintance with the laws of plutonic action is insufficient to take it into account, but as an element in the problem it may be regarded as of inconsiderable moment. Chemical changes could scarcely take place at the limits of sensible cooling, and cannot be regarded as operative at greater depths than 200 or 300 miles. The contraction of this portion cannot be more than one-tenth, if we assume the total contraction of the earth's radius at 30 miles since the formation of a cooled exterior.

OBJECTIONS TO THE CONTRACTIONAL HYPOTHESIS.

By far the greater portion of this cooling must have taken place before the palæozoic age. By far the greater portion of the residue must have occurred before the beginning of the tertiary period, and yet the whole of this contraction would not account for the disturbances which have occurred since the close of the cretaceous period. To account for the tangential compression in mountainous regions we should be compelled to assume contraction since the Permian period. But we find the Laurentian rocks excessively disturbed, and cannot attribute this to secular contraction of the interior. Shrinkage of one-fifth in linear density implies an increase of 95 feet in mean density; and this is incompatible with any reasonable supposition as to the condition of the earth's mass while the Laurentian sediments were accumulating, if we consider their distortion as due to contraction.

Again, a vertical section through the Appalachian chain, and thence westward to the 100th meridian, shows a highly disturbed surface for 250 miles. If the contraction was general, there must have been a vast slip over the nucleus. But the friction and adhesion between the crust and the nucleus seem to have been overlooked. The analytical method applied to this would demonstrate its impossibility. Again, the tendency to corrugation along certain belts with series of parallel folds is assumed on a doubtful basis. The shrinkage of the nucleus would institute a strain in all directions within its own tangent plane. Relief by horizontal yielding in one direction would give no general relief; the intensity of the strain in all other directions would still remain. The case is not that of a collapsing cylinder, but of a dome, and great deformations of the earth's surface must ensue. The plications of the palæozoic rocks are not of this general character. They are localized in long and rather narrow belts. Still more discordant is the evidence of the tertiary plications; the disturbance from Cape Horn to Behring's Sea is a continuous, narrow belt. If we admit contraction along the belt alone, we cannot explain the regular figure of the earth as an ellipsoid of revolution with an eccentricity proportioned to its mean density and angular velocity. Here the analogy of the withered apple fails; if corrugated by shrinkage it fails to preserve its figure, or if preserving it, must corrugate uniformly. To avoid prolixity this argument is not carried into the discussion of details of surface.

Prof. Guyot read a memoir of Prof. James H. Coffin. The following papers were read by title only: A Memoir on the Zodiacal Light, by Prof. S. Alexander; On Some Points in Mallet's Theory of Vulcanicity, by Prof. E. W. Hilgard; The Polarization of the Zodiacal Light, by Prof. A. W. Wright.

Mr. James D. Warner of Brooklyn read a purely technical paper on a New Set of Bernoulli's Numbers, which are a mathematical invention for shortening certain algebraic processes by their application to the coefficients of development of expanding series.

At the conclusion of this paper, without another word *pro* or *con*, without stilted resolutions, or any other of the numerous devices for closing an extended meeting, Prof. Henry simply rose from his chair and said:

"The Academy is now adjourned."

And it was adjourned.

ASSYRIAN RELICS.

PHOTOGRAPHIC COPIES AT WASHINGTON FROM THE BRITISH MUSEUM.

COPIES OF GEORGE SMITH'S RESTORED CHALDEAN TABLETS IN THE SMITHSONIAN INSTITUTION—HOW THE CUNEIFORM CHARACTERS WERE DECIPHERED AND THE STORY THEY TELL—THE RECORD OF THE EXPLOITS AND DECREES OF ANCIENT KINGS.

[FROM AN OCCASIONAL CORRESPONDENT OF THE TRIBUNE.]

WASHINGTON, D. C., April 24.—I make it a point to stroll over the Smithsonian Institution at least twice a month to see the additions to the curiosities which are there on exhibition. Last week my visit was rewarded by a view of the famous tablets which present the Chaldean account of the Deluge. These tablets are copies of those restored by George Smith, curator of the Assyrian and Oriental Departments of the British Museum, and were procured by Professor Henry, at the request of Professor Mason, of Columbia College, Washington. Professor Mason has for several years made a specialty of Oriental languages and history, and is said to be the only man in this country who can decipher the character of the cuneiform inscriptions. He was in the building at the time I visited it, and I found him in the great upper hall busily engaged in hanging the magnificent series of phototypes published by the British Museum, of which mention will be made further on. These copies will be placed in the large upper hall, which is to be devoted to ethnological subjects. All the natural history specimens which have hitherto been kept in that hall will be taken down stairs. New cases have been made for the proper exhibition of ethnological curiosities, and the vast collections of the Smithsonian illustrating the habits and life of North American Indian tribes, as well as of many other uncivilized peoples, including some that are prehistoric in their antiquity, will thus be brought together and arranged with accurate classification for the use of the professional student. The systematic method of arrangement of the collections of the Smithsonian Institute, under the care of Prof. Baird, adds materially to their usefulness and value.

Professor Mason soon became enthusiastically interested in the subject of the tablets, and gave the following history of their discovery and restoration:

Some twenty-five years since, Mr. George Smith, a young engraver in London, showed considerable interest in matters of Oriental art and curiosity deposited in the British Museum, and, finally, upon the return to England of Sir Henry Rawlinson, the distinguished Oriental scholar, astonished the latter one day by easily deciphering the inscription upon one of the Assyrian relics brought by Layard from Nineveh. Mr. Smith became an employé of the Museum, and ultimately curator of the department of Oriental antiquities. In 1846 Mr. Layard, while making his excavations on the supposed site of Nineveh, broke through into a large room, which proved subsequently to be the library of Assurbanipal, who was King of Assyria B. C. 668–640, and who established this library B. C. 667. The writings of the ancients were engraved upon tablets, which, in most instances, were made of stone; but, at the Euphrates's mouth, the area covered by the Chaldean Kingdom is entirely alluvial, and stone is altogether wanting; therefore, the Chaldean tablets are made of terra cotta, or else of unburnt clay. Layard found large numbers of these tablets, arranged about the room in four divisions, lying in piles like blocks. These he collected carefully and sent to England; but during the transit home, owing to careless packing, nearly all were reduced to fragments.

THE STORY OF THE FLOOD.

Large numbers of these tablets comprised the grammar, lexicons, dictionaries, and spelling-books of the language, and one of the four divisions of the library was known as the Mythical and Mythological section. In this latter section Mr. Smith discovered the story of the Deluge, and in a paper read before the Biblical Archæological Society of London described as follows his patient labors in attaining its restoration and translation:

From the Mythical and Mythological section of Assyrian texts I obtained a number of tablets, giving a curious series of legends and including a copy of the story of the Flood. On discovering these documents, which were much mutilated, I searched over all the collections of fragments of inscriptions, consisting of several thousands of smaller pieces, and ultimately recovered 80 fragments of these legends, by the aid of which I was enabled to restore nearly all the text of the description of the Flood and considerable portions of the other legends. These tablets were originally at least 12 in number, forming one story or set of legends, the account of the Flood being on the eleventh tablet. Of the inscription describing the Flood, there are fragments of three copies containing the same text; these copies belong to the time of Assurbanipal, or about 660 years before the Christian era, and were found in the library of that monarch in the palace at Nineveh. The original text, according to the statements on the tablets, must have belonged to the City of Erech, and it appears to have been either written in or translated into the Semitic Babylonian at a very early period. The date when this document was first written or translated is at present very difficult to decide. * * * On comparing the Deluge text with dated texts of the time of Sargon I., it appears to be older than these, and its original composition cannot be placed later than the seventeenth century before the Christian era; while it may be much older

The eleventh tablet, which, as Mr. Smith has proved, contains the account of the Deluge, comprises two hundred and eighty-nine lines of cuneiform characters, inscribed upon both sides of the tablet. The copy sent to the Smithsonian is in two plates, showing each side of the original inscription, which are handsomely mounted to protect them from injury. Assurbanipal, in whose time the library was founded, is supposed to be the King who was known to the Greeks by the name "Sardanapalus," and who occupied the relation to Assyrian history that Pisistratus did to that of the Greeks. The study of the cuneiform characters has since 1802 been closely pursued by Oriental scholars, and the results attained in reading the inscriptions contained in the British Museum have been long foretold as describing the history of the Chaldeans and Assyrians.

FAC-SIMILE PUBLICATIONS BY THE BRITISH MUSEUM.

The British Museum has already published six volumes of the cuneiform texts in fac-simile, giving also the results, as far as ascertained, of the labors of various scholars in their translations. In addition to these, an enterprising London firm has published an extensive series of photograhs of objects in the Museum, and that portion which relates to Assyrian history has just been received at the Smithsonian, and is the collection already spoken of as being prepared by Prof. Mason for exhibition. A large portion of these photographs are of the sculptures in the North-West Palace at Nimrud, which is nearly opposite the supposed site of Nineveh, and are of three groups or periods, B. C. 884, B. C. 745, and B. C. 668, and afford to scholars tests of progression in the art at these three dates. The oldest sculptures discovered by Layard at this place, are of the time of Asshur-na-zir-pal, B. C. 884 to 850. The deeds of this monarch are related at length, and no details seem to have been considered too minute or insignificant to be depicted. The exploits of the King in hunting are as minutely finished as those describing his military expeditions. From these former slabs it appears that he "preserved" his game, having a large park stocked with wild animals, the supply of which was kept up by tribute and by presents. The King is represented riding down his enemies, bending his bow and shooting at their defenses, or receiving submission. All the details of slaughter, and of the cruel, barbarous treatment of prisoners are given—such as impalement on high poles, cutting and disembowelling—and show exactly the various arms, engines, and military implements of the time. The famous "Black Obelisk," found by Layard in the Central Palace at Nimrud, was erected in this palace by Shalmaneser II., and represents the incidents of thirty-one campaigns of that monarch, and among others receiving the embassador and tribute of Jehu, King of Israel. This occupies the top row of one of the four faces, and is the first mention in Assyrian history (B. C. about 850) of a Jewish king. The Assyrian series of plates closes with the reign of Assur-ban-i-pal, and these as works of art present the most advanced specimens. In the hunting scenes the sport is tamer as compared with like scenes in the reign of Asshur-na-zir-pal of 200 years before. The lions are now carried in cages to the spot and then let out, while in the earlier time the game was roused in the open country and hunted down. The very expression depicted upon the face of the game shows the decadence of the sport, and all accessories of the scenes depict a lazier and more ostentatious mode of hunting, and foretells the decay of the empire, which in less than 50 years (B. C. 500) crumbled to pieces. In one of the photographs is shown a small glass vase, found at Nineveh, bearing the name of the Assyrian monarch Sargon, the date of which places it in the year 719 before the Christian era. This is the earliest known specimen of transparent glass.

Many of the tablets bearing decrees of the King are trilingual, though merely variations of the Semitic writing. These inscriptions, being placed in parallel columns, long set at fault the efforts of scholars to decipher them, until it was discovered that the three great divisions of the Chaldean Empire were inhabited by people who varied in speaking and writing their language greatly, and the three columns contained these three variations.

THE POET LONGFELLOW.

LECTURE BY MR. JAMES T. FIELDS.

A DISCOURSE UPON HIS CHARACTER AND POETICAL WORKS—HIS GENIUS AND ZEAL FOR STUDY—INTERESTING DETAILS OF THE ORIGIN OF SOME OF HIS FAMOUS POEMS—HOW THE "PSALM OF LIFE" AND "EXCELSIOR" WERE WRITTEN—HIS TRIBUTES TO HIS FRIENDS—A DELINEATOR OF FINE AND TENDER SYMPATHIES.

[FROM AN OCCASIONAL CORRESPONDENT OF THE TRIBUNE.]

BOSTON, April 24.—The pupils of the Girls' High School have had another addition to the debt they already owe Mr. James T. Fields. He has always taken a great deal of interest in the school, and when he had prepared his interesting lecture on Tennyson, he first submitted it to their indulgent ears. The lecture on Longfellow, which he read to them on April 24, surpasses any of his previous essays of a similar nature in its admiring appreciation of his subject and intimate acquaintance with it. Its delivery may be considered as a sort of literary dress rehearsal, and, if the evident delight of the young ladies and the few score of visitors who heard it is any criterion of the favor with which it will be received by the general public, it will prove more successful than either of the half-dozen similar essays which have been so favorably received during the past Winter. The lecture, which is fully reported below, occupied in delivery hardly an hour.

THE LECTURE.

FELLOW-STUDENTS: I once had the pleasure of speaking to you in this hall on "Alfred Tennyson, the Poet Laureate of England." I am to speak to you now on one of our own stars who have sung, a poet of such marked and varied excellence, a character so reverenced and beloved among us, and indeed everywhere, that I have only to mention the name of Longfellow to secure at once your sympathy and your interest in my theme. It seems to me that this early hour of the day is the selectest one for reading an essay on Longfellow to such an audience as this; for he is always young, always full of the spirit of sunshine and the dawn, always imparting strength and courage to endeavor, and always singing in his own peculiar way that "life is real and earnest;" that we must all strive to "act in the living present," and that "still achieving, still pursuing," should be the end of our flying and fleeting existence. Somehow the world has always had an irreverent habit of elevating its nose at living authors of genius, as if it was a crime for a really great poet or prose writer to be alive and well and enjoying the society of his friends; as if dust and ashes added a certain respectability to merit, and it were highly appropriate to wait till a man be safely under the ground before he was to be considered an heir to fame and celebrated accordingly. As soon as a great author is dead, we all begin to do him justice. Then we crowd about his grave and throw in tributary flowers that should have made glad his heart and all his living senses while he still lived among us, and when he could have heard the voice of praise not with the dull, cold ear of death, and felt the laurels around his living, sensitive brow. Let us try, to-day, to be just to a living poet, and express without reserve that earnest pride we feel in him, and which those who will come after us will be sure to cherish.

THE GRAND AND HEALTHY LESSONS OF HIS POETRY.

The poetry of Longfellow is full of grand and healthy lessons. "Stand up to your work, whatever it may be, and do not be afraid of it," is one of them. We are sometimes unmindful here in America that corn must be ground before it is baked. We are apt to hurry everything, and to forget that if we do not know a thing correctly we really do not know it at all. But Longfellow is to be placed with the army of scholars as well as with the gifted band of world-renowned singers. I am to speak to you of a man whose poetry is not an experiment, but an assured and lasting fact; of one who has no infirmities which I have been able to discover; of one whose fancy never disordered or misdirected the purpose of his muse. Some poets, and good ones, have sometimes flamed out, vaguely bristling with dictionary words, and shocked us with their vagaries of thought and expression; but Longfellow is never false or affected; his language is always that of man to man and human heart to human heart. He never writes of one thing for the purpose of putting another. His purpose is always direct, and he goes to his work with the certainty of the arrow and with a power that is thoroughly in earnest. In the year 1820—just fifty-four years ago—the question was started in *The Edinburgh Review*, which raised such a breeze throughout America that the query is destined never to be forgotten. The exact form of the inquiry is precisely in these words: "In the four quarters of the globe, who reads an American book?" Now I don't think at that period this question was an impertinent one. We really had not much literature to show, as to quantity or quality either, in those days. Twelve months after that question was asked, a young lad had just entered his name as a student in Bowdoin College who was destined, forty years later, to become the most popular poet in the civilized world, including this same kingdom of Great Britain, where *The Edinburgh Review* was published.

MORE READ THAN ANY OTHER LIVING POET.

To-day there is no disputing the fact that Henry Longfellow is more read than any other living poet; that his books are more widely circulated and bring more copyright than any other written in English verse. There must be some reason for this popularity, among high and low; some sufficient cause for this lasting and firm regard for the man who at a very early age came singing out from the borders of Maine into the world of song. Early he says somewhere—and I wish you all to remember this—that "genius is only the infinite capacity of taking trouble." I often think of the infinite pains Longfellow took when a youth to become a scholar, ripe and mature. Starting off in a small brig, in the first year of his college life, he goes into Denmark and studies Danish, and obtains a knowledge of Icelandic, German and Dutch in the same way. He resolved to be not a mere king of shreds and patches, but a real master in the studies he determined to conquer. Holmes speaks somewhere of one who "performs a little with the lead pencil." Little performances were not what Longfellow was after in life. Let me give you a glimpse of him as he appeared years ago, from that little book, "A Year in Spain," and which contains an excellent account of Mr. Longfellow, whom the writer met in his wanderings. He says:

My companion was just from college and full of the ardor excited by classical pursuits, with health unbroken and with a curiosity which had never yet been satisfied. He had sunny locks, a fresh complexion, clear blue eyes, and all the indications of a joyous temperament.

This is a true and interesting picture of the young scholar in his first travels into the grand old world of art and romance. There are those called poets who live in the sleepy hollows of thought, "where it is all the time afternoon." But Longfellow is not one of these. He has made himself controller of that high art called poetry by coming in contact at all points with the great interests of humanity. Having been kissed by the fairy queen of song in his cradle he henceforth became her living subject to do her noblest and best work.

HIS PROFOUND AND SPECIAL SCHOLARSHIP.

Some scholars never carry their understandings about with them, but leave them dozing on the library shelves. A mere scholarly man could not have written as Longfellow wrote. A man may be very expert in all the dead languages, but utterly unlearned in any living one. A quotation quoted from a quotation is not the most enlivening to the present race. This all-alive and sharply modernized world of ours has outgrown the dead-letter times, strange as it may seem perhaps in Oxford and Cambridge. Longfellow's scholarship is profound and special, but it never clogs for a moment the impetus of his nineteenth century genius. He can answer correctly more questions than almost any man of his time out of the pages of the past, but he never intrudes his wisdom into his poetry. It is there, very deep down, like the roots of things, but the garlands of song cover up and conceal the river of knowledge that is flowing beneath them. If he were not known as the great poet, he would certainly be recognized everywhere as a preëminent scholar and thinker. In poetry, we are apt to have many acquaintances but very few friends. With how many men and women are we on speaking terms in poetry, but how few we really love and cannot live without! Our supreme favorites in the poetic art you can easily catalogue, and Longfellow is one of them. There is never any coldness, never any unsympathetic relation between him and his readers. I dare say you all remember those beautiful dedicatory stanzas in the new volume, published in 1849, where he flows out in that deep, tender strain of salutation to all who have ever sent him messages of friendship founded on a perusal of his writings.

MORE WIDELY QUOTED THAN ANY POET SINCE POPE.

Since Pope, no poet has been more quoted than Longfellow. He has added to the stock of English letters and speech as many lines, couplets, and verses as any other of a hundred years. This is a sure test of poetic thought and inspiration. You must look to Shakespeare and a few other great ones for a larger currency of expression than our American Longfellow had. The mottoes on thousands of title-pages are from him; if you go to England, you will hear him cited in Parliament, in Westminster Hall, and in the cathedral; every pulpit admits him, for his thought is wide enough to embrace all creeds and all spiritualities in his hallowed and responsive verse. It is because he humanizes everything he touches, that his lyre has nothing alien to any soil. I have heard him quoted by an American monk with a cowl, and I have heard him sung by a band of humble worshipers in a camp-meeting among the hills of New-Hampshire. No heart but can receive him and find consolation in his melodies, and this is one reason why he is one of the most popular of all poets writing English. Some one seeing a copy of one of his books lying in a low drinking saloon has said, "This is indeed true fame." The poorest cottager, if he have any books at all, must be sure to have something that Longfellow wrote. Being overtaken in the country by night, I found lodging in a humble house, I was shown to a little room next the roof, and there the only book beside the Bible was his "Voices of the Night," and I was forced to repeat, "This is indeed true fame." No poet has ever paid tenderer tributes to his friends than Longfellow, and that is a good sign. When Hawthorne, his friend and fellow-student, was buried on that beautiful May day, in 1864, the heart of the poet seemed to be weeping in that tender requiem that followed almost immediately after the funeral procession of the great romancer. In the lines addressed to the River Charles there is a verse commemorating three friendships, one of which was Charles Sumner's. He sings in his own melodious way:

"More than this, thy name reminds me
  Of three friends, all true and tried,
And that name like music binds me
  Closer, closer, to thy side.
Friends, my soul with joy remembers,
  How like covered flames they start,
When I fan the living embers
  On the hearthstone of my heart."

HOW THE "PSALM OF LIFE" WAS WRITTEN.

It is always interesting to know under what circumstances a poet has framed an immortal poem or sonnet or song. As I happen to know something of the origin and birth of many of Longfellow's poems, let me divulge a few secrets in regard to them. The "Psalm of Life" came into existence on a bright Summer morning in July, 1838, in Cambridge, as the poet sat between two windows at the small table in the corner of his chamber. It was a voice from his inmost heart and he kept it some time in manuscript, unwilling to part with it. It expressed his own feelings at that time, when he was rallying from the depression of a deep affliction, and he hid the poem in his own heart for many months. He was accused of taking the famous verse, "Art is long and time is fleeting," from Bishop's poem, but I happen to know that was not in his mind, and that the thought came to him with as much freshness and originality as if nothing had been written before. "There is a reaper whose name is death" crystallized at once, without effort, in the poet's mind, and he wrote it rapidly down, with tears filling his eyes as he composed it. "The Light of the Stars" was composed as the poet looked out upon a calm and beautiful Summer evening, exactly suggestive of the poem. The moon, a little strip of silver, was just setting behind Mount Auburn, and Mars was blazing in the south. That fine ballad, "The Wreck of the Hesperus," was written in 1839. A violent storm had occurred the night before, and as the poet sat smoking his pipe about midnight by the fire, the wrecked Hesperus came sailing into his mind. He went to bed, but the poem had seized him, and he could not sleep. He got up and wrote the celebrated verses. "The clock was striking three," he said, "when I finished the last stanza." It did not come into his mind by lines, but by whole stanzas, hardly causing him an effort, but flowing without let or hinderance.

THE ORIGIN OF "EXCELSIOR."

One of the best known of all Longfellow's shorter poems is "Excelsior." The word happened to catch his eye late one Autumn evening in 1841 on a torn piece of newspaper, and straightway his imagination took fire at it. Taking the first piece of paper at hand, which happened to be the back of a letter received that night from Charles Sumner, Longfellow crowded it with verses. As first written down, "Excelsior" differs from the perfected and published poem; but it shows in its original conception a rush and glow worthy the theme and author. On a summer afternoon in 1849, as he was riding on the beach, "The Skeleton in Armor" rose as out of the deep before him and would not be laid. The story of "Evangeline" was first suggested to Hawthorne by a friend who wished him to found a romance upon it. Hawthorne did not quite coincide with the idea, and handed the theme to Lonfellow, who saw at once all the essential qualities of a deep and tender idyl.

It is a delightful tribute to Longfellow's genius that all young people delight so in his poetry. They find in it a childlike simplicity as well as the essential quality of supreme interest. The child detects the imitation article quite as readily as the parent, and will pass the spurious lyre and accept the real one with a judgment that is marvelous. Old and young, the laborer and the professor, alike find occasion for the inspiring words of Longfellow which they cannot do without. Everywhere, anywhere, he is in most perfect and delightful keeping. The untaught grace of poetry, the power of infusing the author's mind into the heart of the reader is his, and this endears him to his readers, and will endear him to generations yet to come.

THE DETRACTIONS OF CRITICS.

One of the commonest and most unfounded charges against authorship in every age is plagiarism. Now nine times out of ten what is called plagiarism is parallelism. If I were an artist and could paint like William Hunt, I would make a picture which would stand for all times of Hercules telling his servant to show a fault-finding visitor out of the room. It is a great fault in anybody who cannot praise easily. Habitual fault-finding is an immoral trait in any character, and a lesson we all should learn is to find out good things in what we see. Longfellow has not escaped detraction any more than the rest. The vultures of criticism have hovered and pounced on his reputation after their usual manner, but no great harm has ever resulted from their attacks. Always master of himself and his theme, the poet has sailed away out of his detractors' sight and quietly let them rave. Longfellow now lives of course above the region where the envious critics delight to bark and bite. But some of us remember what dissatisfaction was called up when he published a new volume of his works. The rats of reputation went on gnawing at his laurels for years, though they proved to be powerless against true genius and artistic skill, and the true son of the muses went on from strength to strength, while these vermin died at last from inanition and neglect. One of his purblind critics said he had "really written some brilliant pieces by accident." "Accident, then," I said, "was never better employed. Let us vary our railroad casualties with some accidents of the Longfellow type." I hope they still show the little room down in Bowdoin College, for it was in that pleasant apartment that the young poet of 19 wrote many of his early poems. These were all published in 1825, during his last year in college, in a periodical called *The United States Literary Gazette*, the sapient editor of which advised him to give up poetry and buckle down to law. I am very glad that Longfellow did not take his advice.

THE FRIEND OF HIS RACE.

In estimating Longfellow, I see no reason for comparing him with anybody else. He is sufficient in his own department, and has his own power and influence. Tennyson is Tennyson, Wordsworth is Wordsworth, Longfellow is Longfellow. He may not be this or that, but a writer should not be judged by what he is not. What he is should be the real question. Negations are not answers, but qualities in possession are what will determine cotemporary judgment as well as the judgment of posterity. What a procession of youth and beauty wander in perennial loveliness through Longfellow's pages. It can never grow old or fade away.

If I were called upon suddenly to prove that Longfellow is preëminently a poet in every sense, in imagination, in artistic skill, in all the equipment of a high-born singer, I think I should be willing to select from his later pieces the exquisite poem of Sandalphon, which if you wish, I will read to you. [Mr. Fields here read the poem.]

No English poet-scholar has ever made such masterly translations as Longfellow. Dante, as rendered by him, can be read now in the very spirit of the great Italian poet. Now, just what I claim for Longfellow is this: A high and honorable place in the poetic and prose literature of this century; a rank with the great spirits that still rule us from their urns; a name that can never die out of the annals of English literature and song; for I find in him those priceless qualities of excellence which the world, having once witnessed, never forgets. Longfellow goes in a straight line to his reader's understanding. The highway to the human heart is the one he most travels. His verse gives no translation to his reader. He is never a satirist, never a trifler, never a scorner, but a delineator of fine and tender sympathies, which makes him the friend of his race.

It was never truer than now that poetry has its own exceeding great reward. And let us never forget, my friends, when we are estimating poetry, what Longfellow himself teaches in one of his best and noblest efforts, that—

> "God sent his singers on the earth,
> With songs of sadness and of mirth
> That they might teach the heart of men,
> And bring them back to heaven again."

THE HORSE IN AMERICA.

PROF. MARSH'S DISCOVERIES IN FOSSILS.

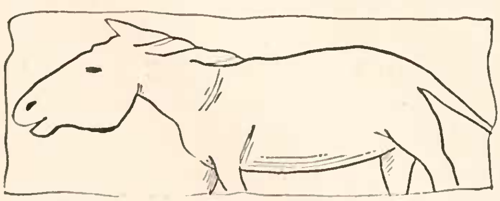
ANCESTRY OF THE NOBLE ANIMAL—THE MORMON BIBLE CONCERNING HORSES—SKETCHES BY PRE-HISTORIC MAN—THE FAMILY TREE OF THE HORSE.

[FROM THE SPECIAL CORRESPONDENT OF THE TRIBUNE.]

NEW-HAVEN, April 18.—Few facts in the history of the race have been the occasion of wider generalizations than the circumstance that the horse—the most important of all the animals which man has pressed into his service—was utterly unknown on the continent of America at the time of the discoveries of Columbus. Not only the horse, but all the related family—the ass, the zebra, and the quagga—were equally wanting. The Western hemisphere, in this total deficiency of both its divisions, presents a marked contrast to the Old World, since Europe, Asia, and Africa are each the native habitat of one or more members of this large family.

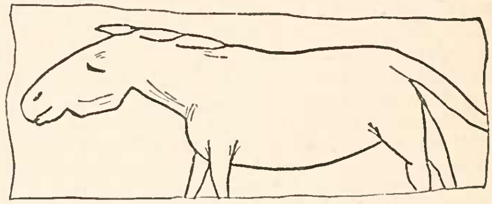
But the recent labors of science have opened a new page in the horse's history, and have changed entirely the scope and nature of the inquiry. It is now known that in the eras with which geology deals, America was not only for countless ages the home of the horse, but of an immense variety of animals of the horse family or nearly allied to it; and in the long series of these varying forms there seems to be presented evidence of change, progress, and development, which is welcomed by the believers in the theory of evolution as supplying many of the missing links in the ancestry of the noble animal.

Foremost among the laborers in this special field of research is Prof. O. C. Marsh of Yale College. Readers of THE TRIBUNE have had descriptions of his explorations at the West, and it will be only necessary here to summarize them in a few words. Almost every Summer for some years past he has organized an exploring party, chiefly at his own expense, in quest of fossil animal remains in the tertiary formation in our Western Territories. He has met with unexampled success. A greater addition of new fossil animal forms has been made since this class of explorations was undertaken, than during any similar period since Cuvier described the extinct animals of the Paris basin. A few of the extraordinary creatures which Prof. Marsh has identified, have been partially described in THE TRIBUNE. His expedition last Summer was peculiarly rich in discoveries of fossils of the horse family. It is to these the present letter relates.



SKETCH OF A HORSE BY PREHISTORIC MAN.

Did the horse exist in America after the advent of man, and become extinct between that period and the date of the discovery of America? This is a question of more interest than would be at first supposed. The horse of Europe was probably cotemporary with the earliest man, and there are traces of the existence of that animal among some of the most ancient relics of the cave-dwellers. In the cavern of La Madelaine, Dordogne, France, among remains of pre-historic man of the flint period, the antler of a reindeer was found having seven figures of horses carved upon it. Coarsely executed though they are, there can be no question as to what these flint carvings were intended to represent. These are horses—not asses, nor of the ass family, since the ears are short, none of the tails are tufted, and one of the tails certainly indicates by its thickness that it had the abundant long hair covering it which distinguishes the horse. It is not at all likely that the cave-dwelling man held the horse in subjection; it was probably one of the animals which he hunted; a kind of venison among game which included the auroch and the cave bear, the reindeer, and perhaps the elephant.

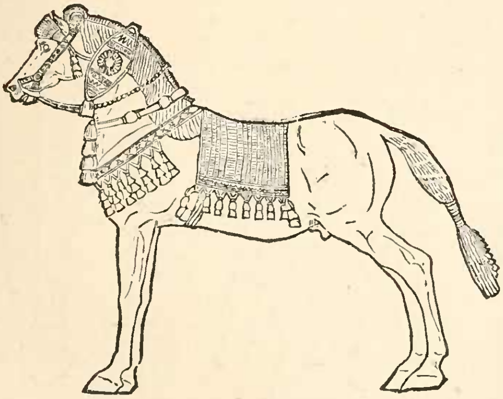


ANOTHER PREHISTORIC SKETCH.

But Brigham Young has hailed the discovery of fossil horses in America as an evidence of the truthfulness of the sacred writings of the Mormons. Years ago, in a discussion in England, the representative of the Mormons was worsted in argument upon the point that these writings make the blunder of describing horses as existing in America coeval with man, but prior to the advent of the Spaniards. There may be other instances in the Mormon Bible, but the following will serve to illustrate the point: The book of Ether describes a period subsequent to the building of the tower of Babel. It gives the particulars of construction, under divine command, of a number of covered barges, "exceeding tight," that would "hold water like a dish," each provided with an air-hole in the top, closed with a stopper, to be opened when needful for ventilation. These remarkable vessels were loaded with provisions; a small colony embarked upon them, and a strong wind, miraculously provided, drove them across the ocean. The voyagers were 344 days afloat, without light or fire; but at last they reached the promised land, where, it is stated:

> In the space of sixty-and-two years they became exceeding rich, having all manner of fruit and of grain, and of silks, and of fine linen, and of gold and of silver, and of precious things, and also all manner of cattle, of oxen, and of cows, and of sheep, and of swine, and of goats; * * * and they also had horses and asses, and there were elephants, and cureloms, and cumoms; all of which were useful unto man, and more especially the elephants, and cureloms, and cumoms.

Now there is not a trace of the horse among the antiquities of the Indian tribes on this continent. Not a legend, not a fragment to mark its coexistence with man, in all the records that have been compiled, in all the mounds that have been opened—unless the two following incidents be accepted as evidence to the contrary: (1) Dr. P. W. Lund was the first discoverer of fossil bones of the horse in South America. He found in 1841, in a cave in Brazil, among other remains of animals, the greater part of the skeleton of a young horse which he described as *Equus neogeus*, and declared to be identical with a specimen found in a another cave associated with human bones. But Owen says, after critically reviewing this case, that it affords no evidence of the contemporaneity of the human and equine races in the Brazilian caves. (2) Prof. Marsh has in his possession a bone picked up by an explorer among the ruins of one of the deserted cities of Central America; it is the coronary bone of a horse; *i. e.*, the first bone above the hoof. There is no doubt of the antiquity of the ruined city; as to that of the coronary bone the reader may form his own judgment.

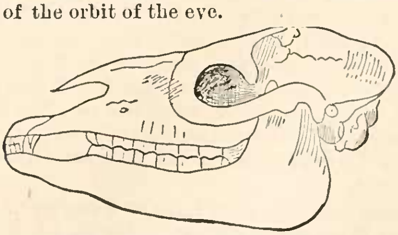


AN ASSYRIAN HORSE.

The omission of all attempts at depicting the horse or any member of the horse family on the part of the American aborigines, if it were known to them, is very remarkable. The earlier sculptures of the old world frequently introduce the horse; on the remains of Nubian tombs and Egyptian temples we find this animal carved. An Assyrian horse among the bas reliefs of Ashurbanipal is not less remarkable for the elaborate trappings of his harness than for his own noble bearing. He is every inch a horse. Surely such an animal would have left some traces in Indian tradition; but we read that "When the Cherokees first saw the horse bestrode by De Soto they were as much amazed as were the soldiers of Fabricius when they first beheld the elephants of Pyrrhus. But they named it instantly 'the animal with a single finger-nail. Modern science has made no better generalization than this uniungulus." This is the distinctive feature of the race; equally true of the horse (*Equus caballus*), of the tame ass (*Asinus vulgaris*), of the wild ass (*A. onager*) still abundant in Mesopotamia, and almost as different from the domestic species as a greyhound from a poodle, of the zebra (*A. zebra*) of South African mountains, the quagga (*A. quagga*) and the peetsi (*A. burchellii*), both also of South Africa, and of the kiang (*A. hemionus*) of Thibet. If you claim the transformation of species, said Cuvier in the early days of the development hypothesis, you must produce, for instance, between the paleotherium and the horse, since the former has three toes and the horse only one, an animal similar to each in other respects, but having the intermediate number of toes. It is precisely this gage, thrown down so confidently by Cuvier a half century ago, that the palæontologist of to-day is prepared to take up: but the present evidence is far more extended in its scope than that which the Father of Palæontology deemed unobtainable.

There is a vast portion of the Territories of Wyoming and Utah, which in the period that geologists call the tertiary, contained enormous lakes. The oldest of these lakes remained so long in eocene times, that the mud and sand accumulated in it by slow deposits to more than a mile in vertical thickness. In these deposits Prof. Marsh has found the remains of the Orohippus. This animal's skeleton resembles that of the horse more than it does that of any other creature of the present day; but it was scarcely larger than a fox. Its skull was proportionally shorter than that of the horse, and the orbit of the eye was not inclosed behind by a bridge of bone. But the remarkable characteristic of the Orohippus was that his fore feet had four toes and his hind feet three toes, all of which reached the ground.

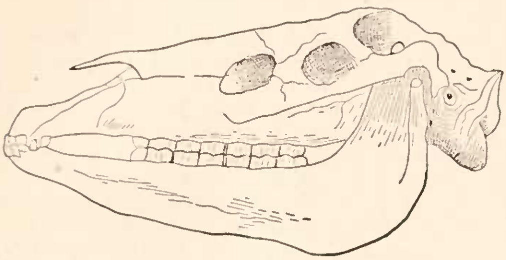
Above the eocene, in the order of geological deposit, many centuries doubtless having elapsed in its formation, the miocene appears. A district known as the Bad Lands of Dakota, Nebraska, and Colorado, and another west of the Blue Mountains in Eastern Oregon, contain deposits of lakes that existed in the miocene period. In the latter of these localities Prof. Marsh has obtained the remains of the Miohippus. It resembles the Orohippus in several particulars, but had this noteworthy peculiarity—it had only three toes in the fore feet as well as behind. All these toes reached the ground, and were useful, or, at all events, usable. There is no depression in front of the orbit of the eye.



SKULL OF THE ANCHITHERIUM.

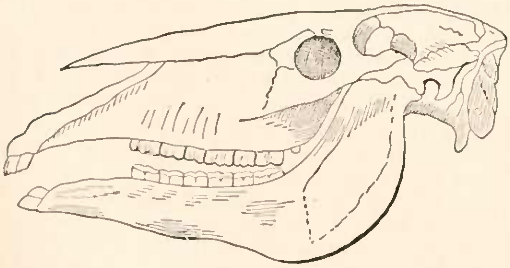
In these miocene lake deposits another animal is found, closely allied to Miohippus, but differing in having a deep depresssion in the skull in front of the orbit. Prof. Marsh has discovered some and Prof. Leidy other species of this animal, which is called the Anchitherium. It had three toes on each fore foot and three on each hind foot; but its outer toes were proportionally smaller than those of the Miohippus. The Anchitherium and the Miohippus were about the size of a sheep.

Above the miocene formation is the pliocene. Again ages have elapsed while this deposit was forming, and here again we have animals of the horse kind. Let us select two of them for examination, the Hipparion and the Protohippus. Each has three toes before and three behind, but in no case do the outer toes touch the ground; they are like the posterior hooflets of the modern deer and ox. The serviceable hoof of each is stouter than in the preceding animals. The skull of each has a deep depression in front of the eye.



SKULL OF THE HIPPARION.

In the Pliocene we also find the Pliohippus—or at least Prof. Marsh does. It has a deep depression under the eye. It and the Hipparion about equal the ass in hight. The Pliohippus has but one toe—that is, its foot is like the modern horse.



SKULL OF THE MODERN HORSE.

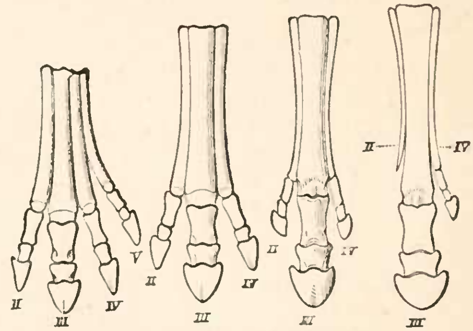
Lastly, at the very top of the pliocene formation and just where it is passing into the quaternary, for the first time the bones of the true horse are found. It equaled in size the horse of the present day, and in some species surpassed it. The existing horse has no depression in front of the orbit. Occasionally it has a superfluous hoof hanging about the true one.

There are many other facts of a similar character about these skeletons and those of other cognate forms, all indicative of a series, of progression, or as the believers in that theory would call it, of development. In respect to the toes the argument may be briefly stated thus: The single-toed hoof represents the highest capacity for speed; four toes might be useful for support in the marshes, but the necessity for speed would sooner or later make animals with fewer superfluous toes take precedence of the others. The reduction in the number of toes may in this manner be due to the gradual elevation and drying of the region inhabited. The struggle for existence of the early horse was principally in successfully running away from beasts of prey. Also, the hoof is a weapon of offense. At the present day, if a horse wounded or a mare embarrassed with colt, is overtaken by prairie wolves, the hoof is used to great advantage, each kick that strikes a wolf squarely usually killing it. Nothing could be more inconvenient than superfluous toes in kicking. But what is to be done with the depression in front of the eye? This was developed without apparent reason and disappeared equally without reason. Ah, there are some things, perhaps, which even the development hypothesis cannot explain.

Let us tabulate our facts:

Geological deposit.	*Name of animal.*	*Comparative size.*	*Depression in front of the eye.*	*Number of toes to foot.*	*Toes that touch the ground.*
eocene	orohippus	fox	none	4 front, 3 hind	all
miocene	miohippus	sheep	none	3 each	all
miocene	anchitherium	sheep	deep	3 each*	all
pliocene	hipparion	ass	deep	3 each	1 each
pliocene	pliohippus	ass	very deep	1 each	1 each
quaternary	equus	horse	none	1 each	1 each

* The two outer, smaller than those of Miohippus.



MODIFICATION OF THE HOOF.

(1) Forefoot of the Orohippus. (2) Foot of the Miohippus. (3) Foot of the Hipparion. (4) Foot of the modern horse as occasionally seen, with superfluous hooflet.

It will be seen that there are yet more worlds to conquer. Prof. Marsh lives in the hope of seeing the skeleton of the predecessor of the Orohippus; say with four toes behind and five in front. And having got that equine ancestor, he will not be satisfied till, somewhere at the bottom of the eocene, or even back in the cretaceous deposits, he finds the greatest-great-grandfather of all the horses, which should be about the size of a first-class black-and-tan, and should have five well-defined toes on each foot, touching the ground. With this fossil in his possession, Prof. Marsh would probably be able to enjoy life without going to the Rocky Mountains every Summer.

HAVE WE TWO BRAINS?

A LECTURE BY DR. BROWN-SEQUARD.

INSTANCES WHERE PATIENTS USED ONE HALF THE BRAIN INDEPENDENTLY OF THE OTHER — THE LEFT BRAIN PRINCIPALLY THE ORGAN OF INTELLIGENCE AND EXTERIOR RELATION; THE RIGHT, OF ORGANIC FUNCTIONS AND NUTRITION—THE NEED AND MEANS OF DEVELOPING BOTH SIDES OF THE BRAIN.

[FROM A SPECIAL CORRESPONDENT OF THE TRIBUNE.]

WASHINGTON, April 22.—The lecture delivered at this date by Dr. Brown-Séquard, which attracted a crowded audience, was one of the "Toner Lectures." As many readers may not recall the circumstances under which that course of lectures was established, a statement of the facts will probably be of interest. Dr. J. M. Toner, believing that the advancement of science—that is, a knowledge of the laws of Nature in any part of her domain, and particularly such discoveries as contribute to the advancement of medicine—tends to ameliorate the condition of mankind, determined in 1872 to convey real and personal property worth about $3,000 to five trustees; 90 per cent of the interest of which was to be applied for at least two annual memoirs or essays by different individuals, and, as the fund increases, as many more as the interest of the trust and revenue will, in the judgment of the trustees, justify. The essays or memoirs must be relative to some branch of medical science, and be read in the City of Washington under the name of the Toner Lectures. Each of these memoirs or lectures is to contain some new truth fully established by experiment or observation, and no such memoir or lecture is to be given to the world under the name of the "Toner Lectures" without having first been critically examined and approved by competent persons selected by the trustees for that purpose. The trustees are the Secretary or chief scientific officer of the Smithsonian Institution (for the time being, Prof. Joseph Henry), the Surgeon-General of the United States Army, the Surgeon-General of the United States Navy, and the President of the Medical Society of the District of Columbia.

THE LECTURE.

LADIES AND GENTLEMEN: I have to-day to put forward views which, if they have the value that I attach to them, deserve all your attention. I confess, however, that although I have come to a conviction myself, and I am, perhaps, rather difficult in that respect, I do not accept easily as proved what is drawn from facts. I confess, however, that I feel great embarrassment, as not only are the facts I have to dwell upon new, and not, perhaps, easily to be accepted, but besides they require for their full understanding a knowledge of medicine, which probably does not exist among many of my hearers. However, I will try my best to render the subject as clear as possible, even to persons who know nothing about medicine.

EVIDENCE THAT WE HAVE TWO BRAINS.

As you perhaps know, the subject is this, putting it in an interrogative way, Have we two brains or one? And if we have two brains why do we not educate both of them?

As you will see by these questions, if the first is decided negatively, of course there is no reason for the lecture. The very fact, therefore, that I am in your presence to speak about an hour on that subject, implies that I have come to the conclusion that we have two brains, perfectly distinct the one from the other. There are views held in science in that respect altogether different from mine. They consist in admitting that the left side of the brain is the only organ serving to the movement and feeling of the right side of the body, and *vice versa*, the right side of the brain is admitted to be the only organ serving to volition and to sensation for the left side of the body. This view I will have first to disprove.

Beginning, however, by what relates to the noblest functions of the brain—that is its aptitude to serve in mental phenomena—I shall say at once that I am not the first to put forward the view that we have two brains. Long ago Sir Henry Olan, who died some time ago, and Dr. Wigan, and a few others, insisted on the fact that each side of the brain is perfectly sufficient for the full performance of the mental functions. But they stopped there, and they have left to others, therefore, to go further, if we have to go further. I shall say that, taking that view, that in reality we have two brains, there is a conclusion which flows out from it, and which —although I shall have to speak of it more at length by and by—I must now say a few words upon. It is quite certain that if it is so, as we make use of only one for most of our actions, we leave aside one-half of the total mass of brain matter, and, therefore, we leave quite useless one-half of the most important of our organs as regards manifestations of intelligence, will, and perception of sensation. If this statement is right you will easily understand how important it is to come to the point which I have in view in this lecture; that is that we ought to give education to the two sides of the brain, or, rather, to the two brains.

As regards intelligence, it is hardly necessary to insist after what has been said by the physiologists I have named, Sir Henry Olan and Dr. Wigan. They both showed that there are a great many facts which conclusively prove that either half of the brain may serve equally intellectual functions. It may be, however, that their proofs were not sufficient. One of the two, Dr. Wigan, has insisted upon a feature of great interest, which is that in insanity sometimes, and I may say very frequently without any insanity, we have two different views on the same subject. There are a great many people who labor through life under the difficulty of making up their minds. It is because they have two minds unfortunately. Better would it be for them to have only one, and I hope you will not conclude at once that what I am to preach here—that is, that we are to educate our two brains—ought to be laid aside on account of the danger of leading men to have two minds, and to be all the time hesitating between two views and two conclusions and two opinions and two decisions. I think I shall be able to prove that the fault in those individuals who cannot make up their mind is, on the contrary, dependent in a measure on the fact that they have not developed sufficiently the power of their two brains.

INSTANCES OF THE SEPARATE USE OF THE HALVES OF THE BRAIN.

Anyhow, Dr. Wigan especially insisted upon those facts which we observe in insanity, that a patient knows he is insane; he knows that he has insane ideas; he will put them forward and immediately after having put them forward he will say: "I know they are insane." He is perfectly right, perfectly rational, while at the same time he is completely insane. Dr. Wigan has concluded, without any positive demonstration, that in those cases one-half of the brain is normal and the other half is wrong; one-half is employed in the mental faculties in a normal way; the other is employed as regards the mental faculties in quite a wrong way. But there are cases which are more interesting, perhaps, and which, I think, fall more clearly under that view, that there are two brains. I saw a boy, for instance, at Nottinghill, in London, once, who had two mental lives. In the course of the day, generally at the same time but not constantly, his head was seen to fall suddenly. He remained erect, however, if he was standing, or if sitting he remained in his position; if talking he stopped talking for a while; if making a movement he stopped moving for a while, and after one or two minutes of that state of falling forward or drooping of the head—and he appeared as if falling asleep suddenly, his eyes closing—immediately after that his head started up, he opened his eyes perfectly bright, looking quite awake and then asking if there was anybody in the room whom he had not seen previously, who the person was, and why he was not introduced to him; being all the time in that state quite different from the state of wakefulness. He had seen me a great many times, and knew me very well. Being with him once when one of those attacks occurred, he lifted his head and asked his mother, "Who is the gentleman? Why don't you introduce him to me?" His mother introduced me to him. He did not know me at all. He shook hands with me, and then I had a conversation with him as a physician may have with a patient. In another instance, when with him again, when he had the same kind of an attack, I found that he recognized me fully, and talked of what we had spoken of in our first interview. I ascertained from what I witnessed in those two instances, and also and chiefly, I may say, from his mother, a very intelligent woman, that he had two lives in reality, two mental lives, one in his ordinary state, and another occurring after that attack of a kind of sleep for about a minute or two, when he knew nothing of what existed in his other life—in his ordinary life; that was all a blank. He knew nothing during that second state but what had occurred in previous periods of that same condition, but he knew full well all that had occurred then, and his recollection of everything was as perfect then as it was during his ordinary life concerning the ordinary acts of his life. He had, therefore, as I have said already, two absolutely distinct lives, in each of which he knew everything that belonged to the wakeful period of that life, and in neither of which did he know anything of what had occurred in the other. He remained in that state of attack for a time which was extremely variable, between one and three or four hours, and after that he fell asleep, and got out of that state of mind pretty much in the same way that he had got into it. I have seen three other cases of that kind, and as so many have fallen under the eyes of one single medical practitioner, such cases cannot be extremely rare.

SPEECH NOT ALTOGETHER DEPENDENT ON ONE SIDE OF THE BRAIN.

As regards the faculty of speech, the fact that we have two brains perfectly distinct, one from the other, is not, perhaps, so easily proved as it may be as regards the man. We well know that a lesion in one-half of the brain, the left side of the brain, will produce loss of the faculty of expressing the ideas by speech; that that belongs almost exclusively to the left side of the brain, but the very fact, I may say, that the loss of the faculty of expressing ideas by speech depends on a disease in the left side of the brain—that fact is itself a proof that the left side of the brain is quite distinct from the right side of the brain, that it is in fact a brain in itself as regards that function of the organ we call brain. Therefore the fact which is perfectly well known, that out of one hundred cases in which the loss of the faculty of expressing ideas by speech existed, there is only one—if one—in which the disease was to be found in the right side of the brain—that fact is extremely important in showing that the two sides of the brain may act independently one from the other. I shall have to return to this by and by, as much of my argument depends on this point.

As regards sight, a theory has been put forward by a celebrated philosopher, Dr. Wollaston of London, which has been admitted by a great many physiologists, although no one has admitted it without some reluctance. But as there was no better theory put forward, that one was received as being at least probable if not demonstrated. Wollaston had the view that the right side of the base of the brain is the center for sight in the two right halves of the eye. The right half of the right eye is of course the one to the right of it, and the right half of the left eye is the one nearest to the nose. The inner half I should say of the left eye and the outer half of the right eye have for their center, according to that view, the right side of the brain and *vice versa* the left side of the brain would be the center for sight in the left or outer half of the left eye and the inner half of the right eye. There is therefore, according to that view, a condition which is quite peculiar. If we admit it for a moment then we ought to find that a disease in the left of the brain at the base must destroy only one half of the power of sight, and objects then if seen are seen in one half. Suppose a man to be looked at there would be visible, if it is the left side of the brain which is affected, only the right half of the body. Wollaston himself had that trouble. One day trying to read the name of an instrument, the barometer, he read "meter" only; the other part of the word, "baro," he could not read. Another eminent friend living in France, Professor Agassiz, had the same trouble. He saw one half of certain objects. And a good many patients who are affected especially with certain disorders of movement and with diabetes have also that trouble, they see but one half of objects. There are, therefore, cases which seem to be in favor of the view. But continuing to review what ought to take place, we find that if the disease exists only in a small part of the left side of the brain, in that portion which serves to sight, we ought to find that then only one half of one eye will be affected. There are such cases. If it is the other part of that same half of the base of the brain which is affected, then it is only one half in the other eye which should be affected. There are also facts of that kind.

So that there are three kinds of facts which seem to support the view of Wollaston. But what of that? We philosophers do not accept conclusions because there are facts which support them. We accept conclusions when all the known facts are either in perfect harmony or clearly prove the conclusion; and also when there is no fact that seems to be in opposition. It is requisite, therefore, either that all the facts prove in favor of the theory, or that together with a number in favor there is none at all in opposition. Such is not the case here. There are a great many facts which show that a disease in one half of the brain will produce complete loss of sight of the two halves of one eye, either on the same side or on the opposite side, or the two halves of both eyes. Therefore there are three series of facts, and one only would be enough, which demonstrate that the theory ought to be rejected.

VISION AND THE HALVES OF THE BRAIN.

But as regards sight we find this, and it is a point of importance in this lecture. We find that a disease anywhere in one-half of the brain can exist without any alteration of sight at all. A disease existing in that part where the optic nerve goes into the brain, destroying that part altogether, may not be a cause of loss of sight; so that one optic track alone may be perfectly sufficient for the functions of the two eyes. Therefore I conclude that it is quite enough to have one brain to have our power of sight; and as it is so for each half of the brain, I can conclude—and this is a point of importance in this lecture—I can conclude that each half of the brain is independent of the other and each of them possesses the powers of serving to the sensations of sight. You will ask how is it that a disease in certain cases in the brain will produce loss of sight, and that a disease in the same part sometimes will not produce loss of sight. As regards that I cannot develop at length what I would have to say, but if some of you were present at my lecture in this city last year and some of you present at the Academy of Sciences to-day are here, they know that an alteration in any part of the nervous system, whether in the brain or elsewhere, can, by producing an irritation, act on other parts, so as to produce the loss of a function of those other parts: and so it is about sight particularly. In many experiments I have ascertained that injuring a small part of the spinal cord produces a loss of sight in the eye on the same side. An injury to the *medulla oblongata* a little higher than the part of the spinal cord which produces loss of sight on the same side, will produce a loss of sight, but to the opposite eye. There is, therefore, a power of producing by irritation a loss of sight; and indeed there is nothing more common in children having worms in their bowels than a diminution in the power of sight for a time, or some trouble in the power of sight—some change in the iris, some change in the vessels of the eye, in fact some disorder in the organs serving to vision. Well, it is in the same way that an irritation existing in certain parts of the brain will produce at a distance from the place where it exists, a loss of the function of sight. The cases that can serve are, therefore, not those in which we find that the disease exists—the loss of sight exists when there is a disease somewhere. The cases that can serve positively must clearly bring us to a conclusion; as those, on the contrary, which establish that an injury in any part or one-half of the brain—even in that part which receives the optic track—can exist without producing any loss of sight; and that fact has been observed—not very frequently, but more than five or six times to my knowledge—and in those cases in the most decisive manner. Therefore the conclusion I have drawn is quite established. Either half of the brain may serve to the power of sight.

THE VOLUNTARY MOVEMENTS.

Now, as regards the volitional movements, the voluntary movements, if you like to call them so. Those movements, as you well know, have been considered as depending on each half of the brain for one-half of the body. Still, many physiologists have ascertained that there are muscles in our system in the neck, in the eye, in the throat, and in the back also—there are many muscles—which escape paralysis when there is disease in one-half of the brain; and for those parts at least some theory has been imagined to try to explain how it was that the left half of the brain, for instance, is not the regulator of the movements in the right side of the body. I shall pass over that theory and come to the point of importance in the object which I have in view.

As regards volitional movements, there are cases on record which leave no doubt that either the anterior lobe of the brain, the middle lobe of the brain, or the posterior lobe, the three essential parts of the organ, can be destroyed and voluntary movements not be interfered with at all; but still more, there are cases—not many, but a few—that exist and are decisive. They have been recorded by the most accurate observers, and some of them in hospitals where there were many medical men and many students, so that there cannot be a doubt about them. There are many cases—perhaps the word "many" is too strong, but there are at least seven or eight to my knowledge—of the destruction of the whole half of the brain without any interference with the voluntary movement. Therefore we are not to look upon one-half of the brain as being necessarily the organ serving to the movement of the body on the opposite side. And also another conclusion; we are to look upon one-half of the brain, in some individuals at least, as being able to control voluntary movements in the two sides of the body. If so, certainly the point I have in view—that is, that we have two brains—is established as regards voluntary movements. We have certainly two brains as regards voluntary movements; and if it is found in most cases that even a slight injury limited to a small part of the brain will produce a paralysis on the opposite side, or sometimes on the corresponding side—if that is found, it is on account of this principle which I mentioned a moment ago; that is, that an irritation in any part of the brain can affect functions in other parts through irritation. And I shall say about voluntary movements what I have said about sight, and a worm in the bowels, as well as an irritation in a tooth, or an irritation in the stomach, an irritation in the lungs, an irritation in the heart, an irritation in the skin; in other words, an irritation wherever there is a nerve subject to be irritated; an irritation there can produce a paralysis as well as an irritation in a part of the brain. And therefore when we see a slight alteration in a very limited part of the brain cause a complete paralysis on the opposite side of the body, we are not to conclude that it is owing to the loss of function of voluntary power there where the disease exists in that small part, but that it depends or it has been brought on by an irritation starting from the place where we see the disease, and acting upon remote parts so as to produce the loss of the function. The mere fact, I may say, that a disease exceedingly limited in extent can produce a complete paralysis in the opposite side of the body, is sufficient to show that it does not depend on the loss of the function of will; for one-half of the body cannot locate in a very limited part of the brain the whole power of the will located in that brain. If it were the other side of the brain which produced that complete paralysis, if we found that paralysis is more or less extensive, more or less durable according to the extent of the disease in one-half of the brain, then we might conclude that the disease has destroyed the power of will in that half of the brain, and thereby produced the loss of voluntary movement on the opposite side. But it is not what we see. We see that the lesion which has destroyed one half of the brain may allow voluntary movement, but a lesion which is not larger than a pea in any one part of the brain can produce a loss of voluntary movement. Therefore we are to admit that when the paralysis of movement comes in connection with disease of one half of the brain, it depends on an influence starting from the place where the disease is acting upon remote parts so as to produce a cessation of activity there, and a paralysis therefore.

SEAT OF THE FACULTY OF SENSATION.

There is the same reasoning to be made as regards perception of sensation. There also we find the same thing. I shall not insist on that point therefore. We know a thousand cases of disease occupying one-half of the brain that has not produced the slightest alteration in the power of feeling. But, if it is so it remains to be explained how it is, however, that the two halves of the brain come to be somewhat different, and that the physiological and pathological study of the two halves of the brain indicates great differences in that respect. If we pass in review what is known, we find very great differences indeed. Those differences depend on the fact that through the fault of our fathers and mothers, the faults that weigh upon us and have led us to make use of only one-half of our body for certain acts, and one-half of our brain for certain other acts also—we find that it is owing to that defect in our education that one-half of our brain is developed for certain things, while the other half of the brain is developed for other things. As regards what belongs to the left side of the brain compared with the right side of the brain, allow me to say the most important feature in its physiology or pathology is what a French physician has discovered. It is, as I have said already, that to that side of the brain belongs the faculty of expressing ideas by speech. Besides, that mental faculty of speech the left side of the brain possesses in a much more marked degree than the right the power of moving the tongue and larynx and muscles of the chest to produce the sounds of articulate voice. Articulation of sounds in speech in a great measure depends on the left side of the brain. I mean by the words "in a great measure" that it is chiefly the left side of the brain which has the power of acting upon those organs. So that more frequently in cases of disease of the left side of the brain do we find the difficulty in the mechanical part of the speech than in cases of disease of the right side of the brain. But that, although mechanical, is something like a gesture. There is a mental sign in it, and although it is a mechanical thing in itself, I cannot but consider it as representing some mental trouble.

MEMORY, NOT MUSCULAR POWER, LOST.

My pupil and assistant in London, who has become a very eminent man since, Dr. Hewling Jackson, has also insisted on that point, that it is the memory of direction of movements of the muscles which serve to articulate, which is lost, and not the mere power of moving the muscles of the tongue, larynx, or chest. I have had proof of it in a great many instances, that, when told to do so, the patient could move the tongue in any direction, could move the larynx and utter sounds very well, but could not articulate, so that it was the mental part of that mechanical act—the mental part of which was altered, and not purely a mechanical action lost. The left side of the brain is also the one that leads in gestures, and that by a very simple reason, which is, that it is the left side of the brain which leads chiefly the movement of the right arm, and it is chiefly with the right arm that we make our gestures. Still, it is likely, as pathological facts show, or at least appear to show, that even the motion of the left arm depends on the left side of the brain as regards gestures, as we find that in patients who have a disease of the right side of the brain the faculty is lost of making gestures with either the right or the left arm. That of course, shows, or at any rate seems to show, that the left side of the brain is the organ for gestures chiefly. In a few cases, however, of disease of the right side of the brain, the power of making gestures has been lost as well as in case of disease of the left side of that organ.

As regards the power of writing, there is a difficulty there, as you will early understand. Still there are many facts which show that the power of writing can be lost more easily, and is lost more frequently in cases of disease of the left side of the brain than in cases of disease of the right side of the brain—a difficulty which many of you have understood without my mentioning it. We conclude that the right arm is not rarely paralyzed in diseases of the left side of the brain, and as we write with the right arm, it is very natural that, on being paralyzed, we cannot write; but very few patients have lost altogether the movements of the fingers, and cannot form the least sign, though many of them cannot at all form a letter. They will be able, however, if they have a letter written by some one whose handwriting is not very much different from theirs (and sometimes when it is different), they will be able to imitate what is under their eye, but they cannot from memory write anything; at all events, they cannot express ideas by writing. They are attacked with what is called the agraphia—that is, a loss of the faculty of expressing ideas by writing. In many of these cases of patients attacked with agraphia there is a perfect power of moving the right arm. The arm is not paralyzed in cases where the left side of the brain is paralysed; there is no paralysis on the right side of the body or the left; no paralysis anywhere. In these cases, it has occurred sometimes that the patient could not write at all; so that it is clear that the loss of the faculty of expressing ideas by writing does not depend on the paralysis which in these cases had no existence.

INTELLECT MOST DEPENDENT ON THE LEFT SIDE OF THE BRAIN.

Another thing depends on disease of the left side of the brain more than the right side of the brain, and that is intelligence. Alterations of the mind manifesting themselves in the various forms of insanity depend more frequently, I should say, on diseases of the left side of the brain than on diseases of the right side. This is all I know now which belongs to the left side of the brain. The right side of the brain is quite different. From all that I have stated about the left side, as you will see, that organ is chiefly the organ serving the mental faculties, either in speech, or in intelligence, or in gesture, or in writing. That organ, therefore, is the important organ in our system adapted to the life of communication between ourselves and our brethren in a mental way. But the other organ—the right side of the brain, in some individuals, as you will see, has the power of this one, and in all perhaps it might have had if the proper development had taken place; but this other serves contrarily to the first one. The right side of the brain serves chiefly to emotional manifestations, hysterical manifestations included, and to the needs of the nutrition of the body in various parts. There is, therefore, taking a large view of the differences between the two brains, this difference, that one of them—the left—serves to what we call the life of relation, while the right serves to what we call the organic life. This view, which I had put forward already five or six years ago, has begun now to receive demonstration from several physicians, and I am therefore the more emboldened in maintaining the correctness of that view of mine. The right side of the brain is remarkable in producing alterations of nutrition either in limbs that are paralyzed, or in the back. It is perfectly well-known that a number of patients die every month in every large city of ulcerations taking place on the *nates* or on the *sacrum* coming from an irritation of the brain. These patients are more numerous among those attacked by disease in the right side of the brain than among those attacked with disease in the left side of the brain. Either œdema or bed sores, either one or the other of those two kinds of ulceration is more frequent in cases of disease of the right side of the brain than in cases of the left side. The proportion is considerable. It is as two-thirds for the right side of the brain and one-third for the left. There are many other points which show the same thing. An ulceration in the lungs, an ulceration in the liver, a hemorrhage for instance and sudden inflammation—all these disturbances can take place under an irritation of the brain as I have shown; but in these cases it is chiefly the right side of the brain that has the power.

I have already said that hysterical and emotional symptoms are more common in cases of disease of the right side of the brain. This has been established already by a good many physicians—Drs. Brequet and Du Floret and a good many others, and myself. We have collected cases of paralysis in one-half of the body, caused by hysteria, and this proportion has been found; but of 121 cases of paralysis caused by hysteria (a paralysis which is usually merely transient, and very rarely lasts long)—in 121 of these cases there was disease of the brain on the right side 97 times, and disease on the left 24 times; so that the right side predominates in this class of affections. That paralysis exists on the left side of the body more frequently than on the right side you well know, and, as it affects chiefly the right side of the brain, it affects chiefly the left side of the body.

SIDES OF THE BRAIN UNEQUALLY DEVELOPED.

Now as regards other points, my pupil, Dr. Jackson, has ascertained that an inflammation of the retina produces amaurosis more frequently in both eyes from disease of the right side of the brain than the left side. Convulsions of the eye take place very frequently in cases of disease of the brain. I have ascertained in taking up the cases published by Dr. Prevost, Dr. Charmel, and many others and myself—I have ascertained that out of 69 cases in which these convulsions of the eye occurred there were 47 due to the disease in the right side of the brain, and 22 due to disease in the left side of the brain. Therefore there is a great difference between the two sides of the brain as you will see. It is so as regards general convulsions. Collender and myself have shown that general convulsions will occur much more frequently in cases of disease of the right side of the brain than in cases of disease of the left side. I have ascertained that both will occur far more frequently in cases of disease of the right side of the brain than in cases of disease of the same extent and the same location in the left side of the brain. Not only disease in the right side of the brain will have the greatest power in that respect, but it will also, if the patient does not die, produce a more marked paralysis; it will produce, also, a more extensive paralysis and a more durable one. So that, as regards degree, as regards extent, as regards duration of the paralysis, the right side of the brain is, by far, worse than the left, showing again that that side has the greater power of nutrition. There are a good many other points showing a difference of the same kind. I pass them over, as time presses. There is, therefore, as you will see, a radical difference between these sides of the brain. But now this depends, as I have said already, not upon the fact that the two sides of the brain are very different originally, but it depends on development. Every organ which is put in use for a certain function gets developed, and more apt to perform that function. Indeed the organ in size shows it. The left side of the brain, which is used most in our system, is larger than the right side of the brain. The left side of the brain besides receives a great deal more blood than the right side of the brain, because it has a preponderance in our system, and every organ that acts much, receives more blood. As regards the influence of action on the brain, there is a fact which hatters know very well. If a person is accustomed for many, many years from adult life—say from 20 up to 40 or more—to go to the same hatter, the hatter will find after a time that he has to enlarge the hat of his customer; and, indeed, a person advanced in life, even having passed 56, as your lecturer has, has a chance to observe such a change. There is no period of six months that has passed that I have not found that my hat, if neglected and put aside, became too small. The head, therefore, growing, is very strong proof that the brain grows also. Action, therefore, is a means of increasing size, is a means of development; and I have no doubt that a good many among you have observed that after they pay great attention to a subject, they have not only acquired knowledge on that subject, but become much more able to solve questions relating to that subject—that they have developed the part of the brain which has been used for the acts that they have performed, and that part has become far more able to perform its functions. This is perfectly well shown by everything in our system. We well know what a power a pianist can have, if that pianist continues to exercise his fingers and brain on the piano. But such a pianist neglecting to perform the acts that he was accustomed to perform before, it is very soon found that there is a defect. We must go on, therefore, exercising the organs in which we desire to have the great activity of life. There is no doubt, therefore, that the left side of the brain, as is shown by its great enlargement compared with the right side, and as is shown also by the quantity of blood that it receives, that organ is the one which is predominant in our system. But our being right-handed, shows it also.

RIGHT-HANDEDNESS NATURAL TO MEN AND ANIMALS.

It is quite certain that right-handedness depends something on nature. As you well know, the wildest populations in the world are right-handed, as we are. There is no population anywhere in the world that has not been found right-handed. There is therefore in man a cause which makes the right side of the body to be selected as the one to be used the most, and together with that right side of the body the left side of the brain, which usually moves that right side, is increased considerably in power and in size. There is, therefore, a development given through some natural cause primitively, but a development given to the left side. We find that individuals who are left-handed make use of the right side of the brain, and when they become confused—when they lose the faculty of expressing ideas by speech—it is the right side of the brain that is affected, showing the connection between the development of one-half of the brain in the use of one arm, and the development of that same half of the brain in the faculty of expressing ideas by speech. There is therefore a connection between these two things, and on that point I shall dwell a little more in a moment. There is primitively a difference between the two brains, and Professor Gracciola has discovered in children the second convolution—the convolution of the left side of the brain—is developed quicker than the convolution on the right side. That may be in a measure owing to hereditary traits, I must say, but at any rate as there is an evidence that there is a natural tendency to make use of the right arm, it is certain that a part of that ability of development on the left side is due to something natural—that something natural will be found, if it is examined, in the greater supply of blood to that part. Even parrots and birds show something very interesting as regards right-handedness. Parrots perch only on the right leg, or mostly only on the right leg. Very few parrots out of 20 taken at random perch on the left leg, according to what Dr. William Ogle ascertained after having examined a great number of them. Parrots of course are known to have something like speech—a parrot's speech of course. It is perfectly well known that the mechanical part of speech belongs to them, and it is remarkable that their left brain receives also more blood by far than their right brain. There is therefore a relation between all these things in the development of the right side of the limbs and the amount of blood received by the left side of the brain. There is another point of importance. Prof. Broadbent and others have found that in the left side of the brain the mass of gray matter is greater and there are more convolutions than in the right side of the brain.

A REVIEW OF SOME POINTS DEMONSTRATED.

Now we come to four points of great importance for this lecture. They are the vital points, I may say, in the argument I have discussed here. The first of these points I have already spoken of. It is, that we find that agrophia is connected with the left side of the brain in persons who are right-handed, and with the right side of the brain in persons who are left-handed. This certainly, is a very strong argument to show that the side of the brain which serves the motion of one side of the body, that side—if the side of the body the one which leads, is the most important of the two—that side of the brain then is the one that serves chiefly to the mental life in our system. The mental life of our system, therefore, seems to be developed considerably in the organ which itself seems to be developed in a great measure owing to the action of will in one-half of the body. There is certainly a connection between these things, but that will come out more by and by

The second point is, that in children who have not yet learned to talk, or who have already learned only a little, if disease comes in the left side of the brain, the one, I repeat, which is the most rapid in its development usually, if disease comes to produce atrophy, so that the left side of the brain becomes useless, those children then learn to talk just as well, or nearly as well, as if they had no such affection, and they learn it with the right side of the brain, which is the only one acting. They were not born (the most of them, if not all of them, if there is any exception I don't know it) of parents who were left-handed, and there was no reason for their being left-handed. They had the misfortune of losing the half of the brain which served usually to the mental faculties, and other mental faculties got developed—the power of speech and action—and they make use of the left arm then just as well as any one of the right-handed people makes use of the right arm. There is in these facts clear proof that the right side of the brain can be educated to become a leader in mental faculties as well as the left side of the brain. There is a clear proof that the right side of the brain can lead movements and obtain execution with the left arm, just as most people who are right handed obtain execution of movement with their right arm. These facts, therefore, are decisive in favor of the view that I have for my object in this lecture.

The third point of importance is that with a given number of individuals, out of 100 examined by Dr. Wm. Ogle, who were left-handed, four only had learned to write with the left arm. They had been taught by their parents, although they were left handed, to make use of the right hand to write, and their writing with the left arm was very clumsy, the author states. In one of the cases he had to hear what the patient had to say; the patient being paralyzed in the left hand he could not have the proof; but in the others he had the proof, and could see. Therefore, the left side of the brain, even in persons who are left handed naturally—even in persons who make use chiefly of the right side of the brain—the left side can be educated so as to produce a very good handwriting instead, and better than the writing by the left arm.

The fourth point of importance is one on which I shall not dwell, as it implies a knowledge of medicine that you have not, but I shall state it in only a few words. It is exceedingly rare that the leg is affected to the same degree by paralysis as the arm, and the leg as you well know, is not a part which we develop as much in its movements as we do develop the right arm. If a patient is struck with paralysis, for instance, on the right side of the body, owing to a disease of the left side of the brain, he will lose more, if he does lose movement at all—he will lose more of it in the right arm which he has been accustomed to train than in the right leg. But, I repeat, that that argument cannot be understood well except by medical men. I pass it over therefore.

There is no reason whatever to object to one teaching children to make use of the two sides of the body. If you have been convinced by the arguments I have given that we have two brains, it is clear that we ought to develop both of them, and I can say, at any rate, as much as this, there is a chance—I would not say more, but at least I can say there is a chance—that if we develop the movements of the two sides of the body, the two arms and the two legs, one just as much as the other, there is a chance that the two sides of the brain then will be developed as regards the mental faculties, one as much as the other.

HOW TO DEVELOP BOTH SIDES OF THE BRAIN.

The facts that I have brought forward, the last especially—what I have called the four points of importance, and particularly the three first, show that there is a connection between the development of the brain as regards the mental faculties, and the development of the brain as regards leading movements in one side of the body. There is a great chance, therefore, that if we give a good deal of attention, or, better, as much attention to the left side of our body as we give to the right, there is a great chance that we would have two brains as regards mental functions, instead of one as we have now. There is no doubt that we can improve the two sides of the body constantly. The facts I have mentioned as regards those children having atrophy on the left side of the body, do not leave room to doubt. It is clear we can develop the left side so as to make it exercise all the functions which exist in most of us in the left side of the brain, and if so in cases of atrophy on one side of the brain, why not so in cases in which we have two brains? I think, therefore, the important point should be to try to make every child, as early as possible, exercise the two sides of the body equally—to make use of them alternately. One day or one week it would be one arm which would be employed for certain things, such as writing, cutting meat, or putting a fork or spoon in the mouth, or in any of the other various organs in which both the hands and the feet are employed. In this way it would be very easy indeed to obtain a great deal, if not all. We know that even adults can come to make use of their left arm. A person who has lost his right arm can learn to write (with difficulty, it is true, because in adult life it is much more difficult to produce these effects than in children), and the left arm can be used in a great variety of ways by persons who wish to make use of it. It is perfectly well known that the left arm is employed in playing on the piano or on certain other instruments almost as well as the right arm. Therefore there is no difficulty in training children to make use of both sides of the body equally.

There is also another fact as regards the power of training. Even in adults who have lost the power of speech from disease of the left side of the brain, it is possible to train the patient to speak, and most likely then, by the use of the right side of the brain, the left side of those patients, with great difficulty, will come to learn. They always have more difficulty than do children, but they learn if they are taught in the same way. It is the same kind of teaching that we employ for a child when we try to make it speak, it is the same way that should be employed to teach an adult who has lost the power of speech. It is so also, as regards gesture, and the rest. I have trained some patients to make gestures with the left arm, who had lost the power of gesture with the right, and who were quite uncomfortable because their left arm, when they tried to move it, at times moved in quite an irregular way, and without any harmony. There is a power of training, therefore, even in adults, and if so, that power exists in children, and as we well know that we can make a child naturally left-handed come to be right-handed, in the same way we can make a child who is naturally right-handed come to be left-handed also. But the great point should be to equally develop the two sides. To point out this has been the object of this lecture, and I have now to thank you for having listened to the long and tedious arguments.

U. S. SURVEY OF THE WEST.

THE WHEELER EXPLORING EXPEDITION.

A VAST WORK, OF WHICH LITTLE HAS BEEN KNOWN OUTSIDE OF GOVERNMENT ARCHIVES—PLAN FOR A UNIFORM SYSTEM OF SURVEY THROUGHOUT THE COUNTRY—DETAILS OF THE WORK ACTUALLY PERFORMED—NEW AND INTERESTING FACTS RESPECTING COLORADO, WESTERN UTAH, ARIZONA, AND NEW MEXICO.

[FROM AN OCCASIONAL CORRESPONDENT OF THE TRIBUNE.]

WASHINGTON, April 30.—The surveys of our Western Territories, conducted at the expense of the Government, have assumed such magnitude in themselves, as well as in the interests which they involve, that the rivalry between them, which has now almost taken the form of a contest, becomes a matter of general interest. Of the two classes of Western surveys, those under civilian management and those under the War Department, the former have by far more greatly enjoyed the advantage of newspaper publicity. Of the labors of the War Department in this field, little has reached the public, except a comparatively brief sketch published in THE TRIBUNE after the return of Lieut. Wheeler's Expedition of 1873. Pending the discussion of the cost, proceeds and value of Territorial surveys which is likely to engage the attention of Congress within a few days, it seems desirable that a full account should be given of the work that has been done by the Bureau of Engineers of the War Department. As a preface to this account, a brief resumé of some of the facts stated in conversation by Lieut. G. M. Wheeler, U. S. A., the officer in charge of the United States Survey West of the 100th Meridian, will prove of interest.

VALUE AND PLAN OF SURVEY.

The need of an accurate and careful topographical survey of our western territory is not open to question. The experience of older countries may be taken in this matter as a guide. In Bohemia, for instance, maps have been published showing by gradations of color not only the elevations, but even the geological sections. As yet such a map of our country could not be constructed. The survey which has been organized and conducted under the War Department owes its origin and character to the absolute needs of that Department; the knowledge obtained is also of vast service to the Department of the Interior, to the settlers of the West, to scientific investigation, to industrial enterprises, and to the country at large.

The scheme of the survey primarily includes the entire mapping of the Territories; not a sporadic survey, touching here and there on points of interest, but a complete one, connecting the work with that of the Coast Survey and extending the determinations of locality over the entire area of the United States. The atlas sheets when finished will delineate the whole country west of the 100th meridian—an area of nearly 1,500,000 square miles. In the past three years the survey has covered 228,000 square miles, and at this rate it will take fully 10 years to complete it without assistance from other sources.

Better to facilitate topographical representation, and to preserve uniformity of publication as to scale and size, the region west of the 100th meridian has been laid off in rectangles, each embracing about 18,000 square miles. Each map published will be on a scale of one inch to eight miles, and will represent the area in one of these rectangles. Thus as the work proceeds the maps will comprise a continuous series in atlas form. Six of these maps are now in the hands of the engraver, and the advance proofs indicate fine examples of topographical work, giving in detail the mountain systems, valleys, water-courses, routes of communication, &c.

SPECIAL FEATURES OF THE WORK.

A line drawn through Cheyenne, Virginia City, Tucson, Camp Apache, and Denver, will, said Lieut. Wheeler, approximately cover the area gone over by us. Our work must be exact, so that it can be referred to by future topographers. It is probably the best of any of the kind. One of the most important branches of the survey is the establishment of the meridian marks, and we do that with the utmost precision. No better work of that kind can be done, the probable errors being a minimum compared with any that have ever been made. Our meridian marks have already become of use to the local surveyors in numerous instances. The determination of the variation of the magnetic needle, which has heretofore given so much trouble, is another of the advantages obtained with the exact meridian.

Our survey, while it gathers information as to the general physical structure of the country, is eminently a mountain survey. It extends to the tops of all the mountains, and their characters and contour are a subject of special study. We have established the meridian at all the main astronomical stations. The percentage of area in the country surveyed suitable for agriculture is not large; a large part of the horizontal area covered by mountains is out of the range of cultivation. Small settlements spring up in the vicinity of the mining camps, but their permanency is uncertain, owing to the migratory character of the miners upon whom they depend for the sale of products. Within a radius of 15, 20 and 30 miles of the mining camps, these ranches are numerous, and the frugal Mormon, who thinks a great deal of a dollar, often brings his products 100 miles to market. With the development of the mining resources and a proper system of irrigation, the western half of Utah is capable of supporting 1,500,000 people.

MINERAL INDICATIONS—TIMBER.

Since we commenced our survey, it has indicated a great many mineral resources that were not generally known before. We visited a great many mining districts, and have gathered a great deal of information which is entirely new. Besides the precious minerals there are copper, lead, iron, and coal. The coal fields in Utah are immense; perhaps greater than those in Wyoming on the Union Pacific Railroad, and when worked will prove of great benefit to the mining industries. The coal is of the caking sort, and is said to be of excellent quality. It will take the place of that now brought from Pittsburgh. Coal crops out from the 35th to the 43d parallel, and in various parts of the great Colorado Plateau. No tin, platinum, or zinc was found. There are evidences of petroleum, but nothing definite. Immense beds of rock salt are found, and also of alkali deposits, from which borax is manufactured. This latter substance, I am informed by persons who know, will become an important article of commerce, since, as it becomes cheaper, it can be put to new uses, and the demand may consequently increase with the supply.

The area of timber in Western Utah is comparatively small. Mr. Walker of the Census Bureau has made a map of the country west of the Mississippi that shows by graduation of color the present timber growth. We gave him such information as we could. There is an immense forest in Arizona and New-Mexico, something like those in the region of the lakes, or even larger. Pine, fir, and quaking aspen are the principal trees. There is some timber that could be utilized in the building of railroads for ties, &c. It would be of great advantage to the Southern Pacific and Atlantic and Pacific roads. We have discovered a new route for the former road, which they could follow with advantage. Besides the routes for railroads, we have examined north and south lines of communication; one near the Rocky Mountains, one along the meridian of Salt Lake, and another west of the Sierra Nevada. Salt Lake City and Denver are the only points south of the 40th parallel that promise to become great commercial centers.

Almost all of this country is destitute of rain for most of the year. There are generally two rainy seasons—in June and July, and in December and January. There are exceptions, however, in this wide territory. Among the plateaus, summer rains are prolonged fully three months.

SCIENTIFIC WORK—INDIANS.

The collections of specimens in natural history are very large, especially those of this last year, considering the brief length of time and small number of collectors. This part of the country has never been explored before, except along certain lines, and many new ornithological and botanical specimens have been secured. From Colorado alone we have over 12.000 botanical specimens, and we shall secure an exhaustive report on the flora of that country. We have a very good botanist; he is now with Prof. Gray. He is a man who will, from time to time, suggest some practical deductions. Our examinations include character of soils, humidity, temperature, &c. Dr. Loew, our chemist, has measured the temperature of the soil at the surface and a foot below, and made many analyses of the soils.

We have given some study to the Indian tribes, in the way of gathering vocabularies of their language, specimens of their work, accounts of their habits and disposition toward settlers and toward each other, and many historical facts that will be interesting material. We have annually sent over to the Interior Department a small map showing the lines that divide these tribes.

When it is understood that the expedition has often been divided into from ten to twelve parties, it will be apparent how a mass of information has been collected of no little value. This is the only systematic interior survey that has ever been undertaken by the Government, west of the Mississippi. It is very needful that there should be a unity of plan and purpose in this matter of surveys, as they come now from a variety of sources. Engineer officers are stationed at the Military Department Headquarters who are constantly making surveys for the information of the commanding officers in the opening of routes of supply, movement of troops, &c. At the headquarters of the army an Engineer officer is also engaged in compiling information; this finally all comes together and is embodied on a general map. Then, again, Congress has been authorizing expeditions from the Interior Department and Smithsonian Institution. I have prepared an elaborate plan covering cost, size, etc., for the prosecution of this work. It is based on a unit of force; but it has not yet gone beyond the War Department. We do not utilize anything obtained by either the Interior Department or Smithsonian Institution in the construction of our maps.

THE WORK OF THE SURVEY.

The following general subjects for observation will give an idea of the undertaking:

(1.) The establishment of primary geographical positions by astronomical methods.

(2.) Obtaining accurate topographical information by trigonometric methods of the various mountain systems of the valleys and of the detrital plains.

(3.) Determination of altitudes (hypsometrically).

(4.) Careful study of geological formations.

(5.) Examination and collections of the living and extinct fauna and flora.

(6.) Investigation of resources (wood, water, grass, and agricultural productions).

(7.) Ascertaining location and extent of precious and economic minerals.

(8.) Observation of climatic oscillations and influences, and seasons of rain and snowfall.

(9.) Selection of routes of communication for rail and common roads, for military and other purposes.

(10.) Researches as to utilizing the present water-supply as a means of irrigation.

(11.) Ascertaining the condition of mining and other industries.

After the conversation with Lieut. Wheeler, of which the main features are given above, the following account of the work of the exploring expeditions under his charge was compiled from materials furnished:

EARLY EXPLORATIONS AT THE WEST.

England, Germany, Spain, Russia and France have made elaborate surveys and maps of their respective territory, the value of which is incalculable. In our own country the most finished and exact have been those of the coast, along which the principal interests were for a long time situated; next came the survey of the great lakes. The results of each of these undertakings are in the highest degree creditable to the officers engaged, and they have proved of great benefit to the country. The earliest history of surveys and exploration in our Western interior is found in the chronicles and adventures of the old Spanish and French travelers and missionaries. Their experience and the wonders which they relate are still full of interest, although the information they gained has been superseded by more accurate and detailed reports. One of the last and most entertaining of this class of historians was Padre Escalanta, a Spanish priest, who penetrated from the Gulf of Mexico to the Great Salt Lake of Utah. Some of the records of his travels are yet in the State Library at Santa Fé, N. M., others among the archives of the Spanish Government at Madrid.

The first to attempt an organized survey were Capts. Lewis and Clark, who were sent out under the auspices of the Government of the United States in 1804. They were absent until 1806. They were followed by Major Pike, U. S. A., 1805–7, who discovered the sources of the Great Colorado of the West. Rector and Robordean were the next, in 1818. After them, Major G. H. Long, U. S. A., conducted an exploring party, under orders from the Secretary of War. The first explorers of the sources of the Mississippi were Lieuts. J. Allen and Schoolcraft, 1832. The wanderings of Capt. Bonneville, U. S. A., from 1832 to 1836, were woven into a graceful narrative by Washington Irving. In the order of dates, subsequent explorations were made by the following officers: Commander Wilkes, U. S. N., 1838–42; Nicollet, under Bureau of Engineers, 1836–44; Lieut. J. C. Fremont, Engineers, 1842; Capt. Boone, of the Dragoons, 1843; Capt. J. Allen, 1843; Lieut. Fremont, 1844–46, assisted by Lieuts. Abert and Peck; Abert, Engineers, 1845; Franklin, Engineers, 1846–47; Abert and Peck, Engineers, 1846–47; Col. St. George Cooke, 1846–47; Warner, Engineers, 1847–49; Derby, Engineers, 1849; Lieut. Webster, Engineers, 1849; Lieut. Simpson, Engineers, 1849; Capt. Marcy, Infantry, 1849; Capt. Stansbury, Engineers, 1849; Col. Johnson, Infantry, assisted by Lieuts. Smith, Bryan and Michler, Engineers, 1849–57; Lieut. Parke, Capt. Pope, Capt. Sitgreaves, Lieut. Woodruff, Engineers, 1851; Capt. Marcy, assisted by Capt. McClellan, Engineers, 1852. From 1852 to 1857 the explorations and surveys for a railroad route from the Mississippi River to the Pacific Ocean were carried on, principally by officers of the Corps of Topographical Engineers. The resulting reports attained a worldwide reputation on account of their valuable data, and to this day they are frequently consulted.

TOPOGRAPHICAL MAPS.

To enumerate all the officers of the army who, fitted by education and training for such work, have taken part in or directed surveys in the Western Territories, is not necessary for the purposes of this letter. There is hardly any important portion of the West that they have not penetrated, and their labors have supplied the basis for the principal topographical maps of our country. The Engineer Bureau of the War Department has, since its organization, published several hundred maps, which are the most accurate, and, consequently, the most frequently consulted. Of the maps prepared and compiled by Lieut. (now Major-Gen.) G. K. Warren, a large edition has been distributed. It is still the best map of Territories west of the Mississippi River. To the common intelligence there is no medium that conveys information so directly as graphic illustration.

In the prosecution of explorations and surveys west of the 100th meridian, it has been the aim of the officer in charge so to direct the operations that the results will meet at least a portion of the needs of the actual settlers, to enable them to carry out their enterprises. At the same time care has been taken to collect data upon scientific problems that are of interest and value. The facts ascertained by the expeditions are promptly reduced to practical results, and the work is vigorously pushed forward to completion. The volumes described hereafter, covering the surveys of Lieut. Wheeler, will be forthcoming as soon as Congress sees fit to order the publication. Photo-lithographic copies of the atlas maps will be issued in advance for immediate use.

ASTRONOMICAL WORK.

The duties in this branch of the survey at the main field stations, conducted with instruments of the most approved pattern, were first undertaken in the year 1871, although in 1869, at Camp Halleck, Elko, Camp Ruby, Peko, and Hamilton, Nev., longitude by telegraph had been determined by connecting with the Coast Survey station at San Francisco, signals having been sent from that point through the kindness of Prof. George Davidson of the Coast Survey and others. In the year 1871 the services of two principal astronomical observers were obtained, and connections were made that year with the meridian of the Naval Observatory at Washington and that of the United States Lake Survey at Detroit. The sending stations were Carlin, Battle Mountain, and Austin, Nevada. Subsequently in the field season of that year, the astronomical position of Fort George, Utah, was determined, connection being made with the Mormon Observatory at Salt Lake City. The longitude of Camp Independence, California, and Prescott, Arizona, was determined by lunar culminations, and at all the stations this year, latitude was determined by the use of the zenith telescope—the method originally introduced by Capt. Andrew Talcott of the Corps of Topographical Engineers.

By the exercise of care and after considerable labor in taking the field in 1872, the organization for astronomical work in its methods, personnel, and instruments, was considerably improved, and three parties, two fully equipped and moving between several points of the field, and one at the Mormon Observatory at Salt Lake City, were actively employed. The results of this season determined with creditable accuracy the positions of the following points: Beaver and Gunnison, Utah; Pioche, Nevada; Fort Fred. Steele, Cheyenne, and Laramie, Wyoming Territory. Observations were begun at the crossing of Green River by the Union Pacific Railroad, and completed in the following year. The observers of this season were Assistants J. H. Clark, E. P. Austin, and William W. Maryatt.

ESTABLISHMENT OF AN OBSERVATORY.

It was proposed to establish a connecting field-observatory at Ogden, Utah, from which point the signals for a large stretch of territory to the north, south, east, and west could be sent. A substantial brick observatory on a stone foundation was planned, and has been essentially completed except the dome. It has three observing rooms that may be increased to five, and is connected with the main wire of the Western Union Telegraph Company. Connections may be at any time made with the wires of the Atlantic and Pacific Company, and of the Deseret Telegraph Company of Utah. To Prof. H. B. Herr of the Lehigh University of Pennsylvania the superintendence of the construction of this building and the charge of the observations necessary to connect it with the observatory at Salt Lake and that of the Lake Survey at Detroit were delegated. He was unable to perform the latter work, having to return to duty at the university. The observations were made later in the season by Dr. F. Kampf. Three main field astronomical parties were organized, and took the field about the 1st of June, 1873, leaving it on or about the 15th of November. They were in charge of Assistants J. H. Clark, Dr. F. Kampf, and Wm. W. Maryatt, respectively. Prof. T. H. Safford of Dearborn Observatory, Chicago, joined the survey on the 15th of June, and conducted the observations necessary for the determinations of Santa Fé and Fort Union, N. M. The following main field stations were occupied during the past field season:

(1.) Santa Fé, N. M.
(2.) Fort Union, N. M.
(3.) Trinidad, Col.
(4.) Labrau, Col.
(5.) Colorado Spring, Col.
(6.) Hughes, Col.
(7.) Georgetown, Col.
(8.) Ogden, Utah.
(9.) Winnemucca, Nev.
(10.) Virginia City, Nev.
(11.) Golden, Montana.
(12.) Green River, Wyoming.

STATIONS DETERMINED AND RESULTS ATTAINED.

During the years 1871, 1872, and 1873 the results, now mostly calculated, give with the utmost exactness now attainable the latitude and longitude of 24 stations in the interior area west of the 100th meridian. These determinations are accurate and trustworthy, as the probable errors show a minimum compared with any as yet obtained of this class of work, either in this country or abroad. They have already been used in checking the surveys made upon the railroads, so that these lines of communication from the Mississippi to the Pacific can be perfectly laid down upon the general map. A scheme developing from the line of stations reaching from Omaha to San Francisco has been begun, which, when carried out to meet the plan originally proposed, will be extended into an astronomical triangulation, which must, necessarily, take the place of the primary triangles in geodetic work, pure and simple, as applied by the Coast Survey in this country and by several surveys organized by the leading Governments of Europe. A large portion of our Western territory is covered with mountain forms, of which little is known, and presenting physical obstacles of such great magnitude as not to permit at present the slow and tedious operations of the primary triangulation prior to the commencement in skeleton alone of the final map. The secondary triangulation, having stations at prominent mountain peaks, and located in part from bases measured at the astronomical stations and from the prosecution of the trigonometric work, gives us points that hereafter may become vertices of a series of primary triangles for which some day the country may call. At each of these stations the true meridian of the place is established. Each of these lines having a known azimuth, will be of important use to the local surveyors and to the engineers of railroads and other corporations in checking their lines of survey made for specified purposes. They will also be useful in determining the annual and other fluctuations of the magnetic needle—an element entering so largely into the record that gives a title to lands.

In due time the standard meridians used by the public surveys, carried respectively from the Valley of the Mississippi westward, and from the Pacific coast eastward, may be adjusted to these geographical positions—a matter of no little importance. At most of these stations substantial stone monuments, constituting observing piers, have been established, and can always be identified. This branch of surveys being the first and most necessary, after it shall have been prosecuted with vigor, as it will be for several years by different parties of the War Department, the necessary data will ultimately be available, so that the accumulated material from a variety of sources, both public and private, may be aggregated upon the general map of the country, which is constantly revised at the Engineer Department, and also upon maps of the geographical military departments of the West, now in process of compilation at the Engineer Office, Headquarters of the Army. Astronomical observations for minor checks upon topographical work are conducted by officers of the corps of engineers, who have also the executive charge of the moving field parties. The mass of geographical positions already gathered, having prominent natural and other objects for their initial points, will soon be published.

TOPOGRAPHICAL WORK.

The present survey was first undertaken while the officer now in charge was on duty upon the staff of Brevet Major-Gen. E. O'C. Ord, then commanding the military Department of California, to which duty he was assigned in the Fall of 1868. In the Spring of 1869 the expedition for the reconnoisance in South-Eastern Nevada, then an almost *terra incognita*, was organized under the authority of the late Major-Gen. Geo. H. Thomas, commanding the Military Division of the Pacific.

Since the expedition of Capt. Timpson in 1859, from Great Salt Lake to Virginia City, no military parties organized for survey of the Western interior had been in the field with the exception of the survey of the 40th parallel, Clarence King in charge, who had begun these surveys in 1867. At the breaking out of the war, the Corps of Topographical Engineers, to which had been intrusted prior to this date this class of duties under the Government, was taken from these and other works of a similar character, and sent with the armies in the field. During the war this class of interior surveys remained dormant.

After the war, engineer officers were detailed at the headquarters of the several military departments and were called upon to carry out surveys of various kinds. The amount of money allotted was very small, and it was impossible to go to the expense of assistants other than in the astronomical and topographical branches of the work, where ability for scientific mapping of the results is a prerequisite. This reconnaisance occupied the entire season of 1869, and its results were reduced at the office in San Fancisco. A preliminary report and maps were published for the use of the Military Department of California, and another map, upon a scale of one inch to to twelve miles, was made for the uses of the War Department. The final report of this expedition is now completed.

The officer in charge, having changed his station to Washington, D. C., commenced in the early Spring of 1871 the organization of a large expedition to take the field that year. The several field parties left the Central Pacific Railroad at Carlin and Battle Mountain, Nev., moving in a southerly direction, closing their labors at the end of the season at Tucson, Arizona. In many respects this was one of the most extraordinary expeditions that ever entered our Western territory; its duties were both on the water and the land. A separate or sub expedition ascended the Colorado River from

Camp Mojave to the mouth of Diamond Creek, in the Grand Cañon. The area covered was over 80,000 square miles, a part of this being the most desert, difficult, and dangerous of any like area within the United States.

EXPLORING THE DEATH VALLEY.

This was especially the case with the great Death Valley in South-Western Nevada, wrinkled with many mountain elevations, between which lie elongated valleys or detrital plains, where the familiar alkali of this peculiar region everywhere meets the eye. The expedition crossed the Death Valley of California along four separate lines, enduring much hardship and many privations from heat and thirst. This peculiar basin interior, being at its greatest depression below the level of the sea, is most remarkable from the fact that the range of mountains lying to the west rises nearly 10,000 feet. Here are found, besides the precious minerals, bodies of timber, springs and running streams, and a peculiar climate; here arise sickly vapors that, in the light of the sun reflected upon the alkaline plains, might be supposed to be sulphurous fumes born of the infernal regions.

The season was particularly fruitful in unraveling the variety of topographical forms in and around the Grand Cañon of the Colorado, along the edges of the great plateau system, in the valley of the Colorado, that occupies large portions of territory in Arizona, Colorado, Utah and New-Mexico. It was proposed this year by the leader of the expedition to name this entire section the "Colorado Plateau," to be divided hereafter into sub-plateaus and mesa-systems. This expedition was fully eight months in the field, and left the Territory of Arizona in the middle of December, 1871. The boat party leaving Camp Mojave on Sept. 13, reached the mouth of Diamond Creek on Oct. 19. The ascent of the river was comparatively easy from the Black and Bowlder Cañons, until reaching the point of crossing to the southward, when, not having fully anticipated the increasing obstacles to entering the jaws of the Grand Cañon, the dangers of the trip were suddenly realized; and only after much privation and severe labor, with a scarcity of food, did the party, hemmed in by frowning walls, reach the mouth of Diamond Creek, where relief awaited them. The exciting scenes and thrilling adventures connected with this trip, will form one of the entertaining features of the published reports. The most easterly point reached this year was Camp Apache, A. T., near the head-waters of the Salt River.

Death Valley in California is a detrital sink of unique physical characteristics, and differs entirely from what it was supposed to be in 1869 by the majority of the inhabitants of Nevada living near a line leading from Camp Halleck via White Pine to Pahranagat Valley. The country thus denominated was really the great "Death Valley" of South-Western Nevada, and covers a large space in the system of Interior Basins that have the Wasatch Range as an eastern and the Sierra Nevada as a western limit. This whole region presents a series of valleys or detrital plains, each entirely inclosed by the ridges of Cordilleras that are more or less distinct as a series of mountain masses. The "Death Valley" proper is one of the most remarkable of all known interior continental depressions, and has portions near the center of its axial line below the level of the sea, although far inland, and lying much to the north of the lower border of the great Interior Basin. It is the sink of the Amargosa River, which has its source in the areas of drainage formed to the south and east of Belmont, Nev., traverses the desert of that name while passing southward, until, reaching lat. 35° 41′ 5″, it makes an abrupt angle to the west, and thence, at right angles to the north, reaches the point of greatest depression, a little less than 300 feet below sea level, in the heart of Death Valley proper. This valley, of the ordinary oval form, is fully 70 miles in length, varying from 5 to 15 miles in width, surrounded by frowning mountains of volcanic and sedimentary origin, the Telescope Range, rising higher than 10,000 feet. The line crossing this dismal area from the mouth of Death Valley Cañon to the thermal springs in Furnace Creek, presenting a labyrinthian maze of efflorescent, saline forms, creates at the level of vision a miniature ocean, the vibrations of whose contorted waves has a sickening effect upon the senses. The lurid glare, horizoned by the bluish haze radiated from the mountain sides, appears focussed to this pit, though broad in expanse. It seems, coupled with the extreme heat, to call for the utmost powers of mental and physical endurance.

The journey through the Valley of Death occasioned the utmost apprehension evinced through the entire season. To this was added the effect of the fearful cloud-burst experienced while among the Telescope Mountain, to the west, and the absence of the guide who had ventured toward the north-western arm of the Valley, it was feared, to return no more. The transit of 48 hours in a temperature that remained at 117° F. at midnight, so exhausted both men and animals that further travel was rendered precarious.

A PATHLESS FOREST.

San Francisco forest, through which Lieut. Ives conducted his land explorations, was traversed for a distance of nearly 200 miles from San Francisco Mountain to the Sierra Blanca range. The subsequent expedition of 1873 extended its limits far into New-Mexico, proving it to be probably the largest continuous forest area in the United States south of the fortieth parallel. The expedition returned to Washington in December, and at once began the preparation of maps, which will be pushed rapidly to completion in pursuance of the proposed atlas scheme. Much of the data was late in being received from the field, and some delay was experienced; still, satisfactory progress is making. In the Spring of 1872, with a larger appropriation, the Survey entered upon its duties with a more completely organized force, having for its field portions of Utah, Nevada and Arizona. The point of departure and return was Salt Lake City. The experience gathered by the topographical assistants and the addition of new skilled labor made the Topographical Corps of this year quite efficient, and permitted the elaboration of methods to meet the growing wants of this class of survey, aided by improved and perfected instruments. The area covered by the topographical work for this year is not so large in extent, but the result is fully as valuable, as more details were gathered. In 1873 the Topographical Corps was still further enlarged, experienced persons being retained and others added. The instruments and methods were also further perfected, and the work of exploration for this year fully elaborated into an entire survey of the new and interesting regions visited. The parties, six in number, took the field from Salt Lake City, Denver, and Santa Fé. The localities of the prominent natural objects, such as mountain peaks, mesa edges, buttes, &c., are determined by a species of secondary triangulation. Each belt of triangles is checked at distances not exceeding 200 miles by bases that now or hereafter will be further checked by the primary astronomical positions. Minor details are gathered by the topographers, using ordinary trigonometric methods for horizontal and vertical distances, so that within specified areas a sufficient amount of material for the scale proposed is gathered. The Survey was most successful in obtaining the requisite topographical information over large areas in Utah, Colorado, Arizona, and New-Mexico. At the present time this is rapidly undergoing reduction for the final atlas sheets. The moving field parties are usually so constituted as to be able to subdivide, and retain in each an executive, astronomical, topographical, meteorological, geological, and natural history assistant.

Topography is one of the most important branches of the work, since it is to trustworthy maps of the country that we must always look for the most ready and certain knowledge of its general features. In this country it has not as yet attained the dignity of a profession. It is hoped, however, that at no distant day it will command the attention it deserves at the hands of our scientific institutions. Up to the present time, the area covered by the survey has been as follows:

TABLE SHOWING THE AREA SURVEYED.

	1869.	1871.	1872.	1873.	'69-'73
Nevada........	26,400	27,200	6,200	....	59.800
California......	....	19,150	....	....	19,150
Utah	....	....	34.400	2,500	36,900
Arizona.......	....	32,400	9,900	17,500	59.800
New-Mexico...	....	....	....	31,000	31,000
Colorado......	....	....	....	21,500	21,500
Total........	26,400	78,750	50,500	72,500	228,150

The total cost of this work has been a little less than $225,000; approximately one dollar per square mile or one-eighth of a cent per acre.

GEOLOGICAL WORK.

The Geological Corps of the Survey has been progressively enlarged in the successive field seasons. Mr. G. K. Gilbert remained a member of it during 1871–2–3. In 1871 he was assisted a portion of the Summer by Mr. A. R. Marvine, who was succeeded in the following years by Mr. E. E. Howell. In 1873 the Survey was so fortunate as to secure also the services of Prof. J. J. Stevenson, and in the same year Dr. O. Loew, in addition to his multifarious labors in other departments, assisted in the geological work.

In the season of 1871 Mr. Gilbert followed a devious course in Nevada and California, starting from Carlin on the Central Pacific Railway and touching in succession the Bull Run mining district, Battle Mountain, Belmont, Hyko, and Pioche, in Nevada; Camp Independence and Desert Wells, in California; and Camp Mohave, Arizona. From the last place he accompanied the boat party up the Colorado River to Diamond Creek, at which point land travel was resumed. At the crossing of the Colorado, near the mouth of the Grand Cañon, he was met by Mr. Marvine, who had just commenced his geological examinations at St. George, Utah, and between that point and Camp Apache the routes of the two geologists intersected a number of times, and they were enabled effectively to combine their observations, the chief bearing of which in this region was upon the definition of the southern or south-western boundary of the great Plateau System.

All that portion of the United States west of the Plains is characterized by corrugation; that is, the geological formations once horizontal have been bent and broken and thrown into ridges so as to produce a mountainous country. The ridges vary greatly as to hight and length, but agree in a general northerly trend; so that in traveling north and south, it is generally easy to follow valleys, while in going east or west one is confronted by range after range that he must climb or go around. In the lower parts of this great mountain system the slow but indefatigable agencies of rain and stream have accumulated so great an amount of detritus that the valleys are clogged and the mountains nearly or quite buried. In this way have been produced the great desert plains of Utah, Arizona, and Southern California—vast seas of sand and saline clay, from the surfaces of which a few half-sunken peaks jut forth as islands. These intermissions of the mountainous character are mere concealments, not interruptions of the corrugated structure; but that structure is interrupted in one place—perhaps in others, but in one notably—by a tract in which the strata are almost undisturbed. The general surface of this exceptional region lies from 6,000 to 8,000 feet above the ocean and it is intersected by the celebrated cañons of the Colorado and its tributaries. By these gorges and by other modifications, chiefly dependent on erosion, it is divided into a great number of plateaus which the surveys now in progress are defining and naming. The geologists of these expeditions have found it convenient to designate the region, considered as a geological province, as the region of the Plateaus, or the Colorado Plateau System. It is surrounded on all sides by areas of corrugation, the ranges at the east constituting the Rocky Mountain System proper, and those at the west having been designated as the Cordilleras. At the north and south these mountain areas coalesce. The northern portion of the Plateau System falls within the belt of country studied by the geologists of the Fortieth Parallel survey and rendered accessible by the Union Pacific Railroad, has become tolerably well known. The definition of the southern half has been accomplished by the recent Engineer explorations.

WESTERN LIGNITES—AGE OF THE ROCKY MOUNTAINS.

The field of operations in 1872 comprised parts of both Cordillera and Plateau regions, and included their joint boundary from the Wahsatch range south-westward to the Colorado River. At the opening of the season Mr. Gilbert crossed the Cordilleras westward from Salt Lake City to the Nevada line, and returned eastward to Beaver, near the line of separation, where he was joined by Mr. Howell, who had spent most of his time east of the bounding line. Between this rendezvous and the next at Toquerville—which also happened to be near the same line—these gentlemen exchanged fields, Mr. Howell keeping to the west among the mountain ranges, and Mr. Gilbert exploring the plateaus about the head waters of the Sevier and Virgin Rivers and Kanal and Paria Creeks. In returning to Salt Lake City Mr. Howell once more bore to the west—this time so far as to touch the mining town of Pioche, Nevada, where a week was spent in a geological examination of the locality; and Mr. Gilbert, after visiting the Colorado cañons at Paria and Kanal Creeks, returned northward over the Sevier Plateau. One of the most interesting subjects of study during the season was the record of an ancient lake that covered the Sevier and Great Salt Lake Deserts, and which Mr. Gilbert refers to the glacial epoch. A great deal of attention was also given to some faults and folds within the Plateau region, of far less magnitude than those found among the Cordilleras, but of the greatest interest, since they are the simplest elements of mountain structure and their study promises to throw great light on dynamical geology.

In 1873 the work of Prof. Stevenson, who accompanied Lieut. Marshall, was confined to the Rocky Mountains, and was quite independent of that of the other geologists. His investigations led him to very definite conclusions in regard to the age of the Western lignites and the age of the Rocky Mountains, and his notes comprise important additions to our knowledge of the distribution of the strata and crystalline rocks of the region, of its ancient glaciers, and of the relation of its economic minerals to its geological structure. Mr. Howell, starting with Lieut. Hoxie from Salt Lake City, remained with his division nearly to the end of the season. The earlier part of the Summer was spent in a portion of the Plateau region immediately east of that examined in the previous year, and was largely devoted to the study of the system of faults, there well displayed. At Fort Wingate he passed—though at a later date—the initial point of Mr. Gilbert's examinations; and in the area to the south—the principal area for that season—the routes of these two geologists were so near as to enable a combination of their work. Dr. Loew's geological examinations moreover were in this region and tracts adjacent to it. Among the results of the Summer were the further definition of the boundary of the Plateau—continuing the work begun in previous years, the recognition and partial survey of some almost unknown volcanic belts of great extent, and the accumulation of many new facts in regard to the great cretaceous coal-field of the Plateau region.

Vol. IV., "Geology," will comprise reports by Messrs. Gilbert, Marvine, Howell, and Stevenson, upon the geology of the regions they have severally examined, and by Drs. Hoffman and Loew upon mineralogy and chemistry. The chemical report will include analyses and discussions of soils, minerals, rocks, mineral waters, coals, and vegetable principles. Among the topics treated in the geological reports will be "the Lignites," geologically and economically considered; iron ores, metalliferous veins, springs and artesian wells, erosion, mountain structure, descriptive and theoretical; stratigraphy and the distribution of the several formations, metamorphic rocks and metamorphism, eruptive rocks and their distribution, and the phenomena of the glacial epoch.

The illustrations will consist principally of woodcuts incorporated with the text and designed for the elucidation of the matter rather than for mere embellishment. Some points of structure and especially certain peculiar phases of erosion will be illustrated by full-page heliotypes or other prints from photographs made in the field. An atlas of geological maps, uniform in size with the topographical, and of course based upon them, will accompany the report.

MINES, MINERAL WATERS, &C.

More than 150 districts of precious metals in the territory covered by the survey have been visited and examined as far as circumstances permitted. The reports show a great number of points at which precious minerals have been discovered. Their value will be realized in connection with the geological and other investigations, and the mining localities will be indicated in the maps. The want felt of comprehensive and accurate maps of the mountain areas about which so little is known has repeatedly been called to the attention of Lieut. Wheeler by prominent men both in public and private life, and especially since the discovery of precious minerals has awakened a new and vast field of industry in those distant regions.

Mineral waters have been collected at various points, and in the more interesting cases several gallons of the water were evaporated, the residuum being kept for a more exact determination of those that occur only in small quantities.

The most interesting mineral springs were those of "Ojos Calientes," on the Jemez Creek, about 50 miles west of Santa Fé. These springs are situated in a deep but spacious cañon, the walls of which are over 1,500 feet in hight. The creek rushes through over a rocky bed with great rapidity, and some Mexican farmers have built huts along the margin. Springs of this class are invariably warm, the cold springs showing limited if any mineral qualities.

The principal warm spring is in continuous and violent action, a current of carbonic acid escaping through the water, which has a temperature of 169° Fahrenheit. This water is used for bathing and drinking by the Mexicans, who flock thither. This spring was found to contain chiefly chloride of sodium, sulphate of soda, carbonate of lime, carbonate of magnesia, and chloride of lithium. Smaller springs of similar composition, a few steps from the chasm, contain, in addition, carbonate of iron, and have a lower temperature, 108° to 130°. Two miles above this group of springs is another, quite distinct, 42 in number, all issuing from calcareous mounds, undoubtedly former spring deposits. There is a cave in one of these mounds whose walls are coated with glittering crystals of calcite, and two snow-white columns stand in front. These springs contain, beside the above-mentioned substances, carbonate of soda, their temperature ranging from 80° to 165°. A quantitative analysis has been made from springs of both groups, and will be reported in the final volumes. These springs have some similarity to those in Marienbad, Bohemia, and undoubtedly deserve attention. At some future time we may here find one of our fashionable watering-places. Mineral springs in the cañon of the Rio Francisco at San Isidro and other localities, have been carefully examined. Lithia was found accompanying the soda salts; borates, which are so frequently encountered in Nevada, have not been found yet in New-Mexico and Arizona.

A FARMER BECOMES A MINER.

An extensive collection of ores from New-Mexico and Colorado was made. These will be subjected to analysis. There is a vein of red oxide of copper of 80 feet width and 3 feet hight, in quartzite, in the vicinity of the Rio Francisco. A deposit of silicate and green carbonate of copper of about the same hight and of a width of 46 feet occurs on the Burro Mountains. Some new copper mines were discovered by the parties of the expedition on Mount Turnbull and in the Gila Valley near the Rio Bonito. The silver mines of New-Mexico are extensive, containing chloride of silver, native silver, argentiferous galena, and argentiferous iron pyrites in many places. A characteristic ore is the deposit of chloride of silver in slate and silenite at Silver City. On the Madelina ruts occur argentiferous cerrussite and massicote. Gold is found in various places in sand along the Rio Francisco and the Rio Membres; in quartz sandstone, talc, and soil on the Placer Mountains. One farmer in the vicinity of Silver City subjected the soil of his corn-field to a washing, and obtained such favorable results that he sunk a shaft. The profit of his labors last year was $1,800 in gold.

The region above 7,000 feet receives nightly dews, and has occasional springs and abundance of timber and grass. The country below this altitude suffers from the dryness of the climate, but the streams are often flanked by belts of good bottom lands that may be irrigated. A report will be made describing in detail the lands suitable for farming. In New-Mexico and Arizona many soils were analyzed. Lithia was present in all of them—a substance not so common in other countries. Potassa and phosphoric acid were found in all in sufficient proportions to insure production of crops. In some localities the soil contains as much of these elements as the best soils known. Some soils were found deficient in lime, some in sulphuric acid; but this want can be easily supplied by an addition of gypsum, which occurs in many places.

There is also a class of soils productive without irrigation. In such cases the underlying strata probably furnish water, which ascends by capillary attraction. Specimens of such soils have been taken in sealed bottles to determine the hygroscopic moisture of the subsoil. This was found to be 4 to 5 per cent, while at the surface it was was from 1 to 2.

The valley of the Rio Grande del Norte, in New-Mexico, recalls the features of the Egyptian Nile. A large population is entirely dependent upon the river. An annual rising of the waters carries a muddy sediment superior in fertilizing properties, as was proved by analysis, to that of the great African river. While the amount of phosphoric acid is nearly the same, the amount of potash is considerably higher. Thousands of acres are lying idle along the valley of the stream awaiting the enterprising farmer.

PLANTS, TEXTILE FIBERS, &C.

There are many plants growing in New-Mexico and Arizona which have strong fibers that could be utilized for the manufacture of rope, paper, &c. One such species, *Yucca Angustifolia*, is now utilized at Denver, but there are many more. The root of this plant is used by the natives as a substitute for soap, and is highly prized on account of its cleansing properties for woolen goods. Another plant of great interest is the *maguey* or *mescal*, growing in Southern Arizona—a peculiar species of yucca. The plant consists of about 80 to 100 lanceolate leaves from two to three feet long, pointed to a sharp thorn at the end; all the developed leaves are concentrically united at the ground; those undeveloped—the heart of the plant—remain soft and perfectly white so long as the sunlight is kept away by the surrounding outer leaves. The Indians bake this heart in coals for eight or 10 hours, when it acquires an exceedingly sweet taste, much like honey. The Mexicans, also, prepare from this baked mescal an alcoholic beverage. The fact of this substance turning into sugar by simple heat has no parallel in our experience. Specimens of all valuable plants collected during the survey, including such as are used by Mexicans and Indians for specific diseases, will be subjected to chemical investigation. The geographical distribution of plants affords a study of peculiar interest in those regions where the altitude changes from 5,000 to 8,000 feet, and on some occasions, 10,000. Above 6,800 feet there are vast forests of pine and fir, and the climate of the eastern mountains, while below 5,000 feet, is a region where the cactus grows. The cacti are especially developed in Southern Arizona, where the grand cactus (*Cereus giganteus*), 30 to 40 feet in hight, and three to four feet diameter, is preëminent. Between the region of these cacti and the zone of the pine, grows the everywhere prevalent juniper, in higher altitudes accompanied by piñon, a peculiar conifer, with an eatable fruit. A large collection of plants was made in New-Mexico and Arizona.

CURIOUS BOTANICAL OBSERVATIONS.

It is hard to believe that the vegetation of the plains, which is so strikingly somber in its *ensemble*, is really as diversified as that of most other regions of similar area. Certain orders, as the Leguminous family about Denver, or the Cactus family further south, do preponderate over the others, just as other orders in other places do on the remaining plants. But there may be as many species and genera in one place as the other, only it requires more than casual observation to distinguish between the allied forms. The vegetation of the plains disturbs all our preconceived ideas of plant life by presenting an extraordinary class of representatives. The physical conditions are just as peculiar as the plant life One is the exact measure of the other. Imagine a vast open expanse absorbing, without the protection of an intervening foliage, most of the sun's rays, and from want of aqueous vapor in the air parting with that heat as readily at night, and the reason why our familiar forms of plant life are crowded out of existence is obvious. They are unable to endure an alternation of temperature so extreme and so rapid.

The mountain flora is especially fresh and attractive, and up almost to the limits at which flowering plants grow the luxuriance and beauty of the vegetation are wonderful. Under the great diversity of physical conditions furnished by the deep shade of the pine woods, the sunny valleys, the rocky slopes, and the snow-fed Alpine bogs, plants seem placed where every tendency they may have to vary is intensified, and it does not in the least surprise one to see some of our best-known forms going off in all sorts of unexpected developments.

The best agricultural region visited by the botanist during the past season was the San Luis Valley. While much of it is barren and unpromising, much more is capable of raising good crops after irrigation has been practiced. The portions bordering some of the creeks are absolutely covered with the most luxuriant growth of grasses and sedges. Indeed in many places one may ride a mile through the grass without the animal being seen among the tall grass. The following facts show plainly the productiveness of the soil ·

	Yield per Acre. bush.	Weight per bush. lb.		Yield per Acre. bush.	Weight per bush. lb.
Oats........	40 to 50	40	Wheat	30	65 to 68
Barley......	40	55	Potatoes..	250 to 300 bush. ..	
Bald Barley	50	75			

Turnips, onions, beets, cabbages, and radishes grow to an immense size. Along the Rio Grande, in the southern portion of the valley, all our familiar garden vegetables were readily raised.

The foot-hills and higher mountain ranges back of these have much valuable pine and spruce timber growing upon them, but it is probable that ere long the greater needs of a rapidly increasing population will have exhausted the supply, and it might therefore be wise in Government to become an active participant in the rage for timber planting which is so prevalent in portions of the West.

In certain places the curious fact was observed, that trees attained their maximum hight and diameter just before the level of timber-line was reached and suddenly were reduced (the same species) in size, disappearing entirely a few hundred feet higher up.

METEOROLOGICAL WORK.

A system of observations with the barometer and prychrometer, combined with a journal of our meteorological phenomena and observed peculiarities of climate and climatic influences is adapted to the fixed stations at the astronomical basis, and to the movable stations of the various field parties. A voluminous record is thus accumulated, containing the elements of much information upon points important to the survey, the elimination of which, from the mass of figures, is a labor of no trifling character. The primary object of this record is the barometric determination of the relief of the country traversed, no other means sufficing except to supplement this general plan.

From the fixed bases of the barometric stations the theodolite and spirit level give local relative altitudes with great exactness; the course of streams, the dip of strata, and even the character of vegetation contribute hypsometric facts in more or less certain figures. And all these sources of information are utilized, but altitudes so determined are only relative and must be fixed by the primary determination by the barometer, which offers a common reference for the survey. In reducing and computing the numerous observations, they are treated in accordance with the latest authoritative views upon barometric hypsometry, and the altitudes so determined will give the relief of the country very satisfactorily.

The Record furnishes statistics of temperature, humidity, rain, snow, and all facts relating to the climate of the country which could be collected. This information will be published in the condensed form of tables, with such an analysis of the barometric readings as will best exhibit the action of the forces at work. It is hoped that by a careful arrangement of the data, material may be presented for further meteorological investigation and assistance rendered in determining the laws of atmospheric movement and their influence upon the barometer.

NATURAL HISTORY.

In 1871, the celebrated Collector F. Bischoff, assisted by Drs. Hoffman and Cochrane, made abundant and valuable collections in the line of entomology, botany, ornithology, &c., many new species of Coleoptera being found. In ornithology the contribution was valuable in numbers as well as in embracing many forms rare and new. Similar results were obtained as to serpents and reptiles. An extensive herbarium of the region visited was obtained. Unfortunately, however, these collections were rendered partially valueless by the Chicago fire, in which the note-books were lost and Mr. Bischoff himself perished.

In 1872 the services of Dr. H. C. Yarrow, U. S. A., of eminent ability both as a surgeon and a naturalist, were secured, with Mr. H. W. Henshaw as an assistant, and Mr. M. S. Severance as an ethnologist. The party under Dr. Yarrow took the field early in the season, their labors resulting in a collection of 800 birds, between 300 and 400 reptiles and a large number of fish, insects, plants, &c. which, on examination by competent naturalists, proved fruitful in the way of elucidating many points with reference to geographical distribution. A large botanical collection was also made. Particular attention was paid to ethnology and philology, and numerous rare crania were added to the extensive collection of the Army Medical Museum, while to the Smithsonian Institution were contributed numbers of specimens illustrative of the manners and customs of the rapidly decreasing tribes which inhabit the section visited, together with several vocabularies of Indian languages. The crania in question have already served a good purpose, not only in the way of materially increasing the number of interesting specimens to be found in the national collections, but also as a means for the comparative study of the subject of craniology. The vocabularies will form part of an extensive work on Indian languages now in course of preparation by the Institution.

NATURAL HISTORY COLLECTIONS IN 1873.

The expedition of 1873 took the field June 1, and though the period of its operations was greatly curtailed by reason of the early close of the season, the result was a collection never, perhaps, exceeded either in the number or value of the specimens, by any made in the same length of time and under similar difficulties. It embraced 1,200 birds, among which many were entirely new, and was fruitful in the way of nests, eggs, fish, reptiles, &c. In botany the field was especially large, and included many rare and valuable specimens. Perhaps no larger collection of the kind was ever secured in a single season in the Western region. It required the services of four of the most distinguished botanists to work up the specimens. A pre-eminently superior collection in ethnology was another of the valuable contributions of this year. The party during this season consisted of Dr. Newberry, Dr. Rothrock, Mr. Henshaw, Prof. Wolfe, and Dr. Loew. The collections were safely transmitted to the Smithsonian Institution, for competent examination by the collaborators of that establishment. As to the birds collected during this period, the gratifying assurance has already been received from the eminent ornithologist, Prof. Baird, that many of them were in such splendid condition as to justify their being sent to Europe to be mounted for exhibition in the national museums. Reports on these collections will be embodied in a quarto volume, with illustrations of the rarer forms. The services of Dr. H. C. Yarrow have been secured by Lieut. Wheeler for the work of 1874. Mr. Henshaw is retained as his assistant, being an eminently successful collector in ornithology. Dr. Rothrock, skillful in botanical collection, will have charge of that department of research. Many other specialists have been invited to join the expedition.

PHILOLOGY AND ETHNOLOGY.

Most valuable data for future elaboration have been secured for the students of philology and ethnology. Many vocabularies have been recorded by the efforts of members of the Expedition, according to the Smithsonian blanks, forms, &c., from the Utes, Pah-Utes, Jase-Utes, Apaches, Navajos, Pueblos, Mojaves, and others, all of whom should probably be classified as one great family, their customs, language, and habits being in some respects very similar. Many ancient mounds have been thoroughly explored, and their interesting contents will without doubt afford us valuable and instructive facts in regard to races long passed away from this earth. In some, skeletons, arms, mills, and warlike implements have been found; in others the sole contents were pottery and debris. Many very interesting photographs have been taken representing the various industrial arts of the present Indians, the cliff dwellings of the ancient Pueblos and Mojaves; and the villages of the present day in which houses and even villages are built one on top of another, and are reached by long ladders, affording ample means of defense from the more predatory tribes. In addition to these pictures, others, and probably the most valuable of all, have been taken showing the ancient hieroglyphic rock-writing of the Indians. These have been placed in the hands of Prof. H. Allen of Philadelphia, who will undertake to decipher them and furnish a report. Many interesting facts have been collated in regard to the customs, religious ceremonies, traditions, and modes of living of the different tribes, and will be duly published. A valuable collection has been made of clothing and implements.

PHOTOGRAPHS AND PUBLICATIONS.

Mr. T. H. O'Sullivan, well known in connection with his work on the Fortieth Parallel Survey and Darien Expedition, was the photographer of the survey for the seasons of 1871 and '73; Mr. Wm. Bell of Philadelphia in

1872. The principal uses of photographs are for the topographers in obtaining an idea of the structural features, and for the geologist. Copies of photographs taken were forwarded to the Vienna Exposition, and some few have been printed for the use of the War Department; but as yet no general distribution has been made, although the views secured are in many cases of peculiar interest. The series are of the landscape and stereoscope sizes; the subjects are various parts of Utah, Nevada, California, Arizona, and New-Mexico. There is also a fine suite relating to the cañons of the Colorado, a selection of which, of the landscape size, will be brought before the public at an early day. In his annual report to the Chief of Engineers Lieut. Wheeler proposes to group the material at his disposal into the following forms:

1. Six quarto volumes.
2. One topographical and one geographical atlas, 19″ by 24″.

Vol. 1 is to include the general report concerning the expedition of 1871 and 1872, describing the country traversed, facts relating to its industries, the condition of present and extinct aboriginal tribes, &c. The text-matter will aggregate about 250 pages and 12 plates in illustration.

Vol. 2 will comprise the systematic report upon the longitude and latitude campaigns of 1871 and 1872 in their due order of sequence, and, if sufficiently delayed before going to press, can receive in addition the results from the field season of 1873, including the establishment of the observatory, and the more matured plan for a comprehensive system of astronomical determinations in the area west of the one-hundredth meridian. This volume will not exceed 250 pages, with but few additional plates.

Vol. 3. This volume will embrace the collected data from a very large number of hourly stations, and from meteorological record connected with altitude work, illustrated by various tables and plates. The text-matter will not exceed 50 pages. The tables and plates will complete a volume of moderate thickness.

Vol. 4 will contain the finished report of the geological work for the years 1871 and 1872. The sections will appear in immediate connection with the text. The size of this volume will not differ greatly from 225 pages, increased by a few geological plates.

Vol. 5. This volume, known to be the one upon "Palæontology," will contain a report and numerous plates of the new vertebrate and invertebrate fossils, for the years 1871, 1872, and 1873. The pages of text matter will not exceed 100, and the plates for illustrating new subjects probably not more than 50 or 60.

Vol. 6. This last volume of the series will render the matured results, for the years 1871, 1872, and 1873, in the different branches of natural history, the manuscript matter for which will call for at least 200 pages of quarto text and several plates.

The following maps have already been published for general distribution. In 1869, map of South-eastern Nevada, 1 inch to 12 miles; 1871, preliminary map, 1 inch to 24 miles; 1872, preliminary map, 1 inch to 24 miles. Advanced copies of Atlas publication are now ready. The finished work appears to be of the best that has been executed in this country. Besides the preliminary sheets, there will be four full atlas sheets presented as photographed, in crayon and in colors, accompanied by an index sheet and general topographical sheets, progress map, and a map showing the areas of drainage and the several basins of the territory west of the Mississippi. This edition will be made as large as the funds of the Survey will admit, but is not expected to meet the constantly increasing demand for trustworthy maps of this section of the country. It is intended to have one topographical and one geological atlas.

The barometric profiles gathered by the observers over the numerous routes of travel followed by the surveying parties are numerous. The limited working force of the office does not admit of their preparation for publication at present.

LOSSES BY DEATH—THE MURDER OF LORING.

Considering the fact that the several expeditions numbering each year from 125 to 200 men, have traversed these remote and inhospitable regions, where want of water, heat, danger from hostile Indians, etc., render the tenure of life often precarious, it may be considered remarkable that only six deaths have occurred, three of which were caused by the murderous hand of the Apache. In 1871, in the well-remembered stage massacre near Hickenburg, three members of the expedition of that year sold their lives dearly. One of them was young Loring, a writer of rare ability and promise; another, Mr. Hamell, chief topographer to the expedition; the third, Mr. Severn, a prominent member of the boat expedition of that year—all serious losses to the Survey. During this year two guides were lost in the Death Valley region, and it is supposed that they perished, no information to the contrary having as yet been received; at the time of their loss strenuous effort was made to discover them, but without avail. In 1872, in Paria Creek, Utah, one gentleman was drowned. During the past season Mr. William W. Maryatt, a most prominent astronomical observer, died at Bozeman, Montana. Other accidents inevitable in a life of so much toil, privation, and adventure, have occurred, but no others were very serious.

DETAILS OF ORGANIZATION.

To secure an economical and yet thorough prosecution of the work intrusted to his charge, it is proposed by Lieut. Wheeler that the unit of force in any given area shall consist of three field parties, with at least one officer in executive charge, one to be known as the triangulation party, the others as parties for collecting topographical, meteorological, geological and other data. These parties will carry on their operations in lines nearly parallel and make a thorough trigonometric connection over the entire district surveyed.

For the main astronomical work there will be three distinct parties; one to occupy the central and connecting station at Ogden, Utah, to be in charge of an engineer officer; a second to occupy points accessible by railroad communication within the area west of the 100th meridian, and a third lightly equipped for duty away from the railroad connections, yet at points where the telegraph has penetrated. The parties so organized would consist of

One officer, in charge.
Officers in charge of parties and as assistants.
Three civilian astronomical assistants.
Six civilian topographical assistants (including meteorological observation).
Four civilian geological assistants.
One naturalist and three assistants.
One photographer.

The following officers and civilian assistants have been connected with the Survey:

Lieut. Geo. M. Wheeler, Corps of Engineers, in charge.
Lieut. R. L. Hoxie, Corps of Engineers.
Lieut. Wm. L. Marshall, Corps of Engineers.
Lieut. S. E. Tillman, Corps of Engineers.
Lieut. Andrew H. Russell, 3d U. S. Cavalry.
A. A. Surgeon H. C. Yarrow, U. S. A., naturalist.
A. A. Surgeon J. T. Rothrock, U. S. A., botanist.
A. A. Surgeon C. G. Newberry, U. S. A.
Hospital Steward T. V. Brown, U. S. A., meteorological observer.
Civilian Assistant John H. Clark, astronomer.
Civilian Assistant Dr. F. Kampf, astronomer.
Civilian Assistant T. H. Safford, astronomer.
Civilian Assistant Wm. W. Maryatt, astronomer.
Civilian Assistant Louis Nell, triangulation and chief topographer.
Civilian Assistant Gilbert Thompson, topographer.
Civilian Assistant John J. Young, topographer.
Civilian Assistant Max Schmidt, topographer.
Civilian Assistant E. J. Sommer, topographer.
Civilian Assistant R. J. Ainsworth, assistant topographer.
Civilian Assistant J. E. Weyss, topographical draughtsman.
Civilian Assistant Charles Herman, topographical draughtsman.
Civilian Assistant A. A. Aguirre, topographical draughtsman.
Civilian Assistant J. C. Lang, topographical draughtsman.
Civilian Assistant G. K. Gilbert, geologist.
Civilian Assistant Prof. J. J. Stevenson, geologist.
Civilian Assistant E. E. Howell, geologist.
Civilian Assistant Dr. Oscar Loew, mineralogist and analytical chemist.
Civilian Assistant H. V. Henshaw, collector (ornithology).
Civilian Assistant John Wolfe, collector (botany).
Civilian Assistant George M. Keasby, collector (palæontology).
Civilian Assistant T. H. O'Sullivan, photographer.
Civilian Assistant C. D. Gedney, meteorological assistant.
Civilian Assistant F. M. Lee, meteorological assistant.
Civilian Assistant Bernard Gilpin meteorological assistant.
Civilian Assistant Francis Klett, disbursing clerk and assistant topographer.
Civilian Assistant Geo. M. Lockwood, property and purchasing clerk.

Among those who have assisted in elaborating the results of the Survey, especially the natural history, may be mentioned the following students of science:

Prof. S. F. Baird, Prof. O. C. Marsh, Prof. E. D. Cope, Prof. H. Allen, Prof. G. W. Tryon, jr., Prof. A. E. Verrill, Prof. T. P. James, Prof. S. T. Olney, Dr. G. A. Vasey, Mr. W. H. Edwards, Prof. Cyrus Thomas, Mr. R. H. Stretch, Mr. Theo. L. Mead, Baron Osten-Sacken, Prof. E. T. Cresson, Prof. P. S. Uhler, Dr. E. Coues, Prof. Wm. Holden, Dr. J. J. Woodward, Dr. Geo. Otis, Mr. W. G. Binney, Prof. Q. A. Allen, Prof. Asa Gray, Mr. H. Ulke, Mr. J. S. Milner, Mr. G. Brown Goode, Prof. H. A. Hagen, Mr. J. H. Emerton, and many others.

THE EFFECTS OF ALCOHOL.

AN ADDRESS BY WM. A. HAMMOND, M. D.

INAUGURAL ADDRESS ON ASSUMING THE PRESIDENCY OF THE NEW-YORK NEUROLOGICAL SOCIETY—DELIVERED MONDAY, MAY 4—THE EFFECTS OF ALCOHOL ON THE NERVOUS SYSTEM, ILLUSTRATED BY EXPERIMENTS ON MEN AND ANIMALS.

The New-York Neurological Society met on May 4, at the College of Physicians and Surgeons. A large number of prominent physicians were present, among whom were Prof. L. A. Sayre, Prof. Willard Parker, Drs. Lente, J. C. Peters, D. B. St. John Roosa, Meredith Clymer, Murray, and others. The occasion was the delivery of the inaugural address on the "Effects of Alcohol," by Prof. William A. Hammond, as President of the Society. He was frequently interrupted by applause, especially when displaying the delicate test for alcohol in the liquor distilled from the brain, spinal cord, and nerves of a rabbit which had been fed on alcohol for several days and then killed. The following foreign physicians were elected honorary members of the Society: Drs. John W. Ogle, B. W. Richardson, G. Fielding Blandford, J. Hughlings Jackson, F. E. Anstie, J. Russell Reynolds, Henry Maudsley, and H. Charlton Bastian of London; Drs. T. Clifford Allbut and J. Crichton Brown of Leeds, Eng.; Drs. Labbadie Lagrave, A. Briére de Boismont, J. Baillarger, and G. B. Duchenne (de Boulogne) of Paris; Drs. Albert Eulenberg and C. Westphal of Berlin, and Dr. Thomas Laycock of Edinburgh. A short discussion followed Dr. Hammond's address.

THE ADDRESS.

GENTLEMEN: In returning thanks for the honor you have conferred upon me, in electing me to the presidency of the New-York Neurological Society, I must congratulate you on the auspicious awakening into life which the Society has exhibited. With a roll of members which in numbers and eminence would be worthy of any society in the country, it enters upon the self-appointed task of studying the science of medicine in all its relations to the nervous system.

INCREASING LIABILITY TO NERVOUS DISEASES.

If there is any higher scientific labor than this for a physician to perform I do not know what it is, and its importance augments daily with the advance of civilization and refinement, those great factors which do not stop at promoting man's intellectual and physical development, but which, as if every good thing must have its attendant evil, render him more liable to a class of diseases before which all others are of secondary rank. The thought which the statesman or the scientist elaborates from his brain, and which may be of momentous weight in the affairs of mankind, often leaves him who gave it birth with weakened or perverted mind, or the prey of some painful affection which of itself makes life a burden. The youth who, by ambition or the constant spurring of his teachers, is induced to make inordinate mental efforts to attain distinction, breaks down mentally and physically in the attempt, or else gains his object at a cost to his nervous system which is a dear price for any possible eminence he may thereafter reach. Not long ago I cut from a daily newspaper an advertisement of a school near this city, in which it was set forth as the sole inducement to parents to send their sons to the institution in question that at it "boys were waked up and set agoing." I thought then, and I often think now, of the anguish in store for some of the "dull boys" whom the teacher, doubtless with the best intentions, may "set agoing." The nervous irritability, the headaches, the sleeplessness, the confusion of ideas, the enfeebled body, the premature old age, the early death—not, perhaps, before the intervention of some organic disease of the brain or other part of the nervous organization—which a forcing system is apt to produce, are but a poor return for the doubtful honor of being "waked up and set agoing"—to say nothing of the lamentable failures attendant upon the process.

I might go on and invite your attention to many other ways in which civilization affects for good and for evil those organs which in their full development place man at the head of all created beings, but I am induced by the preëminent importance of the subject, to limit this address to the effects of alcohol upon the nervous system. I think I was one of the first to study the influence of alcohol upon man, from the standpoint of careful and exact experiment. In the year 1856 I instituted a series of investigations on myself which yielded definite results, and which placed in a very clear light the evils and benefits of the powerful agent under consideration. These related to the general influence of alcohol, and it may be well as a preliminary to the special subject of inquiry to consider, somewhat in detail, the subject of that study, and of the researches of others who have pursued a similar line of research. In so doing I shall draw largely from a former publication, not now readily accessible.

THE USE OF ALCOHOLIC BEVERAGES.

The propriety of the use of alcoholic liquors as beverages, the lecturer said, has been a subject of discussion for many years past, and is at the present time engaging a great deal of attention. Few, however, who have participated in it have considered this matter in its true light, and this is especially true of the advocates of total prohibition who have generally indulged in invection instead of argument, and whose facts are based mainly upon the immoderate use of the agents in question. No one can deny that alcoholic liquors, when imbibed in excessive amount, are not only injurious to the individual who takes them, but are also in the highest degree ruinous to society. We can even go further and admit that there are certain alcoholic compounds—such as the distilled liquors, brandy, whisky, rum, &c.—which, when taken habitually even in moderation by healthy persons, exert a more or less injurious effect, varying according to the quantity imbibed and the constitution and temperament of the individual. It is also undoubtedly true that even fermented liquors—ale, wine, porter, &c.—when used in excess, lead to results in many cases which are decidedly abnormal in character. And it is not to be questioned that the habits and mode of life of a great many persons are such that not only is no stimulant of an alcoholic character requisite, but any such stimulant even when taken in very small quantity acts in a manner prejudicial to the well-being of the organism.

But it is illogical to argue from the excessive use of spirituous liquors by all persons, to the moderate use of some persons, and I shall endeavor to point out in what the difference consists, for that alcoholic liquors are not only beneficial to, but are actually required by certain classes of individuals, is not, I think, a matter for doubt.

The experiments of Dr. Percy have been often brought forward as proving something in regard to alcohol which was not true of any other substance. This observer injected strong alcohol into the stomachs of dogs. The quantity ranged from two to six ounces. Death followed, and upon examining the blood and brain for alcohol, it was always found. The presence of alcohol in the blood and brain, to those who look superficially or ignorantly at the matter has rather a horrible aspect; but when we know that there is no substance capable of being absorbed by the stomach and intestines which cannot also by proper means be detected in the blood and viscera, the subject loses much of its striking character. Dr. Percy used alcohol of 85° specific gravity, which represents a mixture containing about 80 per cent of absolute alcohol. As the strongest brandy contains but about 54 per cent of alcohol, the concentrated character of the liquor used by Dr. Percy is at once seen. In one case six ounces were injected into the stomach of a dog—a quantity amply sufficient to cause death in an adult man. The amount of essential oil present in onions is far less in proportion than the quantity of alcohol contained in the mildest wines, and yet we cannot eat one onion without this oil passing into the blood and impregnating the air exhaled in respiration with its peculiar odor. Doubtless the brain of a person who had dined heartily on onions would exhale the characteristic odor of the vegetable.

EFFECT OF DOSES OF ALCOHOL.

Many other physiologists have detected alcohol in the blood and viscera of animals after its injection into the stomach. I have several times performed experiments with reference to this point, and have never failed to recognize the presence of alcohol in the blood, brain, the stomach, expired air, and urine of dogs to which I had administered strong alcohol. But with liquors containing from 8 to 15 per cent of alcohol, such as the German, French, and Spanish wines, I have never been able to find it in the solids, though detecting it easily in the products of respiration. It is not to be doubted therefore that alcohol, like other substances, is absorbed into the blood and exerts its influence on the system through the medium of this fluid. Pure alcohol is a violent poison. In the dose of less than one ounce I have seen it cause death in a medium-sized dog, and many cases are on record of fatal effects being immediately produced in the human subject after comparatively small quantities had been swallowed. When diluted its effects are not so rapidly manifested, and from this form when taken in sufficient quanties the condition known as intoxication is produced. Previous to this point being reached the nervous and circulating system becomes excited, the mental faculties are more active, the heart beats fuller and more rapidly, the face becomes flushed, and the senses are rendered more acute in their operation. If now the further ingestion is stopped, the organism soon returns to its former condition without any feeling of depression being experienced; but if the potations are continued, the complete command of the faculties is lost and a condition of temporary insanity is produced. If further quantities be imbibed a state of prostration, marked by coma and a complete abolition of the power of sensation and motion follows. Such is a brief outline of the obvious symptoms which ensue upon the use of alcoholic liquors in considerable quantities. When taken in amounts less than are sufficient to induce any marked effect upon the circulatory and nervous systems, there is, nevertheless, an influence which is felt by the individual, and which is mildly excitatory of the physical and intellectual faculties. But there are other results which follow the use of alcohollic liquors which are not obvious to ordinary examination, and which, except in a general way, are not perceived by the subject himself.

We know that a certain amount of tissue is decomposed with every functional action of the organ to which it belongs. Just as steam results from the combustion of fuel, so thought results from the combustion of gray nerve tissue, motion from the combustion of muscle, and the force to secrete bile, from the combustion of the substance of the liver. We know very well that if fresh fuel is not supplied to the engine from time to time steam ceases to be formed, and the machine set in motion by it no longer works. The like is true of the body, and were it not for the formative processes which are continually going on whereby new material derived from the force is deposited to take the place of that which is consumed, death would very soon result. It must be distinctly understood, however, that ordinary food does not directly furnish any force inherent in the body, but that it must first be converted into flesh and brain and heart, etc., from the destruction of which organs the force peculiar to each is evolved. The process by which food is converted into tissue is called progressive metamorphosis, and that by which the tissue of organs is converted into force is called regressive metamorphosis.

USE OF ALCOHOL IN DELAYING THE DESTRUCTION OF TISSUE.

Now it is often advisable to diminish the destruction of tissue without, at the same time lessening the force which would otherwise be derived from its full continuance, or it may be necessary to obtain a great amount of force from an individual in a limited period. In alcohol we have an agent which, when judiciously used, enables us to accomplish both these ends, together with others scarcely less important, which will be alluded to more at length hereafter. The action of alcohol, in limiting the destructive metamorphosis of tissue, will be best illustrated by an example. Let us suppose that a workman laboring twelve hours a day upon a diet consisting of 10 ounces of meat and 16 of bread, finds that he loses weight at the rate of one ounce a day. Now in order to preserve his health and perhaps even his life, he must either take more food or he must lessen the waste of his tissues. Meat and bread are expensive, and he finds it difficult to obtain them; or, what is not at all improbable, the quantity that he eats is as much as he has any appetite for or can digest. The alternative presented to him is to work less. If he is his own master this would be an excellent way of getting rid of the difficulty. He would shorten the period of his labor to ten hours, and then, instead of losing weight, he would hold his own, or perhaps gain an ounce a day. But it may be that this alternative is not open to him—he must work 12 hours a day. In this condition of affairs he takes a mug of porter or a glass of wine, or, what would be worse, a dram of whisky, after his midday meal. He finds that he is pleasantly exhilarated, his vigor is increased, and he labors on to the close of his task contentedly; and when it is concluded he is more cheerful and less fatigued than he has been before, when his day's work was ended. He returns to his home, and on weighing himself finds that he has lost but half an ounce. He repeats his experiment the next day; like results follow, and when he weighs himself he finds that he has lost nothing. The inference, therefore, is that the beverage he has imbibed has retarded the destruction of his tissues, and has itself aided in supplying the material for the development of the force he has expended in his labor. Now, it may be supposed that this is altogether a fancy picture based only upon assumption, like too many others which encumber science. In science, however, we believe nothing which is not demonstrated, and even then we do so provisionally, with the full understanding that if to-morrow new facts are brought forward which appear to be inconsistent with those upon which a favorite theory rests, and which are of greater weight, the hypothesis shall be abandoned without hesitation. Let us see, therefore, what evidence we have to support the view that alcohol retards the destruction of the tissues and supplies material for the generation of force. One of the products of tissue metamorphosis is carbonic acid. Many years ago Dr. Prout ascertained that after the use of alcohol the amount of carbonic acid excreted by the lungs was considerably reduced. Within the last few years other investigators have arrived at similar conclusions, after extending their inquiries to the other excretions of the system.

DR. HAMMOND EXPERIMENTS ON HIMSELF.

Desirous of ascertaining the facts for myself, I instituted a series of experiments calculated to determine the real value of alcohol as an aliment, or a substitute for aliment. Perceiving the difficulties attendant on such investigations when conducted on other persons, I performed these experiments on myself. They consisted of three series:

First: The influence of alcohol when the food was just sufficient for the wants of the organism.

Second: When it was not sufficient.

Third: When it was more than sufficient.

Four drachms of alcohol diluted with an equal quantity of water were taken at each meal. Not being an habitual drinker of alcoholic liquors in any form, the experiments were not open to the objection that they were performed upon a person hardened to the use of intoxicating beverages.

During the first series, when the food was of such a character and quantity as to maintain the weight of the body at its normal standard, I found, as the result of experiments continued for five days, during which time 60 drachms of alcohol had been taken, that the weight of my body had increased 226.40 ℔ to 226.85 ℔, a difference of .45 ℔. In the same period the amount of carbonic acid and aqueous vapor exhaled from the lungs, had undergone diminution, as had likewise the quantity of other excretions.

While these experiments lasted, my general health was somewhat disturbed, my pulse was increased to an average of 90 per minute, and was fuller and stronger than usual, and there was an indisposition to exertion of any kind. There was also headache and a sensation of increased heat of the skin. Later experiments, however, show that alcohol does not actually increase the heat of the body; so that the sensation of heat present after its use is one of those abnormal manifestations of nerve action met with in several other conditions of the system.

The inference to be drawn from these experiments certainly is that where the system is supplied with an abundance of food, and where there are no special circumstances existing which render the use of alcohol advisable, its employment as a beverage is not to be commended. But there are two facts which cannot be set aside, and these are that the body gained in weight and that the excretions were diminished. These phenomena were doubtless owing to the following cause. First: The retardation of the decay of the tissues. Second: The diminution in the consumption of the fat of the body. And Third: The increase in the assimilative powers of the system by which the food was more completely appropriated and applied to the formation of tissue. The quasi morbid results which followed are just such as would have ensued upon the use of an excessive amount of food or the omission of physical exercise when the body has become habituated to its use. If I had increased the amount of exercise taken there is no doubt there would not have been the undue excitement of the circulatory and nervous systems that was manifested.

The truth of these propositions is demonstrated by the second series of investigations, during which the food ingested was such as I had previously ascertained involved an average decrease in the weight of the body of .28 of a pound daily. Under the use of the alcohol not only was this loss overcome, but there was an average increase of .03 of a pound daily. The effects upon the exertions were similar to those which ensued in the course of the experiments of the first series.

But, unlike the first series, no abnormal results were produced in the general working of the organism. Digestion was well performed, the mind was clear and active, and there was no excitement of the circulating or nervous apparatus; in fact, all the organs of the body appeared to act with energy and efficiency. It is in similar cases, therefore, that the proper use of alcohol is to be commended; that is, when the quantity of food is not such as to admit of the due performance of such physical or mental labor as may be necessary, or (what amounts to the same thing) when the digestion or assimilative functions are not so efficiently performed as to cause the digestion and appropriation of a sufficient quantity of the food ingested to meet the requirements of the system.

In the third set of experiments, in which more food was taken than was necessary, the ill effects of the alcohol were well marked. Headache was constantly present, the sleep was disturbed, the pulse was increased in frequency and force, and there was a general feeling of *malaise.* I am sure that had the experiments of this series been continued I should have been made seriously ill. Notwithstanding all these abnormal phenomena, the body continued to increase in weight above the ratio which existed before the alcohol was taken, and the excretions were diminished in quantity. After such results are we not justified in regarding alcohol as food? If it is not food, what is it? We have seen that it takes the place of food, and that the weight of the body increases under its use. Any substance which produces the effects which we have seen to attend on the use of alcohol is essentially food, even though it is not demonstrable at present that it undergoes conversion into tissue. If alcohol is not entitled to this rank, many substances which are now universally placed in the category of aliments must be degraded from their positions.

A COMPARISON BETWEEN ALCOHOL AND ORDINARY FOOD.

Alcohol retards the destruction of the tissues By this destruction force is generated, muscles contract, thoughts are developed, organs secrete and excrete. Food supplies the material for new tissue. Now, as alcohol stops the full tide of this decay, it is very evident that it must furnish the force which is developed under its use. How it does this is not clear. But it is not clear how a piece of iron deflects a magnetic needle when held on the opposite side of a stone wall or a feather bed. Both circumstances are ultimate facts, which for the present at least must satisfy us. That alcohol enters the food and permeates all the tissues, is satisfactorily proven. Lallemand, Peron, and Duroy contend that it is excreted from the system unaltered. If this were true of all the alcohol ingested, its action would be limited to its effects upon the nervous system, produced by actual contact with the nervous tissues, but there is no more reason to suppose that all the alcohol taken into the system is thus excreted from the body than there is for supposing that all the carbon taken as food is excreted from skin and lungs as carbonic acid. It is not at all improbable that alcohol itself furnishes the force directly, by entering into combination with the first products of tissue decay, whereby they are again assimilated without being excreted as urea, uric acid, &c. Many of these bodies are highly nitrogenous, and under certain circumstances might yield their nitrogen to the construction of new tissue. Upon this hypothesis, and upon this alone, so far as I can perceive, can be reconciled the facts that an increase of force and a diminution of the products of the decay of tissue attend upon the ingestion of alcohol.

With these imperfect remarks relative to the general influence of alcohol upon the body, I proceed to the consideration of the special subject of inquiry, the effects upon the nervous system. The general action of a large dose is shown in the following experiment.

EXPERIMENTS ON DOGS.

I caused a dog to take into its stomach three ounces of strong alcohol diluted with a corresponding quantity of water. Immediately on receiving it the animal retired to a corner of the room and lay down. At the end of five minutes I endeavored to make it walk about the ap rt nent, but it did so with evident reluctance, though up to this time the gait was not staggering. I should have stated that I detected alcohol in the expired air in forty-eight seconds after administering the liquid. After eight minutes the dog walked with some difficulty, and on carefully examining the gait I found that the posterior extremities were beginning to be paralyzed. This paralysis gradually increased, the gait became more and more staggering, and at the end of fourteen minutes the animal could no longer stand. The paralysis had now reached the anterior extremities.

Sensitiveness was still present, though evidently lessened in acuteness, loud noises were perceived, and the eyes were involuntarily closed when the motion of striking was made before them. The respiration was hurried, and the action of the heart was greatly accelerated. The pupils were at first contracted, but became dilated in about 15 minutes, and remained in that condition throughout the experiment. In 30 minutes the animal was in a state of profound coma. Sensibility even of the cornea was abolished, the limbs were in a state of complete resolution, the respiration was hurried, the heart beat rapidly but feebly, and the temperature had fallen from 101°, which it was before the ingestion of the alcohol, to 98.5°. The animal remained in a comatose state, and died in one hour and twenty-two minutes after the ingestion of the alcohol.

In this experiment the alchohol was administered in such a large dose that the period of excitation which generally follows in a few minutes was altogether prevented. In the following experiment the quantity was smaller, and the sequence of phenomena was more regular.

I introduced into the stomach of a large dog an ounce of alcohol diluted as before. Nothing occurred worthy of notice during the first few minutes. Then the heart was accelerated, as was also the respiration, and the pupils became contracted. Sensibility and the power of motion were unaffected. In twelve minutes the gait of the animal became uncertain, the limbs were lifted higher than was natural, and the body swayed from side to side, and occasionally strong efforts had to be made to maintain the erect position. The pupils were still contracted, and sensibility appeared to be intact. This condition lasted 22 minutes, and then the pupils began to dilate. The posterior extremities were so far weakened as to render locomotion impossible, and the sensibility of the posterior parts of the body were materially impaired. The respiration was very irregular. The pulse was still rapid, but weaker than at first. In a little less than an hour the animal was in a state of light coma, which lasted about 20 minutes. Recovery took place gradually, the phenomena of intoxication disappearing in an inverse order to their supervention.

Observation of the symptoms which ensue when alcohol in sufficient quantities is given animals shows that the condition of intoxication may, as Marvaud proposes, be divided into these periods or stages:

1. *Period of Excitation*—Uncertainty in the movements, acceleration of pulse and of respiration, contraction of the pupils.

2. *Period of Perversion*—Muscular paralysis, beginning in the posterior extremities, irregularity of pulse and of respiration, dilation of the pupils.

3. *Period of Collapse*—Complete paralysis of motion, anæsthenia, feebleness of the pulse and of respiration, stoppage of respiration and of the heart's action, death.

Now, I was desirous of knowing how much of this condition was due to the presence of alcohol in the brain, and how much to disturbance in the quantity of blood normally present in this organ. In other words, I wished to ascertain whether alcohol increased or diminished the amount of blood circulating within the cranium. For this purpose I performed the following experiments:

I trephined a dog and screwed a cephalohalmometer into the opening made by the trephine in the skull. I then administered an ounce of alcohol diluted as in the previous experiments. In fifty seconds I detected alcohol in the expired air; in four and a half minutes the respiration was accelerated, the action of the heart became more rapid and strong, and the pupils were beginning to contract, still there was no increase in the intra-cranial pressure, and I therefore knew that up to this time the amount of blood on the brain had not been increased. In six minutes and a half the dog's gait was staggering, and though his movements were uncertain there was no paralysis. The intra-cranial pressure was still unaltered.

The fluid remained stationary in the tube of the instrument till 17 minutes had elapsed. Then it began to rise slowly and with this increase in the intra-cranial pressure, paralysis of the posterior extremities supervened. As the amount of blood in the cranium became greater the paralysis extended, the pupils dilated and coma ensued. The return to sensibility and the power of motion was attended with a diminution of the intra-cranial pressure, and was probably directly dependent thereon. I repeated this very instructive experiment twice with similar results. The deductions to be made from them are that the first symptoms which result from the ingestion of alcohol are due to the presence of this substance in the brain, while the later phenomena are in part at least the results of cerebral congestion.

DISEASES CONSEQUENT ON USING ALCOHOL.

The lecturer then proceeded to show the sequence of symptoms in man resulting from taking alcohol into the system. This consideration was more particularly applied to the effects upon the nervous system, showing the successive symptoms supervening with increasing amount of doses and describing the various stages from transitory excitement to complete intoxication. The effects of doses of alcohol given to animals were noted in detail. A valuable portion of the address was a discussion of the separate conditions of delirium tremens, and of the diverse methods of cure indicated by such difference; in the one class of case the free administration of alcoholic stimulants being necessary to save the patient, while in the other class of cases such stimulants would only aggravate the disease. The characteristics of chronic alcoholism were then discussed, and the various symptoms considered. The causes of the destructive effects of alcoholic liquors are then investigated and Dr. Hammond thinks it probable that their impurity adds to their baneful properties. He goes on to say: It is very certain, however, that chronic alcoholic intoxication very rarely, if ever, ensues on the moderate use of the light German or French wines, or of those made in this country, when they are not fortified by the subsequent addition of spirit, and that it is still less apt to ensue from the temperate use of malt liquors. The diseases of the nervous system, which, in addition to those mentioned, the excessive use of alcohol induces, are very numerous. In an address such as this, the most that I can do is simply to enumerate them. When I say that it of all other causes is most prolific in exciting derangements of the brain, the spinal cord, and the nerves, I make a statement which my own experience shows to be correct. I have already spoken of the remarkable affinity which alcohol has for the substance of which these organs are composed. Experiments hitherto have only related to the brain, but I am able to show you that the spinal cord and the nerves likewise absorb alcohol to equally great extent.

For ten days I fed a rabbit largely every day with bread soaked in whisky. In the course of that time the animal received nearly a pint of good Bourbon whisky, and beyond being somewhat stupefied, it did not appear to be seriously inconvenienced. At the end of ten days the animal was killed. I then removed the spinal cord and all the large nerves, and treated them separately with distilled water after cutting them into small pieces. They were then thrown upon a filter and strongly pressed. The three separate portions of liquid extract were then distilled several times, and finally treated with quicklime and again distilled. In these, the test tubes, I have the products. This marked A is the distillate from the brain; this marked B is from the spinal cord, and this C, which, as you notice is scarcely more than a drop, is from the nerves.

ALCOHOL IN THE SPINAL CORD AND NERVES EXHIBITED.

The odor is of itself almost sufficient to show that each consists of alcohol, but we have in the solution of bichromate of potash in sulphuric acid, a more trustworthy test. To show you how delicate it is, I take a test tube containing a little of the test and pass into it a current of air slightly impregnated with the vapor of alcohol. As you perceive the characteristic reaction, the production of a green color at once ensues.

Now, I take the test tube marked A which contains the distillate from the rabbit's brain and I allow a drop or two of the test liquid to mingle with it. A dark green color is at once produced, and it is rendered visible to every one in the room as I disturb the mixture with a little distilled water.

Next, I take the tube marked B which contains the liquid derived from the spinal cord. It is smaller in quantity than that from the brain, because the cord is much smaller than the brain. I pour on it a drop of the test liquid, and again you see the bright emerald green color is formed.

Finally, we examine the distillate from the nerves. The quantity here is extremely small, but the test shows it to be alcohol. So far as I know alcohol has never been before detected in the spinal cord or substance of the nerves of animals which had been fed with it. Neither has it been found in these organs in man. That it is there, however, in alcoholics, there can be no doubt.

We are now prepared for the long list of diseases and disorders of the nervous system produced by the excessive use of alcohol. The catalogue is made up from my note-books, and is based on cases occurring in my private and hospital practice:

OF THE BRAIN.

Cerebral congestion.
Cerebral hemorrhage with its consequences, apoplexy and paralysis.
Meningeal hemorrhage.
Cerebral thrombosis.
Softening of the brain.
Aphasia.
Acute cerebral meningitis.
Chronic cerebral meningitis.
Abscess of the brain.
Multiple cerebral sclerosis, one of those diseases of which tremor is a characteristic symptom.
Every variety of insanity, including general paralysis.

OF THE SPINAL CORD.

Spinal congestion.
Antero lateral spinal sclerosis.
Posterio-spinal sclerosis (Locomotorataxia).

CEREBRO-SPINAL DISEASES.

Epilepsy.
Chorea.
Multiple cerebro-spinal sclerosis, another of those affections characterized by tremor.
Athetosis, a remarkable disease which I was the first to describe, and which is now well recognized both in this country and in Europe. The case on which my description was based was one in which the patient was in the habit of drinking sixty glasses of gin daily.

OF THE NERVES.

Anæsthesia.
Paralysis agitans.
Neuralgia in all situations.
Neuritis.
Neuro-sclerosis.

It will be noticed that sclerosis or hardening is a condition of all parts of the nervous system which alcohol probably often produces. It is doubtless the result of the direct action of alcohol on the nervous tissue.

In addition to being the exciting cause of many diseases of the nervous system, alcohol probably predisposes to various others in which no direct relation can be traced. Neither does its action stop here, for the descendants of persons addicted to the excessive use of alcohol are liable to various disorders of the nervous system.

WHAT CONSTITUTES EXCESS.

Doubtless you have observed that my remarks relative to the evil consequence of alcoholic potations have been based upon the excessive use. It would be only fair for you to ask me what constitutes excess? And if you did, I should answer that, in the abstract, I do not know, any more than I know how much tea or coffee any one of you can drink with comfort or advantage, how many cigars you can smoke without passing from good to bad effects, how much mustard on your beef agrees with you, and how much disagrees, or how much butter you can eat on your buckwheat cakes. In fact I do not know that you can use any of these things without injury. For to some persons tea and coffee and tobacco and mustard are poisonous. Every person must, to a great extent, be a law unto himself in the matter of his food. No one can *a priori* tell him what and how much are good for him. A single glass of wine may be excess for some individuals, while to others it fills a rôle which nothing else can fill. That alcohol even in large quantities is beneficial to some persons, is a point in regard to which I have no doubt; but those persons are not in a normal condition, and when they are restored to health their potations should cease. I have seen many a weak, hysterical woman drink a pint of whisky or brandy a day without experiencing the least intoxicating effects, or even feeling excited by it. The exhausted tissue has seemed to absorb it with an energy as though it were its one thing craved, and recovery has been rapid under the use when all other means have failed. I have seen strong men struck down with pneumonia and fever, and apparently saved from the grave by brandy or other alcoholic liquors. I have prevented epileptic seizures by its moderate use. Neuralgic attacks are often cut short by it, and sometimes entirely prevented. It has been efficacious in catalepsy, and in tetanus it is one of the best antidotes to the bites of poisonous serpents, as I have repeatedly witnessed: in the convulsions of children from teething and other sources of reflex irritation it is invaluable; in the spinal irritation to which women, and especially American women, are so subject nothing takes its place, and in certain forms of gastric dyspepsia it must be given if we wish to cure our patients.

DANGER OF EXCITING ALCOHOLIC THIRST.

You know all this as well as I do, and you know that I have by no means mentioned all the diseases in which so far as our knowledge goes, alcohol in some form or other is the sheet-anchor of our hopes. I would not like to be cut off entirely from the use of alcoholic liquors in my practice, and yet I often try to do without them, for I am fearful of exciting a thirst which will not stop at my bidding. Still, when they are clearly indicated I give them without self-reproach, feeling that I have done my duty, and that I am no more responsible for the consequences of any after abuse than I should be for the shipwreck of a child whom I had in good faith, and with the object of contributing to his welfare, sent on a voyage to Europe. I would not send my son to Europe to be educated if I could in all respects educate him equally well in this country; neither would I prescribe alcoholic liquors if I could do without them. I know that I am digressing from my subject, but in view of the great importance of the whole matter, I ask your indulgence for a little further wandering.

With reference to the moderate use of alcoholic liquors, it must be remembered that we are not living in a state of nature. We are all more or less overworked; we all have anxieties, and sorrows, and misfortunes, which gradually in some cases, suddenly in others, wear away our mind and our bodies. We have honors to achieve, learning to acquire, and perhaps wealth to obtain. Honors and learning and wealth are rarely got honestly without hard work, and hard work exhausts all the tissues of the body, and especially that of the nervous system. Now, when a man finds that the wear and tear of his mind and body are lessened by a glass or two of wine at his dinner, why should he not take it? The answer may be, Because he sets a bad example to his neighbor. But he does not. His example is a good one, for he uses in moderation and decorum one of things which experience has taught him are beneficial to him. And why should he shorten his life for the purpose of affording an example to a man who probably would not heed it, and who, if he did, is of less value to society?

None of us defend dram-drinking. It is a vile, a pernicious practice, but the instinct that drives men and even women to it is human, and we must take it as it exists, just as we are obliged to recognize other instincts fully as vile and pernicious. The inborn craving for stimulants and narcotics is one which no human power can subdue. It is one which all civilized societies possess. Among the earliest acts of any people emerging from savagery is the manufacturing of an intoxicating compound of some kind, and one of the first things a colony establishes is a grog-shop. It was, as Dr. Chambers remarks, "an awful outburst of nature" when out of 500,000 men who took the pledge in the United States 350,000, according to *The Band of Hope Review*, "broke it;" and he very pertinently asks, "Have the same proportion ever broken vows of chastity or any other solemn obligations?"

But if we cannot overcome the instinct by prohibitory laws, we can regulate it and keep its exercise within bounds. My own opinion is that the best way to do this is by discriminating legislation in favor of wines and malt beverages and against spirituous liquors. I would make it difficult to get whisky and at the same time easy to procure beer, and I would likewise offer every encouragement to the growth of the vine and the hop. Experience has shown that total prohibition while failing to a great extent in practice, drives men and women to opium and Indian hemp, substances still more destructive to mind and body than alcohol.

DIPSOMANIA OR METHOMANIA.

Another point seems to require notice. There is a condition, a form of insanity it may be, known as dipsomania, or, more properly methomania. It is described as consisting in an irresistible impulse to indulge in alcoholic liquors. Doubtless there are individuals who, while recognizing the injury which excessive indulgence in alcohol inflicts upon them, are, in a great measure, powerless to control their morbid appetite. At one time they might easily have refrained, but frequent yielding, and perhaps also the direct action of alcohol on the brain, have so weakened their volitional power that restraint is well-nigh impossible. Probably many who pass for ordinary drunkards are in reality methomaniacs. Indeed, I suppose there are very few of those who are habitually more or less intoxicated who in their more sober moments will not lament their inability to abstain, and curse the feebleness of will and the strength of the appetite which keep them drunkards. For all such the lunatic asylum is the proper place, so long as they commit no outrage on the persons or property of others. If they plunge into crime punishment should follow with as much certainty as for sober criminals. As for confiding in the honor of such persons and allowing them to range at large while nominal residents of an inebriate asylum, I regard it as the uttermost kind of folly. What would we think of the wisdom and prudence of a superintendent of a lunatic asylum who would trust to the honor of a patient who had previously attempted suicide, and allow him to go at large on his pledge not to kill himself? And yet this is essentially the nature of the discipline at inebriate asylums. I have never seen a drunkard cured by this kind of restraint, and I have seen many who have told me how readily, while patients in such institutions, they found liquor enough to keep up the desire for more.

Gentlemen of the Neurological Society, I am afraid I have greatly trespassed on your patience, and yet I have very incompletely fulfilled the task I set for myself. To consider the subject of this address with even moderate fullness of detail would require more time than I have to give and much more than I would venture to ask of you. Many of you are, I am sure, much more capable of doing it justice than myself, and I leave it in your hands, confident that it will be elaborated with a completeness worthy of its importance.

As to the influence of alcohol over other parts of the body, and many of its more important relations to the system at large, I have not even alluded, as they did not come within the scope of the limits I have adopted.

There is much for us to do in the department of neurological medicine, to which from time to time your attention will be invited. There is not one among us who cannot contribute an idea of value to the rest. I ask you therefore to show your loyalty to the Society and your devotion to the cause of scientific medicine by freely interchanging such suggestions as may occur to you in the daily exercise of your profession. Remember that facts should come before theories, and that though an hypothesis may suggest a practice, hypothesis by itself is the dreamiest of scientific rubbish. With your aid and forbearance I hope to discharge to your satisfaction the duties of the honorable office to which I am called by your partiality.

THE DISCUSSION.

REMARKS OF DR. WILLARD PARKER.

Dr. Willard Parker, who was present during the delivery of the essay, was invited by Dr. Hammond to give his views upon the subject discussed, and responded as follows:

I should not be willing to take up much of the time of the Society, and should simply say I am very happy of this opportunity of being present. I have heard your address with very great pleasure, and in most points I should agree with you, though in some points I should differ. There is one point I am extremely glad to see brought up before this Association. I do not propose to speak evil of this matter of temperance. There are many men of many minds, and many women, too. We will simply let them have their way. The temperance movement of the last half century has undoubtedly accomplished a great deal. Its purpose has been to accomplish it simply upon the basis of moral suasion, and then they have intended to influence legislation to a certain extent. I say nothing about that, either as opposing it or advocating it. There is no subject before the public mind to-day so important as that of the use of alcohol, not only in our own country, but in all countries. In the northern regions we find more of the stronger distilled liquors used than in the low latitudes. There of course they are using their light wines, unless you come to Germany, where they are drinking beer. The starting point appears to be, first, What is alcohol? I fully concur with you as to its being a poison. Others have experimented upon the subject besides yourself, and all seem to have arrived at the same conclusion.

But because it is a poison gives no one a license to say that it may not be used with the opposite effect at proper times. It is one of the most valuable medicines we have, but as to the advantage or disadvantage of every corner shop here or in Brooklyn practicing in this matter and dealing out this liquor, that is another question, and we shall leave that for the present. The important point here is the scientific aspect, and on that is the stand our professional brethren should take.

The question we have to decide is, first, "What is alcohol?" and then the great question, in the second place, which you, Sir, have handled so ably, is "What does it do to you or to me?" The point is as to alcohol —its use, and what it does to the individual. I am not prepared to agree entirely with the proposition you advocate so strongly, that alcohol produces force. I do not understand it so, and I understood you to say you did not account for it, but simply assumed it does it. It may do it and it may not. I am not ready to assent to that proposition; I am not prepared to say I shall not assent. My views have greatly changed of late years in regard to this matter. When I first took up this subject, if a patient came under my charge pretty well worn down by drink, I knew I had an exceedingly bad subject to manage. One of our first questions is, what kind of a constitution does the individual bring to us, and we recognize, if he is a toper, that he is a bad subject.

I have followed on and followed on, and I have reached a point like this. I don't see how we can make food out of it; but what place can we give it in the dietetic department? My feeling is that no individual system in health is benefited by the introduction of alcohol, but it is not always easy to decide what is health precisely. But when there is feebleness in the system, from age or sickness, and food is to be taken into the stomach, the stomach requires power to convert it into the proper condition to become proper, nourishing blood, I have conceived that, in a person taking that substance into the stomach, by the use of a certain quantity of alcohol, in the shape of wine, or beer, or brandy, the food will, with the presence of the brandy, have a perfect assimilation. In that way it is entitled to a position. I have a chimney in my house, for example, which does not draw very well. That resembles the old man. I put in a little kindling wood, in addition to the other fuel, and by that I get a good fire, and am extremely comfortable. I don't know about it exactly, but I learn from the experiments of these gentlemen that when alcohol is introduced into the stomach it arrests the process of digestion. About the nitrogenous substances I am in doubt, but I fancy it does not do a great deal with the starchy substances. In persons who eat a great deal of meat and drink alcohol, it arrests the process, and after a time the stomach will evacuate itself, and the pieces of meat come up hardened. When the alcohol is taken into the stomach before the food is taken in, it acts upon the pepsin and hardens that. Some French physicians say it passes through without being changed, like an atom which gets into the eye; when it is removed it is unchanged, and the eye quickly recovers. Then other persons are very strongly of the opinion, and I think Dr. Duprey proves, that only a limited quantity of it passes away, that a portion is retained in the stomach. What becomes of that portion? That is not yet settled in my mind. I want to see this subject carried forward in this Society, and if possible to assign to alcohol its true, legitimate, effective position in the materia medica in the world. It has been proved by workers in all kinds of employments as well as by those who were traveling in high latitudes, that their health failed, so that even the insurance companies have been looking to it. There is a fearful cutting short of life and usefulness by the habitual use of alcoholic drinks. I mean wine and the whole list. If there is any difference between wine and rum. there is an article in each which produces the effect. The other ingredients are like the clothing we have on; it may be Winter or Summer clothing. When you come to the matter of beverages, I suppose, as about 80 parts of the body are water, water is the only beverage on earth that repairs the system. You take the milk that we get from the mother's breast. It is only water we have, though there is also sugar and casein. I am exceedingly anxious to see this go on. I will talk with you some other time about the cure of inebriates, for I don't agree with you there. We want a military management of these fellows, as we have at West Point. They are to be re-educated. and moved at the tap of the drum.

Dr. Hammond—If you can treat them as soldiers and lunatics, I think you can cure them. I don't say that chronic alcoholism is absolutely incurable. I say the present inebriate asylums will not cure them. That is, according to my experience.

Dr. Parker—The inebriate asylums have been very great instructors. I find there are three classes of inebriates. One class is made up of respectable gentlemen—young men or the heads of families, who have yielded to a social feeling. and by that have got to a certain point where they cannot live without liquor. Their will power is gone. There is another class where the desire is inherited, and who have their fits once a month, or once a year. In all creation, no human power can restrain them. I have known it to come on from the individual's going into an apothecary-shop and picking up a cologne-bottle and smelling it. Then we have a third class, many of them raised in our cities, the children of those who have suddenly come to wealth, children who have no true education; who feel that having money they must get the worth of it. The only thing that can be done for them is to have a place for incurables, and place them there in order to protect their families and friends.

REMARKS OF DR. J. C. PETERS.

Dr. J. C. Peters—I have but few remarks to make. I have paid but little attention to the subject of late; but 30 years ago—in 1844—I made many post mortems on the cadaver of drunkards, and in many of those cases I was surprised to find the small amount of injury done to the stomach where alcohol had not been used in large quantities; but when taken to excess the appearance was certainly as great as that referred to by Dr. Lente as being hemorrhagic. The amount of hemorrhage found in the mucus membrane of the stomach, bowels and bladder, is certainly extensive, and the injury was very great. I regard the effect of alcohol in larger quantities upon the stomach as very little short of a corrosive poison. The shock is almost equal to that of a surgical shock, and is very much like it. It occurs in the course of a very few hours; and I presume that shock falls upon the great solar plexus, although I presume the injury to the mucous membrane of the stomach itself is very great. We can find a smal quantity of alcohol in the peritoneum: we will not find it lower down in the bowels, as it is absorbed very rapidly.

Experiments, Mr. President, similar to those which you have performed, in which alcohol has been detected in the brain, are numerous. Christison and others have extracted a quantity of alcohol sufficient to be burned, as we burn it usually in a lamp. I might say a few words upon the point which you have especially noticed in connection with your account of my experiments, namely, the great firmness of the brain of one who has used alcohol to excess. It was a fact which struck me very forcibly. We know that alcohol will coagulate albumen. The brain substance is composed in a great degree of albuminous substances, and it is the great affinity of alcohol for the albumen which, I presume, is the grand reason why the brain is so often found in this hardened condition. We know also that alcohol is a stimulant; that it stimulates the stomach and improves digestion. It will increase the quantity of the gastric juice which is thrown out, and this operation of the stimulant will help many a weak stomach to digest food which would otherwise lie in an undigested mass. Alcohol in excess causes the pepsin to be precipitated, and digestion is stopped. I have been exceedingly cautious in advising alcohol for any sick person, especially in the case of women—nervous, hysterical women—because I am so fearful of establishing a habit of using it; but when I do prescribe it, it is for the purpose of food. I never allow alcohol to be taken on an empty stomach under any circumstances. I prescribe it in fixed quantities, as I would arsenic, and when its work is finished I order it stopped, as I do any other medicine after it has accomplished the object for which it was intended to be administered. I was also, at the time I speak of, 30 years ago, struck with the infrequency of tubercular diseases in drunken persons, and those who died from an excessive use of alcohol. The system of giving alcohol in this disease has gradually worked its way into the profession until whiskies and spirits of all varieties is almost an established treatment in diseases of a tubercular character.

Dr. Alonzo Calkins thought that in making these experiments with alcohol an excessive quantity had been used, as much often as two ounces of pure alcohol. The result would be expected to be different if one half-ounce were used. It is analogous to taking an immoderate quantity of food in the stomach; a portion is absorbed, while the greater part passes off in digestion, and only a part of it is appropriated. So it might be with alcohol; a small part of alcohol might be appro priated, but the greater part would pass away.

REMARKS OF DR. MEREDITH CLYMER.

Dr. Meredith Clymer, who was present by invitation, said: Dr. Parker put this question, "What becomes of the portion of the alcohol retained in the system?" in view of recent experiments showing that a portion of the alcohol taken into the system passes out, and a portion remains in. Now, that question is connected with the question of food. This is an interesting subject to us all. Dr. Hammond stated that he could not explain it, and it seems to me that these experiments are decidedly in opposition to the conclusion that alcohol is food. If it were food it would be assimilated; and yet we find by these novel and admirable experiments which Dr. Hammond has shown us, that after a certain time it is retained in the nervous tissues. I only wish these experiments had gone further, and that he had submitted to the same tests the other organisms of the body—the stomach, liver, &c.—and I am quite confident he would have found the same results—that they would have appeared in those tissues just the same as in the brain. The experiments are of great value particularly in regard to these hemorrhages—one of the most common of post-mortem results. What have these observations of osteology shown; that the portion of alcohol retained in the system acts directly upon the nerve tissues, and upon what tissues? First, upon the cellular tissue; then adventitious tissue is gradually substituted for the healthy tissue. We find this takes place in the stomach, the liver, and the brain, and that probably accounts for the hardening process. The first post mortems which I made were in 1843. Some were men who had died from chronic alcoholism. In several cases the odor of alcohol was very strongly perceived on the removal of the cerebral membrane, and its presence in one if not in two cases was shown positively by chemical tests. The change in tissue takes place by the direct poisoning of this tissue. Then comes the effect of mechanical pressure, as well as the vital action of this poisoning upon the essential tissue of these organs. That is a granular fatty degeneration. We have therefore a twofold result or fatty degeneration, in the first place, and secondly, not only a hardening but a substitution of tissue. It has been shown that there is an inflammation upon the surface of the brain and surrounding the membrane, as in the ordinary cases of general paralysis. We have known of this fatty degeneration, but it was not until recently that we knew that this extended to the nervous centers.

Remarks were also made by F. D. Lewis, M. D., of Cold Springs, N. Y., and Dr. Roberts Bartalow of Cincinnati.

THE TRANSIT OF VENUS.

PREPARATIONS FOR OBSERVATION BY DIFFERENT NATIONS.

A BRIEF ACCOUNT OF WHAT OTHER NATIONS ARE DOING—ORGANIZATION OF THE UNITED STATES COMMISSION FOR THE WORK—DETAILS OF THE ARRANGEMENTS FOR THE EXPEDITIONS.

[FROM AN OCCASIONAL CORRESPONDENT OF THE TRIBUNE.]

WASHINGTON, May 7.—A review of the preparations which different nations are making, including our own, for observing the coming transit of Venus, will be found somewhat gratifying to our national vanity. England has selected five stations to which she will send parties. She has now the ship Challenger inspecting islands in advantageous locations in the South Indian Ocean. There will probably be two stations in the Sandwich Islands, one of which will be at Woahoo, for the purpose of observing accelerated ingress (that is, for taking observations at a station which, from its geographical position, will be among the first where the approach of the planet to the sun's disk is visible), and two others at Kerguelen and Rodriguez Islands, for retarded ingress (that is, for observations from a station among the last from which the approach can be perceived); another at Auckland for accelerated egress, and a fifth at Alexandria for retarded egress (those stations being among the first and last where the departure of the planet from the sun can be observed); the two parties at the Sandwich Islands being considered as occupying one station.

The estimates submitted by the Astronomer Royal were for the Woahoo detachment, $12,500; for Rodriguez and Kerguelen's, $10,000 each; Auckland, $5,000, and Alexandria, $3,750; making a total of $41,250. A grant of $52,500 was made in May, 1869. Troughton and Simms make the instruments, and Dent the clocks for all the parties. The Cambridge Observatory lent two, and Mr. De la Rue one, of the telescopes to be used. One of the equatorials was the one formerly used by Admiral Smythe.

ENGLISH METHODS AND INSTRUMENTS.

The buildings for the instruments are substantial structures, stout wooden framework covered with weather boarding, and roofed with zinc and roofing felt Each instrument has a separate building, those for the transit instruments being 10 feet square, with walls six feet high. The alt-azimuth huts are nine feet hexagonal, with a hexagonal dome on circular frames, with six rollers, to permit their being turned with the opening in the roof to any part of the heavens. The buildings are made portable by being constructed in sections, which are connected together by bolts and nuts. For the transit instruments massive Portland stone piers will be provided, with foundation slabs. For the alt-azimuth, stone pier caps only will be sent out, leaving the piers to be provided on the spot. The sources of their personnel are the officers of the Royal Artillery, the students of the Naval College, and some private individuals who are now undergoing a preliminary drill at Greenwich. Photographic observations will be made at Peshawar in Northern India, and Lord Lindsay has equipped a party at his own expense to observe the transit from the Island of Mauritius.

There was a belief current among astronomers that photography could not be used where the photographs were afterward to be subjected to such rigorous measurements as are necessary to give us a more accurate value of the solar parallax than we now possess; or in the words of our own Mr. Rutherfurd, "The photograph of the sun will have a greater or less diameter by many seconds of arc, according to the energy of the rays which have produced the image; and this discrepancy may be produced by a change in the aperture, in the length of the time of exposure, in the transparency of the atmosphere, in the hour of the day, or in the sensibility of the chemicals." Accordingly, the position of Venus on the sun's disk must not be measured from the limb of the sun, but from its center; and it is now found that the probable error of measuring the position of Venus, as given by Prof. Hall, will be about twelve-hundredths of a single second of arc, which is about the one-fourteen-hundredth of the whole diameter of the sun, which is certainly within the probable error of an observation, by the eye, of a contact.

As soon as it became evident that photography would be an important auxiliary, England ordered of Mr. Dallmeyer five photo-heliographs, built under the direction of Mr. De la Rue, whose object-glasses, four inches in diameter, give an image of the sun about half an inch, which is afterward enlarged to four inches in diameter. The whole apparatus, unlike the American photographic apparatus, is moved by clock-work, and mounted in the usual equatorial style; and for the purpose of defraying the expenses of the photographic apparatus $25,000 additional has been appropriated.

RUSSIAN, FRENCH, AND GERMAN PREPARATIONS.

Russia will occupy twenty-seven stations, stretching across her Siberian possessions, about 100 miles apart, from Kamschatka and from the Black Sea. The equipments of the individual parties will not be as complete as either the English or American, and it is the design to determine the geographical position of the stations by the geographical survey, which will use a line of telegraph through Siberia to Nicolaevsk, to determine the longitudes. An appropriation of $52,500 has been made to defray expenses.

The French Commission before the Franco-Prussian war recommended to the Bureau des Longitudes the occupation of St. Paul's Island, New-Amsterdam, Yokohama, Tahiti, Noumea, Mascate, and Suez. Since the close of the war the subject has again been taken up, the French Academy has applied to the Government for aid, and under the head of "Public Instruction" a provisional appropriation of $20,000 has been made to be expended under the direction of a commission whose head is Alphonse Martin. Lately this appropriation has been increased by one-half.

Germany has decided to furnish four parties for heliometric observations—one in Japan or China, and the others probably at Mauritius, Kerguelen's, and Auckland Islands.

Other countries have made preparations on smaller scales, even New-South Wales granting $5,000, and, under the direction of Mr. Russell, establishing three parties at Sydney, Eden, and the third in the Blue Mountains, about 50 miles west from Sydney. Most of the European nations sending parties to comparatively unknown regions have attached a naturalist, and the expeditions in this way will contribute to the natural sciences as well as to astronomy. It would have been desirable to have had a naturalist attached to the United States parties had the funds of the commission having the matter in charge justified the necessary outlay.

AMERICAN PREPARATIONS.

In 1871 the United States Congress appointed a Commission to expend such appropriations as might be made for the observations of the transit of Venus. It consisted of the following members: Rear-Admiral B. F. Sands, Superintendent U. S. Naval Observatory; Prof. Joseph Henry, President National Academy of Sciences; Prof. Benjamin Peirce, Superintendent U. S. Coast Survey; Prof. Simon Newcomb, and Prof. Wm. Harkness, U. S. Naval Observatory. The Commission selected Admiral Sands for chairman, and it is to his warm sympathy with the cause of astronomical science, and to his executive energy in properly bringing the matter before our Government, that the thanks of American scientists are due; for with inadequate provision for defraying the large outlay necessary, we might have given reason for the doubt of De Tocqueville which Prof. Tyndall quoted to us: "The future will prove whether the passion for profound knowledge, so rare and so faithful, can be born and developed so readily in democratic societies as in aristocracies. As for me, I can hardly believe it." The letter of Admiral Sands, March 5, 1872, asking for $150,000 to be expended in three annual installments of $50,000 each, received the indorsement of the Secretary of the Navy, and the appropriations asked were granted by Congress. It was resolved to employ both photography and eye-observations of contact, and after discussion as to the various photographic methods proposed, it was decided to form the image of the sun on the sensitized plate by means of a fixed photographic lens, five inches in diameter, and having a focal length of about forty feet, reflecting the sun's light from one surface of a plate of glass, the plate being moved by clock-work, so that the rays of the sun, after being reflected from the plate, will always strike the photographic lens in lines parallel to the line connecting the center of the reflecting plate, the center of the fixed lens, the center of the sensitized plate. To carry out the methods of observation by the eye and ear, it was resolved to provide five-inch equatorials, furnished with micrometers, by which the distance between the two cusps of Venus could be accurately measured, as Venus entered upon and left the sun's disk.

The principal work of carrying out the views of the Commission has devolved upon those members of it connected with the Naval Observatory. After most of the arrangements had been completed, there was a change in the members of the Commission, caused by the retirement of Admiral Sands from active duty in the Naval Department on account of advanced age, and the resignation of the Superintendent of the Coast Survey. Both these gentlemen were retained as honorary members, and Rear-Admiral C. H. Davis, the present Superintendent of the Observatory, and Capt. Patterson of the Coast Survey, were added to the Commission.

OUR STATIONS AND INSTRUMENTS.

Eight stations were selected, and so far as is now known will be occupied as follows: Vladivostok in Siberia will be occupied by Prof. Hall of the Naval Observatory, with probably Mr. O. B. Wheeler of the Lake Survey as assistant. Pekin will be occupied by Prof. J. Watson of Ann Arbor. The Coast Survey party under Prof. G. Davidson, who retains Mr. O. H. Pittmann as first assistant, will occupy Nagasaki. Capt. Raymond of the United States Engineers will occupy Crozet Island, with Lieut. Tilman as assistant. Lieut.-Commanders Ryan and Train, U. S. N., will occupy Kerguelen's Island. Prof. Harkness of the Naval Observatory with Mr. L. Waldo of Columbia College, N. Y., as assistant, will occupy Hobart Town. Bluff Harbor, New-Zealand, will be occupied by Prof. C. H. F. Peters of Hamilton College, N. Y., assisted by Lieut. Bass of the U. S. Engineers. Mr. E. Smith with Mr. Scott as assistant, both of the Coast Survey, will occupy Chatham Island to the extreme east. Three photographers will be sent with each of the above parties, and all the members of the various parties are subject to the discipline of the Navy during their absence. All of the Southern parties and one of the Northern are now in Washington in active preparation for the transit.

Each party is supplied with an equatorial, a transit instrument so modeled as to be used as a zenith telescope at will, a clock, with chronograph, two box chronometers, a set of engineer's instruments, a magnetometer, a photographic outfit, a chest of carpenter's tools, supplies, &c.; and will carry with them three wooden huts, put up in sections, to be pinned and screwed together when they are needed by the observers. The instrumental outfit has been designed and constructed under the immediate supervision of Prof. Harkness, to whose accurate knowledge of the capabilities of portable instruments much of the success of the expeditions will be owing. Mr. Alvan Clark constructed the equatorials, the photographic apparatus, and the optical parts of the transit instruments, of which the other parts were made by Stackpole Bros. of New-York. The clocks were made by E. Howard of Boston, and the chronometers by J. S. & D. Negus of New-York. The magnetic instruments were made by Mr. Kahler of Washington.

The Southern parties will be conveyed to their destination by the U. S. third-rate sloop-of-war Swatara, under the command of Capt. Ralph Chandler. The Swatara usually carries nine guns, but will carry but one, a 60-pound Parrott, until she is through with the expeditions. She is now fitting up at the Brooklyn Navy-Yard. It is expected she will sail from New-York the last of May. Her route will include the Cape of Good

Hope, thence eastwardly, leaving parties at the stations named. While waiting for the observers to determine their geographical positions and to observe the transit, she will be employed in exploring some of the neighboring islands, or doing work for the Commission. Each party is provided with magnetic apparatus sufficient to determine the magnetic elements of their own station. Negotiations are now in progress having in view the telegraphic determination of the longitudes of the Northern stations, and Hobart Town, with possibly New Zealand, of the Southern stations. The longitudes of the isolated islands will be determined both by means of chronometers, and by observations of star occultations by the moon. Prof. Henry Draper has the management of the photographic part of the expeditions now well under way; and in his work he has derived much benefit from the early efforts of Mr. Walker, photographer to the Treasury Department, to provide only efficient photographers from among the numerous applicants for positions on the various parties.

THE ORIENTAL SOCIETY.

MEETING AT BOSTON.

A SESSION OF MORE THAN USUAL INTEREST—AN ETHIOPIC MANUSCRIPT PICKED UP IN THIS COUNTRY—PHŒNICIAN INSCRIPTIONS IN BRAZIL A FORGERY—CRITICAL EXAMINATION AS TO AUTHENTICITY, &C., OF THE OLD TESTAMENT—THE HEART, LUNGS, AND LIVER IN DIFFERENT LANGUAGES.

[FROM AN OCCASIONAL CORRESPONDENT OF THE TRIBUNE.]

BOSTON, May 21.—Be it known to such as are not acquainted with the facts, that the American Oriental Society was born in the year 1845, that it is therefore twenty-nine years old; that it has no less than 150 members, mostly college professors, literateurs, distinguished philologists, and explorers in the Oriental and the antique—all, however, wearing our American garb, and most of them speaking English without accent. Further, that it has a library in New-Haven of about 4,000 volumes, which is yearly enriched by exchanging its own publications with those of nearly every similar society in the Old World; that it is also in possession of several important Sanscrit inscriptions, and a valuable Greek inscription from Antioch, which is referred to the third century before Christ, not to mention a sufficient amount of trash which always constitutes the lumber of such societies. It is perhaps necessary to add—for nobody would discover it except by accident—that the Society holds two meetings each year, one generally at New-Haven in the Fall, and the other at Boston in the Spring.

The need of this explanation is found in the fact that this Society moves with muffled oars, and is enabled to steal back and forth from New-Haven to Boston without contributing in the slightest to the noise which exists in the vulgar world. A further explanation is that, like all polyglot societies, it is the perfect horror of reporters, and that the horror is to some extent reciprocal. Under these circumstances, it was not surprising that the annual meeting held May 20 in the rooms of the American Academy of Science and Arts, at the Athenæum, was small in point of numbers, and that it received little or no recognition from the daily press. Yet every other man of the twenty who were thus ignored was of scholarly or intellectual prominence, and the meeting was one of the most interesting the Society has held. I send you some crumbs that fell from the table.

There were present Prof. Edward E. Saulsbury, President of the Society, and formerly Professor in Yale College; Dr. Ezra Abbott, Recording Secretary of the Society, and Professor in Harvard Divinity School, one of the most accomplished biblical and classical scholars in the country; the Rev. Dr. A. P. Peabody, Professor of Moral Science in Harvard University; Prof. C. M. Mead of Andover; the Rev. Dr. Rufus Anderson, Secretary of American Board of Foreign Missions; the Rev. Selah Merrill of Andover, Prof. W. D. Whitney of Yale, Corresponding Secretary, known not only to all Oriental and linguistic scholars in this country and Europe for his original contributions to literature, but especially known to your readers as the correspondent of THE TRIBUNE with the Hayden expedition last year; the Hon. J. H. Trumbull of Hartford, the oracle on all matters relating to our Indian languages, and whose Yankee skill in untying philological knots seems almost intuitive; Dr. Wm. Hayes Ward, editor of *The Independent*, who, as an original explorer in Hebrew and Phœnician, never fails to contribute to the interest of the Society; the Rev. J. W. Jenks: Dr. Nathaniel Hoppen of Cambridge, Prof. Frederick Gardiner of Middletown, Conn.; Hon. Stephen Saulsbury of Worcester; Prof. Felix Adler, Professor of Oriental Literature in Cornell University, one of the youngest and boldest contributors of the Society; Dr. Dimmock of Quincey; Prof. Charles Carroll Everett of Harvard University, who has brought a rare genius for philosophy to the interpretation of the Oriental religions; T. S. Perry of Cambridge; and Ex-Mayor Russell.

The routine business of the Society was soon dispatched. The officers of the preceding year were all reëlected. The Rev. H. F. Jenks of Boston; Prof. Felix Adler of Cornell University; Charles P. Otie, Professor of Modern Languages in the Massachusetts Institue of Technology; Howard Osgood of Brooklyn, N. Y.; and Isaac S. Hall of New-York, were elected members. The necrology of the year shows the loss of Charles Astor Bristed, Prof. Alpheus Crosby of Salem, J. F. Meline of Brooklyn and Dr. Francis Mason, and called forth appropriate remarks from Prof. Whitney, the Rev. Dr. Peabody, the Rev. Dr. Anderson, and Dr. Ward.

WHO HAS LOST A MANUSCRIPT?

Prof. Whitney read the correspondence since the last meeting. A letter from the Rev. Charles H. Brigham of Ann Harbor, Mich., may result in finding the owner of a stray manuscript picked up last November on the premises of the Michigan Central Railway by a laborer. The manuscript is made of thin, soft parchment, in the form of a roll, and, according to Mr. Brigham's description, is a genuine Ethiopic document. It was conjectured by some of the members that the manuscript might have been obtained in Abyssinia by some one who accompanied the late English expedition.

The Rev. Mr. Trowbridge from Turkey gave an interesting account of arrow-headed inscriptions in the vicinity of Aintab, to which place he is about to return to establish a new college. In monasteries in the Taurus Mountains he had seen some very beautiful manuscripts in the ancient Armenian language. He expected great good would come from the establishment of the college, which might be regarded by the people as a repository for inscriptions and manuscripts. Mr. Trowbridge was encouraged by the Society to explore ancient ruins in the vicinity of his field of missionary labor, and to send home at the Society's expense whatever might be valuable.

The paper following was by Prof. Fiske P. Brewer, on the Greek inscriptions found near Beirout, which was published in the second number of the proceedings of the American Palestine Exploring Society.

Prof. Mead of Andover read a paper on the use of the Hebrew *Kol* with negatives. In Hebrew a universal negation is expressed by the use of this word (meaning all) with a negative particle. There is no compound word corresponding to our word "none" and "no." Grammarians have referred to but one passage in the Bible of a partial negation (Num. xxiii, 13). Prof. Mead undertook to examine all places in the Bible where *Kol* occurs with a negative. He examined 326 passages. Only six of these can be called cases of partial negation, and all but one of these occur in sentences in which *Kol* is made definite.

The remaining papers of the morning session were on the Chinese *Sien* as Constellations, by Prof. Whitney; on Certain Phœnician and Greek Inscriptions from Cyprus, by Dr. Ward; on the Hamath Inscriptions with remarks on Lenormant, also by Dr. Ward. Copies of these inscriptions were shown to members. Dr. Ward also remarked on a supposed Phœnician inscription found in Brazil purporting to have been left by mariners. He was entirely convinced that it was a forgery, though a very ingenious one. It was dated in the time of King Hiram, which would require a more antique form of letter than that which was used. Palæographically, it would hardly be older than the fifth century B. C. For an inscription so old as this purports to be, the state of preservation was remarkable, and another evidence of the forgery. Dr. Ward thinks this forgery may be an incident of the struggle between the Masons and the priests in Brazil, King Hiram being invoked by the former in this way to give antiquity to their claim.

The Society then took a recess from 1 to 2 o'clock. The afternoon session was more lively than that of the morning, and was distinguished for the bold, straightforward, and scholarly, yet courteous way in which Prof. Adler ventured to arraign previous methods of studying and interpreting the Old Testament. I select his paper from among others, because of its more popular and elementary character, and because, though presented entirely from a philological and philosophical point of view, its bearing on theology gives it a special interest to all classes of readers.

METHODS OF STUDYING AND INTERPRETING THE OLD TESTAMENT.

Prof. Adler, who spoke entirely without notes or manuscript, said: It seems to me that nothing is of so much importance in the range of Semitic study as a clear notion with regard to the chronology of the Old Testament. The question whether a certain part of the Old Testament was written sooner or later than some other part has a significance not only in the study of the Bible, but in Egyptology, in Indian studies, and in many different branches of research. Whatever can throw light upon it ought to claim the attention of scholars. The Professor then gave what his studies in Germany especially qualified him to present—an account of the status of opinion in regard to the exegesis of the Bible in Germany at the present day.

The view which obtained in the beginning of the century was that the book of Genesis, more especially, consisted of a number of fragments joined together by the hand of a later editor, but essentially fragmentary in its character. That was the hypothesis of Vater. He noticed the different accounts of the creation, the difficulties in the history of Joseph, certain other contrary stories and anachronisms, and solved the difficulty to himself by accepting the opinion which Geddes had pronounced before him—that we have here a collection of fragments bound together in a single volume. Astruc introduced a more plausible hypothesis to explain the same phenomena. He regarded the book of Genesis, and, later, the Pentateuch, as the work of a compiler, believing that Moses had before him certain old documents, from which he had selected as the occasion seemed to warrant. This represented Moses in the light of a modern editor, and this view did not gain the allegiance of scholars. Ewald, in denouncing this opinion, put forth his own view, that the prevalence of different names of the deity (Elohim and Jehovah) in different parts of Genesis, was due not to the fact that different authors had written different parts, but was to be attributed to the different terminology which the same author thought it proper to employ on different occasions. He endeavored to show that the names Elohim and Jehovah had their peculiar significance. Tuch's Genesis, a new edition of which has been prepared by Merx, with a prefatory postscript of his own, brought prominently before the world the supplemental hypothesis. Accepting the fact that the hands of different authors were to be seen in Genesis and the Pentateuch, he held that there was one principal record, and to this supplements had been made by the editor and compilers of the books. This hypothesis found favor with many until the appearance of Hupfeld's work created a new phase in Biblical criticism. He made divisions which have been essentially adherd to. First, the main distinction between Elohist and Jehovist; again, with regard to the first of these, a new division into first and second Elohist. We would then have first and second Elohist and the Jehovist. In order to combine these records of different authors he supposed an editor. In addition to this the book of Deuteronomy required its separate author. Here then, including the editor of Genesis, were five persons, to which was added later a sixth, who had joined the book of Deuteronomy and a great part of Joshua to the Tetrateuch. Although important additions and changes have been made, the basis of the work has not been altered.

Boehmer has made some important additions to this theory. He tries to explain different portions of the Bible from the fact that they originated in the Kingdom of Israel or of Judah. Graf applies the theories that have been applied to Genesis to the whole Pentateuch. He calls attention to a statement, which, if true, would be of the greatest importance in establishing the chronology of the Old Testament. He endeavors to show that contrary to the received opinion, the laws of Leviticus are not older than those of Deuteronomy, in which there appears nothing of circumcision, nothing of a day of atonement. Graf then endeavors to prove that the laws of Leviticus were inapplicable to any state of things which had existed in Israel before the time of the Babylonish captivity. He therefore fixes their date after the time of the exile.

What Prof. Adler especially desires to call attention to, is the fact that Graf deduces his propositions in a historical and archæological manner; that he enters into the subjects of the books and endeavors to show from general historical principles what can have been prior and what later. This change of method is of great importance. Hitherto literary peculiarities have taken precedence. But in the case of a book like the Old Testament, containing as it does the relics of the literature of a people, it always seems to be a very precarious thing to deduce important theories from peculiarities of style. The difference in style, excepting the later Chaldaic and the more degenerate style of Ezra, Daniel, and even Ezekiel, is not sufficiently pronounced to warrant important results. An exception may be made as to the change of meaning which is traceable in the history of words—a change which reflects the character of the time and the conditions of life. A good example is incidentally given by Geige in his Urschrift. The word *tsadek* (righteous), he thinks, came to mean a mighty man—a man of violence—in which sense it is used in Isaiah xlix., 24.

It seems to me, said Prof. Adler, that for all the labor that has been expended upon the criticism and exegesis of these books, comparatively scanty results have been obtained, scantier than the nature of the books or the high attainments of the men who have devoted their lives to this study should warrant. There is such diversity with reference to the composition of the books of the Bible that it shows how little the study of this chief part of Semitic literature has become a science. Thus, for instance, with regard to the second Psalm, two prominent critics differ as regards the time of its composition to the extent of an interval of a thousand years. Ewald attributes it to the time of King Solomon; the other critic, whose name escapes me, puts it a thousand years later. Another evidence of disordered criticism is found on the 118th Psalm, 10th verse. A certain modern critic thinks he must find the peculiar circumstances under which these words were written (" In the name of God I will cut them off"), and he tells us with a very sober face that it refers to Alexander Jannæus subduing the Idumeans and forcing them to enter the Jewish community. He would translate, "In the name of God I will circumcise thee."

With Graf I think we have entered the proper path. The proper way seems to be to study the archæology of the Jews—which is being done pretty well—and to study the principles of mental development and the laws of national development, and to attempt to apply them in the particular field which we cultivate ourselves. I do not see why we should hesitate to acknowledge that the greater has risen from the smaller, and the higher from the lesser. I do not see why we should hesitate to acknowledge that idolatry was practiced. The prophets tell us themselves that it was practiced, and I cannot conceive why we should be more scrupulous—if to deny it be more scrupulous—than the prophets themselves.

Now, wherever we have met with idolatry, we have found mythology. It would be strange indeed, if we should have idolatry in the Old Testament and not some relics of the ancient myths. Indeed, it would almost be derogatory to the character of prophecy to suppose such a thing, else where would be the superior nobleness and strength of conviction of the greatest of antiquity if they had not to combat the same difficulties among the Israelites as were found elsewhere?

I do not refer at length to the vast learning and splendid results of Geige. His labors in the field of Biblical criticism are of such great importance, and can be so little appreciated without an intimate knowledge of the later writings of the Jews, that I reserve a more extended discussion for some future occasion.

In conclusion, let me direct your attention to one thing more. It is the fact that the text of the Old Testament was preserved with such scrupulous care by the people, that mistakes made in multiplying manuscripts were perpetuated as well as the correct portions: and we are able now to detect many of these. In the 15th chapter of Exodus, for instance, I think it is clear that the 12th verse ought to be in the place of the 11th; the connection is then properly preserved. So Psalm lxxi., 3, is to be corrected according to Psalm xxxi., 4 (3d verse in Hebrew), and to be read *Beth Mezudot;* the mistake occurring from improperly dividing the lines into words. So in Job xxxiii., 21, "My flesh melts away so that it is no more seen, and my bones are dry: they are not seen;" the word for "seen" in Hebrew is *Ra-ah;* which probably, by the change of a letter, was substituted for *Ravah*, which means to "drink," and which, if restored to the text, makes the parallelism complete; thus, "My bones are dry because they have no drink."

An example of a mythological construction is the story of Achan. Any one who has ever read carefully the Book of Judges must be aware that the mental and social condition of the people there set forth does not permit us to suppose that a reign of pure monotheism preceded. The fact that Jephtha offers his daughter without any blame attaching to himself; the fact of a Levite serving as priest to an idol, gainsay this. The whole character of the book shows that the time of Joshua, as it is represented to us, is rather the picture of a golden age, rather an idealization than a historic period in the realistic sense of the word. Into this period the ideals of the people were projected. The word Achan at first sight seems to have no explanation in Hebrew. But we find that the name of the valley was Amek-Achor, "valley of wailing." We are elsewhere told that in this valley of wailing there was a huge heap of stones. The people had no explanation for this mass of stones thrown together. They sought one. Everybody who has traveled in mountainous countries knows how peculiarities of the country are personified. There, then, was a mass of stones as one element for a tradition; the "Valley of Wailing" furnished the other element. To connect these was simple enough. Amek-Achor was the valley of a man named Achor. The stones were easily associated with the Jewish custom of stoning offenders, and the priests, therefore, laid hold of this fact to impress upon the people the necessity of offering their booty to the synagogue by telling of the punishment which had befallen Achor. There seems to be some verification of this theory in the fact that in 1. Chron. ii., 7, this man Achan is actually called Achor. We should be apt to receive this very readily if it were a Greek myth. As it is a Hebrew myth I doubt whether it would be received as such. I do not offer it with any degree of certainty, but only as one of the means by which those who study the Hebrew books in the light of philology may in time arrive at conclusions which would be more certain than those of to-day.

DISCUSSION ON DR. ADLER'S PAPER.

Dr. Gardiner of Middletown came immediately to the rescue of the inspirational theory; but his good taste prevented him from precipitating a theological discussion. He simply rose in protest, and said he supposed that to take any view opposed to this would be to take theological grounds, which would be out of place. He supposed Prof. Adler had meant to present this view not as the prevailing view of German thinkers, but as the view of some.

Prof. Adler by no means wished to say that that was the generally received opinion in Germany; but it is the received opinion among the majority of writers, if he mistook not Not certainly what he stated in the latter part of his remarks. In what he had presented as more or less generally received he would pause with Graf. He owed to Gerge the view that the ideas of the later period were projected into the former part of Jewish history. He would mention Delitsch as a conservative, differing from those views, but conceding the fact that the Pentateuch was written by Moses while he asserted that there was a Mosaic kernel and a Mosaic spirit.

Dr. Hopkins of Cambridge, who by the way is a sound Episcopalian, had listened to Prof. Adler with a good deal of satisfaction. He thought the discussion entirely proper. As a literary society, it was interesting and instructive to have views of different schools of thought brought before them. He differed from Prof. Adler in a good degree, but was none the less gratified at his clear and learned exposition of a view which is taken by an important school of modern learning. Still he thought some of Prof. Adler's conclusions rather hasty and perhaps rash. He suggested that conjectural emendations of authors, whether sacred or profane, was at the present day one of the great sources of dissatisfaction and error.

HEART, LIVER, AND LUNGS, ETYMOLOGICALLY CONSIDERED.

The Hon. J. H. Trumbull read an interesting and original paper on "The Names for the Heart, Liver and Lungs." The drift of the paper, which exhibited great ingenuity as well as extensive research, was to show the primary and secondary ideas which are associated with the names for the superior viscera not only in the North American Indian languages, but in the European and Asiatic languages. The Chippewa *Opan*, Illinois *Apani*, denote the lungs of a man; and Chippewa *Abanini*, literally "lung man," one who is a slave or servant. To say that a man was "all lungs" was to call him an inferior being. The expression "He is lungy," means he is a dolt, he has no wit. It is so in the Sioux; *Chagu*, lungs, *Chaghuka* a fool. In Arrapahoe, *Kuna*, lungs; *Kunanit*, cowardly.

Take the word "pluck" in English. It has the double meaning of that which is plucked or pulled altogether from the outside of a slaughtered animal: it is then used for courage, spirit, energy, as to pluck up heart or spirit. Heart in the ancient Egyptian is a word denoting mental status and activities; so in the Hebrew and in the Chinese mental constitution; also desire and appetite. Of the latter the liver seems to have been regarded as the peculiar seat. The character for the heart, *sin*, enters into the composition of a great number of words. He found 1,097 beginning with the radical *sin*. In the Indo-European family we have everywhere the reference of the moral character, the will and emotions to the heart. By the Orientals the liver was regarded as the seat of the passions and the animal nature of man. Some Chinese writers make the lungs the seat of righteousness and the liver the seat of benevolence; mere vigor and courage seems to have been assigned to the gall.

The derivation of the French, Spanish, Portuguese, and Italian names of the liver (foie, higado, figado, fegato,) are from the figs with which the Romans used to stew the livers of geese. "It might pass," said the doctor, "for an etymological joke if it were not a fact."

In Chinese, "his lungs and liver" expressed his inmost thoughts. In many languages lungs are named for their lightness. The old naturalists held that the smaller the lungs in proportion to the body the greater the swiftness of the animal. Hence large lungs began to be associated with dullness, sluggishness. The notion of contempt attached to the lungs comes from this notion of lightness, lacking weight, then from the notion that the larger the lungs the slower the animal; and among the American Indians, from the fact that the lungs were the last part and the least worthy part, which was given away when an animal was divided at a feast. The least important guest received the lungs.

Papers were also read by Prof. Whitney on the *Anusvara*; by Prof. Saulsbury, an elegant translation from the German of Schnaase on Mohammedan art in its relations to the ideas of Islam; and by the Rev. Mr. Jenks on the identity of the Hebrew Shaddai and the Egyptian Suti. The Society, after passing a vote of thanks to the American Academy for the use of its rooms, adjourned to meet in New-York on the 30th of October.

SAFETY AT SEA.

IRON VESSELS THAT WILL NOT SINK.

PRINCIPLES OF CONSTRUCTION OF OUR OCEAN STEAMERS—METHOD ADOPTED IN NAVAL VESSELS AND THE GREAT EASTERN—THE CELLULAR OR DOUBLE SKIN SYSTEM.

Iron shipbuilding was made possible by Cort, who in 1784, or thereabouts, introduced his discovery for the manufacture of plates and bars of iron by the use of rolls. In the process of growth of a new science of construction some errors, some misconceptions are inevitable. When iron was first used in shipbuilding, the attempt was made to follow in the metallic construction the plan so long adhered to with wooden ships. In them, ribs of wood are set up attached to the keel at the bottom, and held together at the top by the transverse deck beams. On this plan the earlier iron ships were, and now are, to a certain extent, constructed.

MODE OF CONSTRUCTION.

Iron ribs took the place of the wooden ones, and the sheathing of planks, caulked and covered with copper, was replaced by plates of iron riveted to the ribs. As the experience of the shipbuilders increased and as science was furnished with the data of previous experiments, the transverse construction, or that which more closely imitated the old wooden ships, was found to be less efficient than that known as the longitudinal system. This latter consisted in running along the inside of the ship, parallel with the kelson, strong side kelsons, placed a few feet apart, and meeting or running into one another at the bow or stern, as the ship's lines become fine at either end.

The kelson, it will be understood, is almost like the keel, the difference being that it is placed inside of the ship instead of outside. It runs directly over the keel and is bolted to it. Side kelsons are similar, running parallel with the main kelson. To strengthen these longitudinal beams, angle iron was worked transversely over them, forming a system of ribs which added to the strength, while requiring less iron than was formerly used in the transverse system.

Looking downward into the bottom of a vessel thus constructed, we should see that it was divided into a series of square compartments. Over these were placed plates which, parallel to the skin or outer covering of the ship, formed a second skin, one ship built inside of the other, as it were. Thus by connecting every sixth or eighth transverse rib with the bottom, the whole of the ship's bottom and sides was divided into a number of small water-tight compartments or cells, any one, or almost any number of which, could be filled with water without endangering the ship's ability to float. Two thicknesses of iron had to be pierced before vital damage could be done to the vessel. This is called the "cellular construction," and ships built in this way are said to have a "double bottom" or a "double skin."

GENERAL APPLICABILITY OF THE DOUBLE SKIN.

Though best applied to vessels with the longitudinal system of framing, the cellular or double bottom can be used in ships having transverse frames. This construction was used for vessels of war, where great strength and security were required, but by John Scott Russell it was introduced in the Great Eastern, the first merchant steamer having a double skin. It probably saved the great ship in a moment of peril.

The cellular system must not be confounded with the water-tight compartments or bulkheads used in all our transatlantic steamers. These bulkheads are iron divisions running directly across the ship from side to side, and from kelson to decks, dividing the vessel into as many separate transverse compartments or divisions, any of which may by some accident become full of water without endangering the safety of the vessel. The construction of the bulkheads may be illustrated by a long hall or room divided by walls into a number of sections, communicating by doors. Shut these doors, and any of the divisions might be filled with, say smoke, without the others being penetrated. Their distance apart should be about equal to the ship's beam. The idea originated with the Chinese in their trading vessels, and was introduced in England by Mr. Williams about 1859, or a few years earlier, in very nearly the present form.

The recent loss of so many iron vessels has given a foundation to the idea that their strength is inferior to that of the old wooden steamers, or at least that they are more liable to sudden and serious disasters, and that less rough usage will unfit them as efficient sea-boats. What safeguards are provided against accident in our ordinary transatlantic steamers? They are all provided with water-tight bulkheads, which divide them into seven or eight sections, and which are supposed to be a sufficient safeguard against any ordinary calamity, but they are not built on the cellular system, with double skins from the keel to the water line.

SAFETY OF CELLULAR CONSTRUCTION.

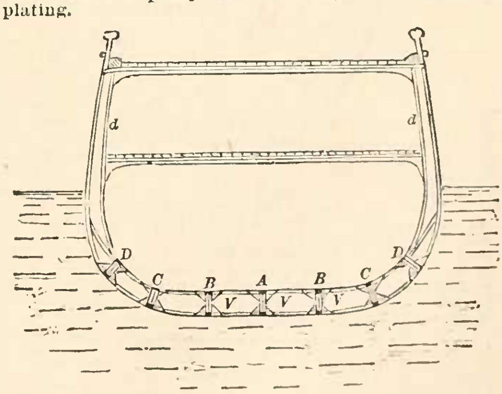
By this latter mode of construction we actually reduce the chances of accident to a fraction, for we place one ship inside the other, and we make it necessary that both the inner and outer skin be pierced before we have recourse to our water-tight bulkheads, which under all circumstances are the last resort. The facts of the case are these: Our iron vessels, as at present built, are not as strong as the old wooden ones. Less force is required to pierce a hole, either by a rock or by a collision, through the plating of our iron steamers than was required to break through the seven or eight inches of solid wood used in the vessels of a few years ago.

Though the desire of the owners of steamships to make money has thus induced them to depart from the sound practice by building single-skinned ships weaker than their modern predecessors, it is no argument against the use of iron in the construction of vessels. The more we study the science of shipbuilding the more we learn to appreciate the fact that a vessel is to be regarded simply as a beam or girder, subject to different strains, depending upon the way she happens to be supported by the waves, whether in the middle by one wave, or whether by two waves, one at each end. Thus, in calculations, we treat a ship, and as the result of our figures we find that the strength must be placed in the bottom and in the top of our vessel; that the resisting power of the upper deck to crushing and tensile strains must be about equal to that of the ship's bottom. It will be observed in looking at an iron beam or girder that the strength is placed at the top and bottom. In this case the dictates of both science and practice have been observed. But, in opposition to this system, which has been proved to be correct, our present iron vessels grow gradually weaker from the bottom up till the upper deck is the weakest of all. Now strength could be insured in the bottom, which should at least equal, if not more than equal, that of our wooden ships; but to do this would require that the iron be much thicker than at present, and the weight would be increased in a greater proportion than the strength.

STRENGTH INCREASED IN PROPORTION TO WEIGHT.

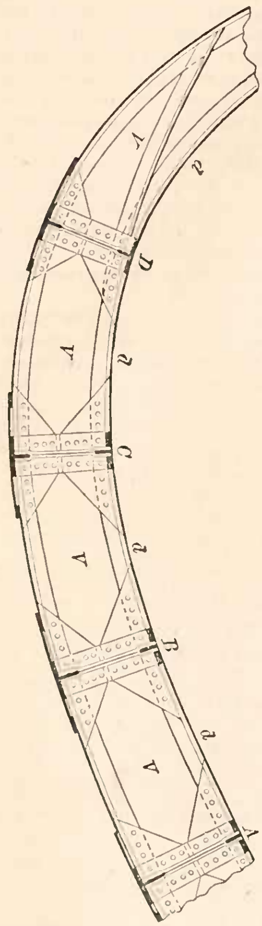
Here comes in the value of the cellular construction with the double bottom; the weight is increased in proportion to the strength, and we obtain a result which for safety is far ahead of that secured by the mass of wood in the wooden ships. If the longitudinal system of framing is adopted, we shall also have a gain as to weight over the transverse system, and this amount of iron saved can be used in making the upper deck cellular also, as was done in the Great Eastern, thus making our vessel conform closely to the structure of a girder or beam, the result which we wish to obtain.

Let us see whether the cellular system has done anything to prevent vessels sinking. When the Great Eastern was entering the Sound she struck on a rock and perforated her outer plating. The damage was serious; seven holes were made, one 85 feet long by four or five wide. Transverse bulkheads as put into a ship would not have saved her; she would have sunk so rapidly that her passengers could not have reached the upper deck, had she not had a double bottom three feet inside of the one pierced, which being intact kept her afloat and would have continued to do so had she desired to make the voyage home again. She was repaired in New-York without being removed from the water by Mr. E. S. Renwick. Other cases can be given of naval vessels with the cellular construction which have been saved after almost equally severe damage to their outer plating.



Two diagrams will more clearly explain the construction of vessels built with the longitudinal system of framing, and with double bottoms. No. 1 shows a cross section of such a ship, and No. 2 is an enlarged view of the bottom from the keel to the water line. The parts lettered A, B, C, D, are the longitudinal frames running the length of the ship, the parts marked d are the plates of the inner skin meeting the outer plating at the water line, on a point a little above it. The gusset pieces are worked in to strengthen the construction, the ribs of angle iron, as shown by d, also giving stiffness to the sides and serving as bracings to the longitudinals A, B, C, D.

It will be seen how comparatively safe must be a ship with all the water-tight cells V, V, V. The mere piercing of the outer shell, sufficient in itself to sink vessels of the present build, will not injure a ship built in this manner. The distance apart of the inner and outer plating should be between two and three feet, preferably the latter. This method of construction can be used either for steamers or sailing vessels, and in either case the protection is of the most perfect nature which can practically be used.

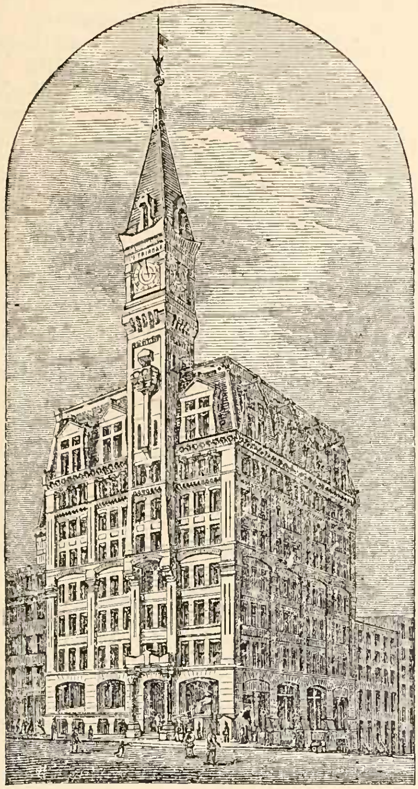


Enough has been said clearly to demonstrate the superiority of cellular ships. Whether the danger menacing them be a rocky coast, an approaching vessel, or an opening in the seams of the plating, so long as we have two thicknesses of iron between us and the water we can rest in the comfortable assurance that no ordinary calamity can cause our vessel to become suddenly unseaworthy. In advocating the adoption of the cellular construction for the transatlantic steamers, it is not proposed that an experiment be tried, but simply that the views of some of the most eminent shipbuilders of the world be adopted. John Scott Russell has, both in his practice and in his great work on shipbuilding, advocated most strenuously the adoption of double bottoms in vessels of any considerable size. Sir William Fairbairn considers that the cellular construction is the only method which presents the maximum of safety, and he advises its adoption. Others equally eminent in all matters pertaining to shipbuilding predict that the longitudinal framing combined with an inner skin will enable iron ships to meet safely the dangers which now are almost certain to cause their destruction. Haste to be rich alone delays the adoption of these improvements. The law may eventually do much, but more can be done by the public—by travelers and shippers of freight not insured above its value, by simply refusing to patronize those lines which do not hold out as an inducement, at least for passenger traffic, the safety afforded by ocean steamers with double bottoms, which shall be a little better than egg shells. Thus can the pocket nerve be touched of those who, with the light of science and experience, for the sake of a saving in first cost, send every year many thousands of souls across the broad Atlantic in ships whose construction violates the known rules of safety.

ERRATA.

Page 36, col. 1, line 7: For "Tacson," read *Tucson*.
Page 37, col. 1, line 28: For "G. H. Long," read *S.* H. Long.
Page 37, col. 1, lines 31-32: For "Lieuts. J. Allen and Schoolcraft," read Lieut. J. Allen and *Dr.* Schoolcraft.
Page 38, col. 2, line 25: For "O'C Ord," read *O. C.* Ord.
Page 38, col. 2, line 33: For "Timpson," read *Simpson*.
Page 40, col. 2, lines 47 and 54: For "Kanal," read *Kanab*.
Page 41, col. 2, line 31: For "Isidro," read *Ysidro*.
Page 41, col. 2, line 53: For "Membres," read *Mimbres*.
Page 43, col. 2, line 37: For "Jase-Utes," read *Go-at-Utes*.
Page 44, col. 2, line 2: For "Hickenburg," read *Wickenberg*.
Page 44, col. 2, line 5: For "Hamell," read *Hamel*.
Page 44, col. 2, line 6: For "Severn," read *Salmon*.
Page 44, col. 2, line 83: For "Kott," read *Klett*.

THE NEW TRIBUNE BUILDING.



The new Tribune Building, now in course of erection, occupies the historic site of The Tribune, on the corner of Spruce and Nassau-sts., one of the most important central points in the City of New-York and the most eligible location on Manhattan Island for a great newspaper office. The new Tribune Building will be the largest newspaper office in the world, and will contain more than four times the space of any other printing-house in the city. When complete it will front 91 feet on Printing-House-square, 100 feet on Spruce-st., and will extend through to Frankfort-st., a clear depth of 168 feet, and with a front of 29 feet on the street last named. Only a portion of the building, that fronting on Printing-House-square, 91 feet, and on Spruce-st., 52 feet, is now erecting, and this will be so far completed as to allow its occupation by The Tribune before the remaining section is begun. In this front building, as well as the completed structure, will be a cellar, basement, and nine stories, excluding the attic. On Printing-House-square, above huge foundations, laid in with granite bond-plates and cap-stones, a majestic tower will rise nearly 260 feet. The main entrance will be in the front of this tower, which, from the starting point of the foundation, 25 feet below the sidewalk level, to the top of the finial, will measure 285 feet. The hights of the stories are as follows: First story, corner office (to be used as The Tribune counting-room), 21 feet, with a rise of 18 inches above the curb at the intersection of Nassau and Spruce-sts.; first story, office north of main entrance, floor 8 feet 6 inches above the curb 14 feet high; second, 12 feet 6 inches; third, 12 feet; fourth, 11 feet 6 inches; fifth, 11 feet; sixth, 10 feet 9 inches; seventh, 10 feet 6 inches; eighth (composing-room), 20 feet, and ninth, 10 feet. From the curbstone to the eaves at the top of the outside wall of the west (Spruce-st.) front will measure 106 feet; the roof is a Mansard, with peaked top, and rises about 40 feet from the eaves to the top of the peak, making the hight from curb to peak on the main front 146 feet. On the Spruce-st. side the decline of the curb is about five feet, so that the hight at the south-eastern corner will be over 150 feet. Sixty feet from the curb, the tower is corbeled out, projecting from the face of the wall 2 feet 6 inches, and this projection is continued to the top of the masonry of the tower, 196 feet above the curb. At the hight of 150 feet a little balcony appears on the front of the tower, and from this the national flag will be displayed on suitable occasions. One hundred and sixty-seven feet from the ground will be an immense clock with four dials each 12 feet in diameter, which will be illuminated at night. The figures on the dials are to be cut in granite and gilded. The inside facing will be of plate glass, through which the light from within will display the figures. The tower will be four-sided, and at the point where it rises above the roof will be 17 feet square. It will be of solid masonry to the hight of 196 feet from the curb, and above that point will be of iron covered with slate, rising 64 feet higher. In the lower part of this spire will be four arched openings to be reached by a staircase, and from these far-reaching views of the city, the bay, and all the surrounding country about may be obtained.

The construction of the building is of the most substantial and enduring kind, such as shall insure its standing for ages a fit memorial of the great Founder of The Tribune, and a perpetual testimony to the success of the great journal into which he breathed the breath of life. The foundation walls rest upon a concrete bed 10 feet wide and 18 inches thick, composed of Portland cement, sand, gravel, and stone, a composition novel in this city, and hardening very quickly into extreme solidity. Upon this concrete is a continued course of granite slabs 18 inches thick, and varying from 10 feet to 6 feet 6 inches in width. Under the piers of the front and the tower walls are other granite slabs over these, some of which weigh more than 10 tons. Upon these granite courses the brick work rests. The piers of the front are of so-called Croton pavers' brick, laid in Portland cement, with granite bond-stones 10 inches thick. The inner walls are of Haverstraw brick, laid in Rosendale cement. On the level of the basement floor starts the granite work of the front extending in solid blocks, bonding alternately through the whole depth of the piers to the second story. Baltimore front brick, laid in black mortar, will be the chief material above the second-story level. The trimmings of the first story will be of Quincy granite, and of the others, white granite. Windows, cornices, and towers will also have heavy granite trimmings. The solid character of the structure is shown by the thickness of the walls, which, beginning at the street level in the first story, will be 5 feet 2 inches thick, diminishing gradually to 2 feet 8 inches at the eaves. The north end south tower walls are to be 4 feet thick to the level of the main cornice, then 3 feet 2 inches to the level of the eaves of the tower roof. The main piers, window piers, and jambs are each to have a reveal of 13 inches. The intervening space between the pilasters, of which there are five, or the western and southern fronts respectively, is 16 feet. Geometrical designs in white, black, and red brick will vary the appearance of the exterior, and a row of small granite columns extending around the entire front, on three streets, will make an imposing feature of the seventh story.

The excellence of the interior of the building will fully equal the merits of its exterior. First among its claims to praise is the fact that it is absolutely fire-proof in every part. All floor beams will be of iron, supported only by solid masonry. The floors will be of tile, and the partitions of tile or plaster of Paris. Not a single cast-iron column will be used as a support. The stairways will be of fire-proof material, and will be built in substantial masonry, and the elevators will be thoroughly protected. As the roof is entirely covered with slate, no danger need be looked for from that quarter. The arrangements for light, heat, and ventilation will be unequaled. All the offices, halls, and staircases will be lighted from the outside, and in every room a direct supply of fresh air will be furnished through openings beneath the window-sills. The heating will be by steam. Three elevators will give easy access to every story, and the whole building will be supplied with every device for comfort and beauty. The main entrance, 9 feet wide and 18 feet 6 inches high, is flanked on either hand with massive columns of highly polished granite. Lining and finishings of granite in the vestibule will correspond to the outside, and the ceiling will be vaulted in groined arches with Baltimore brick. On either hand, as the vestibule is entered, will be seen large directories guiding to the numerous offices in the building.

South of the main portal and entirely distinct from it will be the entrance to THE TRIBUNE counting-room. Just within the doorway will be placed a life-size statue of Mr. Greeley of marble or bronze, the material for the work not having been decided. THE TRIBUNE counting-room will be 20 feet in width, and occupy the whole front on Spruce-st. It will be admirably fitted and provided with pneumatic and speaking-tubes, electric annunciators, and other means of communication with the editorial rooms. These will be in the seventh story, and the compositors' room in the eighth, till the entire building is finished, when the editorial rooms will be in the lofty eighth story—which has a hight of 20 feet—on the Park front, and the composing-room, stereotype-room and proof-room will be in the rear of the same story, running from Spruce to Frankfort-st. With the exceptions of these portions of the building and the basement room looking on Spruce-st., which will be also used by THE TRIBUNE, the entire building, from the ample bankers' office in the basement to the eighth story, will be for rent for professional tenants. No manufacturing business of any kind will be admitted to the front building. In the basement and first story of this building there will be handsome bankers' offices, 45x27 feet, north of the main entrance. The rest of the available space on the first story will be taken up by the counting-room. On each of the floors above, to the eigth, there will be seven eligible apartments, provided with every convenience.

When the front building is finished, THE TRIBUNE will remove into it from its present quarters, which, with the other structures on the estate, will be immediately demolished, and the building of the rest of the edifice will be pushed forward rapidly. Richard M. Hunt of this city is the architect. The mason work is done by Peter T. O'Brien of this city, and the cut-stone work by James G. Batterson of Hartford.

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Which surpassed all other papers, secular and religious, in its reports of the proceedings of the Evangelical Alliance, at its recent meeting in New-York, in October, 1873, publishing daily from 18 to 24 columns, in all 32 pages, closely filled with the narrative of the Alliance meetings, an achievement in journalism for which THE TRIBUNE received the formal thanks of the Alliance and the compliments of the religious press of the country.

Which gave a complete and adequate account of the transactions of the American Association for the Advancement of Science at its recent annual meeting at Portland, Me., and republished the same in a TRIBUNE Extra Sheet.

Which published entire, Agassiz's great series of lectures on the Method of Creation, being a conclusive scientific answer to the Darwinian theory.

Which has reported fully and faithfully, during the past year, the lectures of Tyndall on Light; of John Weiss on Shakespeare; of Wendell Phillips on Art; of Prof. Young on Astronomy; of Prof. Youmans on Science, and of Bret Harte, Parton, and Mark Twain, on lighter subjects.

Which published Beecher's Yale theological lectures in full—eleven practical sermons to young ministers.

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Which anticipated every other paper in the country, and the Government itself, in the news of Custer's victories over the Sioux on the Yellowstone, and of the safety of the Polaris survivors.

Which had the fullest, most graphic, and intelligent accounts of the events of the recent great financial crisis.

Which disclosed the crimes and corruptions of the Brooklyn ring in advance of all other papers.

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Surpassed by no American journal in ability, energy, and enterprise.—[Christian Register, Boston.

THE TRIBUNE is the best paper in the world in our estimation.—[Merchants' and Manufacturers' Bulletin, Cincinnati, O.

Achieving wonders, outstripping itself, in the hands of Mr. Greeley's successors.—[The Old School Presbyterian, St. Louis.

Beyond all question the best newspaper in the United States.—[New-Haven Journal and Courier (Administration Republican).

Beyond a doubt, the most influential, fearless and independent paper in the country.—[Gt. Barrington (Mass.) Courier (Administration Republican).

In the endeavor to popularize science, no other newspaper has ever risen to the hight achieved by THE NEW-YORK TRIBUNE.—[The Universalist, Boston.

If any man wants a very complete, ably conducted, and valuable newspaper, one that keeps up with the times and is nowhere excelled, let him try THE TRIBUNE.—[Watertown (N. Y.) Times (Independent).

THE NEW-YORK TRIBUNE fulfills every requirement of a first-class newspaper. It is prompt and reliable, ably edited, and vigorously managed.—[Newark (N. J.) Register (Independent).

The greatest achievement of newspaper reporting that has ever occurred was that of THE NEW-YORK TRIBUNE with the Evangelical Alliance.—[Cincinnati (Ohio) Commercial (Independent).

American newspaper enterprise is probably at this time more fully illustrated in the daily issues of THE NEW-YORK TRIBUNE than in any other journal.—(Wilmington (N. C.) Star (Democratic).

Unquestionably, in all that relates to the collection and publication of news, the leading journal in the United States. It was never so good a newspaper as it is to-day.—[New-Haven (Conn.) Palladium (Administration Republican).

THE TRIBUNE feels just pride in the success it has achieved and the position it has secured in the front rank of the leading journals of the world. Its honorable record is a glory to all the Press.—[Albany Argus (Democratic).

It is a great newspaper the public care for and they have it in THE TRIBUNE, more so than in any other paper in this or any other country. It is a greater newspaper to-day than at any previous time in its history.—[New-York Commercial Advertiser (Administration Republican).

THE TRIBUNE daily spreads such a feast of good things before its readers that they have no reason to complain. Its reports of current events are extraordinarily full and accurate, and its special correspondence from all quarters of the world has become a marked and important feature.—[Brooklyn (N. Y.) Argus (Independent).

Some one said, years ago, that newspapers in time would do away with all other publications except text-books. THE NEW YORK TRIBUNE, with its scientific lecture numbers, seems to be over-fulfilling the prophecy. Among the poor people it is obviating the necessity for scientific text-books, and is an apostle of compulsory education.—[Leslie's Illustrated Newspaper.

The greatest newspaper of the country, and we think the greatest in the world, is THE TRIBUNE. Great as it was under the immortal Greeley, it is outstripping with wondrous strides all the bright record of the past, and stands to-day as a most illustrious example of successful effort and well-directed aim.—[Scranton (Penn.) Times (Democratic).

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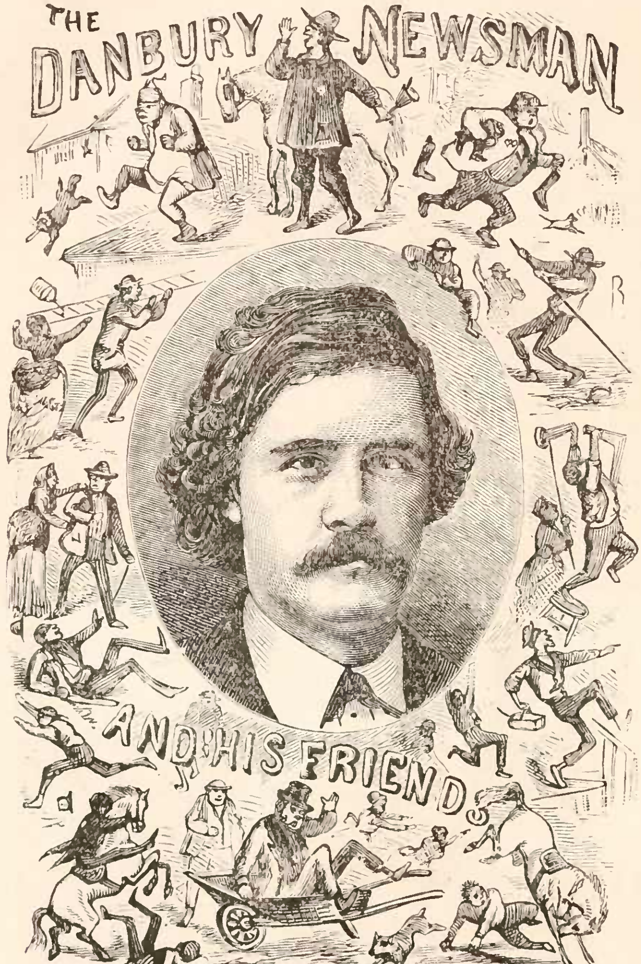

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A Letter from Rev. W. H. H. Murray to "The Danbury News Man."

MY DEAR BAILEY:— BOSTON, June, 1873.

I have never seen you face to face; but I have seen you many times in "my mind's eye," and number you among my close friends, as I number every man who makes the world better through laughter. Go on in your sweet ministry of mirth, to which you was ordained at birth by a greater and wiser Power than the imposition of human hands. You are making more than the foolish and idle laugh: the wise and overworked share in your fun-provoking sentences, and thank you heartily as a dear gift to them. If you could hear them, as I have heard them, read aloud at the family table until father and mother and the youngsters were all in a roar, and in offices and cars, and at the corner of streets, and seen what a ripple of laughter followed your little paper wherever it went, I feel that you would realize that your "labor was not in vain."

I am yours truly, W. H. H. MURRAY.

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DR. TRALL, of Philadelphia, has made a very unpleasant discovery. In about seven years, Jupiter, Saturn, Uranus, and Neptune will approach nearer the earth than they have been in eighteen hundred years, and the result will be a pestilence. When Congress has the manliness to make astronomy an indictable offence, then we shall have relief from these things, but not before. It was not a long while since that some one predicted that the earth would be swamped with a deluge, and you couldn't borrow an umbrella or a pair of rubbers from any one. The next idiot said a comet would strike and demolish the earth in a twinkling. Whereupon many excellent people tied their beds and carpets about their premises, and put cotton in their ears, and sat down on the cellar bottom in dreadful expectation of the shock. Hardly had this alarm passed off when another astronomer came around telling people that the Niagara Falls would be dry in less than nineteen thousand years, and nothing would do but that people should hurry right out there for a farewell look, and in less than twenty-four hours there wasn't people enough in Danbury to entertain a Japanese hermit. And now here is Trall with four planets and no vaccine matter. All Tobacco-chewers are to be killed by these planets, and young ladies who wear stays, and men who bet on the wrong horse. If we understand the old scoundrel correctly, the only people saved are those who drink lemonade out of a dipper and play copenhagen with their aunts.

A WEST STREET man says the longest funeral he ever heard of took place a week ago. His hired girl went to it and hasn't got back yet.

ONE of the saddest sights in this season of the year is a young man who has waited outside the church of an evening until he is chilled through, only to see a girl walk off with some rascal who has been inside all the time and toasting his sinful shins at the stove.

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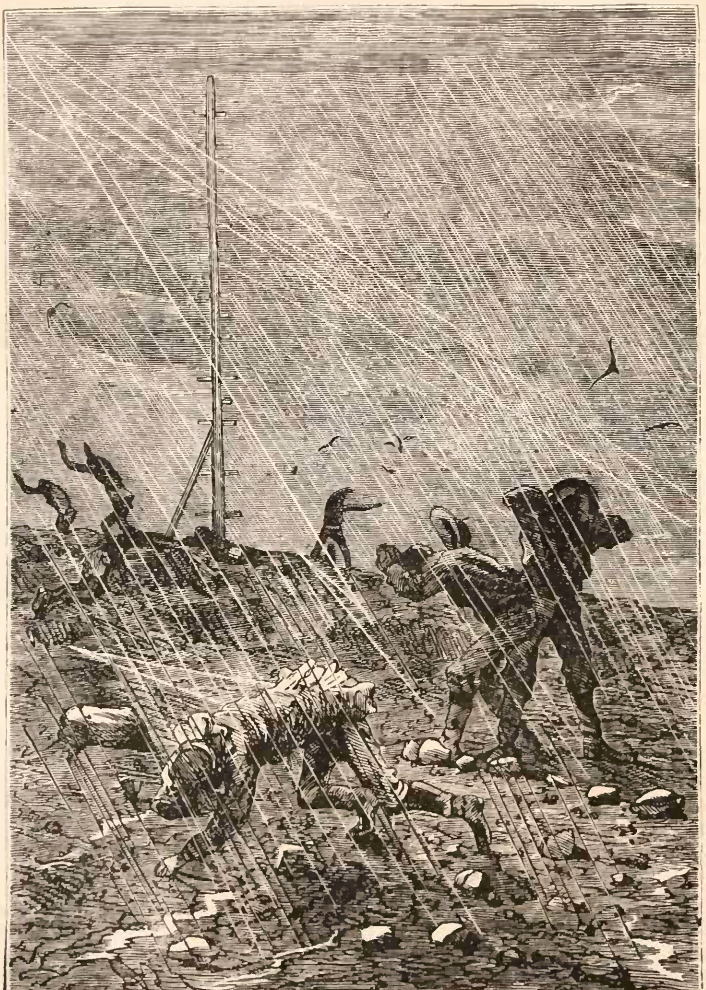

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