Man or Matter

MAN OR MATTER

Introduction

to a Spiritual Understanding of Nature

on the Basis of Goethe's Method

of Training Observation and Thought

by

ERNST LEHRS
Ph. D.

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ERRATA

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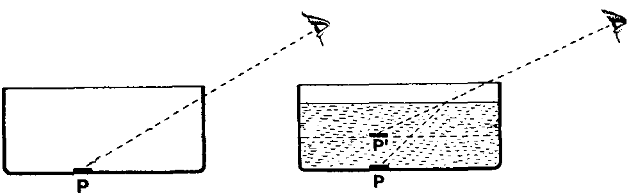
Page 178, line 5 from bottom: *universal* should read *universe.*

Page 184, line 15 from bottom: *volume* should read *amounts.*

Page 230, line 2 from bottom: *plane* should be deleted.

Page 292, fig. 12 should look like this:



Page 299, line 10: after the closing bracket there should be a '[1]' referring to the first footnote.

Page 325, line 3 from bottom: instead of *nature* read *matter*.

Page 354, quotation: between lines 3 and 4 should be inserted *Such harmony is in immortal souls.*

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Author's Note

The author makes grateful acknowledgment of the help he has gained from other works in the wide field opened up by Rudolf Steiner, and of his debt to the friends who in various ways assisted him in preparing his manuscript.

Quotations have been made from the following books by kind permission of their respective publishers:

The Life ofSir William Crookes by E. E. Fournier d'Albe (Messrs. Ernest Benn Ltd.); *Man the Unknown* by A. Carrel (Messrs. Hamish Hamilton Ltd.) *The Philosophy of Physical Science* and *The Nature ofThe Physical Worldly A..* Eddington (University Press, Cambridge); *Science and the Human Temperament* by E. Schrödinger (Messrs. George Allen and Unwin Ltd.); *Centuries of Meditations* and *Poetical Works* by Th. Traherne (Messrs. P. J. and A. E. Dobell).

Preface

In this book the reader will find expounded a method of investigating nature by means of which scientific understanding can be carried across the boundaries of the physical-material to the supersensible sources of all natural events, and thereby into the realm where is rooted the true being of man.

The beginnings of this method were worked out by Goethe more than 150 years ago. The nineteenth century, however, failed to provide any fertile ground for the development of the seeds thus sown. It was left to Rudolf Steiner, shortly before the end of the century, to recognize the significance of 'Goetheanism' for the future development not only of science but of human culture in general. It is to him, also, that we owe the possibility of carrying on Goethe's efforts in the way required by the needs of our own time.

The following pages contain results of the author's work along the path thus opened up by Goethe and Rudolf Steiner—a work begun twenty-seven years ago, soon after he had made the acquaintance of Rudolf Steiner. With the publication of these results he addresses himself to everyone—with or without a specialized scientific training—who is concerned with the fate of man's powers of cognition in the present age.

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The reader may welcome a remark as to the way in which this book needs to be read.

It has not been the author's intention to provide an encyclopaedic collection of new conceptions in various fields of natural observation. Rather did he wish, as the sub-title of the book indicates, to offer a new method of training both mind and eye (and other senses as well), by means of which our modern 'onlooking' consciousness can be transformed into a new kind of 'participating' consciousness. Hence it would be of no avail to pick out one chapter or another for first reading, perhaps because of some special interest in its subject-matter. The chapters are stages on a road which has to be *travelled,* and each stage is necessary for reaching the next. It is only through thus accepting the method with which the book has been written that the reader will be able to form a competent judgment of its essential elements.

E. L.

Hawkwood College
Easter 1950

PART I

Science at the Threshold

CHAPTER I

Introductory

If I introduce this book by relating how I came to encounter Rudolf Steiner and his work, more than twenty-five years ago, and what decided me not only to make his way of knowledge my own, but also to enter professionally into an activity inspired by his teachings, it is because in this way I can most directly give the reader an impression of the kind of spirit out of which I have written. I am sure, too, that although what I have to say in this chapter is personal in content, it is characteristic of many in our time.

When I first made acquaintance with Rudolf Steiner and his work, I was finishing my academic training as an electrical engineer. At the end of the 1914-18 war my first thought had been to take up my studies from where I had let them drop, four years earlier. The war seemed to imply nothing more than a passing interruption of them. This, at any rate, was the opinion of my former teachers; the war had made no difference whatever to their ideas, whether on the subject-matter of their teaching or on its educational purpose. I myself, however, soon began to feel differently. It became obvious to me that my relationship to my subject, and therefore to those teaching it, had completely changed. What I had experienced through the war had awakened in me a question of which I had previously been unaware; now I felt obliged to put it to everything I came across.

As a child of my age I had grown up in the conviction that it was within the scope of man to shape his life according to the laws of reason within him; his progress, in the sense in which I then understood it, seemed assured by his increasing ability to determine his own outer conditions with the help of science. Indeed, it was the wish to take an active part in this progress that had led me to choose my profession. Now, however, the war stood there as a gigantic social deed which I could in no way regard as reasonably justified. How, in an age when the logic of science was supreme, was it possible that a great part of mankind, including just those peoples to whom science had owed its origin and never-ceasing expansion, could act in so completely unscientific a way? Where lay the causes of the contradiction thus revealed between human thinking and human doing?

Pursued by these questions, I decided after a while to give my studies a new turn. The kind of training then provided in Germany at the so-called Technische Hochschulen was designed essentially to give students a close practical acquaintance with all sorts of technical appliances; it included only as much theory as was wanted for understanding the mathematical calculations arising in technical practice. It now seemed to me necessary to pay more attention to theoretical considerations, so as to gain a more exact knowledge of the sources from which science drew its conception of nature. Accordingly I left the Hochschule for a course in mathematics and physics at a university, though without abandoning my original idea of preparing for a career in the field of electrical engineering. It was with this in mind that I later chose for my Ph.D. thesis a piece of experimental research on the uses of high-frequency electric currents.

During my subsequent years of stuffy, however, I found myself no nearer an answer to the problem that haunted me. All that I experienced, in scientific work as in life generally, merely gave it an even sharper edge. Everywhere I saw an abyss widening between human knowing and human action. How often was I not bitterly disillusioned by the behaviour of men for whose ability to think through the most complicated scientific questions I had the utmost admiration!

On all sides I found this same bewildering gulf between scientific achievement and the way men conducted their own lives and influenced the lives of others. I was forced to the conclusion that human thinking, at any rate in its modern form, was either powerless to govern human actions, or at least unable to direct them towards right ends. In fact, where scientific thinking had done most to change the practical relations of human life, as in the mechanization of economic production, conditions had arisen which made it more difficult, not less, for men to live in a way worthy of man. At a time when humanity was equipped as never before to investigate the order of the universe, and had achieved triumphs of design in mechanical constructions, human life was falling into ever wilder chaos. Why was this?

The fact that most of my contemporaries were apparently quite unaware of the problem that stirred me so deeply could not weaken my sense of its reality. This slumber of so many souls in face of the vital questions of modern life seemed to me merely a further symptom of the sickness of our age. Nor could I think much better of those who, more sensitive to the contradictions in and around them, sought refuge in art or religion. The catastrophe of the war had shown me that this departmentalizing of life, which at one time I had myself considered a sort of ideal, was quite inconsistent with the needs of to-day. To make use of art or religion as a refuge was a sign of their increasing separation from the rest of human culture. It implied a cleavage between the different spheres of society which ruled out any genuine solution of social problems.

I knew from history that religion and art had once exercised a function which is to-day reserved for science, for they had given guidance in even the most practical activities of human society. And in so doing they had enhanced the quality of human living, whereas the influence of science has had just the opposite effect. This power of guidance, however, they had long since lost, and in view of this fact I came to the conclusion that salvation must be looked for in the first place from science. Here, in the thinking and knowing of man, was the root of modern troubles; here must come a drastic revision, and here, if possible, a completely new direction must be found.

Such views certainly flew in the face of the universal modern conviction that the present mode of knowledge, with whose help so much insight into the natural world has been won, is the only one possible, given once for all to man in a form never to be changed. But is there any need, I asked myself, to cling to this purely static notion of man's capacity for gaining knowledge? Among the greatest achievements of modern science, does not the conception of evolution take a foremost place? And does not this teach us that the condition of a living organism at any time is the result of the one preceding it, and that the transition implies a corresponding functional enhancement? But if we have once recognized this as an established truth, why should we apply it to organisms at every stage of development except the highest, namely the human, where the organic form reveals and serves the self-conscious spirit?

Putting the question thus, I was led inevitably to a conclusion which science itself had failed to draw from its idea of evolution. Whatever the driving factor in evolution may be, it is clear that in the kingdoms of nature leading up to man this factor has always worked on the evolving organisms from outside. The moment we come to man himself, however, and see how evolution has flowered in his power of conscious thought, we have to reckon with a fundamental change.

Once a being has recognized itself as a product of evolution, it immediately ceases to be that and nothing more. With its very first act of self-knowledge it transcends its previous limits, and must in future rely on its own conscious actions for the carrying on of its development.

For me, accordingly, the concept of evolution, when thought through to the end, began to suggest the possibility of further growth in man's spiritual capacities. But I saw also that this growth could no longer be merely passive, and the question which now beset me was: by what action of his own can man break his way into this new phase of evolution? I saw that this action must not consist merely in giving outer effect to the natural powers of human thinking ; that was happening everywhere in the disordered world around me. The necessary action must have inner effects; indeed, it had to be one whereby the will was turned upon the thinking-powers themselves, entirely transforming them, and so removing the discrepancy between the thinker and the doer in modern man.

Thus far I could go through my own observation and reflexion, but no further. To form a general idea of the deed on which everything else depended was one thing; it was quite another to know how to perform the deed, and above all where to make a start with it. Anyone intending to make a machine must first learn something of mechanics; in the same way, anyone setting out to do something constructive in the sphere of human consciousness—and this, for me, was the essential point—must begin by learning something of the laws holding sway in that sphere. But who could give me this knowledge?

Physiology, psychology and philosophy in their ordinary forms were of no use to me, for they were themselves part and parcel of just that kind of knowing which had to be overcome. In their various accounts of man there was no vantage point from which the deed I had in mind could be accomplished, for none of them looked beyond the ordinary powers of knowledge. It was the same with the accepted theory of evolution; as a product of the current mode of thinking it could be applied to everything except the one essential—this very mode of thinking. Obviously, the laws of the development of human consciousness cannot be discovered from a standpoint within the modern form of that consciousness. But how could one find a viewpoint outside, as it were, this consciousness, from which to discover its laws with the same scientific objectivity which it had itself applied to discovering the laws of physical nature?

It was when this question stood before me in all clarity that destiny led me to Rudolf Steiner and his work. The occasion was a conference held in 1921 in Stuttgart by the Anthroposophical Movement; it was one of several arranged during the years 1920-2 especially for teachers and students at the Hochschulen and Universities. What chiefly moved me to attend this particular conference was the title of a lecture to be given by one of the pupils and co-workers of Rudolf Steiner—'The Overcoming of Einstein's Theory of Relativity'.[1]

The reader will readily appreciate what this title meant for me. In the circles where my work lay, an intense controversy was just then raging round Einstein's ideas. I usually took sides with the supporters of Einstein, for it seemed to me that Einstein had carried the existing mode of scientific thinking to its logical conclusions, whereas I missed this consistency among his opponents. At the same time I found that the effect of this theory, when its implications were fully developed, was to make everything seem so 'relative' that no reliable world-outlook was left. This was proof for me that our age was in need of an altogether different form of scientific thinking, equally consistent in itself, but more in tune with man's own being.

What appealed to me in the lecture-title was simply this, that whereas everyone else sought to prove Einstein right or wrong, here was someone who apparently intended, not merely to add another proof for or against his theory—there were plenty of those already—but to take some steps to *overcome* it. From the point of view of orthodox science, of course, it was absurd to speak of 'overcoming' a theory, as though it were an accomplished fact, but to me this title suggested exactly what I was looking for.

Although it was the title of this lecture that drew me to the Stuttgart Conference (circumstances prevented me from hearing just this lecture), it was the course given there by Rudolf Steiner himself which was to prove the decisive experience of my life. It comprised eight lectures, under the title: 'Mathematics, Scientific Experiment

[1] The speaker was the late Dr. Elizabeth Vreede, for some years leader of the Mathematical-Astronomical Section at the Goetheanum, Dornach, Switzerland.

and Observation, and Epistemological Results from the Standpoint of Anthroposophy'; what they gave me answered my question beyond all expectation.

In the course of a comprehensive historical survey the lecturer characterized, in a way I found utterly convincing, the present mathematical interpretation of nature as a transitional stage of human consciousness—a kind of knowing which is on the way from a past pre-mathematical to a future post-mathematical form of cognition. The importance of mathematics, whether as a discipline of the human spirit or as an instrument of natural science, was not for a moment undervalued. On the contrary, what Rudolf Steiner said about Projective (Synthetic) Geometry, for instance, its future possibilities and its role as a means of understanding higher processes of nature than had hitherto been accessible to science, clearly explained the positive feelings I myself had experienced—without knowing why—when I had studied the subject.

Through his lectures and his part in the discussions—they were held daily by the various speakers and ranged over almost every field of modern knowledge—I gradually realized that Rudolf Steiner was in possession of unique powers. Not only did he show himself fully at home in all these fields; he was able to connect them with each other, and with the nature and being of man, in such a way that an apparent chaos of unrelated details was wrought into a higher synthesis. Moreover, it became clear to me that one who could speak as he did about the stages of human consciousness past, present and future, must have full access to all of them at will, and be able to make each of them an object of exact observation. I saw a thinker who was himself sufficient proof that man can find within the resources of his own spirit the vantage-ground for the deed which I had dimly surmised, and by which alone true civilization could be saved. Through all these things I knew that I had found the teacher I had been seeking.

Thus I was fully confirmed in my hopes of the Conference; but I was also often astonished at what I heard. Not least among my surprises was Rudolf Steiner's presentation of Goethe as the herald of the new form of scientific knowledge which he himself was expounding. I was here introduced to a side of Goethe which was as completely unknown to me as to so many others among my contemporaries, who had not yet come into touch with Anthroposophy. For me, as for them, Goethe had always been the great thinker revealing his thoughts through poetry. Indeed, only shortly before my meeting with Rudolf Steiner it was in his poetry that Goethe had become newly alive to me as a helper in my search for a fuller human experience of nature and my fellow-men. But despite all my Goethe studies I had been quite unaware that more than a century earlier he had achieved something in the field of science, organic and inorganic alike, which could help modern man towards the new kind of knowledge so badly needed to-day. This was inevitable for me, since I shared the modern conviction that art and science were fields of activity essentially strange to one another. And so it was again Rudolf Steiner who opened the way for me to Goethe as botanist, physicist and the like.

I must mention another aspect of the Stuttgart Conference which Belongs to this picture of my first encounter with Anthroposophy, and gave it special weight for anyone in my situation at that period. In Stuttgart there were many different activities concerned with the practical application of Rudolf Steiner's teachings, and so one could become acquainted with teachings and applications at the same time. There was the Waldorf School, founded little more than a year before, with several hundred pupils already. It was the first school to undertake the transformation of anthroposophical knowledge of man into educational practice; later it was followed by others, in Germany and elsewhere. There was one of the clinics, where qualified doctors were applying the same knowledge to the study of illness and the action of medicaments. In various laboratories efforts were made to develop new methods of experimental research in physics, chemistry, biology and other branches of science. Further, a large business concern had been founded in Stuttgart in an attempt to embody some of Rudolf Steiner's ideas for the reform of social life. Besides all this I could attend performances of the new art of movement, again the creation of Rudolf Steiner and called by him 'Eurhythmy', in which the astounded eye could see how noble a speech can be uttered by the human body when its limbs are moved in accordance with its inherent spiritual laws. Thus, in all the many things that were going on besides the lectures, one could find direct proof of the fruitfulness of what one heard in them.[1]

[1] The activities mentioned above do not exhaust the practical possibilities of Spiritual Science. At that time (1921) Rudolf Steiner had not yet given his indications for the treatment of children needing special care of soul and body, or for the renewal of the art of acting, or for the conquest of materialistic methods in agricultural practice. Nor did there yet exist the movement for religious renewal Which Dr. Fr. Rittelmeyer later founded, with the help and advice of Rudolf Steiner.

Under the impression of this Conference I soon began to study the writings of Rudolf Steiner. Not quite two years later, I decided to join professionally with those who were putting Anthroposophy into outer practice. Because it appeared to me as the most urgent need of the time to prepare the new generation for the tasks awaiting it through an education shaped on the entire human being, I turned to Rudolf Steiner with the request to be taken into the Stuttgart School as teacher of natural science. On this occasion I told him of my general scientific interests, and how I hoped to follow them up later on. I spoke of my intended educational activity as something which might help me at the same time to prepare myself for this other task. Anyone who learns so to see nature that his ideas can be taken up and understood by the living, lively soul of the growing child will thereby be training himself, I thought, in just that kind of observation and thinking which the new science of nature demands. Rudolf Steiner agreed with this, and it was not long afterwards that I joined the school where I was to work for eleven years as a science master in the senior classes, which activity I have since continued outside Germany in a more or less similar form.

This conversation with Rudolf Steiner took place in a large hall where, while we were talking, over a thousand people were assembling to discuss matters of concern to the Anthroposophical Movement. This did not prevent him from asking me about the details of my examination work, in which I was still engaged at that time; he always gave himself fully to whatever claimed his attention at the moment. I told him of my experimental researches in electrical high-frequency phenomena, briefly introducing the particular problem with which I was occupied. I took it for granted that a question from such a specialized branch of physics would not be of much interest to him. Judge of my astonishment when he at once took out of his pocket a note-book and a huge carpenter's pencil, made a sketch and proceeded to speak of the problem as one fully conversant with it, and in such a way that he gave me the starting point for an entirely new conception of electricity. It was instantly borne in on me that if electricity came to be understood in this sense, results would follow which in the end would lead to a quite new technique in the use of it. From that moment it became one of my life's aims to contribute whatever my circumstances and powers would allow to the development of an understanding of nature of this kind.

CHAPTER II

Where Do We Stand To-day?

In the year 1932, when the world celebrated the hundredth anniversary of Goethe's death, Professor W. Heisenberg, one of the foremost thinkers in the field of modern physics, delivered a speech before the Saxon Academy of Science which may be regarded as symptomatic of the need in recent science to investigate critically the foundations of its own efforts to know nature.[1] In this speech Heisenberg draws a picture of the progress of science which differs significantly from the one generally known. Instead of giving the usual description of this progress as 'a chain of brilliant and surprising discoveries', he shows it as resting on the fact that, with the aim of continually simplifying and unifying the scientific conception of the world, human thinking, in course of time, has narrowed more and more the scope of its inquiries into outer nature.

'Almost every scientific advance is bought at the cost of renunciation, almost every gain in knowledge sacrifices important standpoints and established modes of thought. As facts and knowledge accumulate, the claim of the scientist to an *understanding* of the world in a certain sense diminishes.' Our justifiable admiration for the success with which the unending multiplicity of natural occurrences on earth and in the stars has been reduced to so simple a scheme of laws—Heisenberg implies—-must therefore not make us forget that these attainments are bought at the price 'of renouncing the aim of bringing the phenomena of nature to our thinking in an immediate and living way'.

In the course of his exposition, Heisenberg also speaks of Goethe,

[1] This address and another by the same author are published together under the common title, *Wandlungen in den Grundlagen der Naturwissenschaft* ('Changes in the foundations of Natural Science'). Heisenberg's name has become known above all by his formulation of the so-called Principle of Indeterminacy.

in whose scientific endeavours he perceives a noteworthy attempt to set scientific understanding upon a path other than that of progressive self-restriction.

'The renouncing of life and immediacy, which was the premise for the progress of natural science since Newton, formed the real basis for the bitter struggle which Goethe waged against the physical optics of Newton. It would be superficial to dismiss this struggle as unimportant: there is much significance in one of the most outstanding men directing all his efforts to fighting against the development of Newtonian optics.' There is only one thing for which Heisenberg criticizes Goethe: 'If one should wish to reproach Goethe, it could only be for not going far enough—that is, for having attacked the *views* of Newton instead of declaring that the whole of Newtonian Physics—Optics, Mechanics and the Law of Gravitation—were from the devil.'

Although the full significance of Heisenberg's remarks on Goethe will become apparent only at a later stage of our discussion, they have been quoted here because they form part of the symptom we wish to characterize. Only this much may be pointed out immediately, that Goethe—if not in the scientific then indeed in the poetical part of his writings—did fulfil what Heisenberg rightly feels to have been his true task.[1]

We mentioned Heisenberg's speech as a symptom of a certain tendency, characteristic of the latest phase in science, to survey critically its own epistemological foundations. A few years previous to Heisenberg's speech, the need of such a survey found an eloquent advocate in the late Professor A. N. Whitehead, in his book *Science and the Modern World*, where, in view of the contradictory nature of modern physical theories, he insists that 'if science is not to degenerate into a medley of *ad hoc* hypotheses, it must become philosophical and enter upon a thorough criticism of its own foundations'.

Among the scientists who have felt this need, and who have taken pains to fulfil it, the late Professor A. Eddington obtains an eminent position. Among his relevant utterances we will quote here the following, because it contains a concrete statement concerning the field of external observation which forms the basis for the modern scientific world-picture. In his *Philosophy of Physical Science* we find him stating that 'ideally, all our knowledge of the universe could have been reached by visual sensation alone—in fact by the simplest form

[1] See, in this respect, Faust's dispute with Mephistopheles on the causes responsible for the geological changes of the earth. (*Faust* II, Act 4)

of visual sensation, colourless and non-stereoscopic'.[1] In other words, in order to obtain scientific cognition of the physical world, man has felt constrained to surrender the use of all his senses except the sense of sight, and to limit even the act of seeing to the use of a single, colour-blind eye.

Let us listen to yet another voice from the ranks of present-day science, expressing a criticism which is symptomatic of our time. It comes from the late physiologist, Professor A, Carrel, who, concerning the effect which scientific research has had on man's life in general, says in his book, *Man the Unknown:* 'The sciences of inert matter have led us into a country that is not ours. . . . Man is a stranger in the world he has created.'

Of these utterances, Eddington's is at the present point of our discussion of special interest for us; for he outlines in it the precise field of sense-perception into which science has withdrawn in the course of that general retreat towards an ever more restricted questioning of nature which was noted by Heisenberg.

The pertinence of Eddington's statement is shown immediately one considers what a person would know of the world if his only source of experience were the sense of sight, still further limited in the way Eddington describes. Out of everything that the world brings to the totality of our senses, there remains nothing more than mere movements, with certain changes of rate, direction, and so on. The picture of the world received by such an observer is a purely *kinematic* one. And this is, indeed, the character of the world-picture of modern physical science. For in the scientific treatment of natural phenomena all the qualities brought to us by our other senses, such as colour, tone, warmth, density and even electricity and magnetism, are reduced to mere movement-changes.

As a result, modern science is prevented from conceiving any valid idea of 'force'. In so far as the concept 'force' appears in scientific considerations, it plays the part of an 'auxiliary concept', and what man naively conceives as force has come to be defined as merely a 'descriptive law of behaviour'. We must leave it for later considerations to show how the scientific mind of man has created for itself the conviction that the part of science occupied with the actions of force

[1] See also Eddington's more elaborate description of this fact in his *New Pathways in Science*. The above statement, like others of Eddington's, has been Contested from the side of professional philosophy as logically untenable. Our own further discussion will show that it accords with the facts.

in nature can properly be treated with purely kinematic concepts. It is the fact itself which concerns us here. In respect of it, note as a characteristic of modern text-books that they often simply use the term 'kinetics' (a shortening of kinematics) to designate the science of 'dynamics'.[1]

In the course of our investigations we shall discover the peculiarity in human nature which—during the first phase, now ended, of man's struggle towards scientific awareness—has caused this renunciation of all sense-experiences except those which come to man through the sight of a single colour-blind eye. It will then also become clear out of what historic necessity this self-restriction of scientific inquiry arose. The acknowledgment of this necessity, however, must not prevent us from recognizing the fact that, as a result of this restriction, modern scientific research, which has penetrated far into the dynamic substrata of nature, finds itself in the peculiar situation that it is not at all guided by its own concepts, but by the very forces it tries to detect. And in this fact lies the root of the danger which besets the present age.[2]

He who recognizes this, therefore, feels impelled to look for a way which leads beyond a one-eyed, colour-blind conception of the world. It is the aim of this book to show that such a way exists and how it can be followed. Proof will thereby be given that along this way not only is a true understanding achieved of the forces already known to science (though not really understood by it), but also that other forces, just as active in nature as for example electricity and magnetism, come within reach of scientific observation and understanding. And it will be shown that these other forces are of a kind that requires to be known to-day if we are to restore the lost balance to human civilization.

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There is a rule known to physicians that 'a true diagnosis of a case contains in itself the therapy'. No true diagnosis is possible, however, without investigation of the 'history' of the case. Applied to our task, this means that we must try to find an aspect of human development, both individual and historical, which will enable us to recognize in

[1] Both words, kinematics and kinetics, are derivatives of the Greek word *kinein,* to move. The term 'kinematic' is used when motion is considered abstractly without reference to force or mass. Kinetics is applied kinematics, or, as pointed out above, dynamics treated with kinematic concepts.

[2] These last statements will find further illustration in the next two chapters.

man's own being the cause responsible for the peculiar narrowing of the scope of scientific inquiry, as described by the scientists cited above.

A characteristic of scientific inquiry, distinguishing it from man's earlier ways of solving the riddles of the world, is that it admits as instruments of knowledge exclusively those activities of the human soul over which we have full control because they take place in the full light of consciousness. This also explains why there has been no science, in the true sense of the word, prior to the beginning of the era commonly called 'modern'—that is, before the fifteenth century. For the consciousness on which man's scientific striving is based is itself an outcome of human evolution.

This evolution, therefore, needs to be considered in such a way that we understand the origin of modern man's state of mind, and in particular why this state of mind cannot of itself have any other relationship to the world than that of a spectator. For let us be clear that this peculiar relationship by no means belongs only to the scientifically engaged mind. Every adult in our age is, by virtue of his psychophysical structure, more or less a world-spectator. What distinguishes the state of man's mind when engaged in scientific observation is that it is restricted to a one-eyed colour-blind approach.

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'Death is the price man has to pay for his brain and his personality'—this is how a modern physiologist (A. Carrel in his aforementioned book, *Man the Unknown)* describes the connexion between man's bodily functions and his waking consciousness. It is characteristic of the outlook prevailing in the nineteenth century that thinking was regarded as the result of the *life* of the body; that is, of the body's matter-building processes. Hence no attention was paid at that time to the lonely voice of the German philosopher, C. Fortlage (1806-81), who in his *System of Psychology as Empirical Science* suggested that consciousness is really based on death processes in the body. From this fact he boldly drew the conclusion (known to us today to be true) that if 'partial death' gave rise to ordinary consciousness, then 'total death' must result in an extraordinary enhancement of consciousness. Again, when in our century Rudolf Steiner drew attention to the same fact, which he had found along his own lines of investigation, showing thereby the true role of the nervous system in regard to the various activities of the soul, official science turned a deaf ear to his pronouncement.[1] To-day the scientist regards it as forming part of 'unknown man' that life must recede—in other words, that the organ-building processes of the body must come to a standstill—if consciousness is to come into its own.

With the recognition of a death process in the nervous system as the bodily foundation of consciousness, and particularly of man's conceptual activities, the question arises as to the nature of those activities which have their foundation in other systems, such as that of the muscles, where life, not death, prevails. Here an answer must be given which will surprise the reader acquainted with modern theories of psycho-physical interaction; but if he meets it with an open mind he will not find it difficult to test.

Just as the conceptual activity has as its bodily foundation the brain, with the nervous appendages, so it is volitional activity which is based on processes taking place in the muscular region of the body and in those organs which provide the body's metabolism.

A statement which says that man's will is as directly based on the metabolic processes of the body, both inside and outside the muscles, as is his perceiving and thought-forming mind on a process in the nerves, is bound to cause surprise. Firstly, it seems to leave out the role commonly ascribed to the so-called motoric part of the nervous system in bringing about bodily action; and secondly, the acknowledgment of the dependence of consciousness on corporeal 'dying' implies that willing is an unconscious activity because of its being based on *life* processes of the body.

The first of these two problems will find its answer at a later stage of our discussion when we shall see what entitles us to draw a direct connexion between volition and muscular action. To answer the second problem, simple self-observation is required. This tells us that, when we move a limb, all that we know of is the intention (in its conceptual form) which rouses the will and gives it its direction, and the fact of the completed deed. In between, we accompany the movement with a dim awareness of the momentary positions of the parts of the body involved, so that we know whether or not they are moving in the intended manner. This awareness is due to a particular sense, the 'sense of movement' or 'muscular sense'—one of those senses whose existence physiology has lately come to acknowledge. Nothing, however, is known to us of all the complex changes which are set into play within the muscles themselves in order to carry out some in-

[1] First published in 1917 in his book *Von Seelenrätseln,*

tended movement. And it is these that are the direct outcome of the activity of our will.

Regarding man's psycho-physical organization thus, we come to see in it a kind of polarity—a death-pole, as it were, represented by the nerves including their extension into the senses, and a life-pole, represented by the metabolic and muscular systems; and connected with them a pole of consciousness and one of unconsciousness—or as we can also say, of waking and sleeping consciousness. For the degree of consciousness on the side of the life-pole is not different from the state in which the entire human being dwells during sleep.

It is by thus recognizing the dependence of consciousness on processes of bodily disintegration that we first come to understand why consciousness, once it has reached a certain degree of brightness, is bound to suffer repeated interruptions. Every night, when we sleep, our nervous system becomes alive (though with gradually decreasing intensity) in order that what has been destroyed during the day may be restored. While the system is kept in this condition, no consciousness can obtain in it.

In between the two polarically opposite systems there is a third, again of clearly distinct character, which functions as a mediator between the two. Here all processes are of a strictly rhythmic nature, as is shown by the process of breathing and the pulsation of the blood. This system, too, provides the foundation for a certain type of psychological process, namely feeling. That feeling is an activity of the soul distinct from both thinking and willing, and that it has its direct counterpart in the rhythmic processes of the body, can be most easily tested through observing oneself when listening to music.

As one might expect from its median position, the feeling sphere of the soul is characterized by a degree of consciousness half-way between waking and sleeping. Of our feelings we are not more conscious than of our dreams; we are as little detached from them as from our dream experiences while these last; what remains in our memory of past feelings is usually not more than what we remember of past dreams.

This picture of the threefold psycho-physical structure of man will now enable us to understand the evolution of consciousness both in individual life and in the life of mankind. To furnish the foundation of waking consciousness, parts of the body must become divorced from life. This process, however, is one which, if we take the word in its widest sense, we may call, ageing. All organic bodies, and equally that of man, are originally traversed throughout by life. Only gradually certain parts of such an organism become precipitated, as it were, from the general organic structure, and they do so increasingly towards the end of that organism's life-span.

In the human body this separation sets in gently during the later stages of embryonic development and brings about the first degree of independence of bones and nerves from the rest of the organism. The retreat of life continues after birth, reaching a certain climax in the nervous system at about the twenty-first year. In the body of a small child there is still comparatively little contrast between living and non-living organs. There is equally little contrast between sleeping and waking condition in its soul. And the nature of the soul at this stage is volition throughout. Never, in fact, does man's soul so intensively *will* as in the time when it is occupied in bringing the body into an upright position, and never again does it exert its strength with the same unconsciousness of the goal to which it strives.

What, then, is the soul's characteristic relationship to the world around at this stage? The following observations will enable us to answer this question.

It is well known that small children often angrily strike an object against which they have stumbled. This has been interpreted as 'animism', by which it is meant that the child, by analogy with his experience of himself as a soul-filled body, imagines the things in his surroundings to be similarly ensouled. Anyone who really observes the child's mode of experience (of which we as adults, indeed, keep something in our will-life) is led to a quite different interpretation of such a phenomenon. For he realizes that the child neither experiences himself as soul-entity distinct from his body, nor faces the content of the world in so detached a manner as to be in need of using his imagination to read into it any soul-entities distinct from his own.

In this early period of his life the human being still feels the world as part of himself, and himself as part of the world. Consequently, his relation to the objects around him and to his own body is one and the same. To the example of the child beating the external object he has stumbled against, there belongs the complementary picture of the child who beats himself because he has done something which makes him angry with himself.

In sharp contrast to this state of oneness of the child's soul, in regard both to its own body and to the surrounding world, there stands the separatedness of the adult's intellectual consciousness, severed from both body and world. What happens to this part of the soul during its transition from one condition to the other may be aptly described by using a comparison from another sphere of natural phenomena. (Later descriptions in this book will show that a comparison such as the one used here is more than a mere external analogy.)

Let us think of water in which salt has been dissolved. In this state the salt is one with its solvent; there is no visible distinction between them. The situation changes when part of the salt crystallizes. By this process the part of the salt substance concerned loses its connexion with the liquid and contracts into individually outlined and spatially defined pieces of solid matter. It thereby becomes optically distinguishable from its environment.

Something similar happens to the soul within the region of the nervous system. What keeps the soul in a state of unconsciousness as long as the body, in childhood, is traversed by life throughout, and what continues to keep it in this condition in the parts which remain alive after the separation of the nerves, is the fact that in these parts—to maintain the analogy—the soul is dissolved in the body. With the growing independence of the nerves, the soul itself gains independence from the body. At the same time it undergoes a process similar to contraction whereby it becomes discernible to itself as an entity distinguished from the surrounding world. In this way the soul is enabled, eventually, to meet the world from outside as a self-conscious onlooker.

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What we have here described as the emergence of an individual's intellectual consciousness from the original, purely volitional condition of the soul is nothing but a replica of a greater process through which mankind as a whole, or more exactly Western mankind, has gone in the course of its historical development. Man was not always the 'brain-thinker' he is to-day.[1] Directly the separation of the nerve system was completed, and thereby the full clarity of the brain-bound consciousness achieved, man began to concern himself with science in the modern sense.

To understand why this science became restricted to one-eyed,

[1] Homer's men still think with the diaphragm *(phrenes)*. Similarly, the ancient practice of Yoga, as a means of acquiring knowledge, shows that at the time When it flourished man's conceptual activity was felt to be seated elsewhere than in the head.

colour-blind observation we need only apply to the human sense system, in particular, what we have learnt concerning man's threefold being.

Sharply distinguished by their respective modes of functioning though they are, the three bodily systems are each spread out through the whole body and are thus to be found everywhere adjacent to each other. Hence, the corresponding three states of consciousness, the sleeping, dreaming and waking, are also everywhere adjacent and woven into one another. It is the predominance of one or other which imparts a particular quality of soul to one or other region of the body. This is clearly shown within the realm of sense activity, itself the most conscious part of the human being. It is sufficient to compare, say, the senses of sight and smell, and to notice in what different degree we are conscious of the impressions they convey, and how differently the corresponding elements of conception, feeling and willing are blended in each. We never turn away as instinctively from objectionable colour arrangement as from an unpleasant smell. How small a part, on the other hand, do the representations of odours play in our recollection of past experiences, compared with those of sight.[1] The same is valid in descending measure for all other senses.

Of all senses, the sense of sight has in greatest measure the qualities of a 'conceptual sense'. The experiences which it brings, and these alone, were suitable as a basis for the new science, and even so a further limitation was necessary. For in spite of the special quality of the sense of sight, it is still not free from certain elements of feeling and will—that is, from elements with the character of dream or sleep. The first plays a part in our perception of colour; the second, in observing the forms and perspective ordering of objects we look at.

Here is repeated in a special way the threefold organization of man, for the seeing of colour depends on an organic process apart from the nerve processes and similar to that which takes place between heart and lungs, whilst the seeing of forms and spatial vision depend upon certain movements of the eyeball (quick traversing of the outline of the viewed object with the line of sight, alteration of the angle between the two axes of sight according to distance), in which the eye is active as a sort of outer limb of the body, an activity which enters our consciousness as little as does that of our limbs. It now becomes clear that no world-content obtained in such more or less

[1] This must not be confused with the fact that a smell may evoke other memories by way of association.

unconscious ways could be made available for the building of a new scientific world-conception. Only as much as man experiences through the sight of a single, colour-blind eye, could be used.[1]

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If we would understand the role of science in the present phase of human development, we must be ready to apply two entirely different and seemingly contradictory judgments to one and the same historical phenomenon. The fact that something has occurred out of historical necessity—that is, a necessity springing from the very laws of cosmic evolution—does not save it from having a character which, in view of its consequences, must needs be called tragic.

In this era of advanced intellectualism, little understanding of the existence of true tragedy in human existence has survived. As a result, the word 'tragedy' itself has deteriorated in its meaning and is nowadays used mostly as a synonym for 'sad event', 'calamity' 'serious event', even 'crime' (Oxford Diet.). In its original meaning, however, springing from the dramatic poetry of ancient Greece, the word combines the concept of calamity with that of inevitability; the author of the destructive action was not held to be personally responsible for it, since he was caught up in a nexus of circumstances which he could not change.

This is not the place to discuss why tragedy in this sense forms part of man's existence. It suffices to acknowledge that it does and, where it occurs, to observe it with scientific objectivity.

Our considerations, starting from certain statements made by some leading scientific thinkers of our time, have helped us not only to confirm the truth inherent in these statements, but to recognize the facts stated by them as being the outcome of certain laws of evolution and thereby having an historic necessity. This, however, does not mean that man's scientific labours, carried out under the historically given restrictions, great and successful as these labours were and are, have not led to calamitous effects such as we found indicated by Professor Carrel. The sciences of matter *have* led man into a country that is not his, and the world which he has created by means of scientific

[1] For one who endeavours to observe historical facts in the manner here described, it is no mere play of chance that the father of scientific atomism, John Dalton, was by nature colour blind. In fact, colour blindness was known, for a considerable time during the last century, as 'Daltonism', since it was through the publication of Dalton's self-observations that for the first time general attention was drawn to this phenomenon.

research is not only one in which he is a stranger but one which threatens to-day to deprive him of his own existence. The reason is that this world is essentially a world of active forces, and the true nature of these is something which modern man, restricted to his onlooker-consciousness, is positively unable to conceive.

We have taken a first step in diagnosing man's present spiritual condition. A few more steps are required to lead us to the point where we can conceive the therapy he needs.

CHAPTER III

The Onlooker's Philosophic Malady

In his isolation as world spectator, the modern philosopher was bound to reach two completely opposite views regarding the objective value of human thought. One of these was given expression in Descartes' famous words: *Cogito ergo sum* ('I think, therefore I am'). Descartes (1596-1650), rightly described as the inaugurator of modern philosophy, thus held the view that only in his own thought-activity does man find a guarantee of his own existence.

In coming to this view, Descartes took as his starting-point his experience that human consciousness contains only the thought pictures evoked by sense-perception, and yet knows nothing of the how and why of the things responsible for such impressions. He thus found himself compelled, in the first place, to doubt whether any of these things had any objective existence, at all. Hence, there remained over for him only one indubitable item in the entire content of the universe—his own thinking; for were he to doubt even this, he could do so only by again making use of it. From the 'I doubt, therefore I am', he was led in this way to the 'I think, therefore I am'.

The other conception of human thought reached by the onlooker-consciousness was diametrically opposed to that of Descartes, and entirely cancelled its conceptual significance. It was put forward—not long afterwards—by Robert Hooke (1635-1703), the first scientist to make systematic use of the newly invented microscope by means of which he made the fundamental discovery of the cellular structure of plant tissues. It was, indeed, on the strength of his microscopic studies that he boldly undertook to determine the relationship of human thought to objective reality. He published his views in the introduction to his *Micrographia,* the great work in which, with the lavish help of carefully executed copper engravings, he made his microscopic observations known to the world.

Hooke's line of thought is briefly as follows: In past ages men subscribed to the naive belief that what they have in their consciousness as thought pictures of the world, actually reproduces the real content of that world. The microscope now demonstrates, however, how much the familiar appearance of the world depends on the structure of our sense apparatus; for it reveals a realm just as real as that already known to us, but hitherto concealed from us because it is not accessible to the natural senses. Accordingly, if the microscope can penetrate through the veil of illusion which normally hides a whole world of potentially visible phenomena, it may be that it can even teach us something about the ideas we have hitherto formed concerning the nature of things. Perhaps it can bring us a step nearer the truth in the sphere of thought, as it so obviously has done in that of observation.

Of all the ideas that human reason can form, Hooke considered the simplest and the most fundamental to be the geometrical concepts of point and straight line. Undoubtedly we are able to think these, but the naïve consciousness takes for granted that it also perceives them as objective realities outside itself, so that thoughts and facts correspond to each other. We must now ask, however, if this belief is not due to an optical deception. Let us turn to the microscope and see what point and line in the external world look like through it.

For his investigation Hooke chose the point of a needle and a knife-edge, as providing the best representatives among physical objects of point and straight line. In the sketches here reproduced we may see how Hooke made clear to his readers how little these two things, when observed through the microscope, resemble what is seen by the unaided eye. This fact convinced Hooke that the apparent agreement between the world of perception and the world of ideas rests on nothing more solid than an optical limitation (Plate I).

Compared with the more refined methods of present-day thought, Hooke's procedure may strike us as somewhat primitive. Actually he did nothing more than has since been done times without number; for the scientist has become more and more willing to allow artificially evoked sense-perceptions to dictate the thoughts he uses in forming a scientific picture of the world.

In the present context we are concerned with the historical import of Hooke's procedure. This lies in the fact that, immediately after Descartes had satisfied himself that in thinking man had the one sure guarantee of his own existence, Hooke proved in a seemingly indubitable manner that thinking was entirely divorced from reality. It required only another century for philosophy to draw from this the unavoidable consequence. It appeared in the form of Hume's philosophic system, the outcome of which was universal scepticism.

As we shall see in due course, Hume's mode of reasoning continues to rule scientific thought even to-day, quite irrespective of the fact that science itself claims to have its philosophical parent in Kant, the very thinker who devoted his life's work to the refutation of Hume.

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On the basis of his investigations into human consciousness Hume felt obliged to reason thus: My consciousness, as I know it, has no contact with the external world other than that of a mere outside onlooker. What it wins for its own content from the outer world is in the nature of single, mutually unrelated parts. Whatever may unite these parts into an objective whole within the world itself can never enter my consciousness; and any such unifying factor entertained by my thought can be only a self-constructed, hypothetical picture. Hume summed up his view in two axioms which he himself described as the alpha and omega of his whole philosophy. The first runs: 'All our distinct perceptions are distinct existences.' The other: 'The Mind never perceives any real connexions between distinct existences.' *(Treatise of Human Nature.)*

If once we agree that we can know of nothing but unrelated thought pictures, because our consciousness is not in a position to relate these pictures to a unifying reality, then we have no right to ascribe, with Descartes and his school, an objective reality to the self. Even though the self may appear to us as the unifying agent among our thoughts, it must itself be a mental picture among mental pictures ; and man can have no knowledge of any permanent reality outside this fluctuating picture-realm. So, with Hume, the onlooker-consciousness came to experience its own utter inability to achieve a knowledge of the objective existence either of a material world be-behind all external phenomena, or of a spiritual self behind all the details of its own internal content.

Accordingly, human consciousness found itself hurled into the abyss of universal scepticism. Hume himself suffered unspeakably under the impact of what he considered inescapable ideas—rightly described from another side as the 'suicide of human intelligence'—and his philosophy often seemed to him like a malady, as he himself called it, against whose grip he could see no remedy. The only thing left to him, if he was to prevent philosophical suicide from ending in physical suicide, was to forget in daily life his own conclusions as far as possible.

What Hume experienced as his philosophical malady, however, was the result not of a mental abnormality peculiar to himself, but of that modern form of consciousness which still prevails in general to-day. This explains why, despite all attempts to disprove Hume's philosophy, scientific thought has not broken away from its alpha and omega in the slightest degree.

A proof of this is to be found, for example, in the principle of Indeterminacy which has arisen in modern physics.

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The conception of Indeterminacy as an unavoidable consequence of the latest phase of physical research is due to Professor W. Heisenberg. Originally this conception forced itself upon Heisenberg as a result of experimental research. In the meantime the same idea has received its purely philosophical foundation. We shall here deal with both lines of approach.

After the discovery by Galileo of the parallelogram of forces, it became the object of classical physics—unexpressed, indeed, until Newton wrote his *Principia*—to bring the unchanging laws ruling nature into the light of human consciousness, and to give them conceptual expression in the language of mathematical formulae. Since, however, science was obliged to restrict itself to what could be observed with a single, colour-blind eye, physics has taken as its main object of research the spatio-temporal relationships, and their changes, between discrete, ideally conceived, point-like particles. Accordingly, the mathematically formulable laws holding sway in nature came to mean the laws according to which the smallest particles in the material foundation of the world change their position with regard to each other. A science of this kind could logically maintain that, if ever it succeeded in defining both the position and the state of motion, in one single moment, of the totality of particles composing the universe, it would have discovered the law on which universal existence depends. This necessarily rested on the presupposition that it really was the ultimate particles of the physical world which were under observation. In the search for these, guided chiefly by the study of electricity, the physicists tracked down ever smaller and smaller units; and along this path scientific research has arrived at the following peculiar situation.

medium of observation. For ordinary things, light provides this. In the sense in which light is understood to-day, this is possible because the spatial extension of the single light impulses, their so-called wave-length, is immeasurably smaller than the average magnitude of all microscopically visible objects. This ensures that they can be observed clearly by the human eye. Much smaller objects, however, will require a correspondingly shorter wave-length in the medium of observation. Now shorter wave-lengths than those of visible light have been found in ultra-violet light and in X-rays; and these, accordingly, are now often used for minute physical research.

In this way, however, we are led by nature to a definite boundary; for we now find ourselves in a realm where the dimensions of the observation medium and the observed object are more or less the same. The result, unfortunately, is that when the 'light' meets the object, it changes the latter's condition of movement. On the other hand, if a 'light' is used whose wave-length is too big to have any influence on the object's condition of movement, it precludes any exact determination of the object's location.

Thus, having arrived at the very ground of the world—that is, where the cosmic laws might be expected to reveal themselves directly—the scientist finds himself in the remarkable situation of only being able to determine accurately either the position of an observed object and not its state of motion, or its state of motion and not its position. The law he seeks, however, requires that both should be known at the same time. Nor is this situation due to the imperfection of the scientific apparatus employed, but to its very perfection, so that it appears to arise from the nature of the foundation of the world—in so far, at least, as modern science is bound to conceive it.

If it is true that a valid scientific knowledge of nature is possible only in the sphere open to a single-eyed, colour-blind observation, and if it is true—as a science of this kind, at any rate, is obliged to believe—that all processes within the material foundation of the world depend on nothing but the movements of certain elementary particles of extremely small size, then the fact must be faced that the very nature of these processes rules out the discovery of any stable ordering of things in the sense of mathematically formulable laws. The discovery of such laws will then always be the last step but one in scientific investigation; the last will inevitably be the dissolution of such laws into chaos. For a consistent scientific thinking that goes this way, therefore, nothing is left but to recognize chaos as the only real basis of an apparently ordered world, a chaos on whose surface the laws that seem to hold sway are only the illusory picturings of the human mind. This, then, is the principle of Indeterminacy as it has been encountered in the course of practical investigation into the electrical processes within physical matter.

In the following way Professor Schrödinger, another leading thinker among modern theoretical physicists, explains the philosophical basis for the principle of Indeterminacy, which scientists have established in the meantime:[1]

'Every quantitative observation, every observation making use of measurement, is by nature discontinuous. . . . However far we go in the pursuit of accuracy we shall never get anything other than a finite series of discrete results. . . . The raw material of our quantitative cognition of nature will always have this primitive and discontinuous character. ... It is possible that a physical system might be so simple that this meagre information would suffice to settle its fate; in that case nature would not be more complicated than a game of chess. To determine a position of a game of chess thirty-three facts suffice. ... If nature is more complicated than a game of chess, a belief to which one tends to incline, then a physical system cannot be determined by a finite number of observations. But in practice a finite number of observations is all that we could make.'

Classical physics, the author goes on to show, held that it was possible to gain a real insight into the laws of the universe, because in principle an infinite number of such discrete observations would enable us to fill in the gaps sufficiently to allow us to determine the system of the physical world. Against this assumption modern physics must hold the view that an infinite number of observations cannot in any case be carried out in practice, and that nothing compels us to assume that even this would suffice to furnish us with the means for a complete determination, which alone would allow us to speak of 'law' in nature. 'This is the direction in which modern physics has led us without really intending it.'

What we have previously said will make it clear enough that in these words of a modern physicist we meet once more the two fundamentals of Hume's philosophy. It is just as obvious, however, that the very principle thus re-affirmed at the latest stage of modern phy-

[1] In his book, *Science and the Human Temperament* (Dublin, 1935).

sical science was already firmly established by Hooke, when he sought to prove to his contemporaries the unreality of human ideas.

Let us recall Hooke's motives and results. The human reason discovers that certain law-abiding forms of thought dwell within itself; these are the rules of mathematical thinking. The eye informs the reason that the same kind of law and order is present also in the outer world. The mind can think point and line; the eye reports that the same forms exist in nature outside. (Hooke could just as well have taken as his examples the apex and edge of a crystal.) The reason mistrusts the eye, however, and with the help of the microscope 'improves' on it. What hitherto had been taken for a compact, regulated whole now collapses into a heap of unordered parts; behind the illusion of law a finer observation detects the reality of chaos!

Had science in its vehement career from discovery to discovery not forgotten its own beginnings so completely, it would not have needed its latest researches to bring out a principle which it had in fact been following from the outset—a principle which philosophy had already recognized, if not in quite the same formulation, in the eighteenth century. Indeterminacy, as we have just seen it explained by Schrödinger, is nothing but the exact continuation of Humean scepticism.

CHAPTER IV

The Country that is Not Ours

The last two chapters have served to show the impasse into which human perception and thinking have come—in so far as they have been used for scientific purposes—by virtue of the relationship to the world in which man's consciousness found itself when it awoke to itself at the beginning of modern times. Now although the onlooker in man, especially in the earliest stage of our period, gave itself up to the conviction that a self-contained picture of the universe could be formed out of the kind of materials available to it, it nevertheless had a dim inkling that this picture, because it lacked all dynamic content, had no bearing on the real nature of the universe. Unable to find this reality within himself, the world-onlooker set about searching in his own way for what was missing, and turned to the perceptible world outside man. Here he came, all unexpectedly, upon . . . electricity. Scarcely was electricity discovered than it drew human scientific thinking irresistibly into its own realm. Thereby man found himself, with a consciousness completely blind to dynamics, within a sphere of only too real dynamic forces. The following description will show what results this has had for man and his civilization.

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First, let us recall how potent a role electricity has come to play in social life through the great discoveries which began at the end of the eighteenth century. To do this we need only compare the present relationship between production and consumption in the economic sphere with what it was before the power-machine, and especially the electrically driven machine, had been invented. Consider some major public undertaking in former times—say the construction of a great mediaeval cathedral. Almost all the work was done by human beings, with some help, of course, from domesticated animals. Under these circumstances the entire source of productive power lay in the will-energies of living beings, whose bodies had to be supplied with food, clothing and housing; and to provide these, other productive powers of a similar kind were required near the same place. Accordingly, since each of the power units employed in the work was simultaneously both producer and consumer, a certain natural limit was placed on the accumulation of productive forces in any one locality.

This condition of natural balance between production and consumption was profoundly disturbed by the introduction of the steam engine; but even so there were still some limits, though of a quite different kind, to local concentrations of productive power. For steam engines require water and coal at the scene of action, and these take up space and need continual shifting and replenishing. Owing to the very nature of physical matter, it cannot be heaped up where it is required in unlimited quantities.

All this changed directly man succeeded in producing energy electro-magnetically by the mere rotation of material masses, and in using the water-power of the earth—itself ultimately derived from the cosmic energies of the sun—for driving his dynamos. Not only is the source of energy thus tapped practically inexhaustible, but the machines produce it without consuming on their own account, apart from wear and tear, and so make possible the almost limitless accumulation of power in one place. For electricity is distinguished from all other power-supplying natural forces, living or otherwise, precisely in this, that it can be concentrated spatially with the aid of a physical carrier whose material bulk is insignificant compared with the energy supplied.

Through this property of electricity it has been possible for man to extend the range of his activity in all directions, far and near. So the balance between production and consumption, which in previous ages was more or less adequately maintained by natural conditions, has been entirely destroyed, and a major social-economic problem created.

In yet another way, and through quite another of its properties, electricity plays an important part in modern life. Not only does it compete with the human will; it also makes possible automatically intelligent operations quite beyond anything man can do on his own. There are innumerable examples of this in modern electrical technology; we need mention here only the photo-electric cell and the many devices into which it enters.

To an ever-increasing, quite uncontrolled degree—for to the mind of present-day man it is only natural to translate every new discovery into practice as soon and as extensively as possible—electricity enters decisively into our modern existence. If we take all its activities into account, we see arising amongst humanity a vast realm of labour units, possessed in their own way not only of will but of the sharpest imaginable intelligence. Although they are wholly remote from man's own nature, he more and more subdues his thoughts and actions to theirs, allowing them to take rank as guides and shapers of his civilization.

Turning to the sphere of scientific research, we find electricity playing a role in the development of modern thinking remarkably similar to its part as a labour-force in everyday life. We find it associated with phenomena which, in Professor Heisenberg's words, expose their mutual connexions to exact mathematical thinking more readily than do any other facts of nature; and yet the way in which these phenomena have become known has played fast and loose with mathematical thinking to an unparalleled degree. To recognize that in this sphere modern science owes its triumphs to a strange and often paradoxical mixture of outer accident and error in human thought, we need only review the history of the subject without prejudice.

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The discovery of electricity has so far been accomplished in four clearly distinct stages. The first extends from the time when men first knew of electrical phenomena to the beginning of the natural scientific age; the second includes the seventeenth and the greater part of the eighteenth centuries; the third begins with Galvani's discovery and closes with the first observations of radiant electricity; and the fourth brings us to our own day. We shall here concern ourselves with a few outstanding features of each phase, enough to characterize the strange path along which man has been led by the discovery of electricity.

Until the beginning of modern times, nothing more was known about electricity, or of its sister force, magnetism, than what we find in Pliny's writings. There, without recognizing a qualitative distinction between them, he refers to the faculty of rubbed amber and of certain pieces of iron to attract other small pieces of matter. It required the awakening of that overruling interest in material nature, characteristic of our own age, for the essential difference between electric and magnetic attraction to be recognized. The first to give a proper description of this was Queen Elizabeth's doctor, Gilbert. His discovery was soon followed by the construction of the first electrical machine by the German Guericke (also known through his invention of the air pump) which opened the way for the discovery that electricity could be transmitted from one place to another.

It was not, however, until the beginning of the eighteenth century that the crop of electrical discoveries began to increase considerably: among these was the recognition of the dual nature of electricity, by the Frenchman, Dufais, and the chance invention of the Leyden jar (made simultaneously by the German, von Kleist, and two Dutchmen, Musschenbroek and Cunaeus). The Leyden jar brought electrical effects of quite unexpected intensity within reach. Stimulated by what could be done with electricity in this form, more and more people now busied themselves in experimenting with so fascinating a force of nature, until in the second third of the century a whole army of observers was at work, whether by way of profession or of hobby, finding out ever new manifestations of its powers.

The mood that prevailed in those days among men engaged in electrical research is well reflected in a letter written by the Englishman, Walsh, after he had established the electric nature of the shocks given by certain fishes, to Benjamin Franklin, who shortly before had discovered the natural occurrence of electricity in the atmosphere:

'I rejoice in addressing these communications to You. He, who predicted and shewed that electricity wings the formidable bolt of the Atmosphere, will hear with attention that in the deep it speeds a humbler bolt, silent and invisible; He, who analysed the electrical Phial, will hear with pleasure that its laws prevail in animate Phials; He, who by Reason became an electrician, will hear with reverence of an instinctive electrician, gifted in his birth with a wonderful apparatus, and with the skill to use it.' (Phil. Trans. 1773.)

Dare one believe that in electricity the soul of nature had been discovered? This was the question which at that time stirred the hearts of very many in Europe. Doctors had already sought to arouse new vitality in their patients by the use of strong electric shocks; attempts had even been made to bring the dead back to life by such means.

In a time like ours, when we are primarily concerned with the practical application of scientific discoveries, we are mostly accustomed to regard such flights of thought from a past age as nothing but the unessential accompaniment of youthful, immature science, and to smile at them accordingly as historical curiosities. This is a mistake, for we then overlook how within them was hidden an inkling of the truth, however wrongly conceived at the time, and we ignore the role which such apparently fantastic hopes have played in connexion with the entry of electricity into human civilization. (Nor are such hopes confined to the eighteenth century; as we shall see, the same impulse urged Crookes a hundred years later to that decisive discovery which was to usher in the latest phase in the history of science, a phase in which the investigating human spirit has been led to that boundary of the physical-material world where the transition takes place from inert matter into freely working energy.)

If there was any doubt left as to whether in nature the same power was at work which, in animal and man, was hidden away within the soul, this doubt seemed finally to have been dispelled through Galvani's discovery that animal limbs could be made to move electrically through being touched by two bits of different metals. No wonder that 'the storm which was loosed in the world of the physicists, the physiologists and the doctors through Galvani's publication can only be compared with the one crossing the political horizon of Europe at the same time. Wherever there happened to be frogs and two pieces of different metals available, everyone sought proof with his own eyes that the severed limbs could be marvellously re-enlivened.'[1]

Like many of his contemporaries, Galvani was drawn by the fascinating behaviour of the new force of nature to carry on electrical experiments as a hobby alongside his professional work, anatomical research. For his experiments he used the room where his anatomical specimens were set out. So it happened that his electrical machine stood near some frogs' legs, prepared for dissection. By a further coincidence his assistant, while playing with the machine, released a few sparks just when some of the specimens were in such contact with the surface beneath them that they were bound to react to the sudden alteration of the electric field round the machine caused by its discharge. At each spark the frogs' legs twitched. What Galvani saw with his own eyes seemed to be no less than the union of two phenomena, one observed by Franklin in the heights of the atmosphere, the other by Walsh in the depths of the sea.

Galvani, as he himself describes, proceeded with immense enthu-

[1] E. du Bois-Raymond: *Investigations into Animal Electricity* (1884). Galvani published his discovery when the French Revolution had reached its zenith and Napoleon was climbing to power.

siasm to investigate systematically what accident had thus put into his hands.[1] He wanted first to see whether changes occurring naturally in the electrical condition of the atmosphere would call forth the same reaction in his specimens. For this purpose he fastened one end of an iron wire to a point high up outside his house; the lower end he connected with the nervous substance of a limb from one of his specimens, and to the foot of this he attached a second wire whose other end he submerged in a well. The specimen itself was either enclosed in a glass flask in order to insulate it, or simply left lying on a table near the well. And all this he did whenever a thunderstorm was threatening. As he himself reported: 'All took place as expected. Whenever the lightning flashed, all the muscles simultaneously came into repeated and violent twitchings, so that the movements of the muscles, like the flash of the lightning, always preceded the thunder, and thus, as it were, heralded its coming.' We can have some idea of what went on in Galvani's mind during these experiments if we picture vividly to ourselves the animal limbs twitching about every time the lightning flashed, as if a revitalizing force of will had suddenly taken possession of them.

In the course of his investigations—he carried them on for a long time—Galvani was astonished to observe that some of his specimens, which he had hung on to an iron railing by means of brass hooks, sometimes fell to twitching even when the sky was quite clear and there was no sign of thunder. His natural conclusion was that this must be due to hitherto unnoticed electrical changes in the atmosphere. Observations maintained for hours every day, however, led to no conclusive result; when twitchings did occur it was only with some of the specimens, and even then there was no discoverable cause. Then it happened one day that Galvani, 'tired out with fruitless watching', took hold of one of the brass hooks by which the specimens were hung, and pressed it more strongly than usual against the iron railing. Immediately a twitching took place. 'I was almost at the point of ascribing the occurrence to atmospheric electricity,' Galvani tells us. All the same he took one of the specimens, a frog, into his laboratory and there subjected it to similar conditions by putting it on an iron plate, and pressing against this with the hook that was stuck through its spinal cord. Immediately the twitching occurred again. He tried with other metals and, for checking pur-

[1] The above account follows A. J. von Oettingen's edition of Galvani's monograph, *De viribus electricitatis in motu musculari*.

poses, with non-metals as well. With some ingenuity he fixed up an arrangement, rather like that of an electric bell, whereby the limbs in contracting broke contact and in relaxing restored it, and so he managed to keep the frog in continuous rhythmical movement.

Whereas Galvani had been rightly convinced by his earlier observations that the movement in the specimens represented a reaction to an electric stimulus from outside, he now changed his mind. In the very moment of his really significant discovery he succumbed to the error that he had to do with an effect of animal electricity located somewhere in the dead creature itself, perhaps in the fashion of what had been observed in the electric fishes. He decided that the metal attachment served merely to set in motion the electricity within the animal.

Whilst Galvani persisted in this mistake until his death, Volta realized that the source of the electric force, as in the first of Galvani's observations, must still be sought outside the specimens, and himself rightly attributed it to the contacting metals. Guided by this hypothesis, Volta started systematic research into the Galvanic properties of metals, and presently succeeded in producing electricity once more from purely mineral substances, namely from two different metals in contact with a conductive liquid.

This mode of producing electricity, however, differed from any previously known in allowing for the first time the production of continuous electrical effects. It is this quality of the cells and piles constructed by Volta that laid open the road for electric force to assume that role in human civilization which we have already described. That Volta himself was aware of this essentially new factor in the Galvanic production of electricity is shown by his own report to the Royal Society:

'The chief of my results, and which comprehends nearly all the others, is the construction of an apparatus which resembles in its effects, viz. such as giving shocks to the arms, &c, the Leyden phial, and still better electric batteries weakly charged; .. . but which infinitely surpasses the virtue and power of these same batteries; as it has no need, like them, of being charged beforehand, by means of a foreign electricity ; and as it is capable of giving the usual commotion as often as ever it is properly touched.'

Whilst Volta's success was based on avoiding Galvani's error, his apparatus nevertheless turned out inadvertently to be a close counterpart of precisely that animal organ which Galvani had in mind when misinterpreting his own discoveries! That Volta himself realized this is clear from the concluding words in his letter:

'This apparatus, as it resembles more the natural organ of the torpedo, or of the electrical eel, than the Leyden Phial or the ordinary electric batteries, I may call an artificial electric organ.'

This new method of producing continuous electrical effects had far-reaching results, one of which was the discovery of the magnetic properties of the electric current by the Dane, Oersted—once again a purely accidental discovery, moving directly counter to the assumptions of the discoverer himself. About to leave the lecture room where he had just been trying to prove the non-existence of such magnetic properties (an attempt seemingly crowned with success), Oersted happened to glance once more at his demonstration bench. To his astonishment he noticed that one of his magnetic needles was out of alignment; evidently it was attracted by a magnetic field created by the current running through a wire he had just been using, which was still in circuit. Thus what had escaped Oersted throughout his planned researches—namely, that the magnetic force which accompanies an electric current must be sought in a direction at right angles to the current—a fortuitous event enabled him to detect.

These repeated strokes of chance and frequently mistaken interpretations of the phenomenon thus detected show that men were exploring the electrical realm as it were in the dark; it was a realm foreign to their ordinary ideas and they had not developed the forms of thought necessary for understanding it. (And this, as our further survey will show, is still true, even to-day.)

In our historical survey we come next to the researches of Faraday and Maxwell. Faraday was convinced that if electrical processes are accompanied by magnetic forces, as Oersted had shown, the reverse must also be true—magnetism must be accompanied by electricity. He was led to this correct conviction by his belief in the qualitative unity of all the forces of nature—a reflexion, as his biography shows, of his strongly monotheistic, Old Testament faith. Precisely this view, however—which since Faraday natural science has quite consciously adopted as a leading principle—will reveal itself to us as a fundamental error.

It seems paradoxical to assert that the more consistently human thought has followed this error, the greater have been the results of the scientific investigation of electricity. Precisely this paradox, however, is characteristic of the realm of nature to which electricity belongs; and anyone earnestly seeking to overcome the illusions of our age will have to face the fact that the immediate effectiveness of an idea in practice is no proof of its ultimate truth.

Another eloquent example of the strange destiny of human thought in connexion with electricity is to be found in the work of Clark Maxwell, who, starting from Faraday's discoveries, gave the theory of electricity its mathematical basis. Along his purely theoretical line of thought he was led to the recognition of the existence of a form of electrical activity hitherto undreamt of—electro-magnetic vibrations. Stimulated by Maxwell's mathematical conclusions, Hertz and Marconi were soon afterwards able to demonstrate those phenomena which have led on the one hand to the electro-magnetic theory of light, and on the other to the practical achievements of wireless communication.

Once again, there is the paradoxical fact that this outcome of Maxwell's labours contradicts the very foundation on which he had built his theoretical edifice. For his starting-point had been to form a picture of the electro-magnetic field of force to which he could apply certain well-known formulae of mechanics. This he did by comparing the behaviour of the electrical force to the currents of an elastic fluid—that is, of a material substance. It is true that both he and his successors rightly emphasized that such a picture was not in any way meant as an explanation of electricity, but merely as an auxiliary concept in the form of a purely external analogy. Nevertheless, it was in the guise of a material fluid that he thought of this force, and that he could submit it to mathematical calculation. Yet the fact is that from this starting-point the strict logic of mathematics led him to the discovery that electricity is capable of behaviour which makes it appear qualitatively similar to … light!

Whilst practical men were turning the work of Faraday and Maxwell to account by exploiting the mechanical working of electricity in power-production, and its similarity to light in the wireless communication of thought, a new field of research, with entirely new practical possibilities, was suddenly opened up in the last third of the nineteenth century through the discovery of how electricity behaves in rarefied air. This brings us to the discovery of cathode rays and the phenomena accompanying them, from which the latest stage in the history of electricity originated. And here once more, as in the history of Galvani's discoveries, we encounter certain undercurrents of longing and expectation in the human soul which seemed to find an answer through this sudden, great advance in the knowledge of electricity—an advance which has again led to practical applications of the utmost significance for human society, though not at all in the way first hoped for.

Interest in the phenomena arising when electricity passes through gases with reduced pressure had simultaneously taken hold of several investigators in the seventies of the nineteenth century. But the decisive step in this sphere of research was taken by the English physicist, William Crookes. He was led on by a line of thought which seems entirely irrelevant; yet it was this which first directed his interest to the peculiar phenomena accompanying cathode rays; and they proved to be the starting-point of the long train of inquiry which has now culminated in the release of atomic energy.[1]

In the midst of his many interests and activities, Crookes was filled from his youth with a longing to find by empirical means the bridge leading from the world of physical effects to that of superphysical causes. He himself tells how this longing was awakened in him by the loss of a much-beloved brother. Before the dead body he came to the question, which thereafter was never to leave him, whether there was a land where the human individuality continues after it has laid aside its bodily sheath, and how that land was to be found. Seeing that scientific research was the instrument which modern man had forged to penetrate through the veil of external phenomena to the causes producing them, it was natural for Crookes to turn to it in seeking the way from the one world into the other.

It was after meeting with a man able to produce effects within the corporeal world by means of forces quite different from those familiar to science, that Crookes decided to devote himself to this scientific quest. Thus he first came into touch with that sphere of phenomena which is known as spiritualism, or perhaps more suitably, spiritism. Crookes now found himself before a special order of happenings which seemed to testify to a world other than that open to our senses; physical matter here showed itself capable of movement in defiance of gravity, manifestations of light and sound appeared without a physical source to produce them. Through becoming familiar with such things at seances arranged by his mediumistic acquaintance, he began to hope that he had found the way by which scientific research could overstep the limits of the physical world. Accordingly,

[1] For what follows see *The Life of Sir William Crookes,* by E. E. Fournier D'Albe (London, 1923).

he threw himself eagerly into the systematic investigation of his new experiences, and so became the father of modern scientific spiritism.

Crookes had hoped that the scientists of his day would be positively interested in his researches. But his first paper in this field, 'On Phenomena called Spiritual', was at once and almost unanimously rejected by his colleagues, and as long as he concerned himself with such matters he suffered through their opposition. It passed his understanding as a scientist why anything should be regarded in advance as outside the scope of scientific research. After several years of fruitless struggle he broke off his investigations into spiritism, deeply disillusioned at his failure to interest official science in it. His own partiality for it continued, however (he served as President of the Society for Psychical Research from 1896-9), and he missed no opportunity of confessing himself a pioneer in the search for the boundary-land between the worlds of matter and spirit. Through all his varied scientific work the longing persisted to know more of this land.

Just as Crookes had once sought to investigate spiritism scientifically, so in his subsequent scientific inquiries he was always something of a spiritist. He admitted, indeed, that he felt specially attracted by the strange light effects arising when electricity passes through rarefied gases, because they reminded him of certain luminous phenomena he had observed during his spiritistic investigations. Besides this, there was the fact that light here showed itself susceptible to the magnetic force in a way otherwise characteristic only of certain material substances. Accordingly, everything combined to suggest to Crookes that here, if anywhere, he was at the boundary between the physical and the superphysical worlds. No wonder that he threw himself into the study of these phenomena with enthusiasm.

He soon succeeded in evoking striking effects—light and heat, and also mechanical—along the path of electricity passing invisibly through the tube later named after him. Thus he proved for the first time visibly, so to say, the double nature—material and supermaterial—of electricity. What Crookes himself thought about these discoveries in the realm of the cathode rays we may judge from the title, 'Radiant Matter', or 'The Fourth State of Matter', which he gave to his first publication about them. And so he was only being consistent when, in his lectures before the Royal Institution in London, and the British Association in Sheffield in 1879, after showing to an amazed scientific audience the newly discovered properties of electricity, he came to the climax of his exposition by saying: 'We have seen that in some of its properties Radiant Matter is as material as this table, whilst in other properties it almost assumes the character of Radiant Energy. We have actually touched here the borderland where Matter and Force seem to merge into one another, the shadowy realm between Known and Unknown, which for me has always had peculiar temptations.' And in boldly prophetic words, which time has partly justified, he added, 'I venture to think that the greatest scientific problems of the future will find their solution in this Borderland, and even beyond; here, it seems to me, lie Ultimate Realities, subtle, far-reaching, wonderful.'

No one can read these words of Crookes without hearing again, as an undertone, the question which had forced itself on him at the bedside of his dead brother, long before. All that is left of the human being whom death has taken is a heap of substances, deserted by the force which had used them as the instrument of its own activity. Whither vanishes this force when it leaves the body, and is there any possibility of its revealing itself even without occupying such a body?

Stirred by this question, the young Crookes set out to find a world of forces which differ from the usual mechanical ones exercised by matter on matter, in that they are autonomous, superior to matter in its inert conglomeration, yet capable of using matter, just as the soul makes use of the body so long as it dwells within it. His aim was to secure proof that such forces exist, or, at any rate, to penetrate into the realm where the transition from matter to pure, matter-free force takes place. And once again, as in Galvani's day, electricity fascinated the eyes of a man who was seeking for the land of the soul. What spiritism denied, electricity seemed to grant.

The aversion to spiritism which Crookes met with in contemporary science was, from the standpoint of such a science, largely justified. Science, in the form in which Crookes himself conceived it, took for granted that the relationship of human consciousness to the world was that of external onlooking. Accordingly, if the scientist remained within the limits thus prescribed for consciousness, it was only consistent to refuse to make anything beyond these limits an object of scientific research.

On the other hand, it says much for the courage and open mindedness of Crookes that he refused to be held back from what was for him the only possible way of extending the boundaries of science beyond the given physical world. Moreover, it was only natural that in his search for a world of a higher order than the physical he should, as a man of his time, first turn his attention to spiritistic occurrences, for spiritism, as it had come over to Europe from America in the middle of the nineteenth century, was nothing but an attempt by the onlooker-consciousness to learn something in its own way about the supersensible world. The spiritist expects the spirit to reveal itself in outwardly perceptible phenomena as if it were part of the physical world.

Towards the end of his life Crookes confessed that if he were able to begin again he would prefer to study telepathic phenomena—the direct transference of thought from one person to another—rather than the purely mechanical, or so-called telekinetic, expressions of psychic forces. But although his interest was thus turning towards a more interior field of psychic investigation, he remained true to his times in still assuming that knowledge about the world, whatever it might be, could be won only by placing oneself as a mere onlooker outside the object of research.

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The stream of new discoveries which followed Crookes's work justified his conviction that in cathode ray phenomena we have to do with a frontier region of physical nature. Still, the land that lies on the other side of this frontier is not the one Crookes had been looking for throughout his life. For, instead of finding the way into the land whither man's soul disappears at death, Crookes had inadvertently crossed the border into another land—a land which the twentieth-century scientist is impelled to call 'the country that is not ours'.

The realm thrown open to science by Crookes's observations, which human knowledge now entered as if taking it by storm, was that of the radioactive processes of the mineral stratum of the earth. Many new and surprising properties of electricity were discovered there—yet the riddle of electricity itself, instead of coming nearer, withdrew into ever deeper obscurity.

The very first step into this newly discovered territory made the riddle still more bewildering. As we have said, Maxwell's use of a material analogy as a means of formulating mathematically the properties of electro-magnetic fields of force had led to results which brought electricity into close conjunction with light. In his own way Crookes focused, to begin with, his attention entirely on the light-like character of electric effects in a vacuum. It was precisely these observations, however, as continued by Lenard and others, which presently made it necessary to see in electricity nothing else than a special manifestation of inert mass.

The developments leading up to this stage are recent and familiar enough to be briefly summarized. The first step was once more an accident, when Röntgen (or rather one of his assistants) noticed that a bunch of keys, laid down by chance on top of an unopened box of photographic plates near a cathode tube, had produced an inexplicable shadow-image of itself on one of the plates. The cathode tube was apparently giving off some hitherto unknown type of radiation, capable of penetrating opaque substances. Röntgen was an experimentalist, not a theorist; his pupils used to say privately that in publishing this discovery of X-rays he attempted a theoretical explanation for the first and only time in his life—and got it wrong!

However, this accidental discovery had far-reaching consequences. It drew attention to the fluorescence of minerals placed in the cathode tube; this inspired Becquerel to inquire whether naturally fluorescent substances gave off anything like X-rays, and eventually—yet again by accident—he came upon certain uranium compounds. These were found to give off a radiation similar to X-rays, and to give it off naturally and all the time. Soon afterwards the Curies succeeded in isolating the element, radium, an element which was found to be undergoing a continuous natural disintegration. The way was now clear for that long series of experiments on atomic disintegration which led finally to the splitting of the nucleus and the construction of the atomic bomb.

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A typical modern paradox emerges from these results. By restricting his cognitive powers to a field of experience in which the concept of force as an objective reality was unthinkable, man has been led on a line of practical investigation the pursuit of which was bound to land him amongst the force-activities of the cosmos. For what distinguishes electric and sub-electric activities from all other forces of physical nature so far known to science, is that for their operation they have no need of the resistance offered by space-bound material bodies; they represent a world of pure dynamics into which spatial limitations do not enter.

Equally paradoxical is the situation of theoretical thinking in face of that realm of natural being which practical research has lately entered. We have seen that this thinking, by virtue of the consciousness on which it is founded, is impelled always to clothe its ideas in spatial form. Wherever anything in the pure spatial adjacency of physical things remains inexplicable, resort is had to hypothetical pictures whose content consists once more of nothing but spatially extended and spatially adjacent items. In this way matter came to be seen as consisting of molecules, molecules of atoms, and atoms of electrons, protons, neutrons, and so forth.

In so far as scientific thought has held to purely spatial conceptions, it has been obliged to concentrate on ever smaller and smaller spatial sizes, so that the spatially conceived atom-picture has finally to reckon with dimensions wherein the old concept of space loses validity. When once thinking had started in this direction, it was electricity which once more gave it the strongest impulse to go even further along the same lines.

Where we have arrived along this path is brought out in a passage in Eddington's *The Nature of the Physical World.* There, after describing the modern picture of electrons dancing round the atomic nucleus, he says: 'This spectacle is so fascinating that we have perhaps forgotten that there was a time when we wanted to be told what an electron is. This question was never answered. No familiar conceptions can be woven round the electron; it belongs to the waiting list.' The only thing we can say about the electron, if we are not to deceive ourselves, Eddington concludes, is: '*Something unknown is doing we don't know what.*'[1]

Let us add a further detail from this picture of the atom, as given in Eddington's *Philosophy of Physical Science.* Referring to the so-called positron, the positive particle regarded as the polar opposite of the negative electron, he remarks: 'A positron is a hole from which an electron has been removed; it is a bung-hole which would be evened up with its surroundings if an electron were inserted.... You will see that the physicist allows himself even greater liberty than the sculptor. The sculptor removes material to obtain the form he desires. The physicist goes further and adds material if necessary—an operation which he describes as removing negative material. He fills up a bung-hole, saying he is removing a positron.' Eddington thus shows to what paradoxical ideas the scientist is driven, when with his accustomed forms of thought he ventures into regions where the conditions necessary for such forms no longer exist; and he concludes his remarks with the following caution: 'Once again I would remind you that objective truth is not the point at issue.'

[1] Eddington's italics. See also, in this respect, Professor White head's criticism of the hypothetical picture of the electron and its behaviour.

By this reminder Eddington shows how far science has reconciled itself to the philosophic scepticism at which man's thinking had arrived in the days of Hume. In so far as the above remark was intended to be a consolation for the bewildered student, it is poor comfort in the light of the actions which science has let loose with the help of those unknown entities. For it is just this resignation of human thought which renders it unable to cope with the flood of phenomena springing from the sub-material realm of nature, and has allowed scientific research to outrun scientific understanding.

PART II

Goetheanism—Whence and Whither?

CHAPTER V

The Adventure of Reason

In 1790, a year before Galvani's monograph, *Concerning the Forces of Electricity,* appeared, Goethe published his *Metamorphosis of Plants,* which represents the first step towards the practical overcoming of the limitations of the onlooker-consciousness in science. Goethe's paper was not destined to raise such a storm as soon followed Galvani's publication. And yet the fruit of Goethe's endeavours is not less significant than Galvani's discovery, for the progress of mankind. For in Goethe's achievement lay the seed of that form of knowing which man requires, if in the age of the electrification of civilization he is to remain master of his existence.

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Among the essays in which Goethe in later years gave out some of the results of his scientific observation in axiomatic form, is one called 'Intuitive Judgment' *('Anschauende Urteilskraft'),* in which he maintains that he has achieved in practice what Kant had declared to be for ever beyond the scope of the human mind. Goethe refers to a passage in the *Critique of Judgment,* where Kant defines the limits of human cognitional powers as he had observed them in his study of the peculiar nature of the human reason. We must first go briefly into Kant's own exposition of the matter.[1]

Kant distinguishes between two possible forms of reason, the *intellectus archetypus* and the *intellectus ectypus.* By the first he means a reason 'which being, not like ours, discursive, but intuitive, proceeds from the synthetic universal (the intuition of the whole as such)

[1] *Critique of Judgment,* II, 11, 27. Goethe chose the title of his essay so as to refute Kant by its very wording. Kant, through his inquiry into man's *Urteilskraft,* arrived at the conclusion that man is denied the power of *Anschauung* (intuition). Against this, Goethe puts his *Anschauende Urteilskraft.*

to the particular, that is, from the whole to the parts'. According to Kant, such a reason lies outside human possibilities. In contrast to it, the *intellectus ectypus* peculiar to man is restricted to taking in through the senses the single details of the world as such; with these it can certainly construct pictures of their totalities, but these pictures never have more than a hypothetical character and can claim no reality for themselves. Above all, it is not given to such a thinking to think 'wholes' in such a way that through an act of thought alone the single items contained in them can be conceived as parts springing from them by necessity. (To illustrate this, we may say that, according to Kant, we can certainly comprehend the parts of an organism, say of a plant, and out of its components make a picture of the plant as a whole; but we are not in a position to think that 'whole' of the plant which conditions the existence of its organism and brings forth its parts by necessity.) Kant expresses this in the following way:

'For external objects as phenomena an adequate ground related to purposes cannot be met with; this, although it lies in nature, must be sought only in the supersensible substrata of nature, from all possible insight into which we are cut off. Our understanding has then this peculiarity as concerns the judgment, that in cognitive understanding the particular is not determined by the universal and cannot therefore be derived from it.'

The attempt to prove whether or not another form of reason than this (the *intellectus archetypus)* is possible—even though declared to be beyond man—Kant regarded as superfluous, because the fact was enough for him 'that we are led to the Idea of it—which contains no contradiction—in contrast to our discursive understanding, which has need of images *(intellectus ectypus),* and to the contingency of its constitution'.

Kant here brings forward two reasons why it is permissible to conceive of the existence of an extra-human, archetypal reason. On the one hand he admits that the existence of our own reason in its present condition is of a contingent order, and thus does not exclude the possible existence of a reason differently constituted. On the other hand, he allows that we can think of a form of reason which in every respect is the opposite of our own, without meeting any logical inconsistency.

From these definitions emerges a conception of the properties of man's cognitional powers which agrees exactly with those on which, as we have seen, Hume built up his whole philosophy. Both allow to the reason a knowledge-material consisting only of pictures—that is, of pictures evoked in consciousness through sense-perception, and received by it from the outer world in the form of disconnected units, whilst denying it all powers, as Hume expressed it, ever 'to perceive any real connections between distinct existences'.

This agreement between Kant and Hume must at first sight surprise us, when we recall that, as already mentioned, Kant worked out his philosophy precisely to protect the cognizing being of man from the consequences of Hume's thought. For, as he himself said, it was his becoming acquainted with Hume's *Treatise* that 'roused him out of his dogmatic slumber' and obliged him to reflect on the foundations of human knowing. We shall understand this apparent paradox, however, if we take it as a symptom of humanity's close imprisonment in recent centuries within the limits of its onlooker-consciousness.

In his struggle against Hume, Kant was not concerned to challenge his opponent's definition of man's reasoning power. His sole object was to show that, if one accepted this definition, one must not go as far as Hume in the application of this power. All that Kant could aspire to do was to protect the ethical from attack by the intellectual part of man, and to do this by proving that the former belongs to a world into which the latter has no access. For with his will man belongs to a world of purposeful doing, whereas the reason, as our quotations have shown, is incapable even in observing external nature, of comprehending the wholes within nature which determine natural ends. Still less can it do this in regard to man, a being who in his actions is integrated into higher purposes.

Kant's deed is significant in that it correctly drew attention to that polar division in human nature which, after all, was already established in Kant's own time. Kant demonstrated also that to win insight into the ethical nature of man with the aid of the isolated intellect alone implied a trespass beyond permissible limits. In order to give the doing part of the human being its necessary anchorage, however, Kant assigned it to a moral world-order entirely external to man, to which it could be properly related only through obedient submission.

In this way Kant became the philosopher of that division between knowledge and faith which to this day is upheld in both the ecclesiastical and scientific spheres of our civilization. Nevertheless, he did not succeed in safeguarding humanity from the consequences of Hume's philosophy; for man cannot live indefinitely in the belief that with the two parts of his own being he is bound up with two mutually unrelated worlds. The time when this was feasible is already over, as may be seen from the fact that ever greater masses of men wish to determine their behaviour according to their own ideas, and as they see no alternative in the civilization around them but to form ideas by means of the discursive reason which inevitably leads to agnosticism, they determine their actions accordingly. Meanwhile, the ethical life as viewed by Kant accordingly shrinks ever further into a powerless, hole-and-corner existence.

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It is Goethe's merit to have first shown that there is a way out of this impasse. He had no need to argue theoretically with Kant as to the justification of denying man any power of understanding apart from the discursive, and of leaving the faculty of intuitive knowledge to a divinity somewhere outside the world of man. For Goethe was his own witness that Kant was mistaken in regarding man's present condition as his lasting nature. Let us hear how he expresses himself on this fact at the beginning of his essay written as an answer to Kant's statement:

'It is true, the author here seems to be pointing to an intellect not human but divine. And yet, if in the moral sphere we are supposed to lift ourselves up to a higher region through faith in God, Virtue and Immortality, so drawing nearer to the Primal Being, why should it not be likewise in the intellectual? By contemplation *(Anschauen)* of an ever-creative nature, may we not make ourselves worthy to be spiritual sharers in her productions? I at first, led by an inner urge that would not rest, had quite unconsciously been seeking for the realm of Type and Archetype, and my attempt had been rewarded: I had been able to build up a description, in conformity with Nature herself. Now therefore nothing more could hinder me from braving what the Old Man of the King's Hill[1] himself calls the *Adventure of Reason.'*

Goethe started from the conviction that our senses as well as our intellect are gifts of nature, and that, if at any given moment they prove incapable through their collaboration of solving a riddle of nature, we must ask her to help us to develop this collaboration adequately. Thus there was no question for him of any restriction of

[1] *'Der Alte vom Königsberge'*—a play upon words with the name of Kant's native town, *Königsberg.*

sense-perception in order to bring the latter in line with the existing power of the intellect, but rather to learn to make an ever fuller use of the senses and to bring our intellect into line with what they tell. 'The senses do not deceive, but the judgment deceives', is one of his basic utterances concerning their respective roles in our quest for knowledge and understanding. As to the senses themselves, he was sure that 'the human being is adequately equipped for all true earthly requirements if he trusts his senses, and so develops them as to make them worthy of trust'.

There is no contradiction in the statement that we have to trust our senses, and that we have to develop them to make them trustworthy. For, 'nature speaks upwards to the known senses of man, downwards to unknown senses of his'. Goethe's path was aimed at wakening faculties, both perceptual and conceptual, which lay dormant in himself. His experience showed him that 'every process in nature, rightly observed, wakens in us a new organ of cognition'. Right observation, in this respect, consisted in a form of contemplating nature which he called a 're-creating (creating in the wake) of an ever-creative nature' *(Nachschaffen einer immer schaffenden Natur).*

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We should do Goethe an injustice if we measured the value of his scientific work by the amount of factual knowledge he contributed to one or other sphere of research. Although Goethe did bring many new things to light, as has been duly recognized in the scientific fields concerned, it cannot be gainsaid that other scientists in his own day, working along the usual lines, far exceeded his total of discoveries. Nor can it be denied that, as critics have pointed out, he occasionally went astray in reporting his observations. These things, however, do not determine the value or otherwise of his scientific labours. His work draws its significance not so much from the 'what', to use a Goethean expression, as from the 'how' of his observations, that is, from his way of investigating nature. Having once developed this method in the field of plant observation, Goethe was able, with its aid, to establish a new view of animal nature, to lay the basis for a new meteorology, and, by creating his theory of light and colour, to provide a model for a research in the field of physics, free from onlooker-restrictions.

In the scientific work of Goethe his botanical studies have a special place. As a living organism, the plant is involved in an endless process of becoming. It shares this characteristic, of course, with the higher creatures of nature, and yet between it and them there is an essential difference. Whereas in animal and man a considerable part of the life-processes conceal themselves within the organism, in order to provide a basis for inner soul processes, the plant brings its inner life into direct and total outer manifestation. Hence the plant, better than anything, could become Goethe's first teacher in his exercise of re-creating nature.

It is for the same reason that we shall here use the plant for introducing Goethe's method. The following exposition, however, does not aim at rendering in detail Goethe's own botanical researches, expounded by him in two extensive essays, *Morphology* and *The Metamorphosis of Plants,* as well as in a series of smaller writings. There are several excellent translations of the chief paper, the *Metamorphosis,* from which the English-speaking reader can derive sufficient insight into Goethe's way of expressing his ideas; a pleasure as well as a profit which he should not deny himself.

Our own way of procedure will have to be such that Goethe's method, and its fruitfulness for the general advance of science, come as clearly as possible into view.[1] Botanical details will be referred to only as far as seems necessary for this purpose.

The data for observation, from which in Goethe's own fashion we shall start, have been selected as best for our purpose, quite independently of the data used by Goethe himself. Our choice was determined by the material available when these pages were being written. The reader is free to supplement our studies by his own observation of other plants.

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Plates II and III show two series of leaves which are so arranged as to represent definite stages in the growth-process of the plant concerned. In each sequence shown the leaves have been taken from a single plant, in which each leaf-form was repeated, perhaps several times, before it passed over into the next stage. The leaves on Plate II come from a Sidalcea (of the mallow family), those on Plate III from a Delphinium. We will describe the forms in sequence, so that we may grasp as clearly as possible the transition from one to another as presented to the eye.

[1] It is naturally to be expected that new light will also be thrown on the various realms of knowledge as such dealt with in these pages.

Starting with the right-hand leaf at the bottom of Plate II, we let our eye and mind be impressed by its characteristic form, seeking to take hold of the pattern after which it is shaped. Its edge bears numerous incisions of varying depths which, however, do not disturb the roundness of the leaf as a whole. If we re-create in our imagination the 'becoming' of such a leaf, that is, its gradual growth in all directions, we receive an impression of these incisions as 'negative' forms, because, at the points where they occur, the multiplication of the cells resulting from the general growth has been retarded. We observe that this holding back follows a certain order.

We now proceed to the next leaf on the same plate and observe that, whilst the initial plan is faithfully maintained, the ratio between the positive and negative forms has changed. A number of incisions, hardly yet indicated in the first leaf, have become quite conspicuous. The leaf begins to look as if it were breaking up into a number of subdivisions.

In the next leaf we find this process still further advanced. The large incisions have almost reached the centre, while a number of smaller ones at the periphery have also grown deeper into the leaf. The basic plan of the total leaf is still maintained, but the negative forms have so far got the upper hand that the original roundness is no longer obvious.

The last leaf shows the process in its extreme degree. As we glance back and along the whole series of development, we recognize that the form of the last leaf is already indicated in that of the first. It appears as if the form has gradually come to the fore through certain forces which have increasingly prevented the leaf from filling in the whole of its ground-plan with matter. In the last leaf the common plan is still visible in the distribution of the veins, but the fleshy part of the leaf has become restricted to narrow strips along these veins.

The metamorphosis of the delphinium leaf (Plate III) is of a different character. Here the plant begins with a highly elaborate form of the leaf, while in the end nothing remains but the barest indication of it. The impression received from this series of leaves is that of a gradual withdrawal of the magnificent form, revealed in its fullness only in the first leaf.

A more intense impression of what these metamorphoses actually mean is achieved by altering our mode of contemplation in the following way. After repeated and careful observation of the different forms on either of the plates, we build up inwardly, as a memory picture, the shape of the first leaf, and then transform this mental image successively into the images of the ensuing forms until we reach the final stage. The same process can also be tried retrogressively, and so repeated forward and backward.

This is how Goethe studied the *doing* of the plant, and it is by this method that he discovered the spiritual principle of all plant life, and succeeded also in throwing a first light on the inner life-principle of animals.

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We chose the transformation of leaf forms into one another as the starting-point of our observations, because the principle of metamorphosis appears here in a most conspicuous manner. This principle, however, is not confined to this part of the plant's organism. In fact, all the different organs which the plant produces within its life cycle —foliage, calyx, corolla, organs of fertilization, fruit and seed—are metamorphoses of one and the same organ.

Man has long learnt to make use of this law of metamorphosis in the plant for what is called *doubling* the flower of a certain species. Such a flower crowds many additional petals within its original circle, and these petals are nothing but metamorphosed stamens; this, for instance, is the difference between the wild and the cultivated rose. The multitude of petals in the latter is obtained by the transformation of a number of the former's innumerable stamens. (Note the intermediate stages between the two, often found inside the flower of such plants.)

This falling back from the stage of an organ of fertilization to that of a petal shows that the plant is capable of *regressive metamorphosis,* and we may conclude from this that in the normal sequence the different organs are transformed from one another by way *of progressive metamorphosis.* It is evident that the regressive type occurs only as an abnormality, or as a result of artificial cultivation. Plants once brought into this condition frequently show a general state of unrest, so that other organs also are inclined to fall back to a lower level. Thus we may come across a rose, an outer petal of which appears in the form of a leaf of the calyx (sepal), or one of the sepals is found to have grown into an ordinary rose leaf.

We now extend our mental exercise to the plant's whole organism. By a similar mental effort as applied to the leaf-formations we strive to build up a complete plant. We start with the seed, from which we first imagine the cotyledons unfolding, letting this be followed by the gradual development of the entire green part of the plant, its stem and leaves, until the final leaves change into the sepals of the calyx. These again we turn into the petals of the flower, until via pistil and stamens the fruit and seed are formed.

By pursuing in this way the living doing of the plant from stage to stage we become aware of a significant rhythm in its total life cycle. This, when first discovered by Goethe, gave him the key to an understanding of nature's general procedure in building living organisms, and in maintaining life in them.

The plant clearly divides into three major parts: firstly, the one that extends from the cotyledons to the calyx, the green part of the plant, that is, where the life principle is most active; secondly, the one comprising the flower itself with the organs of fertilization, where the vitality of the plant gives way to other principles; and lastly, the fruit and seed, which are destined to be discharged from the mother organism. Each of these three contains two kinds of organs: first, organs with the tendency to grow into width—leaf, flower and fruit; second, organs which are outwardly smaller and simpler, but have the function of preparing the decisive leaps in the plant's development: these are the calyx, the stamens, etc., and the seed.

In this succession, Goethe recognized a certain rhythm of expansion and contraction, and he found that the plant passes through it three times during any one cycle of its life. In the foliage the plant expands, in the calyx it contracts; it expands again in the flower and contracts in the pistil and stamens; finally, it expands in the fruit and contracts in the seed.

The deeper meaning of this threefold rhythm will become clear when we consider it against the background of what we observed in the metamorphosis of the leaf. Take the mallow leaf; its metamorphosis shows a step-wise progression from coarser to finer forms, whereby the characteristic plan of the leaf comes more and more into view, so that in the topmost leaf it reaches a certain stage of perfection. Now we observe that in the calyx this stage is not improved on, but that the plant recurs to a much simpler formation.

Whilst in the case of the mallow the withdrawal from the stage of the leaf into that of the calyx occurs with a sudden leap, we observe that the delphinium performs this process by degrees. Whilst the mallow reaches the highly elaborate form of the leaf only in the final stage, the delphinium leaps forth at the outset, as it were, with the fully accomplished leaf, and then protracts its withdrawal into the calyx over a number of steps, so that this process can be watched with our very eyes. In this type of metamorphosis the last leaf beneath the calyx shows a form that differs little from that of a calyx itself, with its simple sepals. Only in its general geometrical arrangement does it still remind us of the original pattern.

In a case like this, the stem-leaves, to use Goethe's expression, 'softly steal into the calyx stage'.[1] In the topmost leaf the plant has already achieved something which, along the other line of metamorphosis, is tackled only after the leaf plan itself has been gradually executed. In this case the calyx stage, we may say, is attained at one leap.

Whatever type of metamorphosis is followed by a plant (and there are others as well, so that we may even speak of metamorphoses between different types of metamorphosis!) they all obey the same basic rule, namely, that before proceeding to the next higher stage of the cycle, the plant sacrifices something already achieved in a preceding one. Behind the inconspicuous sheath of the calyx we see the plant preparing itself for a new creation of an entirely different order. As successor to the leaf, the flower appears to us time and again as a miracle. Nothing in the lower realm of the plant predicts the form, colour, scent and all the other properties of the new organ produced at this stage. The completed leaf, preceding the plant's withdrawal into the calyx, represents a triumph of structure over matter. Now, in the flower, matter is overcome to a still higher degree. It is as if the material substance here becomes transparent, so that what is immaterial in the plant may shine through its outer surface.

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In this 'climbing up the spiritual ladder' Goethe learned to recognize one of nature's basic principles. He termed it *Steigerung* (heightening). Thus he saw the plant develop through Metamorphosis and Heightening towards its consummation. Implicit in the second of these two principles, however, there is yet another natural principle for which Goethe did not coin a specific term, although he shows through other utterances that he was well aware of it, and of its universal significance for all life. We propose to call it here the principle of Renunciation.

[1] Delphinium, in particular, has the peculiarity (which it shares with a number of other species) that its calyx appears in the guise of a flower, whilst the actual flower is quite inconspicuous.

In the life of the plant this principle shows itself most conspicuously where the green leaf is heightened into the flower. While progressing from leaf to flower the plant undergoes a decisive ebb in its vitality. Compared with the leaf, the flower is a dying organ. This dying, however, is of a kind we may aptly call a 'dying into being'. Life in its mere vegetative form is here seen withdrawing in order that a higher manifestation of the spirit may take place. The same principle can be seen at work in the insect kingdom, when the caterpillar's tremendous vitality passes over into the short-lived beauty of the butterfly. In the human being it is responsible for that metamorphosis of organic processes which occurs on the path from the metabolic to the nervous system, and which we came to recognize as the precondition for the appearance of consciousness within the organism.

What powerful forces must be at work in the plant organism at this point of transition from its green to its coloured parts! They enforce a complete halt upon the juices that rise up right into the calyx, so that these bring nothing of their life-bearing activity into the formation of the flower, but undergo a complete transmutation, not gradually, but with a sudden leap.

After achieving its masterpiece in the flower, the plant once more goes through a process of withdrawal, this time into the tiny organs of fertilization. (We shall return later to this essential stage in the life cycle of the plant, and shall then clear up the misinterpretation put upon it ever since scientific biology began.) After fertilization, the fruit begins to swell; once more the plant produces an organ with a more or less conspicuous spatial extension. This is followed by a final and extreme contraction in the forming of the seed inside the fruit. In the seed the plant gives up all outer appearance to such a degree that nothing seems to remain but a small, insignificant speck of organized matter. Yet this tiny, inconspicuous thing bears in it the power of bringing forth a whole new plant.

In these three successive rhythms of expansion and contraction the plant reveals to us the basic rule of its existence. During each expansion, the active principle of the plant presses forth into visible *appearance ;* during each contraction it withdraws from outer embodiment into what we may describe as a more or less pure state of *being.* We thus find the spiritual principle of the plant engaged in a kind of breathing rhythm, now appearing, now disappearing, now assuming power over matter, now withdrawing from it again.

In the fully developed plant this rhythm repeats itself three times in succession and at ever higher levels, so that the plant, in climbing from stage to stage, each time goes through a process of withdrawal before appearing at the next. The greater the creative power required at a certain stage, the more nearly complete must be the withdrawal from outer appearance. This is why the most extreme withdrawal of the plant into the state of being takes place in the seed, when the plant prepares itself for its transition from one generation to another. Even earlier, the flower stands towards the leaves as something like a new generation springing from the small organ of the calyx, as does the fruit to the flower when it arises from the tiny organs of reproduction. In the end, however, nothing appears outwardly so unlike the actual plant as the little seed which, at the expense of all appearance, has the power to renew the whole cycle.

Through studying the plant in this way Goethe grew aware also of the significance of the nodes and eyes which the plant develops as points where its vital energy is specially concentrated; not only the seed, but the eye also, is capable of producing a new, complete plant. In each of these eyes, formed in the axils of the leaves, the power of the plant is present in its entirety, very much as in each single seed.

In other ways, too, the plant shows its capacity to act as a whole at various places of its organism. Otherwise, no plant could be propagated by cuttings; in any little twig cut from a parent plant, all the manifold forces operative in the gathering, transmuting, forming of matter, that are necessary for the production of root, leaf, flower, fruit, etc., are potentially present, ready to leap into action provided we give it suitable outer conditions. Other plants, such as gloxinia and begonia, are known to have the power of bringing forth a new, complete plant from each of their leaves. From a small cut applied to a vein in a leaf, which is then embedded in earth, a root will soon be seen springing downward, and a stalk with leaves rising upward.

A particular observation made by Goethe in this respect is of interest for methodological reasons. In the introduction to his treatise *Metamorphosis of Plants*, when referring to the regressive metamorphosis of stamens into petals as an example of an *irregular* metamorphosis, he remarks that 'experiences of this kind of metamorphosis will enable us to disclose what is hidden from us in the regular way of development, and to see clearly and visibly what we should otherwise only be able to infer'. In this remark Goethe expresses a truth that is valid in many spheres of life, both human and natural. It is frequently a pathological aberration in an organic entity that allows us to see in physical appearance things that do not come outwardly to the fore in the more balanced condition of normal development, although they are equally part of the regular organic process.

An enlightening experience of this kind came to Goethe's aid when one day he happened to see a 'proliferated' rose *(durchgewachsene Rose)*, that is, a rose from whose centre a whole new plant had sprung. Instead of the contracted seed-pod, with the attached, equally contracted, organs of fertilization, there appeared a continuation of the stalk, half red and half green, bearing in succession a number of small reddish petals with traces of anthers. Thorns could be seen appearing further up, petals half-turned into leaves, and even a number of fresh nodes from which little imperfect flowers were budding. The whole phenomenon, in all its irregularity, was one more proof for Goethe that the plant in its totality is potentially present at each point of its organism.[1]

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Goethe's observation of the single plant *in statu agendi* had trained him to recognize things of quite different outer appearance as identical in their inner nature. Leaf, sepal, petal, etc., much as they differ outwardly, yet showed themselves to him as manifestations of one and the same spiritual archetype. His idea of Metamorphosis enabled him to reduce what in outer appearance seems incompatibly different to its common formative principle. His next step was to observe the different appearances of one and the same species in different regions of the earth, and thus to watch the capacity of the species to respond in a completely flexible way to the various climatic conditions, yet without concealing its inner identity in the varying outer forms. His travels in Switzerland and Italy gave him opportunity for such observations, and in the Alpine regions especially he was delighted at the variations in the species which he already knew so well from his home in Weimar. He saw their proportions, the distances between the single parts, the degree of lignification, the intensity of colour, etc., varying with the varied conditions, yet never concealing the identity of the species.

[1] Goethe also describes a proliferated pink.

Having once advanced in his investigations from metamorphosis in the parts of the single plant to metamorphosis among different representatives of single plant species, Goethe had to take only one further, entirely decisive, step in order to recognize how *every* member of the plant kingdom is the manifestation of a single formative principle common to them all. He was thus faced with the momentous task of preparing his spirit to think an idea from which the plant world in its entire variety could be derived.

Goethe did not take such a step easily, for it was one of his scientific principles never to think out an idea prematurely. He was well aware that he who aspires to recognize and to express in idea the spirit which reveals itself through the phenomena of the sense-world must develop the art of waiting—of waiting, however, in a way intensely active, whereby one looks again and yet again, until what one looks at begins to speak and the day at last dawns when, through tireless 're-creation of an ever-creating nature', one has grown ripe to express her secrets openly. Goethe was a master in this art of active waiting.

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It was in the very year that Galvani, through his chance discovery, opened the way to the overwhelming invasion of mankind by the purely physical forces of nature, that Goethe came clearly to see that he had achieved the goal of his labours. We can form some picture of the decisive act in the drama of his seeking and finding from letters written during the years 1785-7.

In the spring of 1785 he writes to a friend in a way that shows him fully aware of his new method of studying nature, which he recognized was a *reading* of her phenomena: 'I can't tell you how the Book of Nature is becoming readable to me. My long practice in spelling has helped me; it now suddenly works, and my quiet joy is inexpressible.' Again in the summer of the following year: 'It is a growing aware of the Form with which again and again nature plays, and, in playing, brings forth manifold life.'

Then Goethe went on his famous journey to Italy which was to bear such significant fruit for his inner life, both in art and in science. At Michaelmas, 1786, he reports from his visit to the botanical garden in Padua that 'the thought becomes more and more living that it may be possible out of one form to develop all plant forms'. At this moment Goethe felt so near to the basic conception of the plant for which he was seeking, that he already christened it with a special name. The term he coined for it is *Urpflanze*, literally rendered *archetypal plant*, or *ur-plant*, as we propose quite simply to call it.[1]

It was the rich tropical and sub-tropical vegetation in the botanical gardens in Palermo that helped Goethe to his decisive observations. The peculiar nature of the warmer regions of the earth enables the spirit to reveal itself more intensively than is possible in the temperate zone. Thus in tropical vegetation many things come before the eye which otherwise remain undisclosed, and then can be detected only through an effort of active thought. From this point of view, tropical vegetation is 'abnormal' in the same sense as was the proliferated rose which confirmed for Goethe's physical perception that inner law of plant-growth which had already become clear to his mind.

During his sojourn in Palermo in the spring of 1787 Goethe writes in his notebook: 'There must be one (ur-plant): how otherwise could we recognize this or that formation to be a plant unless they were all formed after one pattern?' Soon after this, he writes in a letter to the poet Herder, one of his friends in Weimar:

'Further, I must confide to you that I am quite close to the secret of plant creation, and that it is the simplest thing imaginable. The ur-plant will be the strangest creature in the world, for which nature herself should envy me. With this model and the key to it one will be able to invent plants *ad infinitum;* they would be consistent; that is to say, though non-existing, they would be capable of existing, being no shades or semblances of the painter or poet, but possessing truth and necessity. The same law will be capable of extension to all living things.'

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To become more familiar with the conception of the ur-plant, let us bring the life-cycle of the plant before our inner eye once again. There, all the different organs of the plant—leaf, blossom, fruit, etc. —appear as the metamorphic revelations of the one, identical active

[1] The terms 'primeval' or 'primordial' sometimes suggested for rendering the prefix 'ur' are unsuitable in a case like this. 'Primeval plant', for instance, used by some translators of Goethe, raises the misunderstanding—to which Goethe's concept has anyhow been subject from the side of scientific botany—that by his *ur-plant* he had in mind some primitive, prehistoric plant, the hypothetical ancestor in the Darwinian sense of the present-day plant kingdom.

principle, a principle which gradually manifests itself to us by way of successive heightening from the cotyledons to the perfected glory of the flower. Amongst all the forms which thus appear in turn, that of the leaf has a special place; for the leaf is that organ of the plant in which the ground-plan of all plant existence comes most immediately to expression. Not only do all the different leaf forms arise, through endless changing, out of each other, but the leaf, in accordance with the same principle, also changes itself into all the other organs which the plant produces in the course of its growth.

It is by precisely the same principle that the ur-plant reveals itself in the plant kingdom as a whole. Just as in the single plant organism the different parts are a graduated revelation of the ur-plant, so are the single kinds and species within the total plant world. As we let our glance range over all its ranks and stages (from the single-celled, almost formless alga to the rose and beyond to the tree), we are following, step by step, the revelation of the ur-plant. Barely hinting at itself in the lowest vegetable species, it comes in the next higher stages into ever clearer view, finally streaming forth in full glory in the magnificence of the manifold blossoming plants. Then, as its highest creation, it brings forth the tree, which, itself a veritable miniature earth, becomes the basis for innumerable single plant growths.

It has struck biologists of Goethe's own and later times that contrary to their method he did not build up his study of the plant by starting with its lowest form, and so the reproach has been levelled against him of having unduly neglected the latter. Because of this, the views he had come to were regarded as scientifically unfounded. Goethe's note-books prove that there is no justification for such a reproach. He was in actual fact deeply interested in the lower plants, but he realized that they could not contribute anything fundamental to the spiritual image of the plant as such which he was seeking to attain. To *understand* the plant he found himself obliged to pay special attention to examples in which it came to its most perfect expression. For what was hidden in the *alga* was made manifest in the *rose.* To demand of Goethe that in accordance with ordinary science he should have explained nature 'from below upwards' is to misunderstand the methodological basis of all his investigations.

Seen with Goethe's eyes, the plant kingdom as a whole appears to be a single mighty plant. In it the ur-plant, while pressing into *appearance,* is seen to observe the very rule which we have found governing its action in the single plant—that of repeated expansion and contraction.[1] Taking the tree in the sense already indicated, as the state of highest expansion along the ur-plant's way of entering into spatial manifestation, we note that tree-formation occurs successively at four different levels—as fern-tree (also the extinct tree-form of the horse-tail) among the cryptogams, as coniferous tree among the gymnosperms, as palm-tree among the monocotyledons, and lastly in the form of the manifold species of the leaf-trees at the highest level of the plant kingdom, the dicotyledons. All these levels have come successively into existence, as geological research has shown; the ur-plant achieved these various tree-formations successively, thus giving up again its state of expansion each time after having reached it at a particular level.

From the concept of the ur-plant Goethe soon learned to develop another concept which was to express the spiritual principle working in a particular plant species, just as the ur-plant was the spiritual principle covering the plant kingdom as a whole. He called it the *type.* In the manifold types which are thus seen active in the plant world we meet offsprings, as it were, of the mother, the 'ur-plant', which in them assumes differentiated modes of action.

The present part of our discussion may be concluded by the introduction of a concept which Goethe formed for the organ of cognition attained through contemplating nature in the state of becoming, as the plant had taught him to do.

Let us look back once again on the way in which we first tried to build up the picture of leaf metamorphosis. There we made use, first of all, of exact sense-perceptions to which we applied the power of memory in its function as their keeper. We then endeavoured to transform within our mind the single memory pictures (leaf forms) into one another. By doing so we applied to them the activity of mobile fantasy. In this way we actually endowed, on the one hand, objective memory, which by nature is static, with the dynamic properties of fantasy, and, on the other hand, mobile fantasy, which by nature is subjective, with the objective character of memory. Now, for the new organ of cognition arising from the union of these two polar faculties of the soul, Goethe coined the significant expression, *exact sensorial fantasy.*[2] In terms of our knowledge of man's psycho-physical make-

[1] The following observation is not one made by Goethe himself. It is presented here by the author as an example of the *heuristic* value of Goethe's method of pictorial-dynamic contemplation of the sense-world.

[2] *'Exakte sinnliche Phantasie.'*

up, acquired earlier, we can say that, just as the nervous system forms the basis for memory, and the blood the basis for fantasy, so the 'exact sensorial fantasy' is based on a newly created collaboration of the two.

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Our observations have reached a point where we may consider that stage in the life cycle of the single plant where, by means of the process of pollination, the seed acquires the capacity to produce out of itself a new example of the species. Our discussion of this will bring-home the fundamental difference in idea that arises when, instead of judging a process from the standpoint of the mere onlooker, we try to comprehend it through re-creating it inwardly.

Biological science of our day takes it for granted that the process uniting pollen with seed in the plant is an act of fertilization analogous to that which occurs among the higher organisms of nature. Now it is not to be gainsaid that to external observation this comparison seems obvious, and that it is therefore only natural to speak of the pollen as the male, and of the ovule as the female, element, and of their union as entirely parallel to that between the sexes in the higher kingdoms of nature.

Goethe confesses that at first he himself 'had credulously put up with the ruling dogma of sexuality'. He was first made aware of the invalidity of this analogy by Professor Schelver who, as Superintendent of the Jena Botanical Institute, was working under Goethe's direction and had trained himself in Goethe's method of observing plants. This man had come to see that if one held strictly to the Goethean practice of using nothing for the explanation of the plant but what one could read from the plant itself, one must not ascribe to it any sexual process. He was convinced that for a Goethean kind of biology it must be possible to find, even for the process of pollination, an idea derived from nothing but the two principles of plant life: growth and formation.

Goethe immediately recognized the Tightness of this thought, and set about the task of relating the pollination process to the picture of the plant which his investigations had already yielded. His way of reporting the result shows how fully conscious he was of its revolutionary nature. Nor was he in any doubt as to the kind of reception it would be given by official biology.

In observing the growth of the plant, Goethe had perceived that this proceeds simultaneously according to two different principles. On the one hand the plant grows in an axial direction and thereby produces its main and side stems. To this growth principle Goethe gave the name 'vertical tendency'. Were the plant to follow this principle only, its lateral shoots would all stand vertically one above the other. But observation shows that the different plant species obey very different laws in this respect, as may be seen if one links up all the leaf buds along any plant stem; they form a line which winds spiral fashion around it. Each plant family is distinguishable by its own characteristic spiral, which can be represented either geometrically by a diagram, or arithmetically by a fraction. If, for example, the leaves are so arranged in a plant that every fifth leaf recurs on the same side of the stem, while the spiral connecting the five successive leaf-buds winds twice round the stem, this is expressed in botany by the fraction $\frac{2}{5}$. To distinguish this principle of plant growth from the vertical tendency, Goethe used the term 'spiral tendency'.

To help towards a clear understanding of both tendencies, Goethe describes an exercise which is characteristic of his way of schooling himself in what he called exact sensorial fantasy. He first looks out for a phenomenon in which the 'secret' of the spiral tendency is made 'open'. This he finds in such a plant as the convolvulus; in this kind of plant the vertical tendency is lacking, and the spiral principle comes obviously into outer view. Accordingly, the convolvulus requires an external support, around which it can wind itself. Goethe now suggests that after looking at a convolvulus as it grows upwards around its support, one should first make this clearly present to one's inner eye, and then again picture the plant's growth without the vertical support, allowing instead the upward-growing plant inwardly to produce a vertical support for itself. By way of inward re-creation (which the reader should not fail to carry out himself) Goethe attained a clear experience of how, in all those plants which in growing upwards produce their leaves spiral-wise around the stem, the vertical and spiral tendencies work together.

In following the two growth-principles, Goethe saw that the vertical comes to a halt in the blossom; the straight line here shrinks together, so to say, into a point, surviving only in the ovary and pistil as continuations of the plant's stalk. The spiral tendency, on the other hand, is to be found in the circle of the stamens arranged around these; the process which in the leaves strove outwards in spiral succession around a straight line is now telescoped on to a single plane. In other words, the vertical-spiral growth of the plant here separates into its two components. And when a pollen grain lands on a pistil and joins with the ovule prepared in the ovary, the two components are united again. Out of the now complete seed a new and complete plant can arise.

Goethe understood that he would be taught a correct conception of this process only by the plant itself. Accordingly, he asked himself where else in the growing plant something like separation and re-union could be seen. This he found in the branching and reuniting of the veins in the leaves, known as *anastomosis.*

In the dividing of the two growth-principles in the plant through the formation of carpel and pistil, on the one hand, and the pollen-bearing stamens on the other, and in their reunion through the coming together of the pollen with the seed, Goethe recognized a metamorphosis of the process of anastomosis at a higher level. His vision of it caused him to term it 'spiritual anastomosis'.

Goethe held a lofty and comprehensive view of the significance of the male and female principles as spiritual opposites in the cosmos. Among the various manifestations of this polarity in earthly nature he found one, but one only, in the duality of the sexes as characteristic of man and animal. Nothing compelled him, therefore, to ascribe it in the same form to the plant. This enabled him to discover how the plant bore the same polarity in plant fashion.

In the neighbourhood of Weimar, Goethe often watched a vine slinging its foliaged stem about the trunk and branches of an elm tree. In this impressive sight nature offered him a picture of 'the female and male, the one that needs and the one that gives, side by side in the vertical and spiral directions'. Thus his artist's eye clearly detected in the upward striving of the plant a decisively masculine principle, and in its spiral winding an equally definite feminine principle. Since in the normal plant both principles are inwardly connected, 'we can represent vegetation as a whole as being in a secret androgynous union from the root up. From this union, through the changes of growth, both systems break away into open polarity and so stand in decisive opposition to each other, only to unite again in a higher sense.'

Thus Goethe found himself led to ideas regarding the male and female principles in the plant, which were the exact opposite of those one obtains if, in trying to explain the process of pollination, one does not keep to the plant itself but imports an analogy from another kingdom of nature. For in continuance of the vertical principle of the plant, the pistil and carpel represent the male aspect in the process of spiritual anastomosis, and the mobile, wind- or insect-borne pollen, in continuing the spiral principle, represents the female part.

If the process of pollination is what the plant tells us it is, then the question arises as to the reason for the occurrence of such a process in the life cycle of the fully developed plant. Goethe himself has not expressed himself explicitly on this subject. But his term *'spiritual anastomosis'* shows that he had some definite idea about it. Let us picture in our mind what happens physically in the plant as a result of pollination and then try to read from this picture, as from a hieroglyph, what act of the spiritual principle in the plant comes to expression through it.

Without pollination there is no ripening of the seed. Ripening means for the seed its acquisition of the power to bring forth a new and independent plant organism through which the species continues its existence within nature. In the life cycle of the plant this event takes place after the organism has reached its highest degree of physical perfection. When we now read these facts in the light of the knowledge that they are deeds of the activity of the *type,* we may describe them as follows:

Stage by stage the type expends itself in ever more elaborate forms of appearance, until in the blossom a triumph of form over matter is reached. A mere continuation of this path could lead to nothing but a loss of all connexion between the plant's superphysical and physical component parts. Thus, to guarantee for the species its continuation in a new generation, the formative power of the type must find a way of linking itself anew to some part of the plant's materiality. This is achieved by the plant's abandoning the union between its two polar growth-principles and re-establishing it again, which in the majority of cases takes place even in such a way that the bearers of the two principles originate from two different organisms.

By picturing the process in this way we are brought face to face with a rule of nature which, once we have recognized it, proves to hold sway at all levels of organic nature. In general terms it may be expressed as follows:

In order that spiritual continuity may be maintained within the coming and going multitude of nature's creations, the physical stream must suffer discontinuity at certain intervals.

In the case of the plant this discontinuity is achieved by the breaking asunder of the male and female growth-principles. When they have reunited, the type begins to abandon either the entire old plant or at least part of it, according to whether the species is an annual or a perennial one, in order to concentrate on the tiny seed, setting, as it were, its living seal on it.

This is as far as we can go in describing this mysterious process, at least at the present stage of our considerations.

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Our pursuit of Goethe's way of observing the life of the plant has brought us to a point where it becomes possible to rectify a wide-spread error concerning his position as an evolutionary theorist.

Goethe has been honourably mentioned as a predecessor of Darwin. The truth is, that the idea of evolution emerging from Goethe's mode of regarding nature is the exact opposite of the one held by Darwin and—in whatever modified form—by his followers. A brief consideration of the Darwinian concepts of inheritance and adaptation will show this.

Goethe's approach to his conception of the type is clear evidence that he did not undervalue the factor of adaptation as a formative element in nature; we have seen that he became acquainted with it in studying the same plant species under different climatic conditions. In his view, however, adaptation appears not as the passive effect of a blindly working, external cause, but as the response of the spiritual type to the conditions meeting it from outside.

The same applies to the concept of inheritance. Through inheritance Goethe saw single, accessory characteristics of a species being carried over from one generation to the next; but never could the re-appearance of the basic features of the species itself be explained in this way. He was sufficiently initiated into nature's methods to know that she was not in need of a continuity of the stream of physical substance, in the sense of the theory of inheritance, to guarantee a continuance of the features of the species through successive generations, but that it was her craft to achieve such continuance by means of physical discontinuity.

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Goethe was not temperamentally given to reflecting deliberately about his own cognitional processes. Moreover, the excess of re-flexion going on around him in the intellectual life of his younger days inclined him to guard himself with a certain anxiety against philosophical cogitations. His words to a friend—'Dear friend, I have done it well, and never reflected about thinking'—bring this home to us. If in his later years Goethe could become to some degree epistemologically conscious of his spiritual achievements, as, for instance, his essay on *Intuitive Judgment* shows, he owed this to his friendship with Schiller, who became for him a kind of soul mirror, in which he could see the reflexion of his own processes of consciousness. Indeed, at their first personal encounter, significant as it was for their whole later relationship, Schiller—though all unconsciously—performed a decisive service of this kind for him. Goethe himself speaks of the occasion in his essay *Happy Encounter (Gliickliches Ereignis),* written twelve years after Schiller's death.

The occasion was, outwardly regarded, fortuitous: both men were leaving a lecture on natural science at the University of Jena, Schiller having been present as Professor of History in the University, and Goethe as its patron and as a Weimar Minister of State. They met at the door of the lecture hall and went out into the street together. Schiller, who had been wanting to come into closer contact with Goethe for a long time, used the opportunity to begin a conversation. He opened with a comment on the lecture they had just heard, saying that such a piecemeal way of handling nature could not bring the layman any real satisfaction. Goethe, to whom this remark was heartily welcome, replied that such a style of scientific observation 'was uncanny even for the initiated, and that there must certainly be another way altogether, which did not treat of nature as divided and in pieces, but presented her as working and alive, striving out of the whole into the parts'.

Schiller's interest was at once aroused by this remark, although as a thorough Kantian he could not conceal his doubts whether the kind of thing indicated by Goethe was within human capacity. Goethe began to explain himself further, and so the discussion proceeded, until the speakers arrived at Schiller's house. Quite absorbed in his description of plant metamorphosis, Goethe went in with Schiller and climbed the stairs to the latter's study. Once there, he seized pen and paper from Schiller's writing desk, and to bring his conception of the ur-plant vividly before his companion's eyes he made 'a symbolic plant appear with many a characteristic stroke of the pen'.

Although Schiller had listened up to this point 'with great interest and definite understanding', he shook his head as Goethe finished, and said—Kantian that he was at that time: 'That is no experience, that is an idea.' These words were very disappointing to Goethe. At once his old antipathy towards Schiller rose up, an antipathy caused by much in Schiller's public utterances which he had found distasteful.

Once again he felt that Schiller and he were 'spiritual antipodes, removed from each other by more than an earth diameter'. However, Goethe restrained his rising annoyance, and answered Schiller in a tranquil but determined manner: '*I am glad to have ideas without knowing it, and to see them with my very eyes.*'

Although at this meeting Goethe and Schiller came to no real agreement, the personal relationship formed through it did not break off; both had become aware of the value of each to the other. For Goethe his first meeting with Schiller had the significant result of showing him that 'thinking about thought' could be fruitful. For Schiller this significance consisted in his having met in Goethe a human intellect which, simply by its existing properties, invalidated Kant's philosophy. For him Goethe's mind became an object of empirical study on which he based the beginnings of a new philosophy free from onlooker-restrictions.

An essay, written by Goethe about the same time as the one just quoted, shows how he came to think at a later date about the raising of human perception into the realm of ideas. In this essay, entitled *Discovery of an Excellent Predecessor*,[1] Goethe comments on certain views of the botanist, K. F. Wolff, regarding the relationships between the different plant organs, which seemed to be similar to his own, and at which Wolff had arrived in his own way.

Wolff had risen up as an opponent of the so-called preformation theory, still widespread at that time, according to which the entire plant with all its different parts is already present in embryonic physical form in the seed, and simply grows out into space through physical enlargement. Such a mode of thought seemed inadmissible to Wolff, for it made use of an hypothesis 'resting on an extra-sensible conception, which was held to be thinkable, although it could never be demonstrated from the sense world. Wolff laid it down as a fundamental principle of all research that 'nothing may be assumed, admitted or asserted that has not been actually seen and cannot be made similarly visible to others'. Thus in Wolff we meet with a phenomenologist who in his way tried to oppose certain trends of

[1] *Entdeckung eines trefflichen Vorarbeiters.*

contemporary biological thinking. As such, Wolff had made certain observations which caused him to ascribe to the plant features quite similar to those which Goethe had grasped under the conception of progressive and regressive metamorphosis. In this way Wolff had grown convinced that all plant organs are transformed leaves. True to his own principle, he had then turned to the microscope for his eyes to confirm what his mind had already recognized.

The microscope gave him the confirmation he expected by showing that all the different organs of the plant develop out of identical embryonic beginnings. In his absolute reliance on physical observation, however, he tried to go further than this and to detect in this way the reason why the plant does not always bring forth the same organ. He saw that the vegetative strength in the plant diminishes in proportion as its organism enters upon its later stages. He therefore attributed the differentiated evolution of plant organs from identical beginnings to an ever weaker process of development in them.

Despite his joy in Wolff as someone who in his own fashion had arrived at certain truths which he himself had also discovered, and despite his agreement with Wolff's phenomenalistic principle, Goethe could in no way accept his explanation of *why* metamorphosis took place in plants. He said: 'In plant metamorphosis Wolff saw how the same organ continuously draws together, makes itself smaller; he did not see that this contraction alternates with an expansion. He saw that the organ diminishes in volume, but not that at the same time it ennobles itself, and so, against reason, he attributed decline to the path towards perfection.' What was it, then, which had prevented Wolff from seeing things aright? 'However admirable may be Wolff's method, through which he has achieved so much, the excellent man never thought that there may be a difference between seeing and seeing, that the eyes of the spirit have to work in perpetual living connection with those of the body, for one otherwise risks seeing and yet seeing past a thing *(zu sehen und doch vorbeizusehen).'*

Wolff's case was to Goethe a symptom of the danger which he saw arising for science from the rapidly increasing use of the microscope (and similarly the telescope), if thinking was not developed correspondingly but left at the mercy of these instruments. His concern over the state of affairs speaks from his utterance: 'Microscopes and telescopes, in actual fact, confuse man's innate clarity of mind.'

When we follow Goethe in this way he comes before us in characteristic contrast to Robert Hooke. We remember Hooke's microscopic 'proof of the unrelatedness of human thought to outer reality (Chapter III). There can be no doubt how Goethe, if the occasion had arisen, would have commented on Hooke's procedure. He would have pointed out that there would be no such thing as a knife with its line-like edge unless man were able to think the concept 'line', nor a needle with its point-like end unless he were able to think the concept 'point'. In fact, knife and needle are products of a human action which is guided by these two concepts respectively. As such they are embodiments, though more or less imperfect ones, of these concepts. Here too, therefore, just as Goethe had discovered it through his way of observing the plant, we see Ideas with our very eyes. What distinguishes objects of this kind from organic entities, such as the plant, is the different relationship between Object and Idea. Whereas in the case of an organism the Idea actively indwells the object, its relationship to a man-made thing (and similarly to nature's mineral entities) is a purely external one.

Hooke, so Goethe would have argued, allowed the microscope to confuse his common sense. He would have seen in him an example confirming his verdict that he who fails to let the eye of the spirit work in union with the eye of the body 'risks seeing yet seeing past the thing'.

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'Thus not through an extraordinary spiritual gift, not through momentary inspiration, unexpected and unique, but through consistent work did I eventually achieve such satisfactory results.' These words of Goethe—they occur in his essay, *History of my Botanical Studies*, which he wrote in later life as an account of his labours in this field of science—show how anxious he was that it should be rightly understood that the faculty of reading in the Book of Nature, as he knew it, was the result of a systematic training of his mind. It is important for our further studies to make clear to ourselves at this point the nature of the change which man must bring to pass within himself in order to brave Kant's 'adventure of reason'. Goethe's concept for the newly acquired faculty of cognition, exact sensorial fantasy, can give us the lead.

We remember that, to form this faculty, two existing functions of the soul, as such polarically opposite, had to be welded together—memory based on exact sense-perception and the freely working fantasy; one connected with the nervous system of the body, the other with the blood. We also know from earlier considerations (Chapter II) that in the little child there is not yet any such polarization, in body or soul, as there is in man's later life. Thus we see that training on Goethe's lines aims at nothing less than restoring within oneself a condition which is natural in early childhood.

In saying this we touch on the very foundations of the new pathway to science discovered by Goethe. We shall hear more of it in the following chapter.

CHAPTER VI

Except We Become . . .

In this chapter we shall concern ourselves with a number of personalities from the more or less recent past of the cultural life of Britain, each of whom was a spiritual kinsman of Goethe, and so a living illustration of the fact that the true source of knowledge in man must be sought, and can be found, outside the limits of his modern adult consciousness. Whilst none of them was a match for Goethe as regards universality and scientific lucidity, they are all characteristic of an immediacy of approach to certain essential truths, which in the sense we mean is not found in Goethe. It enabled them to express one or the other of these truths in a form that makes them suitable as sign-posts on our own path of exploration. We shall find repeated opportunity in the later pages of this book to remember just what these men saw and thought.

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The first is Thomas Reid (1710-96), the Scottish philosopher and advocate of common sense as the root of philosophy.[1] After having served for some years as a minister in the Church of Scotland, Reid became professor of Philosophy at the University of Aberdeen, whence he was called to Glasgow as the successor of Adam Smith. Through his birth in Strachan, Kincardine, he belonged to the same part of Scotland from which Kant's ancestors had come. Two brief remarks of Goethe show that he knew of the Scotsman's philosophy, and that he appreciated his influence on contemporary philosophers.[2]

Reid, like his contemporary Kant, felt his philosophical conscience

[1] The present writer's interest in Reid was first aroused by a remark of Rudolf Steiner, in his book *A Theory of 'Knowledge according to Goethe's World Conception.*

[2] In a comment on a letter Carlyle had written to him, and in a note dealing with the contemporary philosophy in Germany.

stirred by Hume's *Treatise of Human Nature,* and, like Kant, set himself the task of opposing it. Unlike Kant, however, whose philosophic system was designed to arrest man's reason before the abyss into which Hume threatened to cast it, Reid contrives to detect the bridge that leads safely across this abyss. Even though it was not granted to him actually to set foot on this bridge (this, in his time, only Goethe managed to do), he was able to describe it in a manner especially helpful for our own purpose.

The first of the three books in which Reid set out the results of his labours appeared in 1764 under the title, *Inquiry into the Human Mind on the Principles of Common Sense.* The other two, *Essays on the Intellectual Powers of Man* and *Essays on the Active Powers of Man,* appeared twenty years later. In these books Reid had in view a more all-embracing purpose than in his first work. The achievement of this purpose, however, required a greater spiritual power than was granted to him. Comparing his later with his earlier work, Reid's biographer, A. Campbell Fraser, says:

'Reid's *Essays* form, as it were, the inner court of the temple of which the Aberdonian *Inquiry* is the vestibule. But the vestibule is a more finished work of constructive skill than the inner court, for the aged architect appears at last as if embarrassed by accumulated material. The *Essays,* greater in bulk, perhaps less deserve a place among modern philosophical classics than the *Inquiry,* notwithstanding its narrower scope, confined as it is to man's perception of the extended world, as an object lesson on the method of appeal to common sense.'

Whilst the ideas of Kant, by which he tried in his way to oppose Hume's philosophy, have become within a short space of time the common possession of men's minds, it was the fate of Reid's ideas to find favour among only a restricted circle of friends. Moreover, they suffered decisive misunderstanding and distortion through the efforts of well-meaning disciples. This was because Kant's work was a late fruit of an epoch of human development which had lasted for centuries and in his time began to draw to its close, while Reid's work represents a seed of a new epoch yet to come. Here lies the reason also for his failure to develop his philosophy beyond the achievements contained in his first work. It is on the latter, therefore, that we shall chiefly draw for presenting Reid's thoughts.

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The convincing nature of Hume's argumentation, together with the absurdity of the conclusions to which it led, aroused in Reid a suspicion that the premises on which Hume's thoughts were built, and which he, in company with all his predecessors, had assumed quite uncritically, contained some fundamental error. For both as a Christian, a philosopher, and a man in possession of common sense, Reid had no doubt as to the absurdity and destructiveness of the conclusions to which Hume's reasoning had led him.

'For my own satisfaction, I entered into a serious examination of the principles upon which this sceptical system is built; and was not a little surprised to find that it leans with its whole weight upon a hypothesis, which is ancient indeed, and hath been very generally received by philosophers, but of which I could find no solid proof. The hypothesis I mean is, That nothing is perceived but what is in the mind which perceives it: That we do not really perceive the things that are external, but only certain images and pictures of them imprinted upon the mind, which are called *impressions* and *ideas.*

'If this be true, supposing certain impressions and ideas to exist presently in my mind, I cannot, from their existence, infer the existence of anything else; my impressions and ideas are the only existences of which I can have any knowledge or conception; and they are such fleeting and transitory beings, that they can have no existence at all, any longer than I am conscious of them. So that, upon this hypothesis, the whole universe about me, bodies and spirits, sun, moon, stars, and earth, friends and relations, all things without exception, which I imagined to have a permanent existence whether I thought of them or not vanish at once:

> *'And, like the baseless fabric of this vision . . .*
> *Leave not a rack behind.*

'I thought it unreasonable, upon the authority of philosophers, to admit a hypothesis which, in my opinion, overturns all philosophy, all religion and virtue, and all common sense: and finding, that all the systems which I was acquainted with, were built upon this hypothesis, I resolved to enquire into this subject anew, without regard to any hypothesis.'

The following passage from the first chapter of the *Inquiry* reveals

Reid as a personality who was not dazzled to the same extent as were his contemporaries by the brilliance of the onlooker-consciousness:

'If it [the mind] is indeed what the *Treatise of Human Nature* makes it, I find I have been only in an enchanted castle, imposed upon by spectres and apparitions. I blush inwardly to think how 1 have been deluded; I am ashamed of my frame, and can hardly forbear expostulating with my destiny: Is this thy pastime, O Nature, to put such tricks upon a silly creature, and then to take off the mask, and show him how he hath been befooled? If this is the philosophy of human nature, my soul enter thou not into her secrets. It is surely the forbidden tree of knowledge; I no sooner taste it, than I perceive myself naked, and stript of all things—yea even of my very self. I see myself, and the whole frame of nature, shrink into fleeting ideas, which, like Epicurus's atoms, dance about in emptiness.

'But what if these profound disquisitions into the first principles of human nature, do naturally and necessarily plunge a man into this abyss of scepticism? May we not reasonably judge from what hath happened? Des Cartes no sooner began to dig in this mine, than scepticism was ready to break in upon him. He did what he could to shut it out. Malebranche and Locke, who dug deeper, found the difficulty of keeping out this enemy still to increase; but they laboured honestly in the design. Then Berkeley, who carried on the work, despairing of securing all, bethought himself of an expedient: By giving up the material world, which he thought might be spared without loss, and even with advantage, he hoped by an impregnable partition to secure the world of spirits. But, alas! the *Treatise of Human Nature* wantonly sapped the foundation of this partition and drowned all in one universal deluge.' (Chapter I, Sections vi-vii.)

What Reid so pertinently describes here as the 'enchanted castle' is nothing else than the human head, which knows of no occurrence beyond its boundaries, because it has forgotten that it is only the end-product of a living existence outside of, and beyond, itself. We see here that Reid is gifted with the faculty of entering this castle without forfeiting his memory of the world outside; and so even from within its walls, he could recognize its true nature. To a high degree this helped him to keep free of those deceptions to which the majority of his contemporaries fell victim, and to which so many persons are still subject to-day.

It is in this way that Reid could make it one of the cardinal principles of his observations to test all that the head thinks by relating it to the rest of human nature and to allow nothing to stand, which does not survive this test. In this respect the argument he sets over against the Cartesian, *'cogito ergo sum'* is characteristic: ' "I am thinking," says he, "therefore I am": and is it not as good reasoning to say, I am sleeping, therefore I am? If a body moves, it must exist, no doubt; but if it is at rest, it must exist likewise.'

The following summarizes the position to which Reid is led when he includes the *whole* human being in his philosophical inquiries.

Reid admits that, when the consciousness that has become aware of itself surveys that which lies within its own horizon, it finds nothing else there but transient pictures. These pictures in themselves bring to the mind no experience of a lasting existence outside itself. There is no firm evidence of the existence of either an outer material world to which these pictures can be related, or of an inner spiritual entity which is responsible for them. To be able to speak of an existence in either realm is impossible for a philosophy which confines its attention solely to the mere picture-content of the waking consciousness.

But man is not only a percipient being; he is also a being of will, and as such he comes into a relationship with the world which can be a source of rich experience. If one observes this relationship, one is bound to notice that it is based on the self-evident assumption that one possesses a lasting individuality, whose actions deal with a lasting material world. Any other way of behaviour would contradict the common sense of man; where we meet with it we are faced with a lunatic.

Thus philosophy and common sense seem to stand in irreconcilable opposition to each other. But this opposition is only apparent. It exists so long as philosophy thinks it is able to come to valid conclusions without listening to the voice of common sense, believing itself to be too exalted to need to do so. Philosophy, then, does not realize 'that it has no other root but the principles of Common Sense; it grows out of them, and draws its nourishment from them: severed from this root, its honours wither, its sap is dried up, it dies and rots.' (I, 5.)

At the moment when the philosophical consciousness ceases to regard itself as the sole foundation of its existence and recognizes that it can say nothing about itself without considering the source from which it has evolved, it attains the possibility of seeing the content of its experience in a new light. For it is no longer satisfied with considering this content in the completed form in which it presents itself. Rather does it feel impelled to investigate the process which gives rise to this content as an end-product (the 'impressions' and 'ideas' of Hume and his predecessors).

Reid *has faith* in the fact—for his common sense assures him of it—that a lasting substantiality lies behind the world of the senses, even if for human consciousness it exists only so long as impressions of it are received via the bodily senses. Similarly, he has faith in the fact that his consciousness, although existing but intermittently, has as its bearer a lasting self. Instead of allowing this intuitively given knowledge to be shaken by a mere staring at fugitive pictures, behind which the real existence of self and world is hidden, he seeks instead in both directions for the origin of the pictures and will not rest until he has found the lasting causes of their transient appearances.

In one direction Reid finds himself led to the outer boundary of the body, where sense perception has its origin. This prompts him to investigate the perceptions of the five known senses: smelling, tasting, hearing, touching and seeing, which he discusses in this order. In the other direction he finds himself led—and here we meet with a special attribute of Reid's whole philosophical outlook—to the realm of human speech. For speech depends upon an inner, intelligent human activity, which, once learnt, becomes a lasting part of man's being, quite outside the realm of his philosophizing consciousness, and yet forming an indispensable instrument for this consciousness.

The simplest human reasoning, prompted only by common sense, and the subtlest philosophical thought, both need language for their expression. Through his ability to speak, man lifts himself above an instinctive animal existence, and yet he develops this ability at an infantile stage, when, in so far as concerns the level of his consciousness and his relationship to the world, he hardly rises above the level of the animal. It requires a highly developed intelligence to probe the intricacies of language, yet complicated tongues were spoken in human history long before man awoke to his own individual intelligence. Just as each man learns to think through speaking, so did humanity as a whole. Thus speech can become a means for acquiring insight into the original form of human intelligence. For in speech the common sense of man, working unconsciously within him, meets the fully awakened philosophical consciousness.[1]

[1] This observation of Reid's shows that the origin of language is very different from what the evolutionists since Darwin have imagined it to be.

The way in which the two paths of observation have here been set out must not give rise to the expectation that they are discussed by Reid in a similarly systematic form. For this, Reid lacked the sufficient detachment from his own thoughts. As he presents his observations in the *Inquiry* they seem to be nothing but a systematic description of the five senses, broken into continually by linguistic considerations of the kind indicated above. So, for example, many of his more important statements about language are found in his chapter on 'Hearing'.

Our task will be to summarize Reid's work, taking from his description, so often full of profound observations, only what is essential to illustrate his decisive discoveries. This requires that (keeping to Mr. Eraser's picture) we consider separately the two pillars supporting the roof of the temple's forecourt: speech and sense-impressions. We will start with speech.

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Reid notes as a fundamental characteristic of human language that it includes two distinct elements: first, the purely acoustic element, represented by the sheer succession of sounds, and secondly the variety of meanings represented by various groups of sounds, meanings which seem to have nothing to do with the sounds as such. This state of language, where the sound-value of the word and its value as a *sign* to denote a *thing signified by it,* have little or nothing to do with one another, is certainly not the primeval one. In the contemporary state of language, which Reid calls *artificial language,* we must see a development from a former condition, which Reid calls *natural language.* So long as this latter condition obtained, man expressed in the sound itself what he felt impelled to communicate to his fellows. In those days sound was not merely an abstract sign, but a gesture, which moreover was accompanied and supported by the gestures of the limbs.

Even to-day man, at the beginning of his life, still finds himself in that relationship to language which was natural to all men in former times. The little child acquires the ability to speak through the imitation of sounds, becoming aware of them long before it understands the meaning accorded to the various groups of sounds in the artificial state of contemporary adult speech. That the child's attention should be directed solely to the sound, and not to the abstract meaning of the individual words, is indeed the prerequisite of learning to speak.

If, says Reid, the child were to understand immediately the conceptual content of the words it hears, it would never learn to speak at all.

When the adult of to-day uses language in its artificial state, words are only signs for things signified by them. As he speaks, his attention is directed exclusively towards this side of language; the pure sound of the words he uses remains outside the scope of his awareness. The little child, on the other hand, has no understanding of the meaning of words and therefore lives completely in the experience of pure sound. In the light of this, Reid comes to the conclusion, so important for what follows, that with the emergence of a certain form of consciousness, in this case that of the intellectual content of words, another form submerges, a form in which the experience of the pure sound of words prevails. The adult, while in one respect ahead of the child, yet in another is inferior, for the effect of this change is a definite impoverishment in soul-experience. Reid puts this as follows:

'It is by natural signs chiefly that we give force and energy to language ; and the less language has of them, it is the less expressive and persuasive. . . . Artificial signs signify, but they do not express; they speak to the understanding, as algebraic characters may do, but the passions and the affections and the will hear them not: these continue dormant and inactive, till we speak to them in the language of nature, to which they are all attention and obedience.'

We have followed Reid so far in his study of language, because it is along this way that he came to form the concepts that were to serve him as a key for his all-important findings in the realm of sense-experience. These are the concepts which bear on the connexion between the sign and the thing signified; the distinction between the artificial and the natural state of language; and the disappearance of certain primeval human capacities for experience, of which Reid says that they are brought by the child into the world, but fade as his intellectual capacities develop.

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As soon as one begins to study Reid's observations in the realm of sense-experience, one meets with a certain difficulty, noticeable earlier but not so strikingly. The source of it is that Reid was obliged to relate the results of his observations only to the five senses known in his day, whereas in fact his observations embrace a far greater field of human sense-perception. Thus a certain disharmony creeps into his descriptions and makes his statements less convincing, especially for someone who does not penetrate to its real cause.

However this may be, it need not concern us here; what matter to us are Reid's actual observations. For these led him to the important distinction between two factors in our act of acquiring knowledge of the outer world, each of which holds an entirely different place in ordinary consciousness. Reid distinguishes them as 'sensation' and 'perception'. It is through the latter that we become aware of the object as such. But we are mistaken if we regard the content of this perception as identical with the sum total of the sensations which are caused in our consciousness by the particular object. For these sensations are qualitatively something quite different, and, although without them no perception of the object is possible, they do not by themselves convey a knowledge of the thing perceived. Only, because our attention is so predominantly engaged by the object under perception, we pay no heed to the content of our sensation.

To take an example, the impressions of roundness, angularity, smoothness, roughness, colour, etc., of a table contain, all told, nothing that could assure us of the existence of the object 'table' as the real content of an external world. How, then, do we receive the conviction of the latter's existence? Reid's answer is, *by entering into an immediate intuitive relationship with it.* It is true that to establish this relationship we need the stimuli coming from the impressions which our mind receives through the various senses. Yet this must not induce us to confuse the two.

When nature speaks to man through his senses, something occurs exactly analogous to the process when man communicates with man through the spoken word. In both cases the perception, that is, the result of the process of perception, is something quite other than the sum of sensations underlying it. Per-ceiving by means of the senses is none other than a re-ceiving of nature's language; and this language, just like human language, bears two entirely different elements within it. According as one or the other element prevails in man's intercourse with nature, this intercourse will be either 'natural' or 'artificial'—to use the terms by which Reid distinguished the two stages of human speech.

Just as every human being must once have listened only to the pure sound of the spoken word on a wholly sentient level in order to acquire the faculty of speaking, so also, in order to learn nature's language, the soul must once have been totally surrendered to the pure impressions of the senses. And just as with time the spoken word becomes a symbol for that which is signified by it, the consciousness turning to the latter and neglecting the actual sound-content of the word, so also in its intercourse with nature the soul, with its growing interest in the thing signified, turns its attention more and more away from the actual experiences of the senses.

From this it follows that a philosophy which seeks to do justice to man's whole being must not be satisfied with examining the given content of human consciousness, but must strive to observe the actual process to which this content owes its emergence. In practice this means that a philosopher who understands his task aright must strive to reawaken in himself a mode of experience which is naturally given to man in his early childhood. Reid expresses this in the *Inquiry* in the following way:

'When one is learning a language, he attends to the sounds, but when he is master of it, he attends only to the sense of what he would express. If this is the case, we must become as little children again, if we will be philosophers: we must overcome habits which have been gathering strength ever since we began to think; habits, the usefulness of which atones for the difficulty it creates for the philosopher in discovering the first principles of the human mind.'

'We must become as little children again, if we will be philosophers!' The phrase appears here almost in passing, and Reid never came back to it again. And yet in it is contained the *Open Sesame* which gives access to the hidden spirit-treasures of the world. In this unawareness of Reid's of the importance of what he thus had found we must see the reason for his incapacity to develop his philosophy beyond its first beginnings. This handicap arose from the fact that in all his thinking he was guided by a picture of the being of man which —as a child of his time, dominated by the contemporary religious outlook—he could never realize distinctly. Yet without a clear conception of this picture no justice can be done to Reid's concept of common sense. Our next task, therefore, must be to evoke this picture as clearly as we can

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The following passage in Reid's *Inquiry* provides a key for the understanding of his difficulty in conceiving an adequate picture of man's being. In this passage Reid maintains that all art is based on man's experience of the natural language of things, and that in every human being there lives an inborn artist who is more or less crippled by man's growing accustomed to the state of artificial language in his intercourse with the world. In continuation of the passage quoted on page 99 Reid says:

'It were easy to show, that the fine arts of the musician, the painter, the actor, and the orator, so far as they are expressive; although the knowledge of them requires in us a delicate taste, a nice judgment, and much study and practice; yet they are nothing else but the language of nature, which we brought into the world with us, but have unlearned by disuse and so find the greatest difficulty in recovering it.

'Abolish the use of articulate sounds and writing among mankind for a century, and every man would be a painter, an actor, and an orator. We mean not to affirm that such an expedient is practicable; or if it were, that the advantage would counterbalance the loss; but that, as men are led by nature and necessity to converse together they will use every means in their power to make themselves understood; and where they cannot do this by artificial signs, they will do it as far as possible by natural ones: and he that understands perfectly the use of natural signs, must be the best judge in all expressive arts.'

When Reid says that there are certain characteristics—and these just of the kind whose development truly ennobles human life—*which the soul brings with it into the world,* a picture of man is evoked in us in which the supersensible part of his being appears as an entity whose existence reaches further back than the moment of birth and even the first beginnings of the body. Now such a conception of man is in no way foreign to humanity, in more ancient times it was universally prevalent, and it still lives on to-day, if merely traditionally, in the eastern part of the world. It is only in the West that from a certain period it ceased to be held. This was the result of a change which entered into human memory in historical times, just as the re-dawning of the old knowledge of man's pre-existence, of which Reid is a symptom, is a result of another corresponding alteration in the memory-powers of man in modern times.

For men of old it was characteristic that alongside the impressions they received in earthly life through the senses (which in any case were far less intense than they are to-day), they remembered experiences of a purely supersensible kind, which gave them assurance that before the soul was knit together with a physical body it had existed in a cosmic state purely spiritual in nature. The moment in history when this kind of memory disappeared is that of the transition from the philosophy of Plato to that of Aristotle. Whereas Plato was convinced by clear knowledge that the soul possesses characteristics implanted in it before conception, Aristotle recognized a bodiless state of the soul only in the life after death. For him the beginning of the soul's existence was identical with that of the body.

The picture of man, taught for the first time by Aristotle, still required about twice four hundred years—from the fourth pre-Christian to the fourth post-Christian century—before it became so far the common possession of men that the Church Father Augustine (354-430) could base his teaching on it—a teaching which moulded man's outlook on himself for the coming centuries right up to our own time.

The following passage from Augustine's *Confessions* shows clearly how he was compelled to think about the nature of the little child:

'This age, whereof I have no remembrance, which I take on others' words, and guess from other infants that I have passed, true though the guess be, I am yet loath to count in this life of mine which I live in this world. For no less than that which I lived in my mother's womb, is it hid from me in the shadows of forgetfulness. But if I was shapen in iniquity and in sin my mother did conceive me, where, I beseech thee, O my God, where, Lord, or when, was I thy servant guiltless? But lo! that period I pass by; and what have I to do with that of which I can recall no vestige?'[1]

On the grounds of such experience, Augustine was unable to picture man's being in any other way than by seeing him, from the first moment of his life, as subject to the condition of the human race which resulted from the Fall. Thus he exclaims in his *Confessions:* 'Before Thee, O God, no-one is free from sin, not even the child which has lived but a single day on the earth.' In so far as there was any question of the soul's arising from this fallen state, it was deemed unable to attain this by any effort of its own, but to depend on the

[1] *Confessions,* **Book I,** Chapter 8.

gifts of grace which the Church was able to dispense through the Sacraments.

Compare with this the present-day scientific conception of human nature, as it dominates the thought of specialist and layman alike. Here man appears, both in body and soul, as a sum of inherited characteristics, of characteristics, that is to say, which have been passed on by way of sexual propagation and gradually emerge into full manifestation as the individual grows up. Apart from this inherited predestination the soul is held to present itself, in Locke's classical phrase, as a *tabula rasa* upon which are stamped all manner of external impressions.

The similarity between this modern picture of man and the earlier theological one is striking. In both cases the central assumption is that human development from child to man consists in the unfolding of certain inherited characteristics which are capable of further specific modification under influences proceeding from outside. The only difference between the two pictures is that in the modern one the concepts of heredity and adaptation have been formed without special application to the ethical characteristics of the soul.

It is clear that from both Augustine's and the modern scientific viewpoint there is no sense in requiring—as Reid did—those who seek the truth about themselves and the world to recover a condition which had been theirs as children. Nor from this point of view is there any justification to call on a Common Sense, innate in man, to sit in judgment on the philosophical efforts of the adult reason.

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That even in the days of Augustine the original conception of human nature had not disappeared entirely, is shown by the appearance of Augustine's opponent Pelagius, called the 'arch-heretic'. To consider him at this point in our discussion will prove helpful for our understanding of Reid's historic position in the modern age.

What interests us here in Pelagius's doctrine (leaving aside all questions concerning the meaning of the Sacraments, etc.), is the picture of man which must have lived in him for him to teach as he did.

Leaving his Irish-Scottish homeland and arriving about the year 400 in Rome, where on account of the unusual purity of his being he soon came to be held in the highest esteem, Pelagius found himself obliged to come out publicly against Augustine, for he felt that Augustine's teachings denied all free will to man. In the purely passive surrender of man to the will of God, as Augustine taught it, he could not but see danger for the future development of Christian humanity. How radically he diverged from Augustine in his view of man we may see from such of his leading thoughts as follow:

'Each man begins his life in the same condition as Adam.'

'All good or evil for which in life we are deserving of praise or blame is done by ourselves and is not born with us.'

'Before the personal will of man comes into action there is nothing in him but what God has placed there.'

'It is therefore left to the free will of man whether he falls into sin, as also whether through following Christ he raises himself out of it again.'

Pelagius could think in this way because he came from a part of Europe where the older form of human memory, already at that time almost extinct in the South, was in some degree still active. For him it was therefore a matter of direct experience that the development of man from childhood onwards was connected with a diminution of certain original capacities of the soul. Yet he was so far a child of his age as to be no longer capable of seeing whence these capacities originated.

To provide the necessary corrective to Augustine's doctrine of inheritance, Pelagius would have had to be able to see in the first years of life both a beginning of the earthly and a termination of the pre-earthly existence of the soul. The imperfections of his picture of man, however, led him to underestimate, even to deny, the significance of heredity and so of original sin in human life. For an age which no longer had any direct experience of the soul's pre-natal life, the doctrines of Augustine were undoubtedly more appropriate than those of Pelagius; Augustine was in fact the more modern of the two.

And now, if we move forward a dozen centuries and compare Thomas Reid and Immanuel Kant from this same point of view, we find the same conception of man again triumphant. But there is an essential difference: Kant carried all before him because he based himself on an age-old view of human nature, whereas Reid, uncomprehended up to our own day, pointed to a picture of man only just then dawning on the horizon of the future. Just as through Pelagius there sounded something like a last call to European humanity not to forget the cosmic nature of the soul, so through Reid the memory of this nature announced its first faint renewal. It is common to both that their voices lacked the clarity to make themselves heard among the other voices of their times; and with both the reason was the same: neither could perceive in fullness—the one no longer, the other not yet—the picture of man which ensouled their ideas.

The certainty of Reid's philosophical instinct, if such an expression be allowed, and at the same time his tragic limitations, due to an inability fully to understand the origin of this instinct, come out clearly in the battle he waged against the 'idea' as his immediate predecessors understood it. We know that Plato introduced this word into the philosophical language of mankind. In Greek *ιδέα* (from *ιδειν*, to see) means something of which one knows that it exists, because one sees it. It was therefore possible to use the word 'to see' as Plato did, because in his day it covered both sensible and supersensible perception. For Plato, knowing consisted in the soul's raising itself to perceiving the objective, world-forming IDEAS, and this action comprised at the same time a recollection of what the soul had seen while it lived, as an Idea among Ideas, before its appearance on earth.

As long as Plato's philosophy continued to shape their thought, men went on speaking more or less traditionally of Ideas as real supersensible beings. When, however, the Aristotelian mode of thinking superseded the Platonic, the term 'Idea' ceased to be used in its original sense; so much so that, when Locke and other modern philosophers resorted to it in order to describe the content of the mind, they did so in complete obliviousness of its first significance.

It is thus that in modern philosophy, and finally in ordinary modern usage, 'idea' came to be a word with many meanings. Sometimes it signifies a sense-impression, sometimes a mental representation, sometimes the thought, concept or essential nature of a thing. The only thing common to these various meanings is an underlying implication that an idea is a purely subjective item in human consciousness, without any assured correspondence to anything outside.

It was against this view of the idea that Reid took the field, going so far as to label the philosophy holding it the 'ideal system'. He failed to see, however, that in attacking the abstract use of the term he was actually in a position to restore to it its original, genuine meaning. If, instead of simply throwing the word overboard, he had been able to make use of it in its real meaning, he would have expressed himself with far greater exactitude and consistency.[1] He was

[1] As we have seen, the word had better luck with Goethe.

prevented from doing this by his apparent ignorance of the earlier Greek philosophers, Plato included. All he seems to have known of their teachings came from inferior, second-hand reports of a later and already decadent period.

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There are two historic personalities, both in England, who witness to the fact that the emergence of Reid's philosophy on the stage of history was by no means an accidental event but that it represents a symptom of a general reappearance of the long-forgotten picture of man, in which birth no more than death sets up an absolute limit to human existence. They are Thomas Traherne (1638-74) and William Wordsworth (1770-1850).

Wordsworth's work and character are so well known that there is no need to speak of them here in detail.[1] For our purpose we shall pay special attention only to his *Ode on Intimations of Immortality from Recollections of Early Childhood*, where he shows himself in possession of a memory (at any rate at the time when he wrote the poem) of the pre-natal origin of the soul, and of a capacity for experiencing, at certain moments, the frontier which the soul crosses at birth.

If, despite the widespread familiarity of the Ode, we here quote certain passages from it, we do so because, like many similar things, it has fallen a victim to the intellectualism of our time in being regarded merely as a piece of poetic fantasy. We shall take the poet's words as literally as he himself uttered them. We read:

'Our birth is but a sleep and a forgetting:
The Soul that rises with us, our life's Star,
Hath had elsewhere its setting,
And cometh from afar:
Not in entire forgetfulness,
And not in utter nakedness,
But trailing clouds of glory do we come
From God who is our home:
Heaven lies about us in our infancy!

[1] Wordsworth, with all his limitations, had a real affinity with Goethe in his view of nature. Mr. Norman Lacey gives some indication of this in his recent book, *Wordsworth's View of Nature.*

Shades of the prison house begin to close
Upon the growing Boy.
But he beholds the light, and whence it flows,
He sees it in his joy;
The Youth, who daily farther from the east
Must travel, still is Nature's Priest,
And by the vision splendid
Is on his way attended."

And later:

'Hence in a season of calm weather
Though inland far we be,
Our Souls have sight of that immortal sea
Which brought us hither,
Can in a moment travel thither,
And see the Children sport upon the shore,
And hear the mighty waters rolling evermore."

The fact that Wordsworth in his later years gave no further indication of such experiences need not prevent us from taking quite literally what he says here. The truth is that an original faculty faded away with increasing age, somewhat as happened with Reid when he could no longer continue his philosophical work along its original lines. Wordsworth's Ode is the testament of the childhood forces still persisting but already declining within him; it is significant that he set it down in about the same year of life (his thirty-sixth) as that in which Traherne died and in which Goethe, seeking renewal of his being, took flight to Italy.[1]

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Of Traherne, too, we shall say here only as much as our present consideration and the further aims of this book require. We cannot concern ourselves with the remarkable events which led, half a century ago, to the discovery and identification of his long-lost writings by Bertram Dobell. Nor can we deal with the details of the eventful life and remarkable spiritual development of this contemporary of the Civil War. These matters are dealt with in Dobell's introduction to his edition of Traherne's poems, as also by Gladys I. Wade in her work, *Thomas Traherne.* Our gratitude for the labours of these two

[1] This same period of life played a decisive part in the spiritual evolution of Rudolf Steiner, as may be seen in his autobiography, *The Story of My Life.*

writers by which they have provided mankind with the knowledge of the character and the work of this unique personality cannot hinder us, however, from stating that both were prevented by the premises of their own view of the world from rightly estimating that side of Traherne which is important for us in this book, and with which we shall specially concern ourselves in the following pages.

Later in this chapter we shall discuss Dobell's philosophical misinterpretation of Traherne, to which he fell victim because he maintained his accustomed spectator standpoint in regard to his object of study. Miss Wade has, indeed, been able to pay the right tribute to Traherne, the mystic, whose inner (and also outer) biography she was able to detect by taking seriously Traherne's indications concerning his mystical development. Her mind, however, was too rigidly focused on this side of Traherne's life—his self-training by an iron inner discipline and his toilsome ascent from the experience of Nothingness to a state of Beatific Vision. This fact, combined with her disinclination to overcome the Augustinian picture of man in herself, prevented her from taking Traherne equally seriously where he speaks as one who is endowed with a never interrupted memory of his primeval cosmic consciousness—notwithstanding the fact that Traherne himself has pointed to this side of his nature as the most significant for his fellow-men.

Of the two works of Traherne which Dobell rescued from oblivion, on both of which we shall draw for our exposition, one contains his poems, the other his prose writings. The title of the latter is *Centuries of Meditations.* The title page of one of the two manuscripts containing the collection of the poetical writings introduces these as *Poems of Felicity, Containing Divine Reflections on the Native Objects of an Infant-Eye.* As regards the title 'Centuries of Meditations' we are ignorant of the meaning Traherne may have attached to it, and what he meant by calling the four parts of the book, 'First', 'Second', etc., Century. The book itself represents a manual of devotion for meditative study by the reader.

Let our first quotation be one from the opening paragraph of the third 'Century' in which Traherne introduces himself as the bearer of certain uncommon powers of memory and, arising from these powers, a particular mission as a teacher:

'Those pure and virgin apprehensions I had from the womb, and that divine light wherewith I was born are the best unto this day, wherein I can see the Universe. By the gift of God they attended me into the world, and by His special favour I remember them till now. Verily they seem the greatest gifts His wisdom could bestow, for without them all other gifts had been dead and vain. They are unattainable by books, and therefore I will teach them by experience.' (Ill, 1.)

The picture thus remaining with him of his nature of soul in his earliest years on earth he describes as follows:

'Certainly Adam in Paradise had not more sweet and curious apprehensions of the world, than I when I was a child. All appeared new, and strange at first, inexpressibly rare and delightful and beautiful. I was a little stranger, which at my entrance into the world was saluted and surrounded with innumerable joys. My knowledge was Divine. I knew by intuition those things which since my Apostacy, I collected again by the highest reason. I was entertained like an Angel with the works of God in their splendour and glory, I saw all in the peace of Eden; Heaven and Earth did sing my Creator's praises, and could not make more melody to Adam, than to me. All Time was Eternity, and a perpetual Sabbath. Is it not strange, that an infant should be the heir of the whole world, and see those mysteries which the books of the learned never unfold?' (Ill, 1, 2.)

In a different form the same experience comes to expression in the opening lines of Traherne's poem, *Wonder:*

'How like an Angel came I down!
How bright are all things here I
When first among his Works I did appear
O how their GLORY did me crown!
The World resembled his ETERNITIE,
In which my Soul did Walk;
And evry Thing that I did see
Did with me talk.'[1]

The picture of man thus sketched by Traherne is as close to Reid's as it is remote from Augustine's. This remoteness comes plainly to expression in the way Traherne and Augustine regard the summons of

[1] The difference in spelling between the prose and poetry excerpts arises from the fact that whereas we can draw on Miss Wade's new edition of the poems for Traherne's original spelling, we have as yet only Dobell's edition of the *Centuries*, in which the spelling is modernized.

Christ to His disciples to become as little children, a summons to which Reid was led, as we have seen, on purely philosophical grounds. Let us first of all recall the words of Christ as recorded by Matthew in his 18th and 19th chapters:

'And Jesus called a little child unto him, and set him in the midst of them, and said: Verily I say unto you, except ye be converted, and become as little children, ye shall not enter into the kingdom of Heaven. Whosoever therefore shall humble himself as this little child, the same is the greatest in the kingdom of Heaven.' (xviii, 2-4.)

'Suffer the little children and forbid them not to come unto me: for of such is the kingdom of Heaven.' (xix, 14.)

Augustine refers to these words when he concludes that examination of his childhood memories which he undertook in order to prove the depravity of the soul from its first day on earth. He says: 'In the littleness of children didst Thou, our king, give us a symbol of humility when Thou didst say: Of such is the kingdom of Heaven.'

If we glance back from what Augustine says here to the original passages in the Gospel just quoted, we see what a remarkable alteration he makes. Of the first passage only the last sentence is taken, and this in Augustine's mind is fused into one with the second passage. Thereby the admonition of Christ through one's own effort *to become* as one once was as a child disappears completely. The whole passage thus takes on a meaning corresponding to that passive attitude to the divine will inculcated by Augustine and opposed by Pelagius, and it is in this sense that the words of Christ have sunk into the consciousness of Western Christianity and are usually taken to-day.

We may see how differently this injunction of Christ lived in Traherne's consciousness from the following passage out of his *Centuries:*

'Our Saviour's meaning, when He said, *ye must be born again and become a little child that will enter into the Kingdom of Heaven,* is deeper far than is generally believed. It is not only in a careless reliance upon Divine Providence, that we are to become little children, or in the feebleness and shortness of our anger and simplicity of our passions, but in the peace and purity of all our soul. Which purity also is a deeper thing than is commonly apprehended.' (Ill, 5.)

With Traherne also the passage in question has been fused together with another utterance of Christ, from John's account of Christ's conversation with Nicodemus:

'Verily, verily I say unto you, except a man be born again, he cannot see the Kingdom of God.' (John iii, 3.)

What conception of the infant condition of man must have existed in a soul for it to unite these two passages from the Gospels in this way? Whereas for Augustine it is because of its small stature and helplessness that the child becomes a symbol for the spiritual smallness and helplessness of man as such, compared with the overwhelming power of the divine King, for Traherne it is the child's nearness to God which is most present to him, and which must be regained by the man who strives for inner perfection.

Traherne could bear in himself such a picture of man's infancy because, as he himself emphasizes, he was in possession of an unbroken memory of the experiences which the soul enjoys before it awakens to earthly sense-perception. The following passage from the poem, *My Spirit,* gives a detailed picture of the early state in which the soul has experiences and perceptions quite different from those of its later life. (We may recall Reid's indication of how the child receives the natural language of things.)

'An Object, if it were before
Mine Ey, was by Dame Nature's Law
Within my Soul: Her Store
Was all at once within me; all her Treasures
Were my immediat and internal Pleasures;
Substantial Joys, which did inform my Mind.

'. . . *I could not tell*
Whether the Things did there
Themselvs appear,
Which in my Spirit truly *seem'd to dwell:*
Or whether my conforming Mind
Were not ev'n all that therein shin'd.'

Further detail is added to this picture by the description, given in the poem *The Praeparative,* of the soul's non-experience of the body at that early stage. The description is unmistakably one of an experience during the time between conception and birth.

'My Body being dead, my Limbs unknown;
Before I skill'd to prize
Those living Stars, mine Eys;

Before or Tongue or Cheeks I call'd mine own,
Before I knew these Hands were mine,
Or that my Sinews did my Members join;
When neither Nostril, Foot, nor Ear,
As yet could be discerned or did appear;
I was within
A House I knew not; newly cloath'd with Skin.

Then was my Soul my only All to me,
A living endless Ey,
Scarce bounded with the Sky,
Whose Power, and Act, and Essence was to see;
I was an inward Sphere of Light,
Or an interminable Orb of Sight,
Exceeding that which makes the Days,
A vital *Sun that shed abroad its Rays:*
All Life, all Sense,
A naked, simple, pure Intelligence."

In the stanza following upon this, Traherne makes a statement which is of particular importance in the context of our present discussion. After some additional description of the absence of all bodily needs he says:

'*Without disturbance then I did receiv*
The tru Ideas of all Things'

The manuscript of this poem shows a small alteration in Traherne's hand in the second of these two lines. Where we now read 'true Ideas', there originally stood 'fair Ideas'. 'Fair' described Traherne's experience as he immediately remembered it; the later alteration to 'true' shows how well aware he was that his contemporaries might miss what he meant by 'Idea', through taking it in the sense that had already become customary in his time, namely, as a mere product of man's own mental activity.

This precaution, however, has not saved Traherne from being misinterpreted in our own day in precisely the way he feared—indeed, by no less a person than his own discoverer, Dobell. It is the symptomatic character of this misinterpretation which prompts us to deal with it here.

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In his attempt to classify the philosophical mode of thought behind Traherne's writings, Dobell, to his own amazement, comes to the conclusion that Traherne had anticipated Bishop Berkeley (1684-1753). They seemed to him so alike that he does not hesitate to call Traherne a 'Berkeleyan before Berkeley was born'. In proof of this he refers to the poems, *The Praeparative* and *My Spirit*, citing from the latter the passage given above (page 112), and drawing special attention to its two concluding lines. Regarding this he says: 'I am much mistaken if the theory of non-existence of independent matter, which is the essence of Berkeley's system, is not to be found in this poem. The thought that the whole exterior universe is not really a thing apart from and independent of man's consciousness of it, but something which exists only as it is perceived, is undeniably found in *My Spirit:*

The reader who has followed our exposition in the earlier parts of this chapter can be in no doubt that, to find a philosophy similar to Traherne's, he must look for it in Reid and not in Berkeley. Reid himself rightly placed Berkeley amongst the representatives of the 'ideal system' of thought. For Berkeley's philosophy represents an effort of the onlooker-consciousness, unable as it was to arrive at certainty regarding the objective existence of a material world outside itself, to secure recognition for an objective Self behind the flux of mental phenomena. Berkeley hoped to do this by supposing that the world, including God, consists of nothing but 'idea'-creating minds, operating like the human mind as man himself perceives it. His world picture, based (as is well known) entirely on optical experiences, is the perfect example of a philosophy contrived by the one-eyed, colour-blind world-spectator.

We shall understand what in Traherne's descriptions reminded Dobell of Berkeley, if we take into account the connexion of the soul with the body at the time when, according to Traherne, it still enjoys the untroubled perception of the true, the light-filled, Ideas of things.

In this condition the soul has only a dim and undifferentiated awareness of its connexion with a spatially limited body ('I was within a house I knew not, newly clothed with skin') and it certainly knows nothing at all of the body as an instrument, through which the will can be exercised in an earthly-spatial way ('My body being dead, my limbs unknown'). Instead of this, the soul experiences itself simply as a supersensible sense-organ and as such united with the far spaces of the universe ('Before I skilled to prize those living stars, mine eyes. . . . Then was my soul my only All to me, a living endless eye, scarce bounded with the sky').

At the time when the soul has experiences of the kind described by Traherne, it is in a condition in which, as yet, no active contact has been established between itself and the physical matter of the body and thereby with gravity. Hence there is truth in the picture which Traherne thus sketches from actual memory. The same cannot be said of Berkeley's world-picture. The fact that both resemble each other in certain features need not surprise us, seeing that Berkeley's picture is, in its own way, a pure 'eye-picture' of the world. As such, however, it is an illusion—for it is intended for a state of man for which it is not suited, namely for adult man going upright on the earth, directing his deeds within its material realm, and in this way fashioning his own destiny.

Indeed, compared with Berkeley's eye-picture of the world, that of Reid is in every respect a 'limb-picture'. For where he seeks for the origin of our naïve assurance that a real material world exists, there he reverts—guided by his common sense—to the experiences available to the soul through the fact that the limbs of the body meet with the resistant matter of the world. And whenever he turns to the various senses in his search, it is always the will-activity of the soul within the sense he is investigating—and so the limb-nature within it—to which he first turns his attention. Because, unlike Berkeley, he takes into account the experiences undergone by the soul when it leaves behind its primal condition, Reid does not fall into illusion, but discovers a fundamental truth concerning the nature of the world-picture experienced by man in his adult age. This, in turn, enables him to discover the nature of man's world picture in early childhood and to recognize the importance of recovering it in later life as a foundation for a true philosophy.

Assuredly, the philosopher who discovered that we must become as little children again if we would be philosophers, is the one to whom we may relate Traherne, but not Berkeley. And if we wish to speak of Traherne, as Dobell tried to do, we speak correctly only if we call him a 'Reidean before Reid was born'.

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A little more than a hundred years after Thomas Traherne taught his fellow-men 'from experience' that there is an original condition of man's soul, before it is yet able to prize 'those living stars, mine eyes', in which it is endowed with the faculty to see 'the true (fair) Ideas of all things', Goethe was led to the realization that he had achieved the possibility of 'seeing Ideas with the very eyes'. Although he was himself not aware of it, the conception of the Idea was at this moment restored through him to its true and original Platonic significance.

The present chapter has shown us how this conception of the Idea is bound up with the view that is held of the relationship between human nature in early childhood and human nature in later life. We have seen that, when Plato introduced the term Idea as an expression for spiritual entities having a real and independent existence, men were still in possession of some recollection of their own pre-earthly existence. We then found Traherne saying from his recollections that in the original form of man's consciousness his soul is endowed with the faculty of seeing 'true' Ideas, and we found Reid on similar grounds fighting the significance which the term 'idea' had assumed under his predecessors. By their side we see Goethe as one in whom the faculty of seeing Ideas appears for the first time in adult man as a result of a systematic training of observation and thought.

If our view of the interdependence of the Platonic conception of the Idea with the picture man has of himself is seen rightly, then Goethe must have been the bearer of such a picture. Our expectation is shown to be right by the following two passages from Goethe's autobiography, *Truth and Fiction.*

In that part of his life story where Goethe concludes the report of the first period of his childhood (Book II), he writes:

'Who is able to speak worthily of the fullness of childhood? We cannot behold the little creatures which flit about before us otherwise than with delight, nay, with admiration; for they generally promise more than they perform and it seems that nature, among the other roguish tricks that she plays us, here also especially designs to make sport of us. The first organs she bestows upon children coming into the world, are adapted to the nearest immediate condition of the creature, which, unassuming and artless, makes use of them in the readiest way for its present purposes. The child, considered in and for itself, with its equals, and in relations suited to its powers, seems so intelligent and rational, and at the same time so easy, cheerful and clever, that one can hardly wish it further cultivation. If children grew up according to early indications, we should have nothing but geniuses.'[1]

[1] Oxenford's translation.

We find further evidence in Goethe's account of an event in his seventh year, which shows how deeply his soul was filled at that time with the knowledge of its kinship with the realm from which nature herself receives its existence. This knowledge led him to approach the 'great God of Nature' through an act of ritual conceived by himself. The boy took a four-sectioned music stand and arranged on it all kinds of natural specimens, minerals and the like, until the whole formed a kind of pyramidal altar. On the top of this pyramid he placed some fumigating candles, the burning of which was to represent the 'upward yearning of the soul for its God'. In order to give nature herself an active part in the ritual, he contrived to kindle the candles by focusing upon them through a magnifying-glass the light of the rising sun. Before this symbol of the unity of the soul with the divine in nature the boy then paid his devotions.

'Unity of the soul with the divine in nature'—this was what lived vividly as a conviction in the seven-year-old boy, impelling him to act as 'nature's priest' (Wordsworth). The same impulse, in a metamorphosed form, impelled the adult to go out in quest of an understanding of nature which, as Traherne put it, was to bring back through highest reason what once had been his by way of primeval intuition.

CHAPTER VII

'Always Stand by Form'

Immediacy of approach to certain essentials of nature as a result of their religious or artistic experience of the sense-world, is the characteristic of two more representatives of British cultural life. They are Luke Howard (1772-1864) and John Ruskin (1819-1900), both true readers in the book of nature. Like those discussed in the previous chapter they can be of especial help to us in our attempt to establish an up-to-date method of apprehending nature's phenomena through *reading* them.

At the same time we shall find ourselves led into another sphere of Goethe's scientific work. For we cannot properly discuss Howard without recognizing the importance of his findings for Goethe's meteorological studies or without referring to the personal connexion between the two men arising out of their common interest and similar approach to nature. We shall thus come as a matter of course to speak of Goethe's thoughts about meteorology, and this again will give opportunity to introduce a leading concept of Goethean science in addition to those brought forward already.

Of Ruskin only so much will appear in the present chapter as is necessary to show him as an exemplary reader in the book of nature. He will then be a more or less permanent companion in our investigations.

The following words of Ruskin from *The Queen of the Air* reveal him at once as a true reader in the book of nature:

'Over the entire surface of the earth and its waters, as influenced by the power of the air under solar light, there is developed a series of changing forms, in clouds, plants and animals, all of which have reference in their action, or nature, to the human intelligence that perceives them.' (II, 89.)

Here Ruskin in an entirely Goethean way points *to form* in nature as the element in her that speaks to human intelligence—meaning by form, as other utterances of his show, all those qualities through which the natural object under observation reveals itself to our senses as a whole.

By virtue of his pictorial-dynamic way of regarding nature, Ruskin was quite clear that the scientists' one-sided seeking after external forces and the mathematically calculable interplay between them can never lead to a comprehension of life in nature. For in such a search man loses sight of the real signature of *life:* form as a dynamic element. Accordingly, in his *Ethics of the Dust*, Ruskin does not answer the question: 'What is Life?' with a scientific explanation, but with the laconic injunction: 'Always stand by Form against Force.' This he later enlarges pictorially in the words: 'Discern the moulding hand of the potter commanding the clay from the merely beating foot as it turns the wheel.' (Lect. X.)

In thus opposing form and force to each other, Ruskin is actually referring to two kinds of forces. There exist those forces which resemble the potter's foot in producing mere numerically regulated movements (so that this part of the potter's activity can be replaced by a power-machine), and others, which like the potter's hand, strive for a certain end and so in the process create definite forms. Ruskin goes a step further still in *The Queen of the Air*, where he speaks of selective order as a mark of the spirit:

'It does not merely crystallize indefinite masses, but it gives to limited portions of matter the power of gathering, selectively, other elements proper to them, and binding these elements into their own peculiar and adopted form. . . .

'For the mere force of junction is not spirit, but the power that catches out of chaos, charcoal, water, lime and what not, and fastens them into given form, is properly called "spirit"; and we shall not diminish, but strengthen our cognition of this creative energy by recognizing its presence in lower states of matter than our own.' (II, 59.)[1]

When Ruskin wrote this passage, he could count on a certain measure of agreement from his contemporaries that the essence of

[1] These words should be weighed with the fact in mind that they were written at the time when Crookes was intent on finding the unknown land of the spirit by means of just such 'a mere force of junction'.

man himself is spirit, though certainly without any very exact notion being implied. This persuaded him to fight on behalf of the spirit, lest its activity on the lower levels of nature should not be duly acknowledged. To-day, when the purely physical conception of nature has laid hold of the entire man, Ruskin might have given his thought the following turn: '. . . and we shall certainly attain to no real insight into this creative force (of the spirit) at the level of man, unless we win the capacity to recognize its activity in lower states of matter.'

What Ruskin is really pointing towards is the very thing for which Goethe formed the concept 'type'. And just as Ruskin, like Goethe, recognized the signature of the spirit in the material processes which work towards a goal, so he counted as another such signature what Goethe called *Steigerung*, though certainly without forming such a universally valid idea of it:

'The Spirit in the plant—that is to say, its power of gathering dead matter out of the wreck round it, and shaping it into its own chosen shape—is of course strongest in the moment of flowering, for it then not only gathers, but forms, with the greatest energy.' It is characteristic of Ruskin's conception of the relationship between man's mind and nature that he added: 'And where this life is in it at full power, its form becomes invested with aspects that are chiefly delightful to our own senses.' (II, 60.)

Obviously, a mind capable of looking at nature in this way could not accept such a picture of evolution as was put forward by Ruskin's contemporary, Darwin. So we find Ruskin, in *The Queen of the Air*, opposing the Darwinistic conception of the preservation of the species as the driving factor in the life of nature:

'With respect to plants as animals, we are wrong in speaking as if the object of life were only the bequeathing of itself. The flower is the end and proper object of the seeds, not the seed of the flower. The reason for the seed is that flowers may be, not the reason of flowers that seeds may be. The flower itself is the creature which the spirit makes; only, in connection with its perfectedness, is placed the giving birth to its successor.' (II, 60.)

For Ruskin the true meaning of life in all its stages lay not in the maintenance of physical continuity from generation to generation, but in the ever-renewed, ever more enhanced revelation of the spirit.

He was never for a moment in doubt regarding the inevitable effect of such an evolutionary theory as Darwin's on the general social attitude of humanity. Men would be led, he realized, to see themselves as the accidental products of an animal nature based on the struggle for existence and the preservation of the species.

Enough has been said to stamp Ruskin as a reader in the book of nature, capable of deciphering the signature of the spirit in the phenomena of the sense-world.

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Outwardly different from Ruskin's and yet spiritually comparable, is the contribution made by his older contemporary, Luke Howard, to the foundation of a science of nature based on intuition. Whereas Ruskin throws out a multitude of aphoristic utterances about many different aspects of nature, which will provide us with further starting-points for our own observation and thought, Howard is concerned with a single sphere of phenomena, that of cloud formation. On the other hand, his contribution consists of a definite discovery which he himself methodically and consciously achieved, and it is the content of this discovery, together with the method of research leading to it, which will supply us ever and again with a model for our own procedure. At the same time, as we have indicated, he will help us to become familiar with another side of Goethe, and to widen our knowledge of the basic scientific concepts formed by him.

Anyone interested to-day in weather phenomena is acquainted with the terms used in cloud classification—Cirrus, Cumulus, Stratus, and Nimbus. These have come so far into general use that it is not easy to realize that, until Howard's paper, *On the Modification of Clouds,* appeared in 1803, no names for classifying clouds were available. Superficially, it may seem that Howard had done nothing more than science has so often done in grouping and classifying and naming the contents of nature. In fact, however, he did something essentially different.

In the introduction to his essay, Howard describes the motives which led him to devote himself to a study of meteorological phenomena:

'It is the frequent observation of the countenance of the sky, and of its connexion with the present and ensuing phenomena, that constitutes the ancient and popular meteorology. The want of this branch of knowledge renders the prediction of the philosopher (who in attending his instruments may be said to examine the pulse of the atmosphere), less generally successful than those of the weather-wise mariners and husbandmen.'

When he thus speaks of studying 'the countenance of the sky', Howard is not using a mere form of speech; he is exactly describing his own procedure, as he shows when he proceeds to justify it as a means to scientific knowledge. The clouds with their ever-moving, ever-changing forms are not, he says, to be regarded as the mere 'sport of the winds', nor is their existence 'the mere result of the condensation of vapour in the masses of the atmosphere which they occupy'. What comes to view in them is identical, in its own realm, with what the changing expression of the human face reveals of 'a person's state of mind or body'. It would hardly be possible to represent oneself more clearly as a genuine reader in the book of nature than by such words. What is it but Ruskin's 'Stand by Form against Force' that Howard is here saying in his own way?

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Before entering into a further description of Howard's system, we must make clear why we disregard the fact that modern meteorology has developed the scale of cloud-formation far beyond Howard, and why we shall keep to his own fourfold scale.

It is characteristic of Goethe that, on becoming acquainted with Howard's work, he at once gave a warning against subdividing his scale without limit. Goethe foresaw that the attempt to insert too many transitory forms between Howard's chief types would result only in obscuring that view of the essentials which Howard's original classification had opened up. Obviously, for a science based on mere onlooking there is no objection to breaking up an established system into ever more subdivisions in order to keep it in line with an increasingly detailed outer observation. This, indeed, modern meteorology has done with Howard's system, with the result that, to-day, the total scale is made up of ten different stages of cloud-formation.

Valuable as this tenfold scale may be for certain practical purposes, it must be ignored by one who realizes that through Howard's fourfold scale nature herself speaks to man's intuitive judgment. Let us, therefore, turn to Howard's discovery, undisturbed by the extension to which modern meteorology has subjected it.

Luke Howard, a chemist by profession, knew well how to value the results of scientific knowledge above traditional folk-knowledge. He saw the superiority of scientifically acquired knowledge in the fact that it was universally communicable, whereas folk-wisdom is bound up with the personality of its bearer, his individual observations and his memory of them. Nevertheless, the increasing mathematizing of science, including his own branch of it, gave him great concern, for he could not regard it as helpful in the true progress of man's *understanding* of nature. Accordingly, he sought for a method of observation in which the practice of 'the weatherwise mariner and husbandman' could be raised to the level of scientific procedure. To this end he studied the changing phenomena of the sky for many years, until he was able so to read its play of features that it disclosed to him the archetypal forms of cloud-formation underlying all change. To these he gave the now well-known names (in Latin, so that they might be internationally comprehensible):

Cirrus: Parallel, flexuous or divergent fibres extensible in any and all directions.
Cumulus: Convex or conical heaps, increasing upwards from a horizontal base.
Stratus: A widely extended, continuous, horizontal sheet, increasing from below.
Nimbus: The rain cloud.

Let us, on the background of Howard's brief definitions, try to form a more exact picture of the atmospheric dynamics at work in each of the stages he describes.[1]

Among the three formations of cirrus, cumulus and stratus, the cumulus has a special place as representing in the most actual sense what is meant by the term 'cloud'. The reason is that both cirrus and stratus have characteristics which in one or the other direction tend away from the pure realm of atmospheric cloud-formation. In the stratus, the atmospheric vapour is gathered into a horizontal, relatively arched layer around the earth, and so anticipates the actual water covering below which extends spherically around the earth's centre. Thus the stratus arranges itself in a direction which is already conditioned by the earth's field of gravity. In the language of physics, the stratus forms an equipotential surface in the gravitational field permeating the earth's atmosphere.

[1] See also Goethe's sketch of the basic cloud forms on Plate IV.

As the exact opposite of this we have the cirrus. If in the stratus the form ceases to consist of distinct particulars, because the entire cloud-mass runs together into a single layer, in the cirrus the form begins to vanish before our eyes, because it dissolves into the surrounding atmospheric space. In the cirrus there is present a tendency to expand; in the stratus to contract.

Between the two, the cumulus, even viewed simply as a form-type, represents an exact mean. In how densely mounded a shape does the majestically towering cumulus appear before us, and yet how buoyantly it hovers aloft in the heights! If one ever comes into the midst of a cumulus cloud in the mountains, one sees how its myriads of single particles are in ceaseless movement. And yet the whole remains stationary, on windless days preserving its form unchanged for hours. More recent meteorological research has established that in many cumulus forms the entire mass is in constant rotation, although seen from outside, it appears as a stable, unvarying shape. Nowhere in nature may the supremacy of form over matter be so vividly observed as in the cumulus cloud. And the forms of the cumuli themselves tell us in manifold metamorphoses of a state of equilibrium between expansive and contractive tendencies within the atmosphere.

Our description of the three cloud-types of cirrus, cumulus and stratus, makes it clear that we have to do with a self-contained symmetrical system of forms, within which the two outer, dynamically regarded, represent the extreme tendencies of expansion and contraction, whilst in the middle forms these are held more or less in balance. By adding Howard's nimbus formation to this system, we destroy its symmetry. Actually, in the nimbus we have cloud in such a condition that it ceases to be an atmospheric phenomenon in any real sense of the word; for it now breaks up into single drops of water, each of which, under the pull of gravity, makes its own independent way to the earth. (The symmetry is restored as soon as we realize that the nimbus, as a frontier stage below the stratus, has a counterpart in a corresponding frontier stage above the cirrus. To provide insight into this upper frontier stage, of which neither Howard nor Goethe was at that time in a position to develop a clear enough conception to deal with it scientifically, is one of the aims of this book.)

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In order to understand what prompted Goethe to accept, as he did, Howard's classification and terminology at first glance, and what persuaded him to make himself its eloquent herald, we must note from what point Goethe's labours for a natural understanding of nature had originated.

In his *History of my Botanical Studies* Goethe mentions, besides Shakespeare and Spinoza, Linnaeus as one who had most influenced his own development. Concerning Linnaeus, however, this is to be understood in a negative sense. For when Goethe, himself searching for a way of bringing the confusing multiplicity of plant phenomena into a comprehensive system, met with the Linnaean system, he was, despite his admiration for the thoroughness and ingenuity of Linnaeus's work, repelled by his method. Thus by way of reaction, his thought was brought into its own creative movement: 'As I sought to take in his acute, ingenious analysis, his apt, appropriate, though often arbitrary laws, a cleft was set up in my inner nature: what he sought to hold forcibly apart could not but strive for union according to the inmost need of my own being.'

Linnaeus's system agonized Goethe because it demanded from him 'to memorize a ready-made terminology, to hold in readiness a certain number of nouns and adjectives, so as to be able, whenever any form was in question, to employ them in apt and skilful selection, and so to give it its characteristic designation and appropriate position.' Such a procedure appeared to Goethe as a kind of mosaic, in which one ready-made piece is set next to another in order to produce out of a thousand details the semblance of a picture; and this was 'in a certain way repugnant' to him. What Goethe awoke to when he met Linnaeus's attempt at systematizing the plant kingdom was the old problem of whether the study of nature should proceed from the parts to the whole or from the whole to the parts.

Seeing, therefore, how it became a question for Goethe, at the very beginning of his scientific studies, whether a *natural* classification of nature's phenomena could be achieved, we can understand why he was so overjoyed when, towards the end of his life, in a field of observation which had meanwhile caught much of his interest, he met with a classification which showed, down to the single names employed, that it had been read off from reality.

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The following is a comprehensive description of Goethe's meteorological views, which he gave a few years before his death in one of his conversations with his secretary, Eckermann:

'I compare the earth and her hygrosphere[1] to a great living being perpetually inhaling and exhaling. If she inhales, she draws the hygrosphere to her, so that, coming near her surface, it is condensed to clouds and rain. This state I call water-affirmative *(Wasser-Bejahung).* Should it continue for an indefinite period, the earth would be drowned. This the earth does not allow, but exhales again, and sends the watery vapours upwards, when they are dissipated through the whole space of the higher atmosphere. These become so rarefied that not only does the sun penetrate them with its brilliancy, but the eternal darkness of infinite space is seen through them as a fresh blue. This state of the atmosphere I call water-negative (*Wasser-Verneinung).* For just as, under the contrary influence, not only does water come profusely from above, but also the moisture of the earth cannot be dried and dissipated—so, on the contrary, in this state not only does no moisture come from above, but the damp of the earth itself flies upwards; so that, if this should continue for an indefinite period, the earth, even if the sun did not shine, would be in danger of drying up.' (llth April 1827.)

Goethe's notes of the results of his meteorological observations show how in them, too, he followed his principle of keeping strictly to the phenomenon. His first concern is to bring the recorded measurements of weather phenomena into their proper order of significance. To this end he compares measurements of atmospheric temperature and local density with barometric measurements. He finds that the first two, being of a more local and accidental nature, have the value of 'derived' phenomena, whereas the variations in the atmosphere revealed by the barometer are the same over wide areas and therefore point to fundamental changes in the general conditions of the earth. Measurements made regularly over long periods of time finally lead him to recognize in the barometric variations of atmospheric pressure the basic meteorological phenomenon.

In all this we find Goethe carefully guarding himself against 'explaining' these atmospheric changes by assuming some kind of purely mechanical cause, such as the accumulation of air-masses over a certain area or the like. Just as little would he permit himself

[1] Goethe's *Dunstkreis*—meaning the humidity contained in the air and, as such, spherically surrounding the earth. I had to make up the word 'hygrosphere' (after hygrometer, etc.) to keep clear the distinction from both atmosphere and hydrosphere. Except for this term in the first two sentences, the above follows Oxenford's translation (who, following the dictionaries, has rendered Goethe's term inadequately by 'atmosphere').

lightly to assume influences of an extra-terrestrial nature, such as those of the moon. Not that he would have had anything against such things, if they had rested on genuine observation. But his own observations, as far as he was able to carry them, told him simply that the atmosphere presses with greater or lesser intensity on the earth in more or less regular rhythms. He was not abandoning the phenomenal sphere, however, when he said that these changes are results of the activity of earthly gravity, or when he concluded from this that barometric variations were caused by variations in the intensity of the field of terrestrial gravity, whereby the earth sometimes drew the atmosphere to it with a stronger, and sometimes with a weaker, pull.

He was again not departing from the realm of the phenomenal when he looked round for other indications in nature of such an alternation of drawing in and letting forth of air, and found them in the respiratory processes of animated beings. (To regard the earth as a merely physical structure was impossible for Goethe, for he could have done this only by leaving out of account the life visibly bound up with it.) Accordingly, barometric measurements became for him the sign of a breathing process carried out by the earth.

Alongside the alternating phases of contraction and expansion within the atmosphere, Goethe placed the fact that atmospheric density decreases with height. Observation of differences in cloud formation at different levels, of the boundary of snow formation, etc., led him to speak of different 'atmospheres', or of atmospheric circles or spheres, which when undisturbed are arranged concentrically round the earth. Here also he saw, in space, phases of contraction alternating with phases of expansion.

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At this point in our discussion it is necessary to introduce another leading concept of Goethean nature-observation, which was for him —as it will be for us—of particular significance for carrying over the Goethean method of research from the organic into the inorganic realm of nature. This is the concept of the ur-phenomenon *(Urphänomen).* In this latter realm, nature no longer brings forth related phenomena in the ordering proper to them; hence we are obliged to acquire the capacity of penetrating to this ordering by means of our own realistically trained observation and thought.

From among the various utterances of Goethe regarding his general conception of the ur-phenomenon, we here select a passage from that part of the historical section of his *Theory of Colour* where he discusses the method of investigation introduced into science by Bacon. He says:

'In the range of phenomena all had equal value in Bacon's eyes. For although he himself always points out that one should collect the particulars only to select from them and to arrange them, in order finally to attain to Universals, yet too much privilege is granted to the single facts; and before it becomes possible to attain to simplification and conclusion by means of induction (the very way he recommends), life vanishes and forces get exhausted. He who cannot realize that one instance is often worth a thousand, bearing all within itself; he who proves unable to comprehend and esteem what we called ur-phenomena, will never be in a position to advance anything, either to his own or to others' joy and profit.'

What Goethe says here calls for the following comparison. We can say that nature seen through Bacon's eyes appears as if painted on a two-dimensional surface, so that all its facts are seen alongside each other at exactly the same distance from the observer. Goethe, on the other hand, ascribed to the human spirit the power of seeing the phenomenal world in all its three-dimensional multiplicity; that is, of seeing it in perspective and distinguishing between foreground and background.[1] Things in the foreground he called ur-phenomena. Here the idea creatively determining the relevant field of facts comes to its purest expression. The sole task of the investigator of nature, he considered, was to seek for the ur-phenomena and to bring all other phenomena into relation with them; and in the fulfilment of this task he saw the means of fully satisfying the human mind's need to theorize. He expressed this in the words, 'Every fact is itself already theory'. In Goethe's meteorological studies we have a lucid example of how he sought and found the relevant ur-phenomenon. It is the breathing-process of the earth as shown by the variations of barometric pressure.

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Once again we find Thomas Reid, along his line of intuitively guided observation, coming quite close to Goethe where he deals

[1] We may here recall Eddington's statement concerning the restriction of scientific observation to 'non-stereoscopic vision'.

with the question of the apprehension of natural law by the human mind. He, too, was an opponent of the method of 'explaining' phenomena by means of abstract theories spun out of sheer thinking, and more than once in his writings he inveighs against it in his downright, humorous way.[1]

His conviction that human thinking ought to remain within the realm of directly experienced observation is shown in the following words: 'In the solution of natural phenomena, all the length that the human faculties can carry us is only this, that from particular phenomena, we may, by induction, trace out general phenomena, of which all the particular ones are necessary consequences.'[2] As an example of this he takes gravity, leading the reader from one phenomenon to the next without ever abandoning them, and concluding the journey by saying: 'The most general phenomena we can reach are what we call laws of nature. So that the laws of nature are nothing else but the most general facts relating to the operations of nature, which include a great many particular facts under them.'

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It was while on his way with the Grand Duke of Weimar to visit a newly erected meteorological observatory that Goethe, in the course of informing his companion of his own meteorological ideas, first heard of Howard's writings about the formation of clouds. The Duke had read a report of them in a German scientific periodical, and it seemed to him that Howard's cloud system corresponded with what he now heard of Goethe's thoughts about the force relationships working in the different atmospheric levels. He had made no mistake. Goethe, who immediately obtained Howard's essay, recognized at first glance in Howard's cloud scale the law of atmospheric changes which he himself had discovered. He found here, what he had always missed in the customary practice of merely tabulating the results of scientific measurements. And so he took hold of the Howard system with delight, for it 'provided him with a thread which had hitherto been lacking'.

Moreover, in the names which Howard had chosen for designating the basic cloud forms, Goethe saw the dynamic element in each of

[1] An example of this is Reid's commentary on existing theories about sight as a mere activity of the optic nerve. (*Inq.*, VI, 19.)

[2] See *Inq.*, VI, 13. This is precisely what Kant had declared to be outside human possibility.

them coming to immediate expression in human speech.[1] He therefore always spoke of Howard's system as a 'welcome terminology'.

All this inspired Goethe to celebrate Howard's personality and his work in a number of verses in which he gave a description of these dynamic elements and a paraphrase of the names, moulding them together into an artistic unity. In a few accompanying verses he honoured Howard as the first to 'distinguish and suitably name' the clouds.[2]

The reason why Goethe laid so much stress on Howard's terminology was because he was very much aware of the power of names to help or hinder men in their quest for knowledge. He himself usually waited a long time before deciding on a name for a natural phenomenon or a connexion between phenomena which he had discovered. The Idea which his spiritual eye had observed had first to appear so clearly before him that he could clothe it in a thought-form proper to it. Seeing in the act of name-giving an essential function of man (we are reminded of what in this respect the biblical story of creation says of Adam),[3] Goethe called man 'the first conversation which Nature conducts with God'.

It is characteristic of Goethe that he did not content himself with knowing the truth which someone had brought forward in a field of knowledge in which he himself was interested, but that he felt his acquaintance with this truth to be complete only when he also knew something about the personality of the man himself. So he introduces his account of his endeavours to know more about Howard, the man, with the following words: 'Increasingly convinced that everything occurring through man should be regarded in an ethical sense, and that moral value is to be estimated only from a man's way of life, I asked a friend in London to find out if possible something about Howard's life, if only the simplest facts.' Goethe was uncertain whether the Englishman was still alive, so his delight and surprise were considerable when from Howard himself he received an answer in the form of a short autobiographical sketch, which fully confirmed his expectations regarding Howard's ethical personality.

Howard's account of himself is known to us, as Goethe included a translation of it in the collection of his own meteorological studies. Howard in a modest yet dignified way describes his Christian faith,

[1] Stratus means layer, cumulus—heap, cirrus—curl.
[2] There exists no adequate translation of these verses.
[3] Genesis ii, 19, 20.

his guide through all his relationships, whether to other men or to nature.[1] A man comes before us who, untroubled by the prevailing philosophy of his day, was able to advance to the knowledge of an objective truth in nature, because he had the ability to carry religious experience even into his observation of the sense-world.

*

In view of all this, it is perhaps not too much to say that in the meeting between Howard and Goethe by way of the spiritual bridge of the clouds, something happened that was more than a mere event in the personal history of these two men.

[1] A fact which Howard did not mention, and which presumably remained unknown to Goethe, was the work he had done as chairman of a relief committee for the parts of Germany devastated by the Napoleonic wars. For this work Howard received a series of public honours.

CHAPTER VIII

Dynamics *versus* Kinetics

At the present time the human mind is in danger of confusing the realm of dynamic events, into which modern atomic research has penetrated, with the world of the spirit; that is, the world whence nature is endowed with intelligent design, and of which human thinking is an expression in terms of consciousness. If a view of nature as a manifestation of spirit, such as Goethe and kindred minds conceived it, is to be of any significance in our time, it must include a conception of matter which shows as one of its attributes its capacity to serve Form (in the sense in which Ruskin spoke of it in opposition to mere Force) as a means of manifestation.

The present part of this book, comprising Chapters VIII-XI, will be devoted to working out such a conception of matter. An example will thereby be given of how Goethe's method of acquiring understanding of natural phenomena through reading the phenomena themselves may be carried beyond his own field of observation. There are, however, certain theoretical obstacles, erected by the onlooker-consciousness, which require to be removed before we can actually set foot on the new path. The present chapter will in particular serve this purpose.

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Science, since Galileo, has been rooted in the conviction that the logic of mathematics is a means of expressing the behaviour of natural events. The material for the mathematical treatment of sense data is obtained through measurement. The actual thing, therefore, in which the scientific observer is interested in each case, is the position of some kind of pointer. In fact, physical science is essentially, as Professor Eddington put it, a 'pointer-reading science'. Looking at this fact in our way we can say that all pointer instruments which man has constructed ever since the beginning of science, have as their model man himself, restricted to colourless, non-stereoscopic observation. For all that is left to him in this condition is to focus points in space and register changes of their positions. Indeed, the perfect scientific observer is himself the arch-pointer-instrument.

The birth of the method of pointer-reading is marked by Galileo's construction of the first thermometer (actually, a thermoscope). The conviction of the applicability of mathematical concepts to the description of natural events is grounded in his discovery of the so-called Parallelogram of Forces. It is with these two innovations that we shall concern ourselves in this chapter.

Let it be said at once that our investigations will lead to the unveiling of certain illusions which the spectator-consciousness has woven round these two gifts of Galileo. This does not mean that their significance as fundamentals of science will be questioned. Nor will the practical uses to which they have been put with so much success be criticized in any way. But there are certain deceptive ideas which became connected with them, and the result is that to-day, when man is in need of finding new epistemological ground under his feet, he is entangled in a network of conceptual illusions which prevent him from using his reason with the required freedom.

A special word is necessary at this point regarding the term illusion, as it is used here and elsewhere. In respect of this, it will be well to remember what was pointed out earlier in connexion with the term 'tragedy' (Chapter II). In speaking of 'illusion', we neither intend to cast any blame on some person or another who took part in weaving the illusion, nor to suggest that the emergence of it should be thought of as an avoidable calamity. Rather should illusion be thought of as something which man has been allowed to weave because only by his own active overcoming of it can he fulfil his destiny as the bearer of truth in freedom. Illusion, in the sense used here, belongs to those things in man's existence which are truly to be called tragic. It loses this quality, and assumes a quite different one, only when man, once the time has come for overcoming an illusion, insists on clinging to it.

As our further studies will show, the criticism to be applied here does not only leave the validity of measurement and the mathematical treatment of the data thus obtained fully intact, but by giving them their appropriate place in a wider conception of nature it opens the way to an ever more firmly grounded and, at the same time, enhanced application of both.

*

Our primary knowledge of the existence of something we call 'warmth' or 'heat' is due to a particular sense of warmth which modern research has recognized as a clearly definable sense. Naturally, seen from the spectator-standpoint, the experiences of this sense appear to be of purely subjective value and therefore useless for obtaining an objective insight into the nature of warmth and its effects in the physical world. In order to learn about these, resort is had to certain instruments which, through the change of the spatial position of a point, allow the onlooker-observer to register changes in the thermal condition of a physical object. An instrument of this kind is the thermometer. In the following way an indubitable proof seems to be given of the correctness of the view concerning the subjectivity of the impressions obtained through the sense of warmth, and of the objectivity of thermometrical measurement. A description of it is frequently given in physical textbooks as an introduction to the chapter on Heat.

To begin with, the well-known fact is cited that if one plunges one's hands first into two different bowls, one filled with hot water and the other with cold, and then plunges them together into a bowl of tepid water, this will feel cold to the hand coming from the hot water and warm to the hand coming from the cold. Next, it is pointed out that two thermometers which are put through the same procedure will register an equal degree of temperature for the tepid water. In this way the student is given a lasting impression of the superiority of the 'objective' recording of the instrument over the 'subjective' character of the experiences mediated by his sense of warmth.

Let us now test this procedure by carrying out the same experiment with the help of thermometrical instruments in their original form, that is, the form in which Galileo first applied them. By doing so we proceed in a truly Goethean manner, because we divest the experiment of all accessories which prevent the phenomenon from appearing in its primary form.

To turn a modern thermometer into a thermoscope we need only remove the figures from its scale. If we make the experiment with two such thermoscopes we at once become aware of something which usually escapes us, our attention being fixed on the figures recorded by the two instruments. For we now notice that the two instruments, when transferred from the hot and cold water into the tepid water, behave quite differently. In one the column will fall, in the other it will rise.

It is important to note that by this treatment of the two instruments we have not changed the way in which they usually indicate temperature. For thermometrical measurement is in actual fact never anything else than a recording of the movement of the indicator from one level to another. We choose merely to take a certain temperature level—that of melting ice or something else—as a fixed point of reference and mark it once for all on the instrument. Because we find this mark clearly distinguished on our thermometers, and the scales numbered accordingly, we fail to notice what lies ideally behind this use of the same zero for every new operation we undertake.

What the zero signifies becomes clear directly we start to work with thermometers not marked with scales. For in order to be used in this form as real thermometers, they must be exposed on each occasion first of all to some zero level of temperature, say, that of melting ice. If we then take them into the region of temperature we want to measure, we shall discern the difference of levels through the corresponding movement of the column. The final position of the column tells us nothing in itself. It is always the *change* from one level to another that the thermometer registers—precisely as does the sense of warmth in our hands in the experiment just described.

Hence we see that in the ordinary operation with the thermometers, and when we use our hands in the prescribed manner, we are dealing with the zero level in two quite different ways. While in the/two instruments the zero level is the same, in accordance with the whole idea of thermometric measurement, we make a special arrangement so as to expose our hands to two different levels. So we need not be surprised if these two ways yield different results. If, after placing two thermometers without scales in hot and cold water, we were to assign to each its own zero in accordance with the respective height of its column, and then graduate them from this reference point, they would necessarily record different levels when exposed to the tepid water, in just the same way as the hands do. Our two hands, moreover, will receive the same sense-impression from the tepid water, if we keep them in it long enough.

Seen in this light, the original experiment, designed to show the subjective character of the impressions gained through the sense of warmth, reveals itself as a piece of self-deception by the onlooker-consciousness. The truth of the matter is that, in so far as there is any subjective element in the experience and measurement of heat, it does not lie on the side of our sense of warmth, but in our judgment of the significance of thermometrical readings. In fact, our test of the alleged proof of the absolute superiority of pointer-readings over the impressions gained by our senses gives us proof of the correctness of Goethe's statement, quoted earlier, that the senses do not deceive, but the judgment deceives.

Let it be repeated here that what we have found in this way does not lead to any depreciation of the method of pointer-reading. For the direct findings of the senses cannot be compared quantitatively. The point is that the idea of the absolute superiority of physical measurement as a means of scientific knowledge, in all circumstances, must be abandoned as false.

*

We now turn to Galileo's discovery known as the theorem of the Parallelogram of Forces. The illusion which has been woven round this theorem expresses itself in the way it is described as being connected ideally with another theorem, outwardly similar in character, known as the theorem of the Parallelogram of Movements (or Velocities), by stating that the former follows logically from the latter. This statement is to be found in every textbook on physics at the outset of the chapter on dynamics (kinetics), where it serves to establish the right to treat the dynamic occurrences in nature in a purely kinematic fashion, true to the requirements of the onlooker-consciousness.[1]

The following description will show that, directly we free ourselves from the onlooker-limitations of our consciousness in the way shown by Goethe—and, in respect of the present problem, in particular also by Reid—the ideal relationship between the two theorems is seen to be precisely the opposite to the one expressed in the above statement. The reason why we take pains to show this at the present point of our discussion is that only through replacing the fallacious conception by the correct one, do we open the way for forming a concrete concept of Force and thereby for establishing a truly dynamic conception of nature.

*

Let us begin by describing briefly the content of the two theorems in question. In Fig. 1, a diagrammatical representation is given of the parallelogram of movements. It sets out to show that when a point moves with a certain velocity in the direction indicated by the arrow

[1] As to the terms 'kinetic' and 'kinematic', see Chapter II, page 30, footnote.

a, so that in a certain time it passes from P to A, and when it simultaneously moves with a second velocity in the direction indicated by *b*, through which alone it would pass to B in the same time, its actual movement is indicated by *c*, the diagonal in the parallelogram formed by *a* and *b*. An example of the way in which this

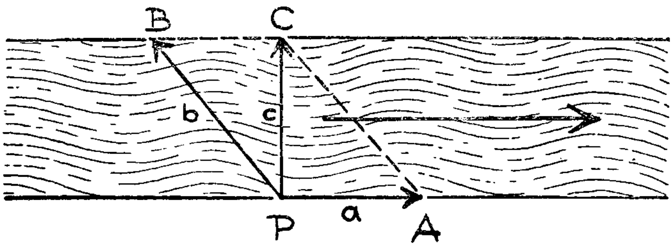

FIG. 1

theorem is practically applied is the well-known case of a rower who sets out from P in order to cross at right angles a river indicated by the parallel lines. He has to overcome the velocity *a* of the water of the river flowing to the right by steering obliquely left towards B in order to arrive finally at C.

It is essential to observe that the content of this theorem does not need the confirmation of any outer experience for its discovery, or to establish its truth. Even though the recognition of the fact which it expresses may have first come to men through practical observation, yet the content of this theorem can be discovered and proved by purely logical means. In this respect it resembles any purely geometrical statement such as, that the sum of the angles of a triangle is two right angles (180°). Even though this too may have first been learnt through outer observation, yet it remains true that for the discovery of the fact expressed by it—valid for all plane triangles—no outer experience is needed. In both cases we find ourselves in the domain of pure geometric conceptions (length and direction of straight lines, movement of a point along these), whose reciprocal relationships are ordered by the laws of pure geometric logic. So in the theorem of the Parallelogram of Velocities we have a strictly geometrical theorem, whose content is in the narrowest sense kinematic. In fact, it is the basic theorem of kinematics.

We now turn to the second theorem which speaks of an outwardly similar relationship between forces. As is well known, this states that two forces of different magnitude and direction, when they apply at the same point, act together in the manner of a single force whose magnitude and direction may be represented by the diagonal of a parallelogram whose sides express in extent and direction the first two forces. Thus in Fig. 2, R exercises upon P the same effect as F_1 and F_2 together.

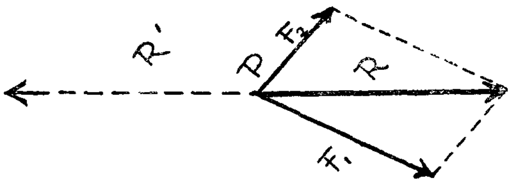

FIG. 2

Expressed in another way, a force of this magnitude working in the reverse direction (R') will establish an equilibrium with the other two forces. In technical practice, as is well known, this theorem is used for countless calculations, in both statics and dynamics, and indeed more frequently not in the form given here but in the converse manner, when a single known force is resolved into two component forces. (Distribution of a pressure along frameworks, of air pressure along moving surfaces, etc.)

It will now be our task to examine the logical link which is believed to connect one theorem with the other. This link is found in the well-known definition of physical force as a product of 'mass' and 'acceleration'—in algebraic symbols $\mathbf{F} = ma$. We will discuss the implications of this definition in more detail later on. Let us first see how it is used as a foundation for the above assertion.

The conception of 'force' as the product of 'mass' and 'acceleration' is based on the fact—easily experienced by anyone who cycles along a level road—that it is not velocity itself which requires the exertion of force, but the change of velocity—that is, acceleration or retardation ('negative acceleration' in the sense of mathematical physics) ; also that in the case of equal accelerations, the force depends upon the mass of the accelerated object. The more massive the object, the greater will be the force necessary for accelerating it. This mass, in turn, reveals itself in the resistance a particular object offers to any change of its state of motion. Where different accelerations and the same mass are considered, the factor *m* in the above formula remains constant, and force and acceleration are directly proportional to each other. Thus in the acceleration is discovered a measure for the magnitude of the force which thereby acts.

Now it is logically evident that the theorem of the parallelogram of velocities is equally valid for movements with constant or variable velocities. Even though it is somewhat more difficult to perceive mentally the movement of a point in two different directions with two differently accelerated motions, and to form an inner conception of the resulting movement, we are nevertheless still within a domain which may be fully embraced by thought. Thus accelerated movements and movements under constant velocity can be resolved and combined according to the law of the parallelogram of movements, a law which is fully attainable by means of logical thought.

With the help of the definition of force as the product of mass and acceleration it seems possible, indeed, to derive the parallelogram of forces from that of accelerations in a purely logical manner. For it is necessary only to extend all sides of an a parallelogram by means of the same factor *m* in order to turn it into an **F** parallelogram. A single geometrical figure on paper can represent both cases, since only the scale needs to be altered in order that the same geometrical length should represent at one time the magnitude *a* and on another occasion *ma*. It is in this way that present-day scientific thought keeps itself convinced that the parallelogram of forces follows with logical evidence from the parallelogram of accelerations, and that the discovery of the former is therefore due to a purely mental process.

Since the parallelogram of forces is the prototype of each further mathematical representation of physical force-relationships in nature, the conceptual link thus forged between it and the basic theorem of kinematics has led to the conviction that the fact that natural events can be expressed in terms of mathematics could be, and actually has been, discovered through pure logical reasoning, and thus by the brain-bound, day-waking consciousness 'of the world-spectator. Justification thereby seemed to be given for the building of a valid scientific world-picture, purely kinematic in character.

*

The line of consideration we shall now have to enter upon for carrying out our own examination of what is believed to be the link between the two theorems may seem to the scientifically trained reader to be of an all too elementary kind compared with the complexities of thought in which he is used to engage in order to settle a scientific problem. It is therefore necessary to state here that anyone who wishes to help to overcome the tangle of modern theoretical science must not be shy in applying thoughts and observations of seemingly so simple a nature as those used both here and on other occasions. Some readiness, in fact, is required to play where necessary the part of the child in Hans Andersen's fairy-story of *The Emperor's New Clothes,* where all the people are loud in praise of the magnificent robes of the Emperor, who is actually passing through the streets with no clothes on at all, and a single child's voice exclaims the truth that 'the Emperor has nothing on'. There will repeatedly be occasion to adopt the role of this child in the course of our own studies.

*

In the scientific definition of force given above force appears as the result of a multiplication of two other magnitudes. Now as is well known, it is essential for the operation of multiplication that of the two factors forming the product at least one should exhibit the properties of a pure number. For two pure numbers may be multiplied together—e.g. 2 and 4—and a number of concrete things can be multiplied by a pure number—e. g. 3 apples and the number 4—but no sense can be attached to the multiplication of 3 apples by 4 apples, let alone by 4 pears! The result of multiplication is therefore always either itself a pure number, when both factors have this property ; or when one of the two factors is of the nature of a concrete object, the result is of the same quality as the latter. An apple will always remain an apple after multiplication, and what distinguishes the final product (apples) from the original factor (apples) is only a pure number.

If we take seriously what this simple consideration tells us of the nature of multiplication, and if we do not allow ourselves to deviate from it for whatever purpose we make use of this algebraic operation, then the various concepts we connect with the basic measurements in physics undergo a considerable change of meaning.

Let us test, in this respect, the well-known formula which, in the conceptual language of physics, connects 'distance' *(s),* 'time' (*t*), and 'velocity' *(c).* It is written

$$c = \frac{s}{t},$$

or

$$s = ct.$$

In this formula, *s* has most definitely the meaning of a 'thing', for it represents measured spatial distance. Of the two factors on the other side of the second equation, one must needs have the same quality as *s:* this is *c.* Thus for the other factor, *t*, there remains the property of a pure number. We are, therefore, under an illusion if we assume the factor *c* to represent anything of what *velocity* implies in outer cosmic reality. The truth is that *c* represents a spatial distance just as *s* does, with the difference only that it is a certain unit-distance. Just as little does real *time* enter into this formula—nor does it into any other formula of mathematical physics. 'Time', in physics, is always a pure number without any cosmic quality. Indeed, how could it be otherwise for a purely kinematic world-observation?

We now submit the formula $\mathbf{F} = ma$ to the same scrutiny. If we attach to the factor *a* on the right side of the equation a definite quality, namely an observable acceleration, the other factor in the product is permitted to have only the properties of a pure number; F, therefore, can be only of the same nature as *a* and must itself be an acceleration. Were it otherwise, then the equation $\mathbf{F} = ma$ could certainly not serve as a logical link between the Velocity and Force parallelograms.

Our present investigation has done no more than grant us an insight into the process of thought whereby the consciousness limited to a purely kinematic experience has deprived the concept of force of any real content. Let us look at the equation $\mathbf{F} = ma$ as a means of splitting of the magnitude F into two components *m* and a. The equation then tells us that F is reduced to the nature of pure acceleration, for that which resides in the force as a factor not observable by kinematic vision has been split away from it as the factor *m.* For this factor, however, as we have seen, nothing remains over but the property of a pure number.

Let us note here that the first thinker to concern himself with a comprehensive world-picture in which the non-existence of a real concept of force is taken in earnest—namely, Albert Einstein—was also the first to consider mass as a form of energy and even to predict correctly, as was proved later, the amount of energy represented by the unit of mass, thereby encouraging decisively the new branch of experimental research which has led to the freeing of the so-called atomic energy. Is it then possible that pure numbers can effect what took place above and within Nagasaki, Hiroshima, etc.? Here we are standing once again before one of the paradoxes of modern science which we have found to play so considerable a part in its development.

To find an interpretation of the formula **F** = *ma,* which is free from illusion, we must turn our attention first of all to the concepts 'force' and 'mass' themselves. The fact that men have these two words in their languages shows that the concepts expressed by them must be based on some experience that has been man's long before he was capable of any scientific reflexion. Let us ask what kind of experience this is and by what part of his being he gathers it.

The answer is, as simple self-observation will show, that we know of the existence of force through the fact that we ourselves must exert it in order to move our own body. Thus it is the resistance of our body against any alteration of its state of motion, as a result of its being composed of inert matter, which gives us the experience of force both as a possession of our own and as a property of the outer world. All other references to force, in places where it cannot be immediately experienced, arise by way of analogy based on the similarity of the content of our observation to that which springs from the exertion of force in our own bodies.

As we see, in this experience of force that of mass is at once implied. Still, we can strengthen the latter by experimenting with some outer physical object. Take a fairly heavy object in your hand, stretch out your arm lightly and move it slowly up and down, watching intently the sensation this operation rouses in you.[1] Evidently the experience of mass outside ourselves, as with that of our own body, comes to us through the experience of the force which we ourselves must exert in order to overcome some resisting force occasioned by the mass. Already this simple observation—as such made by means of the sense of movement and therefore outside the frontiers of the onlooker-consciousness—tells us that mass is nothing but a particular manifestation of force.

Seen in the light of this experience, the equation **F** = *ma* requires to be interpreted in a manner quite different from that to which scientific logic has submitted it. For if we have to ascribe to F and *m* the same quality, then the rule of multiplication allows us to ascribe to *a* nothing but the character of a pure number. This implies that

[1] For the sake of our later studies it is essential that the reader does not content himself with merely following the above description mentally, but that he carries out the experiment himself.

there is no such thing as acceleration as a self-contained entity, merely attached to mass in an external way.

What we designate as acceleration, and measure as such, is nothing else than a numerical factor comparing two different conditions of force within the physical-material world.

Only when we give the three factors in our equation this meaning, does it express some concrete outer reality. At the same time it forbids the use of this equation for a logical derivation of the parallelogram of forces from that of pure velocities.

*

The same method which has enabled us to restore its true meaning to the formula connecting mass and force will serve to find the true source of man's knowledge of the parallelogram of forces. Accordingly, our procedure will be as follows.

We shall engage two other persons, together with whom we shall try to discover by means of our respective experiences of force the law under which three forces applying at a common point may hold themselves in equilibrium. Our first step will consist in grasping each other by the hand and in applying various efforts of our wills to draw one another in different directions, seeing to it that we do this in such a way that the three joined hands remain undisturbed at the same place. By this means we can get as far as to establish that, when two persons maintain a steady direction and strength of pull, the third must alter his applied force with every change in his own direction in order to hold the two others in equilibrium. He will find that in some instances he must increase his pull and in other instances decrease it.

This, however, is all that can be learnt in this way. No possibility arises at this stage of our investigation of establishing any exact quantitative comparison. For the forces which we have brought forth (and this is valid for forces in general, no matter of what kind they are) represent pure intensities, outwardly neither visible nor directly measurable. We can certainly tell whether we are intensifying or diminishing the application of our will, but a numerical comparison between different exertions of will is not possible.

In order to make such a comparison, a further step is necessary. We must convey our effort to some pointer-instrument—for instance, a spiral spring which will respond to an exerted pressure or pull by a change in its spatial extension. (Principle of the spring balance.) In this way, by making use of a certain property of matter—elasticity—the purely intensive magnitudes of the forces which we exert become extensively visible and can be presented geometrically. We shall therefore continue our investigation with the aid of three spring balances, which we hook together at one end while exposing them to the three pulls at the other.

To mark the results of our repeated pulls of varying intensities and directions, we draw on the floor on which we stand three chalk lines outward from the point underneath the common point of the three instruments, each in the direction taken up by one of the three persons. Along these lines we mark the extensions corresponding to those of the springs of the instruments.

By way of this procedure we shall arrive at a sequence of figures such as is shown in Fig. 3.

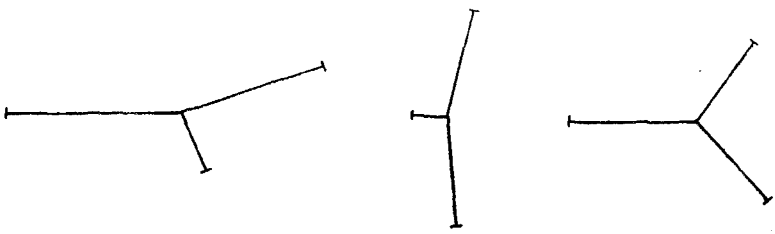

FIG. 3

This is all we can discover empirically regarding the mutual relationships of three forces engaging at a point.

Let us now heed the fact that nothing in this group of figures reveals that in each one of these trios of lines there resides a definite and identical geometrical order; nor do they convey anything that would turn our thoughts to the parallelogram of velocities with the effect of leading us to expect, by way of analogy, a similar order in these figures. And this result, we note, is quite independent of our particular way of procedure, whether we use, right from the start, a measuring instrument, or whether we proceed as described above.

*

Having in this way removed the fallacious idea that the parallelogram of forces can, and therefore ever has been, conceived by way of logical derivation from the parallelogram of velocities, we must then ask ourselves what it was, if not any act of logical reason, that led Galileo to discover it.

History relates that on making the discovery he exclaimed: '*La natura è scritta in lingua matematica!*' ('Nature is recorded in the language of mathematics.') These words reveal his surprise when he realized the implication of his discovery. Still, intuitively he must have known that using geometrical lengths to symbolize the measured magnitudes of forces would yield some valid result. Whence came this intuition, as well as the other which led him to recognize from the figures thus obtained that in a parallelogram made up of any two of the three lines, the remaining line came in as its diagonal? And, quite apart from the particular event of the discovery, how can we account for the very fact that nature—at least on a certain level of her existence—exhibits rules of action expressible in terms of logical principles immanent in the human mind?

*

To find the answer to these questions we must revert to certain facts connected with man's psycho-physical make-up of which the considerations of Chapter II have already made us aware.

Let us, therefore, transpose ourselves once more into the condition of the child who is still entirely volition, and thus experiences himself as one with the world. Let us consider, from the point of view of this condition, the process of lifting the body into the vertical position and the acquisition of the faculty of maintaining it in this position; and let us ask what the soul, though with no consciousness of itself, experiences in all this. It is the child's will which wrestles in this act with the dynamic structure of external space, and what his will experiences is accompanied by corresponding perceptions through the sense of movement and other related bodily senses. In this way the parallelogram of forces becomes an inner experience of our organism at the beginning of our earthly life. What we thus carry in the body's will-region in the form of *experienced geometry*—this, together with the freeing and crystallizing of part of our will-substance into our conceptual capacity, is transformed into our faculty of forming geometrical concepts, and among them the concept of the parallelogram of movements.

Looked at in this way, the true relationship between the two parallelogram-theorems is seen to be the very opposite of the one held with conviction by scientific thinking up to now. Instead of the parallelogram of forces following from the parallelogram of movements, and the entire science of dynamics from that of kinematics, our very faculty of thinking in kinematic concepts is the evolutionary product of our previously acquired intuitive experience of the dynamic order of the world.

If this is the truth concerning the origin of our knowledge of force and its behaviour on the one hand, and our capacity to conceive mathematical concepts in a purely ideal way on the other, what is it then that causes man to dwell in such illusion as regards the relationship between the two? From our account it follows that no illusion of this kind could arise if we were able to remember throughout life our experiences in early childhood. Now we know from our considerations in Chapter VI that in former times man had such a memory. In those times, therefore, he was under no illusion as to the reality of force in the world. In the working of outer forces he saw a manifestation of spiritual beings, just as in himself he experienced force as a manifestation of his own spiritual being. We have seen also that this form of memory had to fade away to enable man to find himself as a self-conscious personality between birth and death. As such a personality, Galileo was able to think the parallelogram of forces, but he was unable to comprehend the origin of his faculty of mathematical thinking, or of his intuitive knowledge of the mathematical behaviour of nature in that realm of hers where she sets physical forces into action.

Deep below in Galileo's soul there lived, as it does in every human being, the intuitive knowledge, acquired in early childhood, that part of nature's order is recordable in the conceptual language of mathematics. In order that this intuition should rise sufficiently far into his conscious mind to guide him, as it did, in his observations, the veil of oblivion which otherwise separates our waking consciousness from the experiences of earliest childhood must have been momentarily lightened. Unaware of all this, Galileo was duly surprised when in the onlooker-part of his being the truth of his intuition was confirmed in a way accessible to it, namely through outer experiment. Yet with the veil immediately darkening again the onlooker soon became subject to the illusion that for his recognition of mathematics as a means of describing nature he was in need of nothing but what was accessible to him on the near side of the veil.

Thus it became man's fate in the first phase of science, which fills the period from Galileo and his contemporaries up to the present time, that the very faculty which man needed for creating this science prevented him from recognizing its true foundations. Restricted as he was to the building of a purely kinematic world-picture, he had to persuade himself that the order of interdependence of the two parallelogram-theorems was the opposite of the one which it really is.

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The result of the considerations of this chapter is of twofold significance for our further studies. On the one hand, we have seen that there is a way out of the impasse into which modern scientific theory has got itself as a result of the lack of a justifiable concept of force, and that this way is the one shown by Reid and travelled by Goethe. 'We must become as little children again, if we will be philosophers', is as true for science as it is for philosophy. On the other hand, our investigation of the event which led Galileo to the discovery that nature is recorded in the language of mathematics, has shown us that this discovery would not have been possible unless Galileo had in a sense become, albeit unconsciously, a little child again. Thus the event that gave science its first foundations is an occurrence in man himself of precisely the same character as the one which we have learnt to regard as necessary for building science's new foundations. The only difference is that we are trying to turn into a deliberate and consciously handled method something which once in the past happened *to* a man without his noticing it.

Need we wonder that we are challenged to do so in our day, when mankind is several centuries older than it was in the time of Galileo?

CHAPTER IX

Pro Levitate

(a) ALERTNESS *contra* INERTNESS

In the preceding chapter we gained a new insight into the relationship between mass and force. We have come to see that our concept of force is grounded on empirical observation in no less a degree than is usually assumed for our concept of number, or size, or position, provided we do not confine ourselves to non-stereoscopic, colourless vision for the forming of our scientific world-picture, but allow other senses to contribute to it. As to the concept mass, our discussion of the formula **F** = *ma* showed that force and mass, as they occur in it, are of identical nature, both having the quality of force. The factors F and *m* signify force in a different relationship to space (represented by the factor *a).* This latter fact now requires some further elucidation.

In a science based on the Goethean method of contemplating the world of the senses, concepts such as 'mass in rest' and 'mass in motion' lack any scientific meaning (though for another reason than in the theory of Relativity). For in a science of this kind the universe—in the sense propounded lately by Professor Whitehead and others—appears as one integrated whole, whose parts must never be considered as independent entities unrelated to the whole. Seen thus, there is no mass in the universe of which one could say with truth that it is ever in a state of rest. Nor is there any condition of movement which could be rightly characterized by the attributes 'uniform' and 'straight line' in the sense of Newton's first law. This does not mean that such conditions never occur in our field of observation. But as such they have significance only in relation to our immediate surroundings as a system of reference. Even within such limits these conditions are not of a kind that would allow us to consider them as the basis of a scientific world-picture. For as such they occur naturally only as ultimate, never as primeval conditions. All masses are originally in a state of curvilinear movement whose rates change continuously. To picture a mass as being in a state of rest, or of uniform motion in a straight line, as the result of no force acting on it, and to picture it undergoing a change in the rate and direction of its motion as the result of some outer force working on it, is a sheer abstraction. In so far as mass appears in our field of observation as being in relative rest or motion of the kind described, this is always the effect of some secondary dynamic cause.

If we wish to think *with* the course of the universe and not *against* it, we must not start our considerations with the state of (relative) rest or uniform motion in a straight line and derive our definition of force from the assumption that there is a primary 'force-free' state which is altered under the action of some force, but we must arrange our definitions in such a way that they end up with this state. Thus Newton's first law, for instance, would have to be restated somewhat as follows: *No physical body is ever in a state of rest or uniform motion in a straight line, unless its natural condition is interfered with by the particular action of some force.*

Seen dynamically, and from the aspect of the universe as an interrelated whole, all aggregations of mass are the manifestation of certain dynamic conditions within the universe, and what appears to us as a change of the state of motion of such a mass is nothing but a change in the dynamic relationship between this particular aggregation and the rest of the world. Let us now see what causes of such a change occur within the field of our observation.

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In modern textbooks the nature of the cause of physical movement is usually defined as follows: 'Any change in the state of movement of a portion of matter is the result of the action on it of another portion of matter.' This represents a truth if it is taken to describe a certain kind of causation. In the axiomatic form in which it is given it is a fallacy. The kind of causation it describes is, indeed, the only one which has been taken into consideration by the scientific mind of man. We are wont to call it 'mechanical' causation. Obviously, man's onlooker-consciousness is unable to conceive of any other kind of causation. For this consciousness is by its very nature confined to the contemplation of spatially apparent entities which for this reason can be considered only as existing spatially side by side. For the one-eyed, colour-blind spectator, therefore, any change in the state of movement of a spatially confined entity could be attributed only to the action of another such entity outside itself. Such a world-outlook was bound to be a mechanistic one.

We cannot rest content with this state of affairs if we are sincerely searching for an understanding of how *spirit* moves, forms, and transforms matter. We must learn to admit non-mechanical causes of physical effects, where such causes actually present themselves to our observation. In this respect our own body is again a particularly instructive object of study. For here mechanical and non-mechanical causation can be seen working side by side in closest conjunction. Let us therefore ask what happens when we move, say, one of our limbs or a part of it.

The movement of any part of our body is always effected in some way by the movement of the corresponding part of the skeleton. This in turn is set in motion by certain lengthenings and contractions of the appropriate part of the muscular system. Now the way in which the muscles cause the bones to move falls clearly under the category of mechanical causation. Certain portions of matter are caused to move by the movement of adjacent portions of matter. The picture changes when we look for the cause to which the muscles owe their movements. For the motion of the muscles is not the effect of any cause external to them, but is effected by the purely spiritual energy of our volition working directly into the physical substance of the muscles. What scientific measuring instruments have been able to register in the form of physical, chemical, electrical, etc., changes of the muscular substance is itself an effect of this interaction.

To mark the fact that this type of causation is clearly distinguished from the type called mechanical, it will be well to give it a name of its own. If we look for a suitable term, the word 'magical' suggests itself. The fact that this word has gathered all sorts of doubtful associations must not hinder us from adopting it into the terminology of a science which aspires to understand the working of the supersensible in the world of the senses. The falling into disrepute of this word is characteristic of the onlooker-age. The way in which we suggest it should be used is in accord with its true and original meaning, the syllable 'mag' signifying power or might (Sanskrit *maha,* Greek *megas,* Latin *magnus,* English *might, much,* also *master).* Henceforth we shall distinguish between 'mechanical' and 'magical' causation, the latter being a characteristic of the majority of happenings in the human, animal and plant organisms.[1]

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Our next step in building up a truly dynamic picture of matter must be to try to obtain a direct experience of the condition of matter when it is under the sway of magical causation.

Let us first remember what is the outstanding attribute with which matter responds to mechanical causation. This is known to be *inertia*. By this term we designate the tendency of physical matter to resist any outwardly impressed change of its existing state of movement. This property is closely linked up with another one, *weight*. The coincidence of the two has of late become a puzzle to science, and it was Albert Einstein who tried to solve it by establishing his General Theory of Relativity. The need to seek such solutions falls away in a science which extends scientific understanding to conditions of matter in which weight and inertia are no longer dominant characteristics. What becomes of inertia when matter is subject to magical causation can be brought to our immediate experience in the following way. (The reader, even if he is already familiar with this experiment, is again asked to carry it out for himself.)

Take a position close to a smooth wall, so that one arm and hand, which are left hanging down alongside the body, are pressed over their entire length between body and wall. Try now to move the arm upward, pressing it against the wall as if you wanted to shift the latter. Apply all possible effort to this attempt, and maintain the effort for about one minute. Then step away quickly from the wall by more than the length of the arm, while keeping the arm hanging down by the side of the body in a state of complete relaxation. Provided all conditions are properly fulfilled, the arm will be found rising *by itself* in accordance with the aim of the earlier effort, until it reaches the horizontal. If the arm is then lowered again and left to itself, it will at once rise again, though not quite so high as before. This can be repeated several times until the last vestige of the automatic movement has faded away.

Having thus ascertained by direct experience that there is a state of

[1] In this sense Ruskin's description of the working of the spirit in the plant as one that 'catches from chaos water, etc., etc., and fastens them into a given form' points to magical action.

matter in which inertia is, to say the least, greatly diminished, we find ourselves in need of giving this state (which is present throughout nature wherever material changes are brought into existence magically) a name of its own, as we did with the two types of causation. A word suggests itself which, apart from expressing adequately the peculiar self-mobility which we have just brought to our experience, goes well alongside the word 'inert' by forming a kind of rhyme with it. This is the term *'alert'*. With its help we shall henceforth distinguish between matter in the inert and alert conditions. We shall call the latter state 'alertness', and in order to have on the other side a word as similar as possible in outer form to alertness, we suggest replacing the usual term inertia by 'inertness'. Thus we shall speak of matter as showing the attribute of 'inertness', when it is subject to mechanical causation, of 'alertness', when it is subject to magical causation.

Anyone who watches attentively the sensation produced by the rising arm in the above experiment will be duly impressed by the experience of the alertness prevailing in the arm as a result of the will's magical intervention.

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In our endeavour to find a modern way of overcoming the conception of matter developed and held by science in the age of the onlooker-consciousness, we shall be helped by noticing how this conception first arose historically. Of momentous significance in this respect is the discovery of the gaseous state of matter by the Flemish physician and experimenter, Joh. Baptist van Helmont (1577-1644). The fact that the existence of this state of ponderable matter was quite unknown up to such a relatively recent date has been completely forgotten to-day. Moreover, it is so remote from current notions that anyone who now calls attention to van Helmont's discovery is quite likely to be met with incredulity. As a result, there is no account of the event that puts it in its true setting. In what follows pains are taken to present the facts in the form in which one comes to know them through van Helmont's own account, given in his *Ortus Medicinae.*

For reasons which need not be described here, van Helmont studied with particular interest the various modifications in which carbon is capable of occurring in nature—-among them carbon's combustion product, carbon dioxide. It was his observations of carbon dioxide which made him aware of a condition of matter whose properties caused him the greatest surprise. For he found it to be, at the same time, 'much finer than vapour and much denser than air'. It appeared to him as a complete 'paradox', because it seemed to unite in itself two contradictory qualities, one appertaining to the realm of 'uncreated things', the other to the realm of 'created things'. Unable to rank it with either 'vapour' or 'air' (we shall see presently what these terms meant in van Helmont's terminology), he found himself in need of a special word to distinguish this new state from the other known states, both below and above it. Since he could not expect any existing language to possess a suitable word, he felt he must create one. He therefore took, and changed slightly, a word signifying a particular cosmic condition which seemed to be imaged in the new condition he had just discovered. The word was CHAOS. By shortening it a little, he derived from it the new word GAS. His own words explaining his choice are: 'Halitum ilium GAS vocavi non longe a Chaos veterum secretum.' ('I have called this mist Gas, owing to its resemblance to the Chaos of the ancients.')[1]

Van Helmont's account brings us face to face with a number of riddles. Certainly, there is nothing strange to us in his describing carbon dioxide gas as being 'finer than vapour and denser than air'; but why did he call this a 'paradox'? What prevented him from ranking it side by side with air? As to air itself, why should he describe it as belonging to the realm of the 'uncreated things'? What reason was there for giving 'vapour' the rank of a particular condition of matter? And last but not least, what was the ancient conception of Chaos which led van Helmont to choose this name as an archetype for the new word he needed?

To appreciate van Helmont's astonishment and his further procedure, we must first call to mind the meaning which, in accordance with the prevailing tradition, he attached to the term Air. For van Helmont, Air was one of the four 'Elements', EARTH, WATER, AIR, and FIRE. Of these, the first two were held to constitute the realm of the 'created things', the other two that of the 'uncreated things'. A brief study of the old doctrine of the Four Elements is necessary at this point in order to understand the meaning of these concepts.

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[1] For Van Helmont, owing to the Flemish pronunciation of the letter G, the two words sounded more alike than their spelling suggests.

The first systematic teaching about the four elementary constituents of nature, as they were experienced by man of old, was given by Empedocles in the fifth century B.C. It was elaborated by Aristotle. In this form it was handed down and served to guide natural observation through more than a thousand years up to the time of van Helmont. From our earlier descriptions of the changes in man's consciousness it is clear that the four terms, 'earth', 'water', 'air', 'fire', must have meant something different in former times. So 'water' did not signify merely the physical substance which modern chemistry defines by the formula H_2O; nor was 'air' the mixture of gases characteristic of the earth's atmosphere. Man in those days, on account of his particular relationship with nature, was impressed in the first place by the various dynamic conditions, four in number, which he found prevailing both in his natural surroundings and in his own organism. With his elementary concepts he tried to express, therefore, the four basic conditions which he thus experienced. He saw physical substances as being carried up and down between these conditions.

At first sight some relationship seems to exist between the concept 'element' in this older sense and the modern view of the different states of material aggregation, solid, liquid, aeriform. There is, however, nothing in this modern view that would correspond to the element Fire. For heat in the sense of physical science is an immaterial energy which creates certain conditions in the three material states, but from these three to heat there is no transition corresponding to the transitions between themselves. Heat, therefore, does not rank as a fourth condition by the side of the solid, liquid and aeriform states, in the way that Fire ranks in the older conception by the side of Earth, Water and Air.

If we were to use the old terms for designating the three states of aggregation plus heat, as we know them to-day, we should say that there is a border-line dividing Fire from the three lower elements. Such a border-line existed in the older conception of the elements as well. Only its position was seen to be elsewhere—between Earth and Water on the one hand, Air and Fire on the other. This was expressed by saying that the elements below this line constituted the realm of the 'created things', those above it that of the 'uncreated things'. Another way of expressing this was by characterizing Earth and Water with the quality Cold; Air and Fire with the quality Warm. The two pairs of elements were thus seen as polar opposites of one another.

The terms 'cold' and 'warm' must also be understood to have expressed certain qualitative experiences in which there was no distinction as yet between what is purely physical and what is purely spiritual. Expressions such as 'a cold heart', 'a warm heart', to 'show someone the cold shoulder', etc., still witness to this way of experiencing the two polar qualities, cold and warm. Quite generally we can say that, wherever man experienced some process of contraction, whether physical or non-physical, he designated it by the term 'cold', and where he experienced expansion, he called it 'warm'. In this sense he felt contractedness to be the predominant characteristic of Earth and Water, expansiveness that of Air and Fire.

With the help of these qualitative concepts we are now in a position to determine more clearly still the difference between the older and the modern conceptions: in particular the difference between the aeriform condition of matter, as we conceive of it to-day, and the element Air. Contractedness manifests as material density, or the specific weight of a particular substance. We know that this characteristic of matter diminishes gradually with its transition from the solid to the liquid and aeriform states. We know also that this last state is characterized by a high degree of expansiveness, which is also the outstanding property of heat. Thus there is reason to describe also from the modern point of view the solid and liquid states as essentially 'cold', and the aeriform state as 'warm'. But aeriform matter still has density and weight, and this means that matter in this state combines the two opposing qualities. Contrary to this, Air, as the second highest element in the old sense, is characterized by the pure quality, warm. Thus, when man of old spoke of 'air', he had in mind something entirely free from material density and weight.[1]

By comparing in this way the older and newer conceptions of 'air', we come to realize that ancient man must have had a conception of gravity essentially different from ours. If we take gravity in the modern scientist's sense, as a 'descriptive law of behaviour', then this behaviour is designated in the older doctrine by the quality 'cold'. If, however, we look within the system of modern science for a law of behaviour that would correspond to the quality 'warm', we do so in vain. Polarity concepts are certainly not foreign to the scientific mind, as the physics of electricity and magnetism show. Yet there is

[1] In a later chapter we shall have opportunity to determine what distinguishes Air from Fire, on the one hand, and Water from Earth on the other.

no opposite pole to gravity, as there is negative opposite to positive electricity, etc.[1]

In the older conception, however, the gravitational behaviour 'cold' was seen to be counteracted by an autonomous anti-gravitational behaviour 'warm'. Experience still supported the conviction that as a polar opposite to the world subject to gravity, there was another world subject to levity.

We refrain at this point from discussing how far a science which aspires to a spiritual understanding of nature, including material processes, needs a revival—in modern form—of the old conception of levity. In our present context it suffices to realize that we understand man's earlier view of nature, and with it the one still held by van Helmont, only by admitting levity equally with gravity into his world-picture. For the four elements, in particular, this meant that the two upper ones were regarded as representing Levity, the two lower ones Gravity.

In close connexion with this polar conception of the two pairs of elements, there stands their differentiation into one realm of created, another of uncreated, things. To understand what these terms imply, we must turn to the ancient concept, Chaos, borrowed by van Helmont.

To-day we take the word Chaos to mean a condition of mere absence of order, mostly resulting from a destruction of existing forms, whether by nature or by the action of man. In its original sense the word meant the exact opposite. When in ancient times people spoke of Chaos, they meant the womb of all being, the exalted realm of uncreated things, where indeed forms such as are evident to the eye in the created world are not to be found, but in place of them are the archetypes of all visible forms, as though nurtured in a spiritual seed-condition. It is the state which in the biblical narration of the creation of the world is described as 'without form and void'.

From this Chaos all the four elements are born, one by one, with the two upper ones retaining Chaos's essential characteristic in that they are 'without form' and tend to be omnipresent, whilst the two lower ones constitute a realm in which things appear in more or less clearly outlined space-bound forms. This is what the terms 'uncreated' and 'created' imply.

[1] It is this apparent uni-polarity of gravity which has given Professor Einstein so much trouble in his endeavour to create a purely gravitational world-picture with bipolar electricity and magnetism fitting into it mathematically.

How strictly these two realms were distinguished can be seen by the occurrence of the concept 'vapour'. When with the increasing interest in the realm of created things—characteristic of the spectator-consciousness which, in view of our earlier description of it, we recognize as being itself a 'created thing'—the need arose for progressive differentiation within this realm, the simple division of it into 'earth' and 'water' was no longer felt to be satisfactory. After all, above the liquid state of matter there was another state, less dense than water and yet presenting itself through more or less clearly distinguishable space-bound objects, such as the mists arising from and spreading over ponds and meadows, and the clouds hovering in the sky. For this state of matter the term 'vapour' had become customary, and it was used by van Helmont in this sense. By its very properties, Vapour belonged to the realm of the created things, whereas Air did not. It was the intermediary position of the newly discovered state of matter between Vapour and Air, that is, between the created and the uncreated world, which caused van Helmont to call it a paradox; and it was its strange resemblance, despite its ponderable nature, to Chaos, which prompted him to name it—Gas.

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Since it could not have been the gaseous state of matter in the form discovered by van Helmont, what particular condition of nature was it to which the ancients pointed when using the term Air? Let us see how the scriptures of past human cultures speak of air.

In all older languages, the words used to designate the element bound up with breathing, or the act of breathing, served at the same time to express the relationship of man to the Divine, or even the Divine itself. One need think only of the words *Brahma* and *Atma* of the ancient Indians, the *Pneuma* of the Greeks, the *Spiritus* of the Romans. The Hebrews expressed the same idea when they said that Jehovah had breathed the breath of life into man and that man in this way became a living soul.

What lies behind all these words is the feeling familiar to man in those times, that breathing was not only a means of keeping the body alive, but that a spiritual essence streamed in with the breath. So long as this condition prevailed, people could expect that by changing their manner of breathing they had a means of bringing the soul into stronger relationship with spiritual Powers, as is attempted in Eastern Yoga.

Remembering the picture of man's spiritual-physical evolution which we have gained from earlier chapters, we are not astonished to find how different this early experience of the breathing process was from our own. Yet, together with the recognition of this difference there arises another question. Even if we admit that man of old was so organized that the experience of his own breathing process was an overwhelmingly spiritual one, it was, after all, the gaseous substance of the earth's atmosphere which he inhaled, and exhaled again in a transformed condition. What then was it that prevented men—apparently right up to the time of van Helmont—from gaining the slightest inkling of the materiality of this substance? To find an answer to this question, let us resort once more to our method of observing things genetically, combined with the principle of not considering parts without considering the whole to which they organically belong.

In modern science the earth is regarded as a mineral body whereon the manifold forms of nature appear as mere additions, arising more or less by chance; one can very well imagine them absent without this having any essential influence on the earth's status in the universe. The truth is quite different. For the earth, with everything that exists on it, forms a single whole, just as each separate organism is in its own way a whole.

This shows that we have no right to imagine the earth without men, and to suppose that its cosmic conditions of being would then remain unaltered—any more than we can imagine a human being deprived of some essential-organ and remaining human. Mankind, and all the other kingdoms of nature, are bound up organically with the earth from the start of its existence. Moreover, just as the highest plants, seen with Goethe's eyes, are the spiritual originators of the whole realm of plants—the creative Idea determining their evolution—so we see man, the highest product of earth evolution, standing behind this evolution as its Idea from the first, and determining its course. The evolutionary changes which we observe in the earth and in man are in fact a *single* process, working through a variety of manifested forms.

From this conception of the parallel evolution of earth and man light falls also on the historic event represented by van Helmont's discovery. Besides being a symptom of a revolution in man's way of *experiencing* the atmosphere, it speaks to us of some corresponding change in the spiritual-physical condition of the atmosphere itself. It was then that men not only came to think differently about air, but inhaled and exhaled an air that actually was different. To find out what kind of change this was, let us turn once more to man's own organism and see what it has to say concerning the condition under which matter is capable of being influenced by mechanical and magical causation respectively, in the sense already described.

What is it in the nature of the bones that makes them accessible to mechanical causation only, and what is it in the muscles that allows our will to rouse them magically? Bones and muscles stand in a definite genetic relationship to each other, the bones being, in relation to the muscles, a late product of organic development. This holds good equally for everything which in the body of living nature takes the form of mineralized deposits or coverings. Every kind of organism consists in its early stages entirely of living substance; in the course of time a part of the organism separates off" and passes over into a more or less mineralized condition. Seen in this light, the distinction between bones and muscles is that the bones have evolved out of a condition in which the muscles persist, though to a gradually waning degree, throughout the life-time of the body. The substance of the muscles, remaining more or less 'young', stands at the opposite pole from the 'aged' substance of the bones. Hence it depends on the 'age' of a piece of matter whether it responds to magical or mechanical causation.

Let us state here at once, that this temporal distinction has an essential bearing on our understanding of evolutionary processes in general. For if mineral matter is a late product of evolution—and nothing in nature indicates the contrary—then to explain the origins of the world (as scientific theories have always done) with the aid of events similar in character to those which now occur in the mineral realm, means explaining them against nature's own evidence. To find pictures of past conditions of the earth in present-day nature, we must look in the regions where matter, because it is still 'youthful', is played through by the magical working of purposefully active spiritual forces. Thus, instead of seeing in them the chance results of blind volcanic and similar forces, we must recognize in the formation and layout of land and sea an outcome of events more closely resembling those which occur during the embryonic development of a living organism.

What, then, does van Helmont's discovery of the gaseous state of matter tell us, if we regard it in the light of our newly acquired insight into the trend of evolution both within and without man? When, in the course of its growing older, mankind had reached the stage which is expressed by the emergence of the spectator-consciousness—consciousness, that is, based on a nervous system which has grown more or less independent of the life forces of the organism—the outer elements had, in their way, arrived at such a state that man began to inhale an air whose spiritual-physical constitution corresponded exactly to that of his nervous system: on either side, Spirit and Matter, in accordance with the necessities of cosmic evolution had lost their primeval union.

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Our extension of the concept of evolution to the very elements of nature, whether these are of material or non-material kind, and our recognition of this evolution as leading in general from a more alert to a more inert condition, at once open the possibility of including in our scientific world-picture certain facts which have hitherto resisted any inclusion. We mean those manifold events of 'miraculous' nature, of which the scriptures and the oral traditions of old are full. What is modern man to make of them?

The doubts which have arisen concerning events of this kind have their roots on the one hand in the apparent absence of such occurrences in our day, on the other in the fact that the laws of nature derived by science from the present condition of the world seem to rule them out.[1] In the light of the concept of the world's 'ageing' which we have tried to develop here, not only do the relevant reports become plausible, but it also becomes understandable why, if such events have taken place in the past, they fail to do so in our own time.

To illustrate this, let us take a few instances which are symptomatic of the higher degree of youthfulness which was characteristic in former times in particular of the element of Fire.

The role which Fire was capable of playing in man's life at a time when even this element, in itself the most youthful of all, was more susceptible to magic interference than of late, is shown by the manifold fire-rites of old. In those days, when no easy means of fire-lighting were available, it was usual for the needs of daily life to keen a fire burning all the time and to kindle other fires from it. Only in cases of necessity was a new fire lit, and then the only way was by the tedious rubbing together of two pieces of dry wood.

[1] See the 'Bishop Barnes' controversy of recent date.

Then both the maintenance of fires, and the deliberate kindling of a new fire, played quite a special role in the ceremonial ordering of human society. Historically, much the best known is the Roman usage in the Temple of Vesta. On the one hand, the unintentional extinction of the fire was regarded as a national calamity and as the gravest possible transgression on the part of the consecrated priestess charged with maintaining the fire. On the other hand, it was thought essential for this 'everlasting' fire to be newly kindled once a year. This took place with a special ritual at the beginning of the Roman year (1st March).

The conception behind such a ritual of fire-kindling will become clear if we compare with it certain other fire-rites which were practised in the northern parts of Europe, especially in the British Isles, until far on in the Christian era. For example, if sickness broke out among the cattle, a widespread practice was to extinguish all the hearth-fires in the district and then to kindle with certain rites a new fire, from which all the local people lit their own fires once more. Heavy penalties were prescribed for anyone who failed to extinguish his own fire—a failure usually indicated by the non-manifestation of the expected healing influence. In Anglo-Saxon speaking countries, fires of this kind were known as 'needfires'.

The spiritual significance of these fires cannot be expressed better than by the meaning of the very term 'needfire'. This word does not derive, as was formerly believed, from the word 'need', meaning a 'fire kindled in a state of need', but, as recent etymological research has shown, from a root which appears in the German word *nieten*—to clinch or rivet. 'Needfire' therefore means nothing less than a fire which was kindled for 'clinching' anew the bond between earthly life and the primal spiritual order at times when for one reason or another there was a call for this.

This explanation of the 'needfire' throws light also on the Roman custom of re-kindling annually the sacred fire in the Temple of Vesta. For the Romans this was a means of reaffirming year by year the connexion of the nation with its spiritual leadership; accordingly, they chose the time when the sun in its yearly course restores—'re-clinches'—the union of the world-spirit with earthly nature, for the rebirth of the fire which throughout the rest of the year was carefully guarded against extinction.

Just as men saw in this fire-kindling a way of bringing humanity into active relation with spiritual powers, so on the other hand were these powers held to use the fire element in outer nature for the purpose of making themselves actively known to mankind. Hence we find in the records of all ancient peoples a unanimous recognition of lightning and thunder on the one hand, and volcanic phenomena on the other, as means to which the Deity resorts for intervening in human destiny. A well-known example is the account in the Bible of the meeting of Moses with God on Mount Sinai. As occurrence in the early history of the Hebrews it gives evidence that even in historical times the fire element of the earth was sufficiently 'young' to serve the higher spiritual powers as an instrument for the direct expression of their will.

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(b) LEVITY *contra* GRAVITY

We said earlier in this chapter that a science which aspires to a spiritual understanding of the physical happenings in nature must give up the idea that inertness and weight are absolute properties of matter. We were able at once to tackle the question of inertness by bringing to our immediate observation matter in the state of diminished inertness, or, as we proposed to say, of alertness. We are now in a position to go into the other question, that of weight or gravity. Just as we found inertness to have its counterpart in alertness, both being existing conditions of matter, so we shall now find in addition to the force of gravity another force which is the exact opposite of it, and to which therefore we can give no better name than 'levity'.

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Already, indeed, the picture of nature which we gained from following Goethe's studies both of the plant and of meteorological happenings has brought us face to face with certain aspects of levity. For when Goethe speaks of systole and diastole, as the plant first taught him to see them and as later he found them forming the basic factors of weather-formation, he is really speaking of the ancient concepts, 'cold' and 'warm'. Goethe's way of observing nature is, in fact, a first step beyond the limits of a science which kept itself ignorant of levity as a cosmic counterpart to terrestrial gravity. To recognize the historical significance of this step, let us turn our glance to the moment when the human mind became aware that to lay a proper foundation for the science it was about to build, it had to exclude any idea of levity as something with a real existence.

Many a conception which is taken for granted by modern man, and is therefore assumed to have been always obvious, was in fact established quite deliberately at a definite historical moment. We have seen how this applies to our knowledge of the gaseous state of matter; it applies also to the idea of the uniqueness of gravity. About half a century after van Helmont's discovery a treatise called *Contra Levitatem* was published in Florence by the *Accademia del Cimento.* It declares that a science firmly based on observation has no right to speak of Levity as something claiming equal rank with, and opposite to, Gravity.

This attitude was in accord with the state into which human consciousness had entered at that time. For a consciousness which is itself of the quality 'cold', because it is based on the contracting forces of the body, is naturally not in a position to take into consideration its very opposite. Therefore, to speak of a force of levity as one felt able to speak of gravity was indeed without meaning.

Just as there was historical necessity in this banishing of levity from science at the beginning of the age of the spectator-consciousness, so was there historical necessity in a renewed awareness of it arising when the time came for man to overcome the limitations of his spectator-relationship to the world. We find this in Goethe's impulse to search for the action of polarities in nature. As we shall see later, it comes to its clearest expression in Goethe's optical conceptions.

Another witness to this fact is Ruskin, through a remark which bears in more than one sense on our present subject. It occurs in his essay, *The Storm-Cloud of the Ninteenth Century.* In its context it is meant to warn the reader against treating science, which Ruskin praises as a fact-finding instrument, as an interpreter of natural facts. Ruskin takes Newton's conception of gravity as the all-moving cause of the universe, and turns against it in the following words:

'Take the very top and centre of scientific interpretation by the greatest of its masters: Newton explained to you—or at least was once supposed to explain, why an apple fell; but he never thought of explaining the exact correlative but infinitely more difficult question, how the apple got up there.'

This remark shows Ruskin once again as a true reader in nature's book. Looking with childlike openness and intensity of participation into the world of the senses, he allows nature's phenomena to impress themselves upon his mind without giving any preconceived preference to one kind or another. This enables him not to be led by the phenomenon of falling bodies to overlook the polarically opposite phenomenon of the upward movement of physical matter in the living plant. Ruskin's remark points directly to the new world-conception which must be striven for to-day—the conception in which death is recognized as a secondary form of existence preceded by life; in which levity is given its rightful place as a force polar to gravity; and in which, because life is bound up with levity as death is with gravity, levity is recognized as being of more ancient rank than gravity.

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In proceeding now to a study of levity we shall not start, as might be expected, with plants or other living forms. We are not yet equipped to understand the part played by levity in bringing about the processes of life; we shall come to this later. For our present purpose we shall look at certain macrotelluric events—events in which large areas of the earth are engaged—taking our examples from meteorology on the one hand and from seismic (volcanic) processes on the other.

In pursuing this course we follow a method which belongs to the fundamentals of a Goetheanistic science. A few words about this method may not be out of place.

When we strive to read the book of nature as a script of the spirit we find ourselves drawn repeatedly towards two realms of natural phenomena. They are widely different in character, but studied together they render legible much that refuses to be deciphered in either realm alone. These realms are, on the one hand, the inner being of man, and, on the other, the phenomena of macrotelluric and cosmic character. The fruitfulness of linking together these two will become clear if we reflect on the following.

The field of the inner life of man allows us, as nothing else does, to penetrate it with our own intuitive experience. For we ourselves are always in some sense the cause of the events that take place there. In order to make observations in this region, however, we need to bring about a certain awakening in a part of our being which—so long as we rely on the purely natural forces of our body—remains sunk in more or less profound unconsciousness.

If this realm of events is more intimately related than any other to our intuitive experience, it has also the characteristic of remaining closed to any research by external means. Much of what lies beyond the scope of external observation, however, reveals itself all the more clearly in the realms where nature is active on the widest scale. Certainly, we must school ourselves to read aright the phenomena which come to light in those realms. And once more we must look to the way of introspection, previously mentioned, for aid in investing our gaze with the necessary intuitive force. If we succeed in this, then the heavens will become for us a text wherein secrets of human nature, hidden from mere introspection, can be read; while at the same time the introspective way enables us to experience things which we cannot uncover simply by observing the outer universe.

Apart from these methodological considerations, there is a further reason for our choice. Among the instances mentioned earlier in this chapter as symptoms of a greater 'youthfulness' prevailing in nature, and particularly in the element Fire, at a comparatively recent date, were the manifestations of the Divine-Spiritual World to man reported in the Bible as the event on Mount Sinai. There, thunder and lightning from above and volcanic action from below form the setting for the intercourse of Jehovah with Moses. To-day the function of these types of phenomena, though metamorphosed by the altered conditions of the earth, is not essentially different. Here, more than in any other sphere of her activities, nature manifests that side of her which we are seeking to penetrate with understanding.

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Let us start with an observation known to the present writer from a visit to the *Solfatara,* a volcanic region near Naples.

The *Solfatara* itself is a trough surrounded by hilly mounds; its smooth, saucepan-like bottom, covered with whitish pumice-sand, is pitted with craters containing violently boiling and fuming mud—the so-called *fango,* famous for its healing properties. All around sulphurous fumes issue from crevices in the rocks, and in one special place the *Solfatara* reveals its subterranean activity by the emergence of fine, many-coloured sand, which oozes up like boiling liquid from the depths below. The whole region gives the impression of being in a state of labile balance. How true this is becomes apparent if one drops pieces of burning paper here and there on the ground: immediately a cloud of smoke and steam rises. The effect is even more intense if a burning torch is moved about over one of the boiling *fango* holes. Then the deep answers instantly with an extraordinary intensification of the boiling process. The hot mud seems to be thrown into violent turmoil, emitting thick clouds of steam, which soon entirely envelop the spectator near the edge.

The scientific mind is at first inclined to see in this phenomenon the mechanical effect of reduced air-pressure, due to the higher temperatures above the surface of the boiling mud, though doubts are raised by the unusual intensity of the reaction. The feeling that the physical explanation is inadequate is strengthened when the vapours have thinned out and one is surprised to see that every crack and cranny in the *Solfatara,* right up to the top of the trough, shows signs of increased activity. Certainly, this cannot be accounted for by a cause-and-effect nexus of the kind found in the realm of mechanical causation, where an effect is propagated from point to point and the total effect is the sum of a number of partial effects. It looks rather as if the impulse applied in one spot had called for a major impulse which was now acting on the *Solfatara* as a whole.

As observers who are trying to understand natural phenomena by recognizing their significance as letters in nature's script, we must look now for other phenomena which can be joined with this one to form the relevant 'word' we have set out to decipher.

All scientific theories concerning the causes of seismic occurrences, both volcanic and tectonic, have been conceived as if the spatial motion of mineral matter were the only happening that had to be accounted for. No wonder that none of these theories has proved really satisfactory even to mechanistically orientated thinking. Actually there are phenomena of a quite different kind connected with the earth's seismic activities, and these need to be taken into equal account.

There is, for instance, the fact that animals often show a premonition of volcanic or tectonic disturbances. They become restive and hide, or, if domestic, seek the protection of man. Apparently, they react in this way to changes in nature which precede the mechanical events by which man registers the seismic occurrence.

Another such phenomenon is the so-called earthquake-sky, which the present writer has had several occasions to witness. It consists of a peculiar, almost terrifying, intense discoloration of the sky, and, to those acquainted with it, is a sure sign of an imminent or actual earthquake somewhere in the corresponding region of the earth. This phenomenon teaches us that the change in the earth's condition which results in a violent movement of her crust, involves a region of her organism far greater than the subterranean layers where the cause of the purely mechanical events is usually believed to reside.[1]

That man himself is not excluded from experiencing directly the super-spatial nature of seismic disturbances is shown by an event in Goethe's life, reported by his secretary Eckermann, who himself learnt the story from an old man who had been Goethe's valet at the time.[2]

This is what the old man, whom Eckermann met by accident one day near Weimar, told him: 'Once Goethe rang in the middle of the night and when I entered his room I found he had rolled his iron bed to the window and was lying there, gazing at the heavens. "Have you seen nothing in the sky?" asked he, and when I answered "No", he begged me to run across to the sentry and inquire of the man on duty if he had seen nothing. He had not noticed anything and when I returned I found the master still in the same position, gazing at the sky. "Listen," he said, "this is an important moment; there is now an earthquake or one is just going to take place." Then he made me sit down on the bed and showed me by what signs he knew this.' When asked about the weather conditions, the old man said: 'It was very cloudy, very still and sultry.' To believe implicitly in Goethe was for him a matter of course, 'for things always happened as he said they would'. When next day Goethe related his observations at Court, the women tittered: 'Goethe dreams' ('*Goethe schwärmt*'), but the Duke and the other men present believed him. A few weeks later the news reached Weimar that on that night (5th April, 1783) part of Messina had been destroyed by an earthquake.

There is no record by Goethe himself of the nature of the phenomenon perceived by him during that night, except for a brief remark in a letter to Mme de Stein, written the following day, in which he claims to have seen a 'northern light in the south-east' the extraordinary character of which made him fear that an earthquake had taken place somewhere. The valet's report makes us inclined to think

[1] To the same category belong the mighty thunderstorms which in some parts of the world are known to occur in conjunction with earthquakes.

[2] See *Goethe's Conversations with Eckermann* (translated by J. Oxenford), 13th November, 1823.

that there had been no outwardly perceptible phenomenon at all, but that what Goethe believed he was seeing with his bodily eyes was the projection of a purely supersensible, but not for that reason any less objective, experience.

In a picture of the seismic activities of the earth which is to comprise phenomena of this kind, the volcanic or tectonic effects cannot be attributed to purely local causes. For why, then, should the whole meteorological sphere be involved, and why should living beings react in the way described? Clearly, we must look for the origin of the total disturbance not in the interior of the earth but in the expanse of surrounding space. Indeed, the very phenomenon of the *Solfatara,* if seen in this light, can reveal to us that at least the volcanic movements of the earth's crust are not caused by pressure from within, but by suction from without—that is, by an exceptional action of levity.

We recall the fact that the whole *Solfatara* phenomenon had its origin in a flame being swayed over one of *the fango* holes. Although it remains true that the suction arising from the diminished air pressure over the hole cannot account for the intense increase of ebullition in the hole itself, not to speak of the participation of the entire region in this increase, there is the fact that the whole event starts with a suctional effect. As we shall see in the next chapter, any local production of heat interferes with the gravity conditions at that spot by shifting the balance to the side of levity. That the response in a place like the *Solfatara* is what we have seen it to be, is the result of an extraordinary lability of the equilibrium between gravity and levity, a characteristic appertaining to the earth's volcanism in general.

For the people living near the *Solfatara* it is indeed common knowledge that there are times when this lability is so great that the slightest local disturbance of the kind we have described can provoke destructive eruptions of great masses of subterranean mud. (At such times access to the *Solfatara* is prohibited.) We shall understand such an eruption rightly if we picture it as the counter-pole of an avalanche. The latter may be brought about by a fragment of matter on a snow-covered mountain, perhaps a little stone, breaking loose and in its descent bringing ever-accumulating masses of snow down with it. The levity-process polar to this demonstration of gravity is the production of a mightily growing 'negative avalanche' by comparatively weak local suction, caused by a small flame.

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Earlier in this chapter (page 150) we said that if we want to understand how spirit moves, forms and transforms matter, we must recognize the existence of non-mechanical (magical) causes of physical effects. We have now found that the appearance of such effects in nature is due to the operations of a particular force, levity, polar to gravity. Observation of a number of natural happenings has helped us to become familiar in a preliminary way with the character of this force. Although these happenings were all physical in appearance, they showed certain definitely non-physical features, particularly through their peculiar relationship to three-dimensional space. More characteristics of this kind will appear in the following pages.

In this way it will become increasingly clear that in levity we have to do with something which, despite its manifesting characteristics of a 'force' not unlike gravity and thereby resembling the latter, differs essentially from anything purely physical. It is only by its interactions with gravity that levity brings about events in the physical world—events, however, which are themselves partly of a physical, partly of a superphysical kind. Seeing things in this aspect, we are naturally prompted to ask what causes there are in the world which make gravity and levity interact at all. This question will find its answer in due course. First, we must make ourselves more fully acquainted with the various appearances of the gravity-levity interplay in nature.

CHAPTER X

The Fourth State of Matter

When William Crookes chose as one of the titles of his paper on the newly discovered properties of electricity, 'The Fourth State of Matter', it was to express his belief that he had found a state of matter, additional to the three known ones, which represented 'the borderland where matter and force seem to merge into one another, the shadowy realm between known and unknown' for which his soul had been longing ever since the death of his beloved brother.[1] All that has followed from his discovery, down to the transformation of matter itself into freely working energy, shows that he was right in thinking he had reached some borderland of nature. But the character of the forces which are thus liberated makes it equally clear that this is not the borderland he was looking for. Nature—by which we mean *physical* nature—has in fact two borders, one touching the realm of the intramaterial energies which are liberated by disrupting the structure of atomic nuclei, the other leading over into creative Chaos, the fountain-head of all that appears in nature as intelligent design.

It was Crookes's fate to open the road which has brought man to nature's lower border and even across it, although he himself was in search of her upper border. What he was denied, we are in a position to achieve to-day, provided we do not expect to succeed by methods similar to those of atomic physics, and do not look for similar results.

To show that there is a fourth state of matter, rightly so called, which represents in actual fact the upper border of nature, and to point the way that leads to it and across it, is the purpose of this chapter.

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[1] See Chapter IV. The other title of the paper, 'Radiant Matter', will gain significance for us in a later context.

From our previous comparison of the older conception of the four elementary conditions of nature with that now held of the three states of ponderable matter, we may expect that the fourth state will have something in common with heat. Heat is indeed the energy which transforms matter by carrying it from the solid to the liquid and gaseous states. Not so obvious is the fact that heat, apart from being an agent working *at* matter in this way, is the very essence underlying all material existence, out of which matter in its three ponderable states comes into being and into which it is capable of returning again. Such a conception of matter was naturally absent from the age of the Contra-Levitatem orientation of the human mind. To create this conception, a new Pro-Levitate orientation is required.

Apart from producing liquefaction and vaporization, heat has also the property of acting on physical matter so that its volume increases. Both facts are linked together by science through the thermodynamic conception of heat. As this conception firmly blocks the road to the recognition of the role of heat as the fourth state of matter, our first task will be to determine our own standpoint with regard to it. Further obstacles on our way are the so-called Laws of Conservation, which state that no matter and no energy—which for present-day science have become one and the same thing—can ever disappear into 'nothing' or come into being out of 'nothing'. This idea, also, will therefore require our early attention.[1]

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In the light of our previous studies we shall not find it difficult to test the reality-value of the thermodynamic conception of heat.

As we know of mass through a definite sense-perception, so we know of heat. In the latter case we rely on the sense of warmth. In Chapter VIII we took the opportunity to test the objectivity of the information received through this sense. Still, one-eyed, colour-blind observation is naturally unable to take account of these sense-messages. To this kind of observation nothing is accessible, we know, except spatial displacements of single point-like entities. Hence we find Bacon and Hooke already attributing the sensation of warmth to

[1] Since the above was written, certain conclusions drawn from modern sub-atomic research have led some astro-physicists to the idea that hydrogen is continuously created in the cosmos 'out of nothing'. This does not affect the considerations of the present chapter.

minute fast-moving particles of matter impinging on the skin. Some time later we find Locke taking up the same picture. We see from this how little the mechanical theory of heat owes to empirical facts. For even in Locke's time the connexion between heat and mechanical action, as recognized to-day, was completely unknown.

With this idea firmly rooted in his mind, modern man had no difficulty in using it to explain both thermal expansion and the effect of heat on the different states of matter, and so, finally, these states themselves. Thermal expansion was thus attributed to an increase in the average distance between the assumed minute particles, caused by an increase in their rate of movement; the liquid state was held to differ from the solid, and similarly the gaseous from the liquid, by the interspaces between the particles becoming relatively so great that the gravitational pull between them became too weak to hold them together.

Tested from a view-point outside the onlooker-consciousness, this whole picture of the interaction between matter and heat appears to run counter to the cosmic order of things in a way typical of other spectator-theories. Ancient man, if confronted with this picture, would have said that it means explaining the element Fire by the quality Cold. For each of those minute particles, in its solidity and state of spatial separation from the others, represents an effigy of the earth and thereby the element Earth itself. He would be unable to understand why phenomena of the 'warm' element Fire should be explained by its very opposite. Moreover, Fire forms part of the ever 'youthful' realm of the world, whereas anything which exists as a spatially discernible entity, capable of being moved about mechanically, must have grown cosmically 'old'.

That Ruskin was as much on the alert in regard to this theory as he was in regard to Newton's theory of gravitation, is shown by the following utterance from his *The Queen of the Air*. Obviously stirred by Tyndall's newly published treatise, *Heat as a Mode of Motion*, Ruskin felt the need to criticize the endeavour of contemporary science 'to simplify the various forms of energy more and more into modes of one force, or finally into mere motion, communicable in various states, but not destructible', by declaring that he would himself 'like better in order of thought[1] to consider motion as a mode of heat than heat as a mode of motion'.

These words of Ruskin touch also on the law of conservation of

[1] Note the expression!

energy, of which we said that it also called for a preliminary examination. What we now have to find out is the factual basis on which this law rests.

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The conception of the law of conservation of energy arose from the discovery of the constant numerical relation between heat and mechanical work, known as the mechanical equivalent of heat. This discovery was made at about the same time by Joule in England and J. R. Mayer in Germany, although by entirely different routes. Joule, a brewer, was a man of practical bent. Trained by Dalton, the founder of the atomic theory, in experimental research, he continued Rumford's and Davy's researches which they had undertaken to prove that heat is not, as it was for a time believed to be, a ponderable substance, but an imponderable agent. As a starting-point he took the heating effect of electric currents. The fact that these could be generated by turning a machine, that is, by the expenditure of mechanical energy, gave him the idea of determining the amount of work done by the machine and then comparing this with the amount of heat generated by the current. A number of ingenious experiments enabled him to determine with increasing exactitude the numerical relation between work and heat, as well as to establish the absolute constancy of the relation.

This he regarded as proof of the mechanical theory of heat, which he had taken from Rumford and Davy. What simpler explanation could there be for the constant numerical relation between work and heat than the conception that transformation of one form of energy into another was simply a transmission of motion from one object to another? From the quantitative equality of expended and generated energy was it not natural to argue the qualitative similarity of the two forms of energy, which only externally seemed different?

It was by quite a different path that the Heilbronn doctor, Mayer, arrived at his results. To escape from the narrowness of his South German home town, he went, while still a youth, as doctor to a Dutch ship sailing to Java. When in the tropics he treated a number of sailors by blood-letting, he observed that the venous blood was much nearer in colour to the paler arterial blood than was usual at home. This change in the colour he attributed to the diminished intensity of bodily combustion, due, he believed, to the higher temperature of the tropics.

Scarcely had this thought passed through his mind than it induced another—that of a universal interrelationship between all possible forms of energy. This last idea so took possession of him that during the return voyage, as he himself related, he could scarcely think of anything but how to prove the correctness of his idea and what the consequences would be for the general view of nature. From the moment of his return he devoted his life to practical research into the connexion between the various manifestations of energy. It was in this way that he was led to the determination of the so-called mechanical equivalent of heat, shortly before the same discovery was made in a quite different manner by Joule.

If one considers how slender a connexion there was between Mayer's observation on the sailors in Java and the idea of the quantitative equilibrium of all physical nature-forces, and if one contrasts this with the fanaticism he showed during the rest of his life in proving against all obstacles the correctness of his idea, one must feel that the origin of the thought in Mayer's mind lay elsewhere than in mere physical observations and logical deductions. Confirmation of this may be found in what Mayer himself declared to be his view concerning the actual grounds for the existence of a constant numerical association between the various manifestations of natural energy.

So far as science allowed Mayer any credit for his work, this was based on the opinion that through his discovery he had provided the final vindication of the mechanical theory of heat. This judgment, however, was only piling one wrong upon another. Mayer's destiny was truly tragic. When he began to publicize his conviction of the numerical equilibrium between spent and created energy, he met with so much scepticism, even derision, that from sheer despair his mind at times became clouded. When at last toward the end of his life he received the recognition his discovery deserved (not before being dragged through a painful priority dispute which Joule forced upon him and lost), the scientists had begun to use his idea for bolstering up a hypothesis directly counter to the idea which had led him to his discovery, and for the sake of which he had accepted so much suffering.

Mayer's spiritual kin are not to be found among the heat-theorists of his time, such as Helmholtz and others, but among thinkers of the stamp of Goethe, Howard and Ruskin. His basic idea of the inner connexion between all forms of energy in nature corresponds entirely with Goethe's idea of metamorphosis. Just as Goethe saw in the ur-plant the Idea common to all plant-forms or, in the various plant-organs, the metamorphosis of one and the same ur-organ, so was Mayer convinced of the existence of an ur-force which expressed itself in varying guises in the separate energy-forms of nature. In the picture of the physical universe which hovered before him, the transformation of one form of energy into another—such as mechanical energy into electrical, this into chemical and so on—was somewhat similar to Goethe's picture of the organic life of the earth, in which the metamorphosis of one living form into another constantly occurred. 'There is in nature', said Mayer, 'a specific dimension of immaterial constitution which preserves its value in all changes taking place among the objects observed, whereas its form of appearance alters in the most manifold ways.'

For the physicist, accustomed to a purely quantitative observation of nature, it is difficult to comprehend that Mayer could have arrived at the thought of a constant quantitative relation between the various manifestations of natural energy, without deriving from it the conviction of their qualitative indentity—i.e., without concluding from the existence of the mechanical heat-equivalent that heat is itself nothing else than a certain form of spatial movement. Mayer actually had a picture directly contrary to the mechanistic conception. For him, the arising of heat represented a *disappearance* of mechanical energy.

If this, then, was Mayer's belief, what was it that convinced him of the existence of a numerical balance between appearing and vanishing energy, even before he had any experimental proof?

Later in this book there will be occasion to introduce a concept of number in tune with our qualitative world-outlook. What led Mayer to look upon number as an expression of existing spiritual associations in nature will then become clear. Let this much be said here, that number in the universe has quite different functions from that of serving merely as an expression for a total of calculable items, or as a means of comparing spatial distances. It is in the nature of the onlooker-consciousness that it is unable to interpret numerical equality between natural phenomena save as indicating the presence of an equal number of calculable objects or of spatial movements of equal magnitude. It was therefore consistent for such a consciousness to regard the discovery by Mayer of the mechanical heat-equivalent as a confirmation of the existing mechanical conception of heat.

For Mayer such an interpretation was not necessary. His conviction of the existence of an ur-force, manifesting through metamorphosis in all natural forces, led him to expect a constant numerical relation amongst these, without requiring him to deny the objective existence of qualitative differences, as these displayed themselves in the field of phenomena. He was spiritually akin to Goethe, also, in that he guarded himself strictly against substituting for the contents of our perception conveyed by nature purely hypothetical entities which, while fashioned after the world of the senses, are, in principle, imperceptible. Mayer sought after a truly empirically founded concept of force, and his method was that of reading from all the various manifestations of force which were open to sense observation. One such manifestation, capable of empirical determination, was the balance between appearing and disappearing energy.

Science treated Mayer in the same way as it treated Howard. It took from him what it wanted for its purpose without concerning itself with the epistemological principle which had led him to his discovery. Thus it was that Mayer's discovery led to most important consequences for the development of modern technical devices, whereas it was the fate of his guiding idea to be first derided, then misunderstood and finally forgotten. The consequence was that the knowledge of the numerical equilibrium between created and expended energy in the economy of nature has widened more and more the abyss separating spirit and matter in human life, instead of leading, as indeed it might have done, to a bridging of the abyss. The thought, therefore, regarding the appearing and disappearing of measurable cosmic substance, to which we are led when following Goethe's method of observing nature, stands in no sort of contradiction to what Mayer himself conceived as the relation of the various forms of energy to one another, and the maintenance of the numerical balance between them.

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Having thus determined our standpoint with regard to the thermodynamic theory of heat and the law of conservation, we may proceed to the study, first of the phenomenon of thermal expansion, and then of the effect of heat on the various states of physical matter, by applying to them, unimpeded by any preconceived mechanistic idea, what we have learnt through our previous studies. We must start by developing a proper picture of the dynamic condition of matter in the solid state.

In a solid body the material substance is centred on an inner point, the so-called centre of gravity—a characteristic which such a body shares with the earth as a whole. Likewise, two such bodies exert on one another the same influence that the earth exerts on each of them: they try to assume the shortest possible distance from each other. Since the days of Faraday science has been accustomed to ascribe these phenomena to the existence of *certainfields offorce,* connected with each body and working on one another through the intermediary space. It is to this concept of the field of force that we must now give special attention. For the field-concept, in the form introduced by Faraday into scientific thinking, is one of the few scientific concepts which have been obtained by being 'read' from the corresponding phenomena themselves, and which therefore retain their validity in a science which is based on the method of reading.

According to the field-concept, terrestrial manifestations of gravity are due to the earth's being the bearer of a gravitational field centred within the globe, and extending thence in all directions through space, across and beyond the earth's body. Every point in space, both inside and outside the earth, is characterized by a definite intensity of this field, the so-called gravitational potential. This is subject to variations due to the presence of other physical masses, which carry their own fields of gravity. What happens between such masses and that of the earth, as well as mutually between such masses themselves, is brought about by the particular conditions in space resulting from the interpenetration of the various fields.

It is essential to realize that all fields dealt with by physical science, the gravitational, electric, magnetic—however much they differ otherwise—have this one characteristic in common, that they have a centre where the field is at its highest intensity, diminishing as the distance from the centre increases. Motion in such a field naturally takes place from regions of lower to those of higher intensity—in other words, it follows the rising potential of the field. This accounts for the tendency of physical masses to arrive at the shortest possible distance between them.

It was natural for the modern mind to picture a dynamic condition of the kind just described, that is, one in which the centre and source, as it were, is a point round which the dynamic condition spreads with steadily diminishing strength as the distance from the point grows. For such is the condition of man's head-bound consciousness. The locus from which modern man watches the world is a point within the field of this consciousness, and the intensity with which the world acts on it diminishes with increasing spatial distance from this point. This is the reason why levity was banished from scientific inquiry, and why, when the field-concept was created by the genius of Faraday, it did not occur to anyone that with it the way was opened to comprehend field-types other than the centric one characteristic of gravity and kindred forces. To make use of the field-concept in this other way is one of the tasks we have to undertake if we are to overcome the impasse in which present-day scientific cognition finds itself.

To develop a picture of the type of field represented by levity, let us recall certain results from the observations of the last chapter.

There the volcanic phenomenon, when taken in its wider implications, made us realize that the upward movement of physical masses, in itself part of the total phenomenon, is due to a dynamic cause which we had to describe, in contrast to centripetally working pressure, as peripherally working suction. Of this concept of suction we must now observe that we may apply it with justification only if we realize that suction can be caused in two different ways. In the sense in which we are wont to use the term, suction is the result of a difference of pressure in adjacent parts of space, the action taking place in the direction of the minor pressure. Apart from this, however, suction can occur also as a result of the outward-bound increase of the strength of a levity-field.

It is in this sense that we may speak of the seismic movements of the earth as being caused by suction acting from without. In the same sense we may say that the upward movement of the saps in the plant (to which Ruskin pointed as being responsible for the apple appearing at the top of the tree) and with it the entire growth-phenomenon in the plant world, is due to peripheral suction.

Considerations of this kind lead one to a picture in which the earth is seen to be surrounded and penetrated by a field of force which is in every respect the polar opposite of the earth's gravitational field. As the latter has its greatest intensity at its centre, which is identical with the centre of the earth's globe, so has the levitational field its greatest intensity at its circumference which is somewhere in the width of the universal. (Later considerations will enable us to locate its position more precisely.)

As the gravity-field decreases in strength with increasing distance from the centre of the field, that is, in the outward direction, so does the levity-field decrease in strength with increasing distance from its periphery, or in the inward direction. In both fields the direction of movement is from regions of lower to those of higher intensity. This is why things 'fall' under the influence of gravity and 'rise' under the influence of levity.[1]

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How does thermal expansion read as a letter in nature's script when seen in the light of the two contrasting field-concepts?

Let us, for simplicity's sake, imagine a spherically shaped metallic body, say, a ball of copper, which we expose to the influence of heat. As we have seen, it is the centrically orientated gravity-field which gives the ball its permanency of shape. Consequently, the dynamic orientation of the material constituting its body is directed towards the interior of the body itself.

Now, the moment we bring heat to bear on the body we find its surface moving in the outward direction. The whole mass is clearly under the influence of some suction which is directed on to the body from outside. Just as the plants grow in the anti-gravitational direction as a result of the suctional effect of levity (other factors which account for its growing into a particular shape, etc., being left out of consideration), so our copper ball grows in volume by being sucked away from its centre of gravity. It is the action of heat which has changed the ratio between gravity and levity at this spot in such a way as to allow levity to produce this effect.[2]

What we have thus found to be the true nature of the event perceived as a body's growth in volume under the influence of heat has a definite effect on our conception of spatially extended matter as such. For a physical body is always in some thermal state which may be regarded as higher than another, and it may therefore be regarded as being at all times thermally expanded to some extent. Hence, it is all the time under the sway of both gravitational pressure and anti-gravitational suction. In fact, we may say ideally that, if there were no field working inwards from the cosmic periphery, the entire material content of the earthly realm would be reduced by gravitation to a spaceless point; just as under the sole influence of the peripheral field of levity it would dissipate into the universe.

[1] For a vivid description of the interplay of both types of force in nature, see E. Carpenter's account of his experience of a tree in his *Pagan and Christian Creeds.*

[2] Note how this picture of thermal expansion fits in with the one obtained for the *Solfatara* phenomenon when we took into account all that is implicit in the latter,

To ordinary scientific thinking this may sound paradoxical, but in reality it is not. Observation of the nature of solid matter has led atomistic thought to regard a physical body as a heap of molecules so far apart that by far the greater part of the volume occupied by the body is just 'empty' space. In the scientific picture of molecules constituting a physical body, of atoms constituting the molecules, of electrons, protons, etc., constituting the atoms, all separated by spaces far exceeding the size of the elementary particles themselves, we find reflected, in a form comprehensible to the onlooker-consciousness, the fact that matter, even in the solid state, is kept in spatial extension by a field of force relating it to the cosmic periphery.

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With this picture of solid matter as being held in spatial extension by its subjection to gravity and levity alike, we proceed to a study of the liquid and gaseous states of matter, while taking into account the role of heat in bringing these states about.

Following out our method of seeking to gain knowledge of a phenomenon by regarding it as part of a greater whole, let us ask what sort of change a portion of physical substance undergoes in its relation to the earth as a whole when, for instance, through the influence of heat, it passes from a solid to a liquid state. Here we must keep in mind that it is part of the nature of a liquid to have no form of its own. The only natural boundary of a liquid substance is its upper surface. Since this surface always lies parallel with the surface of the earth it forms part of a sphere, the centre point of which is identical with that of the gravitational centre of the earth. The passage of a portion of matter from solid to liquid thus signifies that it ceases to possess a centre of gravity of its own and is now merely obedient to the general gravity-field of the earth. We can thus speak of a transition of matter from the individual to the planetary condition. This is what heat brings about when a solid body melts.

A large part of the heat used in melting is known to be absorbed by the substance during the process of melting. This is indicated by the thermometer remaining at the temperature of the melting-point once this has been reached, until the whole of the melting substance has liquefied. Physics here speaks of 'free' heat becoming 'latent'. From the Goethean point of view we see heat passing through a metamorphosis. Whereas, previously, heat was perceptible to our sense of warmth, it now manifests as a gravity-denying property of matter.

In order to obtain an idea of the liquid state of matter corresponding to reality, we must take into account yet another of its characteristics. When the heat becomes latent, it goes even further in contradicting gravity than by robbing matter of its own point of gravity and relating it to the earth's centre of gravity. This effect is shown in the well-known urge of all liquids to evaporate. Hence we must say that even where matter in a liquid state preserves its own surface, this does not by any means represent an absolute boundary. Above the surface there proceeds a continuous transition of substance into the next higher condition through evaporation. We see here the activity of heat going beyond the mere denial of gravity to a positive affirmation of levity.

With the help of this conception of the integration of the liquid state within the polarity of gravity and levity, we are now able to draw a picture of the earth which, once obtained, answers many a question left unanswered by current scientific notions, among them the question why the earth's volcanic activity is confined to maritime regions.

Regarding the distribution of land and water on the earth's surface, we may say that to an observer in cosmic space the earth would not look at all like a solid body. Rather would it appear as a gigantic 'drop' of water, its surface interspersed with solid formations, the continents and other land masses. Moreover, the evidence assembled ever since Professor A. Wegener's first researches suggests that the continents are clod-like formations which 'float' on an underlying viscous substance and are able to move (very slowly) in both the vertical and horizontal directions. The oceanic waters are in fact separated from the viscous substratum by no more than a thin layer of solid earth, a mere skin in comparison with the size of the planet. Further, this 'drop' of liquid which represents the earth is in constant communication with its environment through the perpetual evaporation from the ocean, as well as from every other body of water.

This picture of the earth shows it lying under the twofold influence of the compressive force of gravity and the sucking force of levity. Wherever land meets sea, there levity tends to prevail over gravity. It is in maritime regions, accordingly, that the inner strata of the earth succumb most readily to those sudden changes in the gravity-levity tension wherein we have recognized the origin of seismic occurrences.

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Turning to the gaseous condition, we realize that although even here matter retains traces of a connexion with terrestrial gravity, levity is now the dominant factor. There are three characteristics of the gaseous condition which bring this out. One is the extreme readiness of gases to expand when heated; we see here how much easier than with solid substances it is for heat to overcome the influence of gravity. The second characteristic is the property of gases, peculiar to them, of expanding spontaneously, even when not heated. Here we find gaseous matter displaying a dynamic behaviour which at lower stages occurs only under the stimulus of heat. The third characteristic is shown by the fact that all gases, unlike solids or liquids, respond with the same increase of volume to a given rise of temperature, however diverse their other qualities may be. Once gases are mixed, therefore, they cannot be separated merely by raising or lowering the temperature. Here we find the unifying effect of the cosmic periphery prevailing over the differentiating effect of terrestrial gravity.

At this point we may recall Goethe's reply to the botanist, Wolff, who had ascribed the metamorphosis of plant-organs from root to blossom to a gradual stunting or atrophy of their vegetative force, whereas it was clear to Goethe that simultaneously with a physical retrogression, there is a spiritual progress in the development of the plant. The fact that all Wolff's efforts to see clearly did not save him from 'seeing past the thing' seemed to Goethe an inevitable result of Wolff's failure to associate with the eyes of the body those of the spirit.

Exactly the same thing holds good for the sequence of physical states of matter which we are considering here. Observation of this sequence with the bodily eyes alone will show nothing but a reduction of the specific gravity of the material concerned. He who is at pains to observe also with the eye of the spirit, however, is aware of a positive increase of lightness going hand in hand with a decrease of heaviness. Regarded thus, the three ponderable conditions form what Goethe would have called a 'spiritual ladder'. As 'rungs' of such a ladder they clearly point to a fourth rung—that is, a fourth state in which levity so far prevails over gravity that the substance no longer has any weight at all. This picture of the fourfold transformation of matter calls for an inquiry into the transition between the third and fourth states, corresponding to the well-known transitions between the three ponderable states.

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Our observations have led us to a concept of heat essentially different from that held by modern science. Science looks on heat simply as a condition of ponderable matter. We, on the contrary, are led to recognize in heat a fourth condition into which matter may pass on leaving the three ponderable conditions, and out of which it may emerge on the way to ponderability.

Before showing that such transitions are actually known in nature, it may be well to discuss here an objection which the customary way of thinking might plausibly advance against our whole method. It could be said that to assume a continuation of the sequence of the three ponderable conditions in the manner suggested is justified only if, as solids can be turned into liquids and these into gases, so gases could be transformed into a fourth condition and, conversely, be produced from the latter.

In reply it can be said that the fact of our not being able at present to change gases artificially into pure heat does not justify the conclusion that this is in principle impossible. We know from previous considerations that the earth has reached an evolutionary stage at which all elements, including fire, have in certain degree grown 'old'. This applies in quite a special degree to the manipulations to which man, led by his death-bound consciousness, has learnt to submit matter in his laboratories. To decide what is possible or not possible in nature, therefore, can by no means be left to the judgment of laboratory research. As is shown by the following instance, taken from the realm of vegetable life, a case of the creation of matter 'out of nothing' is already known to biology—though biology, bound in its concepts to the Law of Conservation, shows some natural reluctance to recognize the true significance of the phenomenon.

The plant which performs this strange feat is the *Tillandsia usneoides*, indigenous to tropical America, and generally known as 'Spanish Moss'. Its peculiarity is that it grows and flourishes without taking from its support any material whatsoever for the building up of its substance. Its natural habitat is the dry bark of virgin forest trees. Since civilization invaded its home it has acquired the habit of growing even on telegraph wires, which has given it the popular name of 'telegraph tresses'. Chemical analysis of this plant shows the presence of an average of 17 per cent iron, 36 per cent silicic acid and 1·65 per cent phosphoric acid. This applies to samples taken from districts where the rainwater—the only source from which the plant could extract these substances in physical form—contains at most

1·65 per cent iron, 0·01 per cent silicic acid and *no phosphoric acid at all.*

The Tillandsia phenomenon is to a certain extent reminiscent of another well-known plant activity. This is the process of assimilation of carbon from the carbon dioxide of the air. If we leave aside the change in the chemical combination which the carbon undergoes, there remains the picture of the plant drawing this matter to itself from its environment and at the same time subjecting it to a spatial condensation. A similar but even more far-reaching process is exhibited by the Tillandsia as regards the three substances referred to above. From the conditions given, it follows that the plant cannot possibly get these substances elsewhere than out of the surrounding atmosphere, and that in drawing upon them it submits them to a high degree of condensation. A special role, however, is played by the phosphorus, which shows that the assimilative power of the plant is sufficient to transform phosphorus from a physically not traceable state into one of spatially bounded materiality. Following Goethe in his coining of the concept of 'spiritual anastomosis' for the pollinating process of plants, we can here speak of 'spiritual assimilation'.

In this respect Tillandsia provides an instance 'worth a thousand, bearing all within itself. For what nature here unmistakably demonstrates serves as an eye-opener to a universal fact of the plant kingdom and of nature in general. The problem of the so-called *trace-elements* may serve as an illustration of this.

Modern agricultural chemistry has found of a number of chemical elements that their presence in the soil in scarcely traceable volume is necessary in order to enable the plant to unfold healthily its latent characteristics. All sorts of deficiencies in cultivated plants have led to a recognition that the soil is impoverished of certain elements by intensive modern cultivation, and that it is to the lack of these elements that the deficiencies are due. Much work has meanwhile been done in classifying the various deficiencies and in devising ways of giving the soil chemical substitutes for what is lacking.

A large part of the work here involved could be saved were it only to be acknowledged that the soil owes the natural occurrence of the proper elements to a process which the plants themselves bring about in the soil, if men refrain from hindering them by cleverly thought-out methods of cultivation which fail to reckon with the nature of a living organism.

Let us be clear what it is that occurs when a plant exhibits any of the observed abnormalities. Expressed in a Goethean manner, these are the consequence of an insufficient direction of the organic processes in the plant body by the spiritual plant-type underlying it. That which Ruskin called the 'spirit' of the plant, and to which he drew attention in his aphorism 'Stand by Form against Force' (by 'form' *all* the peculiar qualities of the plant are to be understood), is unable to express itself in full measure. Now we know that, in order to unfold its activities on the physical plane, spirit requires 'young' matter—that is, matter which is either in, or has just emerged from, a purely dynamic state. Normally a definite spiritual type co-ordinates the dynamic functions present in the superphysical sphere of nature in the manner required to give the plant-organism its appropriate form. As, through the action of the type, these functions are brought down from the sphere of levity into that of gravity, they condense to the corresponding material elements and thus reach the soil in material form via the physical organism of the plant.

The pattern as usually seen is now reversed; the presence of the various elements in the soil no longer appears as the origin of one or another function in the building up of the plant-body, but quite the reverse. The functions appear now as the cause, and the soil-elements as the effect. We may thus recognize the value of the latter as *symptoms* from which we can read the existence of a healthy connexion between the plant and the corresponding form-creating functions working on it from its surroundings.

With this reversal of the relationship between cause and effect it is not, however, intended to represent the commonly accepted order of things as entirely incorrect. In the realm of life, cause and effect are not so onesidedly fixed as in the realm of mechanical forces. We may therefore admit that a reverse effect of the soil-elements upon the plant does take place. This is plainly demonstrable in the case of phosphorus which, however, by reason of its appearance in the soil in proportions hardly to be called a mere 'trace', represents a borderline case. What may apply within limits to phosphorus is wholly valid for the trace-elements—namely, that they are playing their essential role while they are themselves about to assume ponderable form.

It thus becomes clear how mistaken it is to attempt to cure deficiencies in plants by adding to the soil chemical substitutes for the trace-elements. In the condition in which this material is offered to the plant, it is truly 'old' material. In order to be able to use it functionally, the plant has first to convert it into the 'young' condition. This indeed happens whilst the material is rising in the plant combined with the juices drawn by the plant from the soil under the influence of levity-force. Only when this has occurred are the chemical elements able to serve the plant functionally. Thus, by trying to give help to the plant in this way, we injure it at the same time. For by forcing it to perform the operation described, its general life-forces are diminished. A seeming success brought about in this manner, therefore, will not last long.[1]

There is, nevertheless, a way of helping the plant by adding to the soil certain material substances, provided these are first brought into a purely dynamic condition. That this can be done is a fact long since known, even if not recognized in its true significance. So far then, as serves the purpose of this book, we shall deal with it here.

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The method in question is associated with the school of medicine known as Homoeopathy, founded by the German doctor, Hahnemann. The word 'homoeopathy' means 'healing through like'; the basic principle is to treat disease symptoms with highly diluted substances which produce similar symptoms if ingested in normal quantity. Experience has in fact shown that the physiological effect of a substance taken from external nature is reversed when the substance is highly diluted.

The method of diluting, or 'potentizing', is as follows:

A given volume of the material to be diluted is dissolved in nine times its volume of distilled water. The degree of dilution thus arrived at is 1 : 10, usually symbolized as Ix. A tenth part of this solution is again mixed with nine times its bulk of water. The degree of dilution is now 1 : 100, or 2x. This process is continued as far as is found necessary for a given purpose. Insoluble substances can be dealt with in the same manner by first grinding them together with corresponding quantities of a neutral powder, generally sugar of milk. After a certain number of stages the powder can be dissolved in water; the solution may then be diluted further in the manner described. Here we have to do with transfer of the quality of a substance, itself insoluble, to the dissolving medium, and then with the further treatment of the latter as if it were the original bearer of the quality concerned.

[1] This throws light also on the problem of the use of chemicals as artificial fertilizers.

This fact alone shows that potentization leads into a realm of material effects at variance with the ordinary scientific conception of matter. Moreover, we can carry the dilutions as far as we please without destroying the capacity of the substance to produce physiological reactions. On the contrary, as soon as its original capacity is reduced to a minimum by dilution, further dilution gives it the power to cause actually stronger reactions, of a different and usually opposite kind. This second capacity rises through stages to a variable maximum as dilution proceeds.

A simple calculation shows—if we accept the ordinary scientific view as to the size of a molecule—that not a single molecule of the original substance will remain in the solution after a certain degree of dilution has been reached. Yet the biological and other reactions continue long after this, and are even enhanced.

What this potentizing process shows is that, by repeated expansions in space, a substance can be carried beyond the ponderable conditions of matter into the realm of pure functional effect. The potentizing of physical substances thus gains a significance far wider than that of its medical use.[1] There opens up, for example, the possibility of stimulating deficient functions in the plant by giving it the corresponding elements in homoeopathic doses. By this means the plant is brought into direct connexion with the relevant spiritual energy, and then left to carry out for itself the necessary process of materialization, instead of being forced by mere chemical additions to the soil first to potentize the substance itself.[2]

The same principle holds good for man and beast. They also need 'young material' for their nourishment, so that the type active in them—which in animals is the group-soul of the species and in man is the single individual—can express its true form and character. (We saw earlier that the will requires 'young' material in order to penetrate into the material layers of the muscles, as happens when the limbs are set in motion). In this respect, the difference between ensouled creatures and plants is that, what is harmful to plants is

[1] See L. Kolisko: *Wirksamkeit kleinster Entitäten* ('Effects of Smallest Entities'), Stuttgart, 1922, an account of a series of experiments undertaken by the author at the Biological Institute of the Goetheanum following suggestions by Rudolf Steiner. Her aim was to examine the behaviour of matter on the way to and beyond the boundary of its ponderable existence.

[2] Instead of using the trace-elements in mineral form, it is still better to use parts of certain plants with a strong 'functional tendency', specially prepared. This is done in the so-called Bio-Dynamic method of farming and gardening, according to Rudolf Steiner's indications.

natural for men and animals: when taking nourishment the latter are able to bring about quickly and purposefully a transformation of matter into the purely dynamic state. Their metabolic system is designed to enable them to take alien material from outer nature and to transform it through the forces of the various digestive enzymes; in the course of this process the material passes through a condition of complete 'chaos'.

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Having in this way established the existence of certain processes of materialization and dematerialization in single organisms within the earth's vegetable and other kingdoms, we shall now turn to the earth as a whole to find out where—organic being that she herself is—she manipulates corresponding processes on a macrotelluric scale.

In an age following van Helmont's discovery of the gaseous state of matter and the statement of the *Contra Levitatem* maxim, men were bound to think that the circulation of atmospheric moisture was limited to the three stages of liquid, vaporous (peculiar to the clouds, etc.) and the invisible aeriform condition. Yet the role played by clouds in the myths of early peoples shows that they were once given a quite different status, between the 'created' and 'uncreated' worlds. Our observations lead to a corresponding conception, but along the path of knowledge, guided by sense-perception, as befits our own age.

In discussing Howard's discovery of the stages of cloud-formation we found something lacking, for it was clear that the three stages of cloud proper—stratus, cumulus and cirrus—have a symmetry which is disturbed by the addition of a fourth stage, represented by the nimbus. This showed that there was need for a fifth stage, at the top of the series, to establish a balanced polarity. We can now clear up this question of a fifth stage, as follows.

In the three actual cloud-forms, gravity and levity are more or less in equilibrium, but in the nimbus gravity predominates, and the atmospheric vapour condenses accordingly into separate liquid bodies, the drops of rain. The polar opposite of this process must therefore be one in which cloud-vapour, under the dominating influence of levity, passes up through a transitional condition into a state of pure heat.

Such a conception by no means contradicts the findings of external research. For meteorology has come to know of a heat-mantle surrounding the earth's atmosphere for which various hypothetical explanations have been advanced. Naturally, none of them envisages the possibility of atmospheric substance changing into the heat-condition and back again. But if we learn to look on the chain of cloud-forms as a 'spiritual ladder', then we must expect the chain to conclude with a stage of pure heat, lying above the cirrus-sphere.[1]

The line of consideration pursued in the last part of this chapter has led us from certain observations in the plant kingdom, concerning the coming into being of ponderable matter from 'nothing', to a corresponding picture of the earth's meteorological sphere. When discussing the plant in this respect we found as an instance 'worth a thousand, bearing all within itself the case of Tillandsia and more particularly the surprising appearance of phosphorus in it. Now, in the meteorological realm it is once more phosphorus which gives us an instance of this kind. For there is the well-known fact of the presence of phosphorus in conspicuous quantities in snow without a source being traceable in the atmosphere whence this substance can have originated in ponderable condition. The phosphorus appearing in snow, therefore, brings before our very eyes the fact that the heights of the atmosphere are a realm of procreation of matter. (In our next chapter we shall learn what it is in phosphorus that makes it play this particular role in both fields of nature. What interests us in the present context is the fact itself.)

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The knowledge we have now gained concerning the disappearance and appearance of physical water in the heights of the atmosphere will enable us to shake off one of the most characteristic errors to which the onlooker-consciousness has succumbed in its estimation of nature. This is the interpretation of thunderstorms, and particularly of lightning, which has held sway since the days of Benjamin Franklin.

Before developing our own picture of a thunderstorm let us recognize that science has found it necessary to reverse the explanation so long in Vogue. Whereas it was formerly taken for granted—and the assumption was supposed to rest upon experimental proof—that the

[1] Note, in this respect, the close of Goethe's poem dedicated to the cirrus-formation and the poem inspired by his sight of a waterfall in the Bernese Alps as indications of the fact that he was himself aware of the water-rejuvenating process in the higher reaches of the atmosphere.

condensing of atmospheric vapour which accompanied lightning was the consequence of a release of electrical tension by the lightning, the view now held is that the electrical tension responsible for the occurrence of lightning is itself the effect of a sudden condensing process of atmospheric moisture.

The reason for this uncertainty is that the physical conditions in the sphere where lightning occurs, according to other experiences of electric phenomena, actually exclude the formation of such high tensions as are necessary for the occurrence of discharges on the scale of lightning. If we look at this fact without scientific bias we are once again reminded of the Hans Andersen child. We cannot help wondering how this child would behave in a physics class if the teacher, after vainly trying to produce a lightning-flash in miniature with the help of an electrical machine, explained that the moisture prevalent in the air was responsible for the failure of the experiment, and that he would have to postpone it to a day when the air was drier. It would scarcely escape the Hans Andersen child that the conditions announced by the teacher as unfavourable to the production of an electric spark by the machine, prevail in a much higher degree exactly where lightning, as a supposed electric spark, actually does occur.

To conclude from the presence of electric tensions in the earth's atmosphere as an accompaniment of lightning, in the way first observed by Franklin, that lightning itself is an electrical process, is to be under the same kind of illusion that led men to attribute electrical characteristics to the human soul because its activity in the body was found to be accompanied by electrical processes in the latter. The identification of lightning with the electric spark is a case of a confusion between the upper and lower boundaries of nature, characteristic of the onlooker-consciousness. As such, it has stood in the way of a real understanding both of non-electrical natural phenomena and of electricity itself.

What we observe in lightning is really an instantaneous execution of a process which runs its course continually in the atmosphere, quietly and unnoticed. It is the process by which water reverts from the imponderable to the ponderable condition, after having been converted to the former through levity set in action by the sun (as usually happens in a high degree just before a thunderstorm). We form a true picture of the course of a storm if we say that nature enables us to witness a sublime display of the sudden bringing to birth of matter in earthbound form. What falls to the ground as rain (or hail) is substantially identical with what was perceptible to the eye, a moment before, as a majestic light-phenomenon. The accompanying electrical occurrence is the appropriate counter-event at nature's lower boundary. Since the two form part of a larger whole they necessarily occur together; but the electrical occurrence must not be identified with the event in the heavens. The reason for their conjunction will become clear later, when we shall show how electrical polarity arises from the polarity between gravity and levity.

If one learns to view a thunderstorm in this way, its spiritual connexion with the earth's volcanic processes becomes manifest; there is in fact a polar relationship between them. For just as in volcanic activity heavy matter is suddenly and swiftly driven heavenwards under the influence of levity, so in a storm does light matter stream earthwards under the influence of gravity.

It is this combination of kinship and polar opposition which led people of old to regard both lightning in the heights and seismic disturbances in the depths as signs of direct intervention by higher powers in the affairs of men. A trace of this old feeling lingers in the Greek word *θειον* (theion), divine, which was used to denote both lightning and sulphur. Influenced by the same conception, the Romans regarded as holy a spot where lightning had struck the earth; they even fenced it off to protect it from human contact. Note in this respect also the biblical report of the event on Mount Sinai, mentioned before, telling of an interplay of volcanic and meteorological phenomena as a sign of the direct intervention of the Godhead.

CHAPTER XI

Matter as Part of Nature's Alphabet

In the preceding chapter we drew attention to the fact that any spatially extended mass is under the sway of both gravity and levity. We then saw that with the transition of matter from the solid via the liquid to the gaseous state, not only does the specific gravity of the substance decrease, but at the same time an increase takes place of what we might call 'specific levity'. In the gaseous state, therefore, we find gravity-bound matter becoming so far levity-bound that it assumes the property of actively expanding in space.

Having once adopted the Goethean way of thinking-in-polarities, we may feel sure that there is somewhere in nature a phenomenon which represents the polar opposite of the levity-gravity relationship peculiar to the gaseous state. In this latter state we find ponderable matter so far brought under the sway of levity that its behaviour is of a kind which van Helmont, when he first observed it, could not help describing as 'paradoxical'. Where, we must now ask, do we find imponderable essence so much under the sway of gravity that it shows the correspondingly paradoxical features? In other words, where does nature show levity concentrated in a limited part of space—that is, in a condition characteristic of ponderable matter?

Such concentrations of levity do indeed exist in varied forms. One is the 'warmth-body' represented by the blood-heat of the higher animals and man. There is, however, an occurrence of this kind also on the purely mineral level of nature, and it is this which has particular significance for our present study of matter. We meet it in all physical substances which have the peculiarity of being combustible.

Our next task is to study certain fundamentals in regard to the different ways in which levity and gravity are found to be intertwined in combustible substances, manifesting through the difference of their relation to the process of combustion—that is, the process by which levity is restored to its original condition. It is the aim of the present chapter to show that by doing justice to the imponderable aspect of combustion, the way is opened to a view of the 'elements', as scientific chemistry understands them, which will be in line with our dynamic conception of matter.

There is nothing surprising in the fact that a new conception of the chemical element can arise from a re-study of the process of combustion, if we remember that it was the picture of combustion, characteristic of the spectator-consciousness, which determined the conception of the chemical element as it prevails in modern science. Let us see how this conception came to pass historically in order to find where we stand to-day.

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With the establishment of the knowledge of a state of physical matter which, as the definition ran, 'neither results from a combination of other physical substances nor is resolvable into such', the conviction arose that man's searching mind had reached 'rock-bottom'. This conviction, however, was shaken when, with the discovery of radium, an element became known whose property it is to disintegrate into two other elements, helium and lead. Although this did not force science to abandon the element-concept altogether, it became necessary to find a new definition for it.

This definition was established by Professor W. Ostwald at the beginning of the present century, when he stated that the chemical element represents a condition of physical matter in which 'any chemical change results in an increase of weight'. In this way, the chemical concept of the element achieved a meaning which had actually been implicit in it from its first conception. For its very formation had been the outcome of the *Contra-Levitatem* maxim. The following glance over the history of chemistry will show this.

The birth of chemistry as a science, in the modern sense, is closely connected with a revolutionary change in the conception of what can be called the chemical arch-process—combustion, or, to use a more scientific term, oxidation. This change arose out of the *Contra-Levitatem* maxim and the new conception of heat which this maxim required. In the old doctrine of the four Elements, Heat had been conceived as a manifestation of the element of Fire, and so, together with Air, as belonging to the realm of the 'uncreated things'. Hence the release of heat from created substance was always felt to be a sacred act, as is shown by the fire rites of old.

Modern man's conception of the same process is revealed in the answer one invariably receives from both layman and scientist when they are asked what they understand by combustion. It is described as a process through which oxygen combines with the combustible substance. And yet this side of combustion, first observed by J. Priestley (1771), is neither the one for the sake of which man produces combustion in the service of his everyday life, nor is it at all observed by ordinary sense-perception. Nevertheless, to describe the obvious fact, that combustion is liberation of heat from the combustible substance, will hardly occur to anyone to-day. This shows to what extent even the scientifically untrained consciousness in our time turns instinctively to the tangible or weighable side of nature, so that some effort is required to confess simply to what the eye and the other senses perceive.

During the first hundred years after the establishment of the *Contra-Levitatem* maxim, man's situation was in a certain sense the opposite of this. Then, people were struggling hard to get away from the old concept which saw in combustion nothing but the liberation of a super-terrestrial element from earthly fetters. This struggle found expression in a theory of heat which at that time greatly occupied scientific thinking. It is the so-called phlogiston-theory first proposed by the chemist Stahl (1660-1734).

This theory reveals the great uncertainty into which man's thinking about the world of the senses had arrived at that time. Clinging to ideas inherited from antiquity, man's consciousness was already so far restricted to the forming of pure matter-bound concepts that he was tempted to conceive heat as a material element. To this heat-substance the name 'phlogiston' was given. At the same time, under the *Contra-Levitatem* maxim, it was impossible to conceive of substance except as ponderable substance. This led to the conviction that whenever heat appears as a result of some treatment of matter (combustion or friction), the material substance subject to this treatment must lose weight.

The experiments of Lavoisier (1743-94), which he undertook following Priestley's discovery of the role of oxygen in combustion, put an end to this theory. These experiments are rightly regarded as the actual beginning of modern chemistry. In Lavoisier we find an observer of nature who was predominantly interested in what the scales could tell about changes in substances. It was from this aspect that he investigated the process of oxidation. What had already been observed by a few others, though without being taken seriously by them, he found confirmed—that, contrary to the phlogiston-theory, matter does not lose weight through oxidation but gains weight. Further experiments proved beyond doubt that in all chemical reactions the total weight of the components remained constant. However much the substance resulting from the chemical reaction of others might differ from these, its weight always proved to be the same as their total weight. What else could be concluded from the apparent unchangeability of weight throughout all the chemical happenings in nature than that the ponderable world-content was of eternal duration? We see here how much modern chemistry and its concept of the chemical element has been ruled right from the start by the one-sided gravity concept of the onlooker-consciousness.

Together with the overcoming of the fallacy that heat is a ponderable substance (full certainty was indeed established only some time later through the investigations of Davy and Rumford into heat generated by friction)—human thinking was led into a one-sided conception of combustion which was merely the opposite of the one held earlier. Whereas formerly man's mind was pre-eminently occupied by the liberation of the imponderable element through combustion, it now turned entirely to what goes on in the ponderable realm.

As we have seen, one outcome of this one-sided view of combustion was the modern concept of the chemical element. To-day our task is to overcome this concept by taking a step corresponding to the one that led to it, that is, by a study of combustibility which does justice to both sides of the process involved.

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As objects of our observation we choose three chemical elements all of which have the property of combustibility: Sulphur, Phosphorus, and Carbon. As will become clear, our choice of these three is determined by the fact that together they represent an instance 'worth a thousand, bearing all within itself.

We begin by comparing Sulphur and Phosphorus. In their elementary state they have in common the fact that any chemical change is bound up with an increase in their weight. In this state both are combustible. Apart from this similarity, there is a great difference between them, as the way of storing them illustrates. For while elementary sulphur needs only an ordinary container, phosphorus has to be kept under cover of water in order to prevent the atmospheric oxygen from touching it. The reason is that the combustible state is natural for sulphur, but not for phosphorus, the latter's natural state being the oxidized one. This different relationship of sulphur and phosphorus to the oxidizable (reduced) and the oxidized state manifests itself in all their chemical reactions.

To object here that the different reactions of the two substances are due only to the difference of their respective temperatures of ignition, and that above these temperatures the difference will more

FIG. 4.

or less disappear (all combustible substances at a sufficiently high temperature becoming more or less similar to phosphorus), would not meet the argument. For what matters here is just how the particular substance behaves at that level of temperature on which the earth unfolds her normal planetary activity. To ignore this would be to violate one of the principles we have adopted from Goethe, which is never to derive fundamental concepts of nature from observations obtained under artificial conditions.

Sulphur andphosphorus are thus seen to represent two polarically opposite tendencies with regard to the levity-gravity coherence which breaks up when combustion occurs. In the case of sulphur, the ponderable and imponderable entities appear to cling together; in the case of phosphorus, they seem to be anxious to part. These two different tendencies—which are characteristic of many other substances and represent a basic factor in the chemical happenings of the earth—are in their own way a pair of opposites. Since each of them represents in itself a relationship between two poles of a polarity—gravity and levity—so in their mutual relationship they represent a 'polarity of polarities'. In Fig. 4 an attempt has been made to represent this fact by a symbolic diagram.

In this figure the shaded part represents the imponderable, the black part the ponderable entity. In the left-hand symbol both are shown in a relationship corresponding to the one characteristic of sulphur; in the right-hand figure the relationship is characteristic of phosphorus.

Here we have an instance of a kind of polarity which belongs to the fundamentals of nature as much as does the levity-gravity polarity itself. Wherever two poles of a polarity meet, they have the possibility of being connected in two ways which in themselves are again polarically opposite. Our further studies will bring up various other instances of this kind, and will show us that part of the epistemological trouble in which science finds itself to-day results from the fact that the scientific mind has been unable to distinguish between the two kinds of polarity—that is, as we shall say henceforth, between *polarities of the first order* (primary polarities) and *polarities of the second order* (secondary polarities).

In actual fact, the distinction between the two orders of polarity has been implicit in the descriptions given in this book right from the start. Remember, in this respect, how the picture of the threefold psycho-physical structure of man, which has proved a master-key for unlocking the most varied scientific problems, was first built up. There, 'body' and 'soul' represented a polarity which is obviously one of the first order. By our observation of the human organism, in relation both to the different functions of the soul and to the different main organic systems, we further recognized the fact that the ways in which body and soul are interrelated are polarically opposite in the region of the brain and nerves and in the region of the metabolic processes, which again results in two polarically opposite activities of the soul, mental on the one hand, and volitional on the other. In what we called the pole-of-consciousness and the pole-of-life we therefore have a clear polarity of the second order, and so in everything that is connected with these two, as our further discussions will show.

Remembering that our first occasion to concern ourselves overtly with the concept of polarity was in connexion with the four elements, we may now ask whether the old doctrine did not embrace some conception of secondary polarity as well as of primary polarity, and if so, whether this might not prove as helpful in clarifying our own conceptions as was the primary polarity, cold-warm. That this is indeed so, the following description will show.

Beside the two qualities cold and warm the doctrine of the four elements pointed to two further qualities forming in themselves a pair of opposites, namely, dry and moist. Just as the four elements were seen as grouping themselves in two pairs, Fire-Air on the one hand,

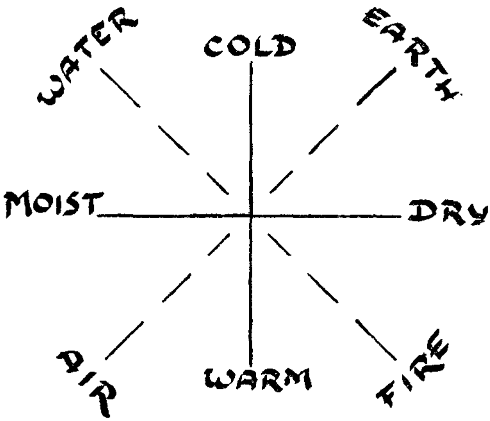

FIG. 5.

Water-Earth on the other, the first being characterized by the quality warm, the second by cold, so were they seen to form two opposing groups, Fire-Earth and Air-Water, of which one was characterized by the quality dry, the other by the quality moist. Fig. 5 shows how the four elements in their totality were seen to arise out of the various combinations of the four qualities.

In this diagram the element Earth appears as a combination of the qualities Dry and Cold; Water of Cold and Moist; Air of Moist and Warm; Fire of Warm and Dry. As a result, Earth and Fire, besides representing opposite poles, are also neighbours in the diagram. Here we encounter a picture characteristic of all earlier ways of looking at the world: the members of a system of phenomena, when ranked in due order of succession, were seen to turn back on themselves circle-wise—or, more precisely, spiral-wise.

In what way do the qualities dry and moist form a polarity of the second order, and how do they represent the chemical polarity characteristic of sulphur and phosphorus as well as all the other secondary polarities dealt with in this book? To understand this we must submit the couple dry-moist to the same scrutiny as we applied to cold and warm in our earlier discussion of the four elements.

It lies in the nature of things that we instinctively associate these qualities with the solid and liquid states of matter respectively. This certainly agrees with the diagram given above, where the elements Earth and Water are distinguished precisely by their connexion with these two characteristics. Yet, in addition to this, the qualities dry and moist are found to be characteristic also of Fire and Air respectively, though with the difference that they are linked not with the quality cold, as in the case of the lower elements, but with the quality warm. So we see that the concepts Dry and Moist, as they lived in the old picturing of them, mean a good deal more than we understand by them to-day.

That these two respective attributes do not belong exclusively to the solid and the liquid states of matter can be seen at once by observing the different reactions of certain liquids to a solid surface which they touch. One need only recall the difference between water and quicksilver. If water runs over a surface it leaves a trail; quicksilver does not. Water clings to the side of a vessel; again, quicksilver does not. A well-known consequence of this difference is that in a narrow tube the surface of the liquid—the so-called meniscus—stands higher at the circumference than at the centre in the case of water; with quicksilver it is just the reverse. In the sense of the two qualities, dry and moist, water is a 'moist' liquid; quicksilver a 'dry' one. On the other hand, the quality of moistness in a solid substance appears in the adhesive power of glue.

Let us now see how, in accordance with the scheme given in Fig. 5, the four qualities in their respective combinations constitute the four elements. From the description we shall give here it will be realized how little such ancient schemes were based on abstract thoughts, and how much they were read from the facts of the world. Moreover, a comparison with our description of the four stages of matter, given in the previous chapter, would show how far the conceptual content of the old doctrine covers the corresponding facts when they are read by the eye of the modern reader in nature, notwithstanding the changes nature has undergone in the meantime.

The element Fire reveals its attributes of warm and dry in a behaviour which combines a tendency to dynamic expansion with a disinclination to enter into lasting combination with the other elements. Correspondingly, the behaviour of the element Earth unites a tendency to contraction with an inclination to fall out of conjunction with the other elements. Thus the attribute, dry, belongs equally to pure flame and sheer dust, though for opposite reasons. Distinct from both these elements are the middle elements Water and Air; with them the attribute, moist, comes to expression in their tendency both to interpenetrate mutually and to absorb their neighbours—the liquid element absorbing solid matter and the aeriform element taking up heat. What distinguishes them is that water has a 'cold' nature, from which it gains its density; while air has a 'warm' nature, to which it owes its tendency to expand.

In the most general sense, the quality 'moist' applies wherever two different entities are drawn into some kind of intimate relationship with one another; 'dry' applies where no such relationship prevails. Seen thus, they reveal themselves as a true polarity of the second order, for they describe the relationship between two entities which already exists, and, in the case of the four elements, are themselves a polarity. As such, they characterize precisely those polar relationships of the second order on which the threefold structure of man, we found, is based. For from the physical, as much as from the superphysical aspect the nerve-system represents the 'dry' part, and the metabolic system the 'moist' part of man's being. The same is true of the relationship between the soul and the surrounding world at both poles. Here we have the antithesis between the 'dry' onlooker-relationship of the intellect to the world, conceived as a mere picture whose essence remains outside the boundaries of the soul, and the 'moist' intermingling of the will-force with the actual forces of the world.

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It needs no further explanation to realize that sulphur and phosphorus, by the way in which levity and gravity are interlinked in each of them, are representatives of these very qualities 'moist' and 'dry'. As such they are universally active bearers of these qualities in every realm of nature's varied activities, as their physical presence in such cases confirms. Consequently, sulphur is found in the protein-substances of the human body wherever they are bearers of metabolic processes, while the presence of phosphorus is characteristic of the nerves and bones. (Although its full significance will become clear to us only later, the fact may here be mentioned that the composition of the bone-material in the different parts of man's skeleton, as scientific analysis has shown, is such that the content of phosphate of calcium in proportion to carbonate of calcium is higher in all those parts which are spherically shaped, such as the upper parts of the skull and the upper ends of the limb-bones.)

In particular the plant reveals clearly the functional significance of phosphorus as the bearer of the quality 'dry'. For its healthy growth the plant needs the quality 'dry' in two places: at the root, where it unites with the element earth, and in the flower, where it opens itself to the fire element. Root and flower as distinct from the middle parts of the plant are both 'dry' formations. In a still higher degree this applies to the seed, which must separate itself from the mother plant to produce a separate new organism. All these are functions in the plant which, as was mentioned in the last chapter, require phosphorus for their healthy performance.

Our examination of phosphorus and sulphur from the functional point of view throws light also on their effect on the alternating conditions of waking and sleeping, necessary for the life of the higher organisms. This rhythmic change, which affects especially the nervous system, is an alternation between the qualities dry and moist. Disturbance of this alternation in one direction or the other makes it difficult for the organism to react in full wakefulness or normal sleep. It follows that treatment with phosphorus or sulphur in suitable preparations, according to the nature of the disturbance, can be beneficial.

If we study the functional properties of such substances we see that they can teach us a rational understanding of therapeutic practices, which otherwise must remain mere results of trial and error. The same applies to phosphorus and sulphur treatment in cases where in the functionally 'dry' bone system or in the functionally 'moist' metabolic system of the organism the wrong quality predominates. If the bones remain too 'moist' there is a tendency to rickets; against this, certain fish-oils are a well-known remedy on account of their highly phosphoric nature. Conversely, the application of sulphur can help where weakness of the metabolic forces produces rheumatic or gouty sediments in parts of the body whose function is to serve by their mobility the activities of the will. In this case the abnormal predominance of the quality 'dry' can be counteracted by the medical application of sulphur.

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Having observed the action of sulphur and phosphorus in the laboratory and in living organisms, we will now turn to phenomena of a macrotelluric nature which reveal the participation of sulphur and phosphorus. There, sulphur points unmistakably to the earth's volcanism. It is a fact that, wherever mineral sulphur occurs in the earth, there we find a spot of former or present volcanic activity. Similarly, there is no such spot on the earth without sulphur being present in one form or another. Hence the name *Solfatara* for the fumarole described in Chapter IX.

Once again it is the *Solfatara* which offers us a phenomenon, this time in connexion with the special role sulphur plays in its activities, which, regarded with the eye of the spirit, assumes the significance of an instance 'worth a thousand'.

In spite of the very high temperature of the sulghurous fumes emitted from various crevices on the edge of the *Solfatara,* it is possible, thanks to the complete dryness of the fumes, to crawl a little way into the interior of these crevices. Not far away from the opening of the crevice, where the hot fumes touch the cooler rock surface, one is met by a very beautiful spectacle—namely, the continual forming, out of nothing as it seems, of glittering yellow sulphur crystals, suspended in delicate chains from the ceiling.

In this transformation of sulphurous substance from a higher material state, nearer to levity, to that of the solid crystal, we may behold an image of the generation of matter. *For every physical substance and, therefore, every chemical element, exists originally as a pure function in the dynamic processes of the universe.* Wherever, as a result of the action of gravity, such a function congeals materially, there we meet it in the form of a physical-material substance. In the same sense, sulphur and phosphorus, in their real being, are pure functions, and where they occur as physical substances, there we meet these functions in their congealed state.

One of the characteristics of the volcanic regions of the earth is the healing effect of substances found there. Fango-mud, for instance, which was mentioned in the last chapter, is a much-used remedy against rheumatism. This is typical of functional sulphur. We may truly characterize the earth's volcanism as being qualitatively sulphurous. It is the sulphur-function coming to expression through a higher degree of 'moistness' in the relationship between gravity and levity which distinguishes volcanic regions from the rest of the otherwise 'dry' earth's crust.

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To develop a corresponding picture of the function of phosphorus, we must try to find the macrotelluric sphere where this function operates similarly to that of sulphur in volcanism. From what has been said in the last chapter it will be evident that we must look to the atmosphere, as the site of snow-formation. It is this process which we must now examine more closely.

In the atmosphere, to begin with, we find water in a state of vapour, in which the influence of the terrestrial gravity-field is comparatively weak. Floating in this state, the vapour condenses and crystallization proceeds. Obeying the pull of gravity, more and more crystals unite in their descent and gradually form flakes of varying sizes. The nearer they come to earth, the closer they fall, until at last on the ground they form an unbroken, more or less spherical, cover.

Imagine a snow-covered field glistening in the sun on a clear, quiet winter's day. As far as we can see, there is no sign of life, no movement. Here water, which is normally fluid and, in its liquid state, serves the ever-changing life-processes, covers the earth in the form of millions of separate crystals shaped with mathematical exactitude, each of which breaks and reflects in a million rays the light from the sun (Plate V). A contrast, indeed, between this quiet emergence of forms from levity into gravity, and the form-denying volcanism surging up out of gravity into levity, as shown by the ever-restless activity of the *Solfatara*. As we found volcanism to be a macrotelluric manifestation of functional sulphur, we find in the process of snow-formation a corresponding manifestation of functional phosphorus.

In the formation of snow, nature shows us *in statu agendi a* process which we otherwise meet in the earth only in its finished results, crystallization. We may, therefore, rightly look upon snow-formation as an ur-phenomenon in this sphere of nature's activities. As such it allows us to learn something concerning the origin in general of the crystalline realm of the earth; and, vice versa, our insight into the 'becoming' of this realm will enable us to see more clearly the universal function of which phosphorus is the main representative among the physical substances of the earth.

It has puzzled many an observer that crystals occur in the earth with directions of their main axes entirely independent of the direction of the earthly pull of gravity. Plate VI shows the photograph of a cluster of Calcite crystals as an example of this phenomenon. It tells us that gravity can have no effect on the formation of the crystal itself. This riddle is solved by the phenomenon of snow-formation provided we allow it to speak to us as an ur-phenomenon. For it then tells us that matter must be in a state of transition from lightness into heaviness if it is to appear in crystalline form. The crystals in the earth, therefore, must have originated at a time when the relation between levity and gravity on the earth was different from what it is, in *this* sphere, to-day.

The same language is spoken by the property of transparency which is so predominant among crystals. One of the fundamental characteristics of heavy solid matter is to resist light—in other words, to be opaque. Exposed to heat, however, physical substance loses this feature to the extent that at the border of its ponderability all matter becomes pervious to light. Now, in the transparent crystal matter retains this kinship to light even in its solid state.

A similar message comes from the, often so mysterious, colouring of the crystals. Here again nature offers us an instance which, 'worth a thousand', reveals a secret that would otherwise remain veiled. We refer to the pink crystals of tourmaline, whose colour comes from a small admixture of lithium. This element, which belongs to the group of the alkaline metals, does not form coloured salts (a property only shown by the heavier metals). If exposed to a flame, however, it endows it with a definite colour which is the same as that of the lithium-coloured tourmaline. Read as a letter in nature's script, this fact tells us that precious stones with their flame-like colours are characterized by having kept something of the nature that was theirs before they coalesced into ponderable existence. In fact, they are 'frozen flames'.

It is this fact, known from ancient intuitive experience, which prompted man of old to attribute particular spiritual significance to the various precious stones of the earth and to use them correspondingly in his rituals.

Crystallization, seen thus in its cosmic aspect, shows a dynamic orientation which is polarically opposite to that of the earth's seismic activities. Just as in the latter we observe levity taking hold of ponderable matter and moving it in a direction opposite to the pull of gravity, so in crystallization we see imponderable matter passing over from levity into gravity. And just as we found in volcanism and related processes a field of activity of 'functional sulphur', so we found in snow-formation and related processes a field of activity of 'functional phosphorus'. Both fields are characterized by an interaction between gravity and levity, this interaction being of opposite nature in each of them.

Here, again, sulphur and phosphorus appear as bearers of a polarity of the second order which springs from the two polarically opposite ways of interaction between the poles of the polarity of the first order: levity-gravity.

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As in man there is a third system, mediating between the two polar systems of his organism, so between sulphur and phosphorus there is a third element which in all its characteristics holds a middle place between them and is the bearer of a corresponding function. This element is carbon.

To see this we need only take into consideration carbon's relationship to oxidation and reduction respectively. As it is natural for sulphur to be in the reduced state, and for phosphorus to be in the oxidized state, so it is in the nature of carbon to be related to both states and therefore to oscillate between them. By its readiness to change over from the oxidized to the reduced state, it can serve the plant in the assimilation of light, while by its readiness to make the reverse change it serves man and animal in the breathing process. We breathe in oxygen from the air; the oxygen circulates through the blood-stream and passes out again in conjunction with carbon, as carbon dioxide, when we exhale. In the process whereby the plants reduce the carbon dioxide exhaled by man and animal, while the latter again absorb with their food the carbon produced in the form of organic matter by the plant, we see carbon moving to and fro between the oxidized and the reduced conditions.

Within the plant itself, too, carbon acts as functionary of the alternation between oxidation and reduction. During the first half of the year, when vegetation is unfolding, there is a great reduction process of oxidized carbon, while in the second half of the year, when the withering process prevails, a great deal of the previously reduced carbon passes into the oxidized condition. As this is connected with exhaling and inhaling of oxygen through carbon, carbon can be regarded as having the function of the lung-organ of the earth. Logically enough, we find carbon playing the same role in the middle part of the threefold human organism.

Another indication of the midway position of carbon is its ability to combine as readily with hydrogen as with oxygen, and, in these polar combinations, even to combine with itself. In this latter form it provides the basis of the innumerable organic substances in nature, and serves as the 'building stones' of the body-substances of living organisms. Among these, the carbohydrates produced by the plants show clearly the double function of carbon in the way it alternates between the states of starch and sugar.

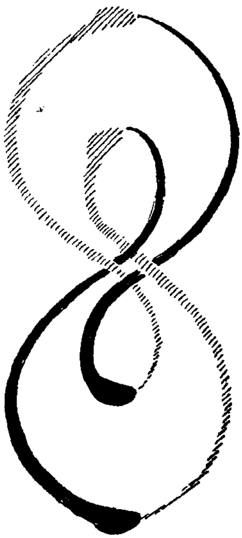

FIG. 6.

When the plant absorbs through its leaves carbonic acid from the air and condenses it into the multiple grains of starch with their peculiar structure characteristic for each plant species, we have a biological event which corresponds to the formation of snow in the meteorological realm. Here we see carbon at work in a manner functionally akin to that of phosphorus. Sugar, on the other hand, has its place in the saps of the plants which rise through the stems and carry up with them the mineral substances of the earth. Here we find carbon acting in a way akin to the function of sulphur.

This twofold nature of carbon makes itself noticeable down to the very mineral sphere of the earth. There we find it in the fact that carbon occurs both in the form of the diamond, the hardest of all mineral substances, and also in the form of the softest, graphite. Here also, in the diamond's brilliant transparency, and in the dense blackness of graphite, carbon reveals its twofold relation to light.

In Fig. 6 an attempt has been made to represent diagrammatically the function of Carbon in a way corresponding to the previous representation of the functions of Sulphur and Phosphorus.

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By adding carbon to our observations on the polarity of sulphur and phosphorus we have been led to a triad of functions each of which expresses a specific interplay of levity and gravity. That we encounter three such functions is not accidental or arbitrary. Rather is it based on the fact that the interaction of forces emanating from a polarity of the first order, produces a polarity of the second order, whose poles establish between them a sphere of balance.

Through our study of levity and gravity in the matter-processes of the earth, a perspective thus opens up into a structural principle of nature which is actually not new to us. We encountered it at the very beginning of this book when we discussed the threefold psycho-physical order of man's being.

In the days of an older intuitive nature-wisdom man knew of a basic triad of functions as well as he knew of the four elementary qualities. We hear a last echo of this in the Middle Ages, when people striving for a deeper understanding of nature spoke of the trinity of Salt, Mercury and Sulphur. What the true alchemists, as these seekers of knowledge called themselves, meant by this was precisely the same as the conception we have here reached through our own way of studying matter ('Salt' standing for 'functional phosphorus', 'Mercury' for 'functional carbon'). Only the alchemist's way was a different one.

This is not the place to enter into a full examination of the meaning and value of alchemy in its original legitimate sense (which must not be confused with activities that later on paraded under the same name). Only this we will say—that genuine alchemy owes its origin to an impulse which, at a time when the onlooker-consciousness first arose, led to the foundation of a school for the development of an intuitive relationship of the soul with the world of the senses. This was to enable man to resist the effects of the division which evolution was about to set up in his soul-life—the division which was to give him, on the one hand, an abstract experience of his own self, divorced from the outer world, and on the other a mere onlooker's experience of that outer world. As a result of these endeavours, concepts were formed which in their literal meaning seemed to apply merely to outwardly perceptible substances, while in truth they stood for the spiritual functions represented by those substances, both within and outside the human organism.

Thus the alchemist who used these concepts thought of them first as referring to his own soul, and to the inner organic processes corresponding to the various activities of his soul. When speaking of Salt he meant the regulated formative activity of his thinking, based on the salt-forming process in his nervous system. When he spoke of Mercury he meant the quickly changing emotional life of the soul and the corresponding activities of the rhythmic processes of the body. Lastly, Sulphur meant the will activities of his soul and the corresponding metabolic processes of the body. Only through studying these functions within himself, and through re-establishing the harmony between them which had been theirs in the beginning, and from which, he felt, man had deviated in the course of time, did the alchemist hope to come to an understanding of their counterparts in the external cosmos.

Older alchemical writings, therefore, can be understood only if prescriptions which seem to signify certain chemical manipulations are read as instructions for certain exercises of the soul, or as advices for the redirection of corresponding processes in the body. For instance, if an alchemist gave directions for a certain treatment of Sulphur, Mercury and Salt, with the assertion that by carrying out these directions properly, one would obtain Aurum (gold), he really spoke of a method to direct the thinking, feeling and willing activities of the soul in such a way as to gain true Wisdom.[1]

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[1] Roger Bacon in the thirteenth, and Berthold Schwartz in the fourteenth century, are reputed to have carried out experiments by mixing physical salt (in the form of the chemically labile saltpetre) with physical sulphur and—after some initial attempts with various metals—-with charcoal, and then exposing the mixture to the heat of physical fire. The outcome of this purely materialistic interpretation of the three alchemical concepts was not the acquisition of wisdom, or, as Schwartz certainly had hoped, of gold, but of ... gunpowder!

As in the case of the concepts constituting the doctrine of the four elements, we have represented here the basic alchemical concepts not only because of their historical significance, but because, as ingredients of a still functional conception of nature, they assume new significance in a science which seeks to develop, though from different starting-points, a similar conception. As will be seen in our further studies, these concepts prove a welcome enrichment of the language in which we must try to express our readings in nature.

CHAPTER XII

Space and Counter-Space

With the introduction, in Chapter X, of the peripheral type of force-field which appertains to levity as the usual central one does to gravity, we are compelled to revise our conception of space. For in a space of a kind we are accustomed to conceive, that is, the three-dimensional, Euclidean space, the existence of such a field with its characteristic of *increasing* in strength in the *outward* direction is a paradox, contrary to mathematical logic.

This task, which in view of our further observations of the actions of the levity-gravity polarity in nature we must now tackle, is, however, by no means insoluble. For in modern mathematics thought-forms are already present which make it possible to develop a space-concept adequate to levity. As referred to in Chapter I, it was Rudolf Steiner who first pointed to the significance in this respect of the branch of modern mathematics known as Projective Geometry. He showed that Projective Geometry, if rightly used, carries over the mind from the customary abstract to a new concrete treatment of mathematical concepts. The following example will serve to explain, to start with, what we mean by saying that mathematics has hitherto been used abstractly.

One of the reasons why the world-picture developed by Einstein in his Theory of Relativity deserves to be acknowledged as a step forward in comparison with the picture drawn by classical physics, lies in the fact that the old conception of three-dimensional space as a kind of 'cosmic container', extending in all directions into infinity and filled, as it were, with the content of the physical universe, is replaced by a conception in which the structure of space results from the laws interrelating this content. Our further discussion will show that this indeed is the way along which, to-day, mathematical thought must move in order to cope with universal reality.

However, for reasons discussed earlier, Einstein was forced to conceive all events in the universe after the model of gravity as observable on the earth. In this way he arrived at a space-structure which possesses neither the three-dimensionality nor the rectilinear character of so-called Euclidean space—a space-picture which, though mathematically consistent, is incomprehensible by the human mind. For nothing exists in our mind that could enable us to experience as a reality a space-time continuum of three dimensions which is curved within a further dimension.

This outcome of Einstein's endeavours results from the fact that he tried by means of gravity-bound thought to comprehend universal happenings of which the true causes are non-gravitational. A thinking that has learnt to acknowledge the existence of levity must indeed pursue precisely the opposite direction. Instead of freezing time down into spatial dimension, in order to make it fit into a world ruled by nothing but gravity, we must develop a conception of space sufficiently fluid to let true time have its place therein. We shall see how such a procedure will lead us to a space-concept thoroughly conceivable by human common sense, provided we are prepared to overcome the onlooker-standpoint in mathematics also.

Einstein owed the possibility of establishing his space-picture to a certain achievement of mathematical thinking in modern times. As we have seen, one of the peculiarities of the onlooker-consciousness consists in its being devoid of all connexion with reality. The process of thinking thereby gained a degree of freedom which did not exist in former ages. In consequence, mathematicians were enabled in the course of the nineteenth century to conceive the most varied space-systems which were all mathematically consistent and yet lacked all relation to external existence. A considerable number of space-systems have thus become established among which there is the system that served Einstein to derive his space-time concept. Some of them have been more or less fully worked out, while in certain instances all that has been done is to show that they are mathematically conceivable. Among these there is one which in all its characteristics is polarically opposite to the Euclidean system, and which is destined for this reason to become the space-system of levity. It is symptomatic of the remoteness from reality of mathematical thinking in the onlooker-age that precisely this system has so far received no special attention.[1]

[1] For further details, see the writings of G. Adams and L. Locher-Ernst who, each in his own way, have made a beginning with applying projective geometry on the lines indicated by Rudolf Steiner. Professor Locher-Ernst was the first to apply the term 'polar-Euclidean' to the space-system corresponding to levity.

For the purpose of this book it is not necessary to expound in detail why modern mathematical thinking has been led to look for thought-forms other than those of classical geometry. It is enough to remark that for quite a long time there had been an awareness of the fact that the consistency of Euclid's definitions and proofs fails as soon as one has no longer to do with finite geometrical entities, but with figures which extend into infinity, as for instance when the properties of parallel straight lines come into question. For the concept of infinity was foreign to classical geometrical thinking. Problems of the kind which had defeated Euclidean thinking became soluble directly human thinking was able to handle the concept of infinity.

We shall now indicate some of the lines of geometrical thought which follow from this.

*

Let us consider a straight line extending without limits in either direction. Projective geometry is able to state that a point moving along this line in one direction will eventually return from the other. To see this, we imagine two straight lines *a* and *b* intersecting at P. One of these lines is fixed *(a);* the other *(b)* rotates uniformly about C. Fig. 7 indicates the rotation of *b* by showing it in a number of

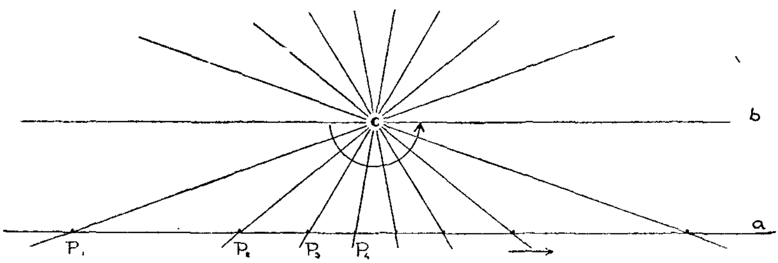

FIG. 7.

positions with the respective positions of its point of intersection with *a* (P_1, P_2. . .). We observe this point moving along *a,* as a result of the rotation of *b,* until, when both lines are parallel, it reaches infinity. As a result of the continued rotation of *b,* however, P does not remain in infinity, but returns along *a* from the other side.

We find here two forms of movement linked together—the rotational movement of a line *(b)* on a point (C), and the progressive movement of a point (P) along a line (a). The first movement is continuous, and observable throughout within finite space. Therefore the second movement must be continuous as well, even though it partly escapes our observation. Hence, when P disappears into infinity on one side of our own point of observation, it is at the same time in infinity on the other side. In order words, an unlimited straight line has only one point at infinity.

It is clear that, in order to become familiar with this aspect of geometry, one must grow together in inward activity with the *happening* which is contained in the above description. What we therefore intend by giving such a description is to provide an opportunity for a particular mental exercise, just as when we introduced Goethe's botany by describing a number of successive leaf-formations. Here, as much as there, it is the act of 're-creating' that matters.

The following exercise will help us towards further clarity concerning the nature of geometrical infinity.

We imagine ourselves in the centre of a sphere which we allow to expand uniformly on all sides. Whilst the inner wall of this sphere withdraws from us into ever greater distances, it grows flatter and flatter until, on reaching infinite distance, it turns into a plane. We thus find ourselves surrounded everywhere by a surface which, in the strict mathematical sense, is a plane, and is yet one and the same surface on all sides. This leads us to the conception of the plane at infinity as a self-contained entity although it expands infinitely in all directions.

This property of a plane at infinity, however, is really a property of any plane. To realize this, we must widen our conception of infinity by freeing it from a certain one-sidedness still connected with it. This we do by transferring ourselves into the infinite plane and envisaging, not the plane from the point, but the point from the plane. This operation, however, implies something which is not obvious to a mind accustomed to the ordinary ways of mathematical reasoning. It therefore requires special explanation.

In the sense of Euclidean geometry, a plane is the sum-total of innumerable single points. To take up a position in a plane, therefore, means to imagine oneself at one point of the plane, with the latter extending around in all directions to infinity. Hence the journey from any point in space to a plane is along a straight line from one point to another. In the case of the plane being at infinity, it would be a journey along a radius of the infinitely large sphere from its centre to a point at its circumference.

In projective geometry the operation is of a different character. Just as we arrived at the infinitely large sphere by letting a finite sphere grow, so must we consider any finite sphere as having grown from a sphere with infinitely small extension; that is, from a point. To travel from the point to the infinitely distant plane in the sense of projective geometry, therefore, means that we have first to identify ourselves with the point and 'become' the plane by a process of uniform expansion in all directions.

As a result of this we do not arrive at one point in the plane, with the latter extending round us on all sides, but we are present in the plane as a whole everywhere. No point in it can be characterized as having any distance, whether finite or infinite, from us. Nor is there any sense in speaking of the plane itself as being at infinity. For any plane will allow us to identify ourselves with it in this way. And any such plane can be given the character of a plane at infinity by relating it to a point infinitely far away from it (i.e. from us).

Having thus dropped the one-sided conception of infinity, we must look for another characterization of the relationship between a point and a plane which are infinitely distant from one another. This requires, first of all, a proper characterization of Point and Plane in themselves.

Conceived dynamically, as projective geometry requires, Point and Plane represent a pair of opposites, the Point standing for utmost contraction, the Plane for utmost expansion. As such, they form a polarity of the first order. Both together constitute Space. Which sort of space this is, depends on the relationship in which they are envisaged. By positing the point as the unit from which to start, and deriving our conception of the plane from the point, we constitute Euclidean space. By starting in the manner described above, with the plane as the unit, and conceiving the point from it, we constitute polar-Euclidean space.

The realization of the reversibility of the relationship between Point and Plane leads to a conception of Space still free from any specific character. By G. Adams this space has been appositely called archetypal space, or ur-space. Both Euclidean and polar-Euclidean space are particular manifestations of it, their mutual relationship being one of metamorphosis in the Goethean sense.

Through conceiving Euclidean and polar-Euclidean space in this manner it becomes clear that they are nothing else than the geometrical expression of the relationship between gravity and levity. For gravity, through its field spreading outward from an inner centre, establishes a point-to-point relation between all things under its sway; whereas levity draws all things within its domain into common plane-relations by establishing field-conditions wherein action takes place from the periphery towards the centre. What distinguishes in both cases the plane at infinity from all other planes may be best described by calling it the *all-embracing plane*; correspondingly the point at infinity may be best described as the *all-relating point.*

In outer nature the all-embracing plane is as much the 'centre' of the earth's field of levity as the all-relating point is the centre of her field of gravity. All actions of dynamic entities, such as that of the ur-plant and its subordinate types, start from this plane. Seeds, eye-formations, etc., are nothing but individual all-relating points in respect of this plane. All that springs from such points does so because of the point's relation to the all-embracing plane. This may suffice to show how realistic are the mathematical concepts which we have here tried to build up.

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When we set out earlier in this book (Chapter VIII) to discover the source of Galileo's intuition, by which he had been enabled to find the theorem of the parallelogram of forces, we were led to certain experiences through which all men go in early childhood by erecting their body and learning to walk. We were thereby led to realize that man's general capacity for thinking mathematically is the outcome of early experiences of this kind. It is evident that geometrical concepts arising in man's mind in this way must be those of Euclidean geometry. For they are acquired by the will's struggle with gravity. The dynamic law discovered in this way by Galileo was therefore bound to apply to the behaviour of mechanical forces—that is, of forces acting from points outward.

In a similar way we can now seek to find the source of our capacity to form polar-Euclidean concepts. As we were formerly led to experiences of man's early life on earth, so we are now led to his embryonic and even pre-embryonic existence.

Before man's supersensible part enters into a physical body there is no means of conveying to it experiences other than those of levity, and this condition prevails right through embryonic development. For while the body floats in the mother's foetal fluid it is virtually exempt from the influence of the earth's field of gravity.

History has given us a source of information from these early periods of man's existence in Traherne's recollections of the time when his soul was still in the state of cosmic consciousness. Among his descriptions we may therefore expect to find a picture of levity-space which will confirm through immediate experience what we have arrived at along the lines of realistic mathematical reasoning. Among poems quoted earlier, his *The Praeparative* and *My Spirit* do indeed convey this picture in the clearest possible way. The following are relevant passages from these two poems.

In the first we read:

'Then was my Soul my only All to me,
A living endless Ey,
Scarce bounded with the Sky
Whose Power, and Act, and Essence was to see:
I was an inward Sphere of Light,
Or an interminable Orb of Sight,
Exceeding that which makes the Days . . .'

In the second poem the same experience is expressed in richer detail. There he says of his own soul that it—

. . . *being Simple, like the Deity,*
In its own Centre is a Sphere,
Not limited but everywhere.

It acts not from a Centre to
Its Object, as remote;
But present is, where it doth go
To view the Being it doth note . . .

A strange extended Orb of Joy
Proceeding from within,
Which did on ev'ry side display
Its force; and being nigh of Kin
To God, did ev'ry way
Dilate its Self ev'n instantaneously,

Yet an Indivisible Centre stay,
In it surrounding all Eternity.
'Twas not a Sphere;
Yet did appear
One infinite: 'Twas somewhat everywhere.'

Observe the distinct description of how the relation between circumference and centre is inverted by the former becoming itself an 'indivisible centre'. In a space of this kind there is no Here and There, as in Euclidean space, for the consciousness is always and immediately at one with the whole space. Motion is thus quite different from what it is in Euclidean space. Traherne himself italicized the word 'instantaneous', so important did he find this fact. (The quality of instantaneousness—equal from the physical point of view to a velocity of the value ∞ —will occupy us more closely as a characteristic of the realm of levity when we come to discuss the apparent velocity of light in connexion with our optical studies.)

By thus realizing the source in man of the polar-Euclidean thought-forms, we see the discovery of projective geometry in a new light. For it now assumes the significance of yet another historical symptom of the modern re-awakening of man's capacity to remember his pre-natal existence.

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We know from our previous studies that the concept of polarity is not exhausted by conceiving the world as being constituted by polarities of one order only. Besides primary polarities, there are secondary ones, the outcome of interaction between the primary poles. Having conceived of Point and Plane as a geometrical polarity of the first order, we have therefore to ask what formative elements there are in geometry which represent the corresponding polarity of the second order. The following considerations will show that these are the radius, which arises from the point becoming related to the plane, and the spherically bent surface (for which we have no other name than that again of the sphere), arising from the plane becoming related to the point.

In Euclidean geometry the sphere is defined as 'the locus of all points which are equidistant from a given point'. To define the sphere in this way is in accord with our post-natal, gravity-bound consciousness. For in this state our mind can do no more than envisage the surface of the sphere point by point from its centre and recognize the equal distance of all these points from the centre. Seen thus, the sphere arises as the sum-total of the end-points of all the straight lines of equal length which emerge from the centre-point in all directions. Fig. 8 indicates this schematically. Here the radius, a straight line, is clearly the determining factor.

We now move to the other pole of the primary polarity, that is to the plane, and let the sphere arise by imagining the plane approaching an infinitely distant point evenly from all sides. We view the process realistically only by imagining ourselves in the plane, so that we surround the point from all sides, with the distance between us and

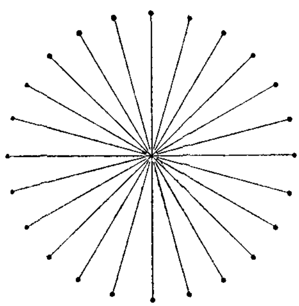

FIG. 8.

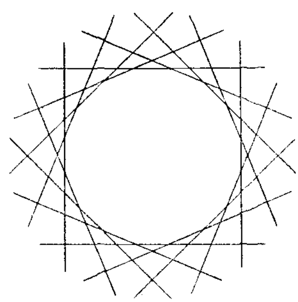

FIG. 9.

the point diminishing gradually. Since we remain all the time on the surface, we have no reason to conceive any change in its original position; that is, we continue to think of it as an all-embracing plane with regard to the chosen point.

The only way of representing the sphere diagrammatically, as a unit bearing in itself the character of the plane whence it sprang, is as shown in Fig. 9, where a number of planes, functioning as tangential planes, are so related that together they form a surface which possesses everywhere the same distance from the all-relating point.

Since Point and Plane represent in the realm of geometrical concepts what in outer nature we find in the form of the gravity-levity polarity, we may expect to meet Radius and Sphere as actual formative elements in nature, wherever gravity and levity interact in one way or another. A few observations may suffice to give the necessary evidence. Further confirmation will be furnished by the ensuing chapters.

The Radius-Sphere antithesis appears most obviously in the human body, the radial element being represented by the limbs, the spherical by the skull. The limbs thus become the hieroglyph of a dynamic directed from the Point to the Plane, and the skull of the opposite. This indeed is in accord with the distribution in the organism of the sulphur-salt polarity, as we learnt from our physiological and psychological studies. Inner processes and outer form thus reveal the same distribution of poles.

In the plant the same polarity appears in stalk and leaf. Obviously the stalk represents the radial pole. The connexion between leaf and sphere is not so clear: in order to recognize it we must appreciate that the single plant is not a self-contained entity to the same degree as is the human being. The equivalent of the single man is the entire vegetable covering of the earth. In man there is an individual centre round which the bones of his skull are curved; in the plant world the equivalent is the centre of the earth. It is in relation to this that we must conceive of the single leaves as parts of a greater sphere.

In the plant, just as in man, the morphological polarity coincides with the biological. There is, on the one hand, the process of assimilation (photosynthesis), so characteristic of the leaf. Through this process matter passes over from the aeriform condition into that of numerous separate, characteristically structured solid bodies—the starch grains. Besides this kind of assimilation we have learnt to recognize a higher form which we called 'spiritual assimilation'. Here, a transition of substance from the domain of levity to that of gravity takes place even more strikingly than in ordinary (physical) assimilation (Chapter X).

The corresponding process in the linear stalk is one which we may call 'sublimation'—again with its extension into 'spiritual sublimation'. Through this process matter is carried in the upward direction towards ever less ponderable conditions, and finally into the formless state of pure 'chaos'. By this means the seed is prepared (as we have seen) with the help of the fire-bearing pollen, so that after it has fallen to the ground, it may serve as an all-relating point to which the plant's Type can direct its activity from the universal circumference.

In order to find the corresponding morphological polarity in the animal kingdom, we must realize that the animal, by having the main axis of its body in the horizontal direction, has a relationship to the gravity-levity fields of the earth different from those of both man and plant. As a result, the single animal body shows the sphere-radius polarity much less sharply. If we compare the different groups of the animal kingdom, however, we find that the animals, too, bear this polarity as a formative element. The birds represent the spherical (dry, saline) pole; the ruminants the linear (moist, sulphurous) pole. The carnivorous quadrupeds form the intermediary (mercurial) group. As ur-phenomenal types we may name among the birds the eagle, clothed in its dry, silicic plumage, hovering with far-spread wings in the heights of the atmosphere, united with the expanses of space through its far-reaching sight; among the ruminants, the cow, lying heavily on the ground of the earth, given over entirely to the immensely elaborated sulphurous process of its own digestion. Between them comes the lion—the most characteristic animal for the preponderance of heart-and-lung activities in the body, with all the attributes resulting from that.

Within the scope of this book it can only be intimated briefly, but should not be left unmentioned for the sake of those interested in a further pursuit of these lines of thought, that the morphological mean between radius and sphere (corresponding to Mercurius in the alchemical triad) is represented by a geometrical figure known as the 'lemniscate', a particular modification of the so-called Cassinian curves.[1]

[1] For particulars of the lemniscate as the building plan of the middle part of man's skeleton, see K. König, M.D.: *Beitrage zu einer reinen Anatomic des menschlichen Knochenskeletts* in the periodical *Natura* (Dornach, 1930-1). Some projective-geometrical considerations concerning the lemniscate are to be found in the previously mentioned writings of G. Adams and L. Locher-Ernst.

CHAPTER XIII

'Radiant Matter'

When man in the state of world-onlooker undertook to form a dynamic picture of the nature of matter, it was inevitable that of all the qualities which belong to its existence he should be able to envisage only those pertaining to gravity and electricity. Because his consciousness, at this stage of its evolution, was closely bound up with the force of gravity inherent in the human body, he was unable to form any conception of levity as a force opposite to gravity. Yet, nature is built bipolarically, and polarity-concepts are therefore indispensable for developing a true understanding of her actions. This accounts for the fact that the unipolar concept of gravity had eventually to be supplemented by some kind of bipolar concept.

Now, the only sphere of nature-phenomena with a bipolar character accessible to the onlooker-consciousness 'was that of electricity. It was thus that man in this state of consciousness was compelled to picture the foundation of the physical universe as being made up of gravity and electricity, as we meet them in the modern picture of the atom, with its heavy electro-positive nucleus and the virtually weightless electro-negative electrons moving round it.

Once scientific observation and thought are freed from the limitations of the onlooker-consciousness, both gravity and electricity appear in a new perspective, though the change is different for each of them. Gravity, while it becomes one pole of a polarity, with levity as the opposite pole, still retains its character as a fundamental force of the physical universe, the gravity-levity polarity being one of the first order. Not so electricity. For, as the following discussion will show, the electrical polarity is one of the second order; moreover, instead of constituting matter as is usually believed, electricity turns out to be in reality a product of matter.

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We follow Goethe's line when, in order to answer the question, 'What is electricity?' we first ask, 'How does electricity arise?' Instead of starting with phenomena produced by electricity when it is already in action, and deriving from them a hypothetical picture, we begin by observing the processes to which electricity owes its appearance. Since there is significance in the historical order in which facts of nature have come to man's knowledge in the past, we choose as our starting-point, among the various modes of generating electricity, the one through which the existence of an electric force first became known. This is the rousing of the electric state in a body by rubbing it with another body of different material composition. Originally, amber was rubbed with wool or fur.

By picturing this process in our mind we become aware of a certain kinship of electricity with fire, since for ages the only known way of kindling fire was through friction. We notice that in both cases man had to resort to the will-power invested in his limbs for setting in motion two pieces of matter, so that, by overcoming their resistance to this motion, he released from them a certain force which he could utilize as a supplement to his own will. The similarity of the two processes may be taken as a sign that heat and electricity are related to each other in a certain way, the one being in some sense a metamorphosis of the other. Our first task, therefore, will be to try to understand how it is that friction causes heat to appear in manifest form.

There is no friction unless the surfaces of the rubbed bodies have a structure that is in some way interfered with by the rubbing, while at the same time they offer a certain resistance to the disturbance. This resistance is due to a characteristic of matter, commonly called cohesion. Now we know that the inner coherence of a physical body is due to its point-relationship, that is to the gravitational force bound up with it. Indeed, cohesion increases as we pass from the gaseous, through the liquid, to the solid state of matter.

Whilst a body's cohesion is due to gravity, its spatial extendedness is, as we have seen, due to levity. If we reduce the volume of a piece of physical matter by means of pressure, we therefore release levity-forces previously bound up in it, and these, as always happens in such cases, appear in the form of free heat. Figuratively speaking, we may say that by applying pressure to matter, latent levity is pressed out of it, somewhat like water out of a wet sponge.

The generation of free heat by friction rests on quite similar grounds. Obviously, friction always requires a certain pressure. This alone, however, would not account for the amount of heat easily produced by friction. To the pressure there is in this case added a certain measure of encroachment upon the unity of the material substance. In the case of friction between two solid bodies, this may go so far that particles of matter are completely detached from the cohesive whole. The result is an increase in the number of single mass-centres on the earth, as against the all-embracing cosmic periphery. This diminishes the hold of levity on the total amount of physical matter present on the earth. Again, the levity thus becoming free appears as external heat. (In the reverse case when, for instance through melting, a number of single physical bodies become one, free heat becomes latent.)

Both the diminishing of spatial extension and the breaking up of a whole into parts entail an increase in the quality 'dry'. This applies not only in the sense that the parts which have become independent units are 'dry' in relation to each other—formerly coherent matter being turned into dust—but also in the other sense, and one valid in both cases, that levity and gravity are losing part of their previous inter-connexion. If this twofold process of 'becoming dry' reaches a certain intensity, the substances concerned, provided they are inflammable, begin to burn, with the result that dry heat escapes and dry ash is formed. We note that in each case we are dealing with a change in the relationship between the poles of a polarity of the first order.

We will now apply this picture of the process of friction to the instance when, as a result of this action, electricity appears.

Originally the evoking of the electric condition was ascribed solely to the nature of amber, the only substance known to possess this property. To-day we know that not the amber alone, but its coming together with another substance of different nature, in this instance an animal substance of the nature of hair or silk, is required. Whatever substances we use for friction, they must always be different in nature, so as to allow both kinds of electricity to appear at once. Which of the two kinds imposes its presence the more strongly upon the observer depends on purely extraneous conditions which have nothing to do with the process itself.

Obviously, if we wish to understand the qualitative difference between the two kinds of electricity, we must investigate the qualitative difference in the material substances, which give rise to electricity when they are rubbed together. We shall again follow the historical line by examining the two substances which first taught man the polar nature of electricity. They are glass and resin, after which, as we mentioned, the two electricities were even named in the beginning.

Our functional conception of matter, developed earlier (Chapter XI), allows us to recognize in these two substances representatives of the Salt-Sulphur polarity. Indeed, glass as a mineral substance, which actually owes its specific character to the presence of silicon in it, clearly stands on the phosphoric-crystalline side, while resin, being itself a sort of 'gum', on the sulphurous-volcanic side. In fact, sulphur itself was soon found to be a particularly suitable substance for producing 'resin'-electricity.

Now the usual way of producing one kind of electricity is by rubbing resin (or sulphur, or ebonite) with wool or fur, and the other by rubbing glass with leather. At first sight, it does not seem as if the two counter-substances represent the required alchemic counter-poles to resin and glass. For both hair and leather are animal products and therefore seem to be of like nature. Closer inspection, however, shows that they do obey the rule. For hair, like all horny substances, is a dead product of external secretion by the animal organism. An ur-phenomenal example of it, showing its kinship to glass-like substances, is the transparent cornea of the eye, close to the crystal-lens. Leather, on the other hand, is a product of the hypodermic part of the body and, as such, belongs to those parts of the organism which are filled with blood, and, therefore, permeated with life. (Note as a characteristic of leather that it requires a special treatment, tanning, to make it as immune from decay as hair is by nature.) Hair and leather, therefore, represent in themselves a salt-sulphur polarity, and thus fulfil the corresponding function when brought together with resin or glass respectively.

What is true for the particular substances which originally led man to discover the dual nature of electricity, holds good equally for any pair of substances capable of assuming the electric state when rubbed against each other. If we examine from this point of view the series of such substances, as usually given in the textbooks on electricity, we shall always find a substance of extreme salt-character at the one end, and one of extreme sulphur-character at the other, the substances as a whole forming a gradual transition from one extreme to the other. Which kind of electricity appears on each, when submitted to friction, depends on whether the counter-substance stands on its right or left, in the series. It is the particular relation between the two which makes them behave in one way or the other.

There are cases which seem to elude this law, and investigation has shown that other characteristics of the rubbed bodies, such as surface quality, can have a modifying influence. For lack of a guiding idea they are treated in the textbooks as 'irregularities'. Observation led by a true polarity concept shows that in these cases also the rule is not violated. In this respect, interesting information can be gained from the observations of J. W. Ritter (1776-1810), an ingenious *Naturphilosoph* from the circle round Goethe, but to whom, also, physical science is indebted for his discovery of the ultra-violet part of the spectrum and of galvanic polarization. Among his writings there is a treatise on electricity, giving many generally unknown instances of frictional electricity which are in good accord with our picture and well worth investigating. According to Ritter, even two crystalline substances of different hardness, such as Calcite and quartz, become electric when rubbed together, the softer playing the part of 'resin' and the harder that of 'glass'.

These few facts connected with the generation of frictional electricity are enough to allow us to form a picture of the nature of the polarity represented by the two kinds of electricity.

We remember that in the case of the generation of heat through friction, as a result of an encroachment upon the cohesion of the material body involved, the relationship between levity and gravity in it changes from 'moist' to 'dry' and that the effect of this is the appearance of 'fire' and 'dust' as poles of a primary polarity. This process, however, is altered when the bodies subjected to friction are opposed to each other in the sense of a salt-sulphur polarity. The effect then is that the liberated levity, under the influence of the peculiar tension between the two bodies, remains bound in the realm of substance and becomes itself split up polarically.

Clearly, then, in the case of electrical polarity we encounter a certain form *of gravity-bound levity*, and this in a twofold way. Owing to the contrasting nature of the two bodies involved in the process, the coupling of gravity and levity is a polar one on both sides. The electrical polarity thus turns out to be itself of the nature of a secondary polarity.

Two more recently discovered means of evoking the electric condition in a piece of matter confirm this picture. They are the so-called piezoelectricity and pyro-electricity. Both signify the occurrence of the electrical polarity at the two ends of an asymmetrically built (hemimorphous) crystal, as the result of changing the crystal's spatial condition. In piezo-electricity the change consists in a diminution of the crystal's volume through pressure; in pyro-electricity, in an increase of the crystal volume by raising its temperature. The asymmetry of the crystal, due to a one-sided working of the forces of crystallization, plays the same role here as does the alchemic opposition between the two bodies used for the production of frictional electricity.

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It is typical of the scientist of the past that he was dependent on phenomena brought about by a highly developed experimental technique for becoming aware of certain properties of the electrical force, whereas for the realistic observer these properties are revealed at once by the most primitive electric phenomena. We remember Eddington's description of the positron as 'negative material', and his subsequent remarks, which show the paradoxical nature of this concept if applied to the hypothetical interior of the atom (Chapter IV). The quite primitive phenomenon of electrical repulsion and attraction shows us the same thing in a manner of which it is not difficult to form a conception.

Modern physics itself, with the help of Faraday's field-concept, describes these phenomena as caused by pressure—resulting from the meeting in space of two similar electrical fields—and suction—resulting from the meeting of two dissimilar fields. In the first case the space between the two electrically charged bodies assumes a degree of density, as if it were filled with some elastic material. In the second instance the density of the space where the two fields intermingle is lower than that of its surroundings. Here, clearly, we have a state of negative density which acts on the electrically charged bodies just as a lowering of pressure acts on a gas: in both cases movement occurs in the direction leading from the higher to the lower density. Electricity thus shows itself capable of producing both gravity and levity effects, thereby once more confirming our picture of it.

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Our next task will be to examine the galvanic form of generating electricity, in order to gain further light on our picture of the electrical polarity.

Galvanism, as it became established through Volta's work, rests on certain properties of the metallic substances of the earth. Compared with the substances which may be used for producing electricity through friction, the metals hold a mid-position. They are all essentially mercurial substances. (In quicksilver, which for this reason was given the name 'mercury' by the alchemists, this fact comes to an ur-phenomenal appearance.) Among the many facts proving the mercurial nature of the metals, there is one of particular interest to us. This is their peculiar relationship to the processes of oxidation and reduction.

Metals, in their metallic state, are bearers of latent levity, which can be set free either through combustion or through corrosion. They differ from one another by their relative degree of eagerness to enter into and remain in the metallic, that is, the reduced state, or to assume and keep the state of the oxide (in which form they are found in the various metallic oxides and salts). There are metals such as gold, silver, etc., for which the reduced state is more or less natural; others, such as potassium, sodium, etc., find the oxidized state natural and can be brought into and kept in the reduced state only by artificial means. Between these extremes there are all possible degrees of transition, some metals more nearly resembling the 'noble', others more nearly the 'corrosive', metals.

We remember that it was the different relationship of sulphur and phosphorus to reduction and oxidation which led us to envisage them as ur-phenomenal representatives of the alchemic polarity. We may therefore say that there are metals which from the alchemic point of view more nearly resemble sulphur, others more nearly phosphorus, whilst others again hold an intermediary position between the extremes. It is on these differences among the various metals that their galvanic properties are based.

Let us from this point of view contemplate the following series of chemical elements, which is a representation of the so-called voltaic series:

Graphite, Platinum, Gold, Silver, Copper, Iron, Tin, Lead, Zinc, Aluminium, Magnesium, Sodium, Potassium.

Any two of these metals constitute a voltaic cell. Its electromotive force is determined by the distance in the series between the metals used. Just as in the case of frictional electricity, the kind of electricity which is supplied by a certain metal depends on whether the other metal with which it is coupled stands to the right or to the left of it in the series.[1]

Let us now see what happens in a galvanic cell when the two different metals are simultaneously exposed to the chemical action of the connecting fluid. Each metal by itself would undergo oxidation with greater or less intensity, and the calorific energy hidden in it would become free in the form of heat. This process suffers a certain alteration through the presence of the second metal, which sets up an alchemic tension between the two. Instead of a proper segregation of the primary polarity, heat—dust (in this case, heat—oxide), the heat remains matter-bound and appears on the surface of the two metals in a secondarily split form as positive and negative electricity.

The similarity between this process and the frictional generation of electricity is evident.

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Our observations have shown that the emergence of the electric state, whether it be caused by friction or galvanically, depends on matter entering into a condition in which its cohesion is loosened—or, as we also put it, on its being turned into 'dust'—and this in such a way that the escaping levity remains dust-bound. This picture of electricity now enables us to give a realistic interpretation of certain phenomena which, in the interpretation which the physicist of the past was bound to give them, have contributed much to the tightening of the net of scientific illusion.

Some sixty years after Dalton had established, purely hypothetically, the theory of the atomistic structure of matter, scientific research was led to the observation of actual atomistic phenomena. Crookes found electricity appearing in his tubes in the form of discrete particles, with properties hitherto known only as appertaining to mass. What could be more natural than to take this as evidence that the method of thought developed during the past era of science was on the right course?

The same phenomena appear in quite a different light when we view them against the background of the picture of electricity to

[1] Note that the series starts on the left with graphite, i.e. with carbon. This substance appears here as a metal among metals, and indeed as the most 'noble' of all. Electricity in this way reveals a secret of carbon well known to the mediaeval alchemist and still known in our day to people in the Orient.

which our observations have led. Knowing that the appearance of electricity depends on a process of atomization of some sort, we shall expect that where electricity becomes freely observable, it will yield phenomena of an atomistic kind. The observations of electricity in a vacuum, therefore, yield no confirmation whatsoever of the atomistic view of matter.

The same is true of the phenomena bound up with radioactivity, which were discovered in direct consequence of Crookes's work. We know that the naturally radioactive elements are all in the group of those with the highest atomic weight. This fact, seen together with the characteristics of radioactivity, tells us that in such elements gravity has so far got the upper hand of levity that the physical substance is unable to persist as a spatially extended, coherent unit. It therefore falls asunder, with the liberated levity drawn into the process of dispersion. Seen thus, radioactivity becomes a symptom of the earth's old age.

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Before entering into a discussion of the question, which naturally arises at this point, as to how levity and gravity by their two possible ways of interaction—'sulphurous' or 'saline'—determine the properties of so-called positive and negative electricity, we shall first study the third mode of generating electricity, namely, by electromagnetic induction. Along this way we shall arrive at a picture of the magnetic force which corresponds to the one already obtained of electricity. This will then lead us to a joint study of the nature of electric polarity and magnetic polarity.

The discovery of the phenomena we call electromagnetic depended on the possibility of producing continuous electrical processes. This arose with Volta's invention. When it became necessary to find a concept for the process which takes place in an electric conductor between the poles of a galvanic cell, the concept of the 'current', borrowed from hydrodynamics, suggested itself. Ever since then it has been the rule to speak of the existence of a current within an electric circuit; its strength or intensity is measured in terms of a unit named in honour of Ampere.

This concept of the current has had a fate typical of the whole relation of human thought to the facts connected with electricity. Long after it had been coined to cover phenomena which in themselves betray no movement of any kind between the electrical poles, other phenomena which do in fact show such movements became known through Crookes's observations. Just as in the case of atomism, they seemed to prove the validity of the preconceived idea of the current. Soon, however, radiant electricity showed properties which contradicted the picture of something flowing from one pole to the other. The cathode rays, for instance, were found to shoot forth into space perpendicularly from the surface of the cathode, without regard to the position of the anode. At the same time Maxwell's hydrodynamic analogy (as our historical survey has shown) led to a view of the nature of electricity by which this very analogy was put out of court. By predicting certain properties of electricity which come to the fore when its poles alternate rapidly, he seemed to bring electricity into close kinship with light. Mathematical treatment then made it necessary to regard the essential energy process as occurring, not from one pole to the other, but at right angles to a line joining the poles (Poynting's vector). This picture, however, satisfactory though it was in the realm of high frequency, failed as a means of describing so-called direct-current processes.

As a result of all this the theory of electricity has fallen apart into several conceptual realms lying, as it were, alongside one another, each consistent in itself but lacking any logical connexion with the others. Although the old concept of the electric current has long lost its validity, scientific thought (not to speak of the layman's) has not managed to discard it. To do this must therefore be our first task, if we want to attain to a realistic picture of electromagnetism.

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While keeping strictly to the historical order of things, we shall try first to form a picture of what happens when we connect two electrically charged bodies by a conductor. We know that we rightly describe the change of the dynamic properties of the part of space, in which the two bodies are present, by saying that a certain electric field prevails in it. This field possesses different 'potentials' at its various points and so there exists a certain potential difference between the two electric charges. What then happens when a so-called 'conductor' is brought into such a field?

From the point of view of the field-concept, conductivity consists in the property of a body not to allow any change of potential along its surface. Such a surface, therefore, is always an equipotential plane. In the language of alchemy, conductivity is a mercurial property. In the presence of such a body, therefore, no Salt-Sulphur contrasts can obtain. In view of what we found above as the mean position of the metals in the alchemic triad, it is significant that they, precisely, should play so outstanding a role as electrical conductors.

If we keep to pure observation, the only statement we can make concerning the effect produced by the introduction of such a body into the electric field is that this field suddenly disappears. We shall see later in which direction this vanishing occurs. For the present it is sufficient to have formed the picture of the disappearance of the electrical condition of space as a result of the presence of a body with certain mercurial properties.

Nothing else, indeed, happens when we make the process continuous by using a galvanic source of electricity. All that distinguishes a galvanic cell from the sources of electricity used before the time of Volta is its faculty of immediately re-establishing the field which prevails between its poles, whenever this field becomes extinguished by the presence of a conductor. Volta himself saw this quite correctly. In his first account of the new apparatus he describes it as 'Leyden jars with a continuously re-established charge'. Every enduring electrical process, indeed, consists in nothing but a vanishing and re-establishment of the electrical field with such rapidity that the whole process appears continuous.

Here, also, pure observation of the effect of a conductor in an electric field tells us that its action consists in the annihilation of the field. There is no phenomenon which allows us to state that this process takes place along the axis of the conductor. If we wish to obtain a picture of the true direction, we must consider the condition of space which arises in place of the electric condition that has disappeared.

With the possibility of turning the cancellation of the electrical condition of space into a continuous process, it became possible to observe that the neutralization of electric charges entails the appearance of heat and magnetism. We must now ask which are the qualities of electricity on the one hand, and of heat and magnetism on the other, which account for the fact that where electricity disappears, the two latter forces are bound to appear. Since magnetism is the still unknown entity among the three, we must now deal with it.

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Unlike electricity, magnetism was first known in the form of its natural occurrence, namely as a property of certain minerals. If we follow the same course which led us to start our study of electricity with the primitive process of generating it, we shall turn now to the basic phenomenon produced by a magnetic field already in existence. (Only when we have learnt all we can from this, shall we proceed to ask how magnetism comes into being.) Obviously, we shall find this basic phenomenon in the effect of a magnet on a heap of iron filings.

Let us, to begin with, compare a mass of solid iron with the same quantity of it in powdered form. The difference is that the powder lacks the binding force which holds the solid piece together. Now lei us expose the powdered iron to the influence of a magnet. At once a certain ordering principle takes hold of the single particles. They no longer lie at random and unrelated, apart from the inconspicuous gravitational effect they exert on one another, but are drawn into a coherent whole, thus acquiring properties resembling those of an ordinary piece of solid matter.

Read thus, the phenomenon tells us that a part of space occupied by a magnetic field has qualities which are otherwise found only where a coherent solid mass is present. A magnetic piece of solid iron, therefore, differs from a non-magnetic piece by giving rise in its surroundings to dynamic conditions which would otherwise exist only in its interior. This picture of the relatedness of magnetism to solidity is confirmed by the fact that both are cancelled by heat, and increased by cold.[1]

By its magnetic properties iron thus reveals itself as a substance capable of assuming the condition of solid matter to a degree surpassing ordinary solidity. As an exceptional kind of metal it forms the counter-pole to mercury, in which the solid-fluid condition characteristic of all metallic matter is as much shifted towards the fluid as in iron it is to the solid. (Note in this respect the peculiar resistance of iron to the liquefying effect which mercury has on the other metals.)

This picture of magnetism enables us to understand at once why it must occur together with heat at the place where an electric polarity has been cancelled by the presence of a conductor. We have seen that electricity is levity coupled in a peculiar way with gravity; it is polarized levity (accompanied by a corresponding polarization of gravity). An electric field, therefore, always has both qualities, those of levity and of gravity. We saw a symptom of this in electrical attraction and

[1] There is even a gas which assumes magnetic properties when exposed to extreme cold—oxygen in the solid state.

repulsion, so called; the attraction, we found, was due to negative density, the repulsion to positive density, imparted to space by the electrical fields present there. Now we see that when, through the presence of a conductor, the electrical field round the two opposing poles vanishes, in its place two other fields, a thermal and a magnetic, appear. Clearly, one of them represents the levity-part, the other the gravity-part, of the vanished electric field. The whole process reminds one of combustion through which the ponderable and imponderable parts, combined in the combustible substance, fall apart and appear on the one hand as heat, and on the other as oxidized substance ('ash'). Yet, between these two manifestations of heat there is an essential qualitative difference.

Although, from our view-point, magnetism represents only one 'half of a phenomenon, the other half of which is heat, we must not forget that it is itself a bipolar force. Thus, despite its apparent relation to gravity it does not represent, as gravity does, one pole of a primary polarity, with heat as the other pole. Rather must it carry certain qualities of levity which, together with those of gravity, appear in a polarically opposite manner at its two poles. (Details of this will be shown later when we come to investigate the individual qualities of the two poles of magnetism and electricity.) Hence the heat that forms the counterpart to magnetism cannot be pure levity either. As the result of a certain coupling with gravity, it too has somehow remained polarically split.

This can easily be seen by considering the following. Unlike the levity-gravity polarity, in which one pole is peripheral and the other point-centred, both Doles of the electrical polarity are point-centred; both are located in physical space, and thereby determine a definite direction within this space. It is this direction which remains a characteristic of both the magnetic and the thermal fields. The direction of the thermal field as much as that of the magnetic is determined by its having as its axis the conductor joining the poles of the antecedent electrical field. Both fields supplement each other in that the thermal radiation forms the radii which belong to the circular magnetic lines-of-force surrounding the conductor.[1]

Our picture of the process which is commonly called an electric

[1] By watering plants with water that had been exposed to heat from different sources, E. Pfeiffer has shown in the chemical laboratory of the Goetheanum that heat engendered by means of electricity is 'dead' heat. It follows that it is not the same for human health whether the heat used for cooking or heating purposes is obtained by burning wood or coal, or by means of electricity.

current is now sufficiently complete to allow us to make a positive statement concerning the direction in which it takes place. Let us once more sum up: In order that this process may occur, there must be present in an electrically excited part of space a body which does not suffer the particular polarization of space bound up with such a field. As a result, the electrical field disappears, and in place of it appear a thermal field and a magnetic field, both having as their axis the line connecting the two poles. Each of them spreads out in a direction at right angles to this fine. Obviously, therefore, it is in this radial direction that the transformation of the electrical into the thermo-magnetic condition of space must take place.

This picture of the electro-thermo-magnetic happening, as regards its direction, is in complete accord with the result obtained (as indicated earlier) by the mathematical treatment of high-frequency phenomena. Once more we see that quite primitive observations, when properly read, lead to findings for which scientific thought had to wait until they were forced on it by the progress of experimental technique—as even then science was left without a uniformly valid picture of the dynamic behaviour of electricity.

Further, we can now see that when we apply electricity to practical purposes, we are in fact seldom using electricity itself, but other forces (that is, other combinations of gravity and levity) which we make effective by making electricity disappear. The same is true of most of the methods of measuring electricity. As a rule, the force which sets the instrument in motion is not electricity but another force (magnetism, heat, etc.) which appears in the place of the vanishing electricity. Thus the so-called intensity of an electric current is actually the intensity with which the electricity in question disappears! Electricity serves us in our machines in the same way that food serves a living organism: it gets itself digested, and what matters is the resulting secondary product.

Just as alterations in the electrical condition of space give rise to the appearance of a magnetic field, any alteration of the magnetic state of space gives rise to the appearance of an electrical field. This process is called electromagnetic induction. With its discovery, the generation of electricity through friction and in the galvanic way was supplemented by a third way. By this means the practical use of electricity on a large scale became possible for the first time. If our picture of the two earlier processes of generating electricity is correct, then this third way must also fit into the picture, although in this case we have no longer to do with any direct atomization of physical matter. Our picture of magnetism will indeed enable us to recognize in electromagnetic induction the same principle on which we found the two other processes to rest.

Magnetism is polarized gravity. Hence it has the same characteristic of tending always to maintain an existent condition. In bodies subject to gravity, this tendency reveals itself as their inertia. It is the inertia inherent in magnetism which we employ when using it to generate electricity. The simplest example is when, by interrupting a 'primary current', we induce a 'secondary current' in a neighbouring circuit. By the sudden alteration of the electric condition on the primary side, the magnetic condition of the surrounding space is exposed to a sudden corresponding change. Against this the magnetic field 'puts up' a resistance by calling forth, on the secondary side, an electrical process of such direction and strength that the entire magnetic condition remains first unaltered and then, instead of changing suddenly, undergoes a gradual transformation which ideally needs an infinite time for its accomplishment (asymptotic course of the exponential curve). This principle rules every process of electromagnetic induction, whatever the cause and direction of the change of the magnetic field.

We know that electromagnetic induction takes place also when a conductor is moved across a magnetic field in such a way that, as the technical term goes, it 'cuts' the field's lines of force. Whereas the process discussed above is employed in the transformer, this latter process is used in generation of electricity by dynamo. We have seen that a magnetic field imparts to the relevant part of space qualities of density which otherwise prevail only in the interior of solid masses. We remember further that the appearance of electricity, in the two other modes of generating it, is caused by the loosening of the coherence of the material substance. A similar loosening of the coherence of the magnetic field takes place when its field-lines are cut by the movement of the conductor across it. Just as heat occurs when we move a solid object through a liquid, electricity occurs when we move a conductor across a magnetic field. In each case we interfere with an existing levity-gravity relationship.

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Having established thus far the picture of both electricity and magnetism which shows each as an outcome of certain levity-gravity interactions, we now ask how, in particular, negative and positive electricity on the one hand and north and south magnetism on the other are determined by these interactions. Let us again begin with electricity.

We remember that Galvani was led to his observations by the results of Walsh's study of the electric fishes. While Galvani clung to the view that in his own experiments the source of the electrical force lay within the animal bodies, Volta saw the fallacy of that. He then conceived the idea of imitating with purely inorganic substances the set-up which Galvani had come upon by accident. The paradoxical result—as he himself noticed with surprise—was that his apparatus turned out to be a close replica of the peculiar organ with which the electric fishes are endowed by nature. We must now take a closer view of this organ.

The electric organ of such a fish consists of many thousands of little piles, each made up of a very great number of plates of two different kinds, arranged in alternating layers. The two kinds differ in substance: in one case the plate is made from a material similar to that present in the nervous system of animals; in the other the resemblance is to a substance present in the muscular system, though only when the muscles are in a state of decay. In this way the two opposing systems of the animal body' seem to be brought here into direct contact, repeated many thousands of times.

In the electric fishes, accordingly, sensation and will are brought into a peculiar interrelation. For the will-pole is related to its bodily foundation in a manner which otherwise obtains only between the nervous system and the psychological processes co-ordinated with it. These fishes then have the capacity to send out force-currents which produce in other animals and in man 'concussion of the limbs', or in extreme cases paralysis and even death. Through describing the process in this way we realize that electricity appears here as metamorphosed animal will, which takes this peculiar form because part of the animal's volitional system is assimilated to its sensory system in an exceptional manner.

It is known to-day that what nature reveals so strikingly in the case of the electric fish, is nothing but the manifestation of a principle at work in the bodies of all beings endowed with sensation and volition—in corporeal terms, with the duality of a nervous and a muscular system—and therefore at work also in the human body. Observation has shown that the activities of these two systems in man and animal are accompanied by the occurrence of different electric potentials in different parts of the body. Plate A, Fig. iii, shows the distribution of the two polar electric forces in the human body. The bent lines in the diagram stand for curves of equal electric potential. The straight line between them is the neutral zone. As might be expected, this line runs through the heart. What seems less obvious is its slanting position. Here the asymmetry, characteristic of the human body, comes to expression.

If we remember that the nervous system represents the salt-pole, and the metabolic system the sulphur-pole, of the human organism, and if we take into account the relationship between levity and gravity at the two poles, we can see from the distribution of the two electricities that the coupling of levity and gravity at the negative pole of the electrical polarity is such that levity descends into gravity, while at the positive pole gravity rises into levity. Negative electricity therefore must have somehow a 'spherical' character, and positive electricity a 'radial'.

This finding is fully confirmed by electrical phenomena in the realm of nature most remote from man (though it was an effort to solve the enigma of man which led to the discovery of this realm). Since Crookes's observations of the behaviour of electricity in a vacuum it is common knowledge that only the negative kind of electricity occurs as a freely radiating force (though it retains some properties of inertia), whereas positive electricity seems to be much more closely bound to minute particles of ponderable matter. Here again we find gravity-laden levity on the negative side, levity-raised gravity on the positive.

The same language is spoken by the forms in which the luminous phenomena appear at the two poles of a Crookes tube. Fig. i on Plate A represents the whole phenomenon as far as such a diagram allows. Here we see on the positive side radial forms appear, on the negative side planar-spherical forms. As symbols of nature's script, these forms tell us that cosmic periphery and earthly centre stand in a polar relation to each other at the two ends of the tube. (Our optical studies will later show that the colours which appear at the anode and cathode are also in complete accord with this.)

At this point in our discussion it is possible to raise, without risk of confusing the issue, the question of the distribution of the two electric forces over the pairs of substances concerned in the generation of electricity both by friction and in the galvanic way. This distribution seems to contradict the picture to which the foregoing observations have led us, for in both instances the 'sulphurous' substances (resin in one, the nobler metals in the other) become bearers of negative electricity; while the 'saline' substances (glass and the corrosive metals) carry positive electricity. Such a criss-crossing of the poles—surprising as it seems at first sight—is not new to us. We have met it in the distribution of function of the plant's organs of propagation, and we shall meet a further instance of it when studying the function of the human eye. Future investigation will have to find the principle common to all instances in nature where such an interchange of the poles prevails.

While the electric field arising round an electrified piece of matter does not allow any recognition of the *absolute* characteristics of the two opposing electrical forces, we do find them revealed by the distribution of electricity in the human body. Something similar holds good for magnetism. Only, to find the phenomena from which to read the absolute characteristics of the two sides of the magnetic polarity, we must not turn to the body of man but to that of the earth, one of whose characteristics it is to be as much the bearer of a magnetic field as of gravitational and levitational fields. There is significance in the fact that even to-day, when the tendency prevails to look for causes of natural phenomena not in the macrocosmic expanse, but in the microscopic confines of space, the two poles of magnetism are named after the magnetic poles of the earth. It indicates the degree to which man's feeling instinctively relates magnetism to the earth as a whole.

In our newly developed terminology we may say that magnetism, as a polarity of the second order, represents a field of force both of whose poles are situated within finite space, and that in the macrotelluric mother-field this situation is such that the axis of this field coincides more or less with the axis of the earth's physical body. Thus the magnetic polarization of the earth as a letter in nature's script bids us rank it alongside other phenomena which in their way are an expression of the earth's being polarized in the north-south direction.

The Austrian geographer, E. Suess, in his great work *The Countenance of the Earth,* first drew attention to the fact that an observer approaching the earth from outer space would be struck by the one-sided distribution and formation of the earth's continents. He would notice that most of the dry land is in the northern hemisphere, leaving the southern hemisphere covered mainly with water. In terms of the basic elementary qualities, this means that the earth is predominantly 'dry' in its northern half, and 'moist' in its southern.

In this fact we have a symbol which tells us that the earth represents a polarity of the second order, with its 'salt'-pole in the north and its 'sulphur'-pole in the south. Hence the magnetism called 'North' must be of saline and therefore spherical nature, corresponding to the negative pole in the realm of electricity, while 'South' magnetism must be of sulphurous—i.e. radial—nature, corresponding to positive electricity. Moreover, this must hold good equally for the fields of magnetic force generated by naturally magnetic or artificially magnetized pieces of iron. For the circumstance that makes a piece of matter into a magnet is simply that part of the general magnetic field of the earth has been drawn into it. Of especial interest in this respect is the well-known dependence of the direction of an electrically produced magnetic field on the position of the poles of the electric field.

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The insight we have now gained into the nature of electricity has led us to the realization that with every act of setting electromagnetic energies in motion we interfere with the entire levity-gravity balance of our planet by turning part of the earth's coherent substance into cosmic 'dust'. Remembering our picture of radioactivity, in which we recognized a sign of the earth's old age, we may say that whenever we generate electricity we speed up the earth's process of cosmic ageing. Obviously this is tremendously enhanced by the creation of artificial radioactivity along the lines recently discovered, whereby it has now become possible to transmute chemical elements into one another, or even to cancel altogether their gravity-bound existence.

To see things in this light is to realize that with our having become able to rouse electricity and magnetism from their dormant state and make them work for us, a gigantic responsibility has devolved upon mankind. It was man's fate to remain unaware of this fact during the first phase of the electrification of his civilization; to continue now in this state of unawareness would spell peril to the human race.

The fact that modern science has long ceased to be a 'natural' science is something which has begun to dawn upon the modern scientific researcher himself. What has thus come to him as a question finds a definite answer in the picture of electricity we have been able to develop. It is again Eddington who has drawn attention particularly to this question: see the chapter, 'Discovery or Manufacture?' in his *Philosophy of Physical Science.* It will be appropriate at this point to recall his remarks, for they bear not only on the outcome of our own present discussion, but also, as the next chapter will show, on the further course of our studies.

Eddington starts by asking: 'When Lord Rutherford showed us the atomic nucleus, did *he find* it or did he *make* it?' Whichever answer we give, Eddington goes on to say, makes no difference to our admiration for Rutherford himself. But it makes all the difference to our ideas on the structure of the physical universe. To make clear where the modern physicist stands in this respect, Eddington uses a striking comparison. If a sculptor were to point in our presence to a raw block of marble saying that the form of a human head was lying hidden in the block, 'all our rational instinct would be roused against such an anthropomorphic speculation'. For it is inconceivable to us that nature should have placed such a form inside the block. Roused by our objection, the artist proceeds to verify his theory experimentally—'with quite rudimentary apparatus, too: merely using a chisel to separate the form for our inspection, he triumphantly proves his theory.'

'Was it in this way', Eddington asks, 'that Rutherford rendered concrete the nucleus which his scientific imagination had created?' One thing is certain: 'In every physical laboratory we see ingeniously devised tools for executing the work of sculpture, according to the designs of the theoretical physicist. Sometimes the tool slips and carves off an odd-shaped form which he had not expected. Then we have a new experimental discovery,'

To this analogy Eddington adds the following even more drastic one: 'Procrustes, you will remember,' he says, 'stretched or chopped down his guests to fit the bed he constructed. But perhaps you have not heard the rest of the story. He measured them up before they left the next morning, and wrote a learned paper *On the Uniformity of Stature of Travellers* for the Anthropological Society of Attica.'

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Besides yielding a definite answer to the question of how far the seemingly discovered facts of science are manufactured facts, our newly won insight into the nature of the electric and magnetic polarties throws light also on the possibility of so handling both that their application will lead no longer to a cancellation, but to a true continuation, of nature's own creative deeds.

An example of this will appear in the next part of our studies, devoted to observations in the field of optics.

CHAPTER XIV

Colours as 'Deeds and Sufferings of Light'

'As for what I have done as a poet, I take no pride in it whatever. Excellent poets have lived at the same time as myself; poets more excellent have lived before me, and others will come after me. But that in my century I am the only person who knows the truth in the difficult science of colours—of that, I say, I am not a little proud, and here I have a consciousness of a superiority to many.'

In these words spoken to his secretary, Eckermann, in 1829, a few years before his death, Goethe gave his opinion on the significance of his scientific researches in the field of optical phenomena. He knew that the path he had opened up had led him to truths which belong to the original truths of mankind. He expressed this by remarking that his theory of colour was 'as old as the world'.

If in this book we come somewhat late to a discussion of Goethe's colour-theory, in spite of the part it played in his own scientific work, and in spite of its significance for the founding of a physics based on his method, the reasons are these. When Goethe undertook his studies in this field he had not to reckon with the forms of thought which have become customary since the development of mechanistic and above all—to put it concisely—of 'electricalistic' thinking. Before a hearing can be gained in our age for a physics of Light and Colour as conceived by Goethe, certain hindrances must first be cleared away. So a picture on the one hand of matter, and on the other of electricity, such as is given when they are studied by Goethean methods, had first to be built up; only then is the ground provided for an unprejudiced judgment of Goethe's observations and the deductions that can be made from them to-day.

As Professor Heisenberg, in his lecture quoted earlier (Chapter II), rightly remarks, Goethe strove directly with Newton only in the realms of colour-theory and optics. Nevertheless his campaign was not merely against Newton's *opinions* in this field. He was guided throughout by the conviction that the fundamental principles of the whole Newtonian outlook were at stake. It was for this reason that his polemics against Newton were so strongly expressed, although he had no fondness for such controversies. In looking back on that part of the *Farbenlehre* which he had himself called 'Polemical' in the title, he said to Eckermann: 'I by no means disavow my severe dissections of the Newtonian statements; it was necessary at the time and will also have its value hereafter; but at bottom all polemical action is repugnant to my nature, and I can take but little pleasure in it.'

The reason why Goethe chose optics as the field of conflict, and devoted to it more than twenty years of research and reflexion, amidst all the other labours of his rich life, lay certainly in his individual temperament—*'zum Sehen geboren, zum Schauen bestellt'*.[1] At the same time one must see here a definite guidance of humanity. Since the hour had struck for mankind to take the first step towards overcoming the world-conception of the one-eyed, colour-blind onlooker, what step could have been more appropriate than this of Goethe's, when he raised the eye's capacity for seeing colours to the rank of an instrument of scientific cognition?

In point of fact, the essential difference between Goethe's theory of colour and the theory which has prevailed in science (despite all modifications) since Newton's day, lies in this: While the theory of Newton and his successors was based on excluding the colour-seeing faculty of the eye, Goethe founded his theory on the eye's experience of colour.

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In view of the present scientific conception of the effect which a prismatic piece of a transparent medium has on light passing through it, Goethe's objection to Newton's interpretation and the conclusions drawn from it seems by no means as heretical as it did in Goethe's own time and for a hundred years afterwards. For, as Lord Rayleigh and others have shown, the facts responsible for the coming into being of the spectral colours, when these are produced by a diffraction grating, invalidate Newton's idea that the optical apparatus serves to *reveal* colours which are inherent in the original light. To-day it is known that these colours are an *outcome* of the interference

[1] 'To see is my dower, to look my employ.' Words of the Tower-Watcher in *Faust, II, 5,* through which Goethe echoes his own relation to the world.

of the apparatus (whether prism or grating) with the light. Thus we find Professor R. W. Wood, in the opening chapter of his *Physical Optics,* after having described the historical significance of Newton's conception of the relation between light and colour, saying: 'Curiously enough, this discovery, which we are taking as marking the beginning of a definite knowledge about light, is one which we shall demolish in the last chapter of this book,[1] for our present ideas regarding the action of the prism more nearly resemble the idea held previous to Newton's classical experiments. We now believe that the prism actually manufactures the coloured light.'

We find ourselves faced here with an instance of the problem, 'Discovery or Manufacture?' dealt with by Eddington in the manner described in our previous chapter. This very instance is indeed used by Eddington himself as a case in which the answer is definitely in favour of 'manufacture'. Nevertheless, Eddington complains, experts, in spite of knowing better, keep to the traditional way of speaking about the spectral colours as being originally contained in the light. 'Such is the glamour of a historical experiment.'[2] It is for the same reason that Goethe's discovery continues to be unrecognized by the majority of scientists, who prefer, instead of examining the question for themselves, to join in the traditional assertion that 'Goethe never understood Newton'.

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As Goethe relates at the conclusion of the 'historical' part of his *Farbenlehre,*[3] he was drawn to study colour by his wish to gain some knowledge of the objective laws of aesthetics. He felt too close to poetry to be able to study it with sufficient detachment, so he turned to painting—an art with which he felt sufficiently familiar without being connected with it creatively—hoping that if he could discover the laws of one art they would prove applicable to others.

His visit to Italy, a land rich both in natural colour and in works of art, gave him a welcome opportunity to pursue this inquiry, but for a long time he made no headway. The paintings he saw suggested no inherent law in their arrangement of colours, nor could the painters he questioned tell him of one. The only qualitative distinction

[1] The last chapter but two in the edition of 1924.

[2] For the drastic and as such very enlightening way in which Eddington presents the problem, the reader is referred to Eddington's own description.

[3] *Konfession des Verfassers.*

they seemed to recognize was between 'cold' and 'warm' colours.

His own observations led him to a definite experience of the quality of the colour blue, for which he coined the phrase 'feebleness of blue' *('Ohnmacht des Blau').* In some way this colour seemed to him to be related to black. In order to rouse his artist friends and to stimulate their reflexions, he liked to indulge in paradoxes, as when he asserted that blue was not a colour at all. He found, however, as time went on, that in this way he came no nearer his goal.

Although the splendour of colour in the Italian sky and the Italian landscape made a powerful impression on Goethe, he found not enough opportunity for systematic study to allow him to arrive at more than a dim surmise of some law underlying the occurrence of colour in nature. Still, there was one thing he took home with him as a result of his labours. He had grown convinced that 'the first approach to colours as physical phenomena had to be sought from the side of their occurrence in nature, if one would gain an understanding of them in relation to art'.

Back at home, he strove to recollect the theory of Newton as it was being taught in schools and universities—namely, that 'colours in their totality are contained in light'. Hitherto he had had no occasion to doubt the correctness of this theory. Like everyone else, he had heard it expounded in lectures as an incontestable result of empirical observation, though without this ever having been shown to him by way of experiment. He convinced himself by consulting a manual that his recollection was correct, but at the same time he found that the theory there set forth gave no help in answering his questions.[1] So he decided to examine the phenomena for himself.

For this purpose he borrowed a set of prisms from a friend living in near-by Jena, the physicist, Büttner. Since, however, he had at that time no opportunity of arranging a dark chamber on Newton's lines, where the necessary ray of light from a tiny hole in the window-covering was sent through a prism, he postponed the whole thing, until in the midst of all his many other interests and duties it was forgotten. In vain Büttner pressed many times for the return of the prisms; at last he sent a mutual acquaintance with the injunction not to return without them. Goethe then searched for the long-neglected apparatus and determined to take a rapid glance through one of the prisms before he gave them back.

[1] Colour as *quality* being no essential factor in the scientific explanation of the spectrum.

He recalled dimly his pleasure as a boy at the vision of the world given him through a bit of similarly shaped glass. 'I well remember that everything looked coloured, but in what manner I could no longer recollect. I was just then in a room completely white; remembering the Newtonian theory, I expected, as I put the prism to my eye, to find the whole white wall coloured in different hues and to see the light reflected thence into the eye, split into as many coloured lights.

'But how astonished was I when the white wall seen through the prism remained white after as before. Only where something dark came against it a more or less decided colour was shown, and at last the window-bars appeared most vividly coloured, while on the light-grey sky outside no trace of colouring was to be seen. It did not need any long consideration for me to recognize that a *boundary or edge is necessary to call forth the colours,* and I immediately said aloud, as though by instinct, that the Newtonian doctrine is false.'

For Goethe, there could be no more thought of sending back the prisms, and he persuaded Büttner to leave them with him for some time longer.

Goethe adds a short account of the progress of the experiments he now undertook as well as of his efforts to interest others in his discovery. He makes grateful reference to those who had brought him understanding, and who had been helpful to him through the exchange of thoughts. Among these, apart from Schiller, whom Goethe especially mentions, we find a number of leading anatomists, chemists, writers and philosophers of his time, but not a single one of the physicists then active in teaching or research. The 'Guild' took up an attitude of complete disapproval or indifference, and so have things remained till a hundred years after his death, as Goethe himself prophesied.

One of the first systematic pieces of work which Goethe undertook in order to trace the cause of the Newtonian error was to go through Book I of Newton's *Optics,* sentence by sentence, recapitulate Newton's experiments and rearrange them in the order which seemed to him essential. In so doing he gained an insight which was fundamental for all future work, and often proved very beneficial in the perfecting of his own methods. His examination of the Newtonian procedure showed him that the whole mistake rested on the fact that 'a complicated phenomenon should have been taken as a basis, and the simpler explained from the complex'. Nevertheless, it still needed 'much time and application in order to wander through all the labyrinths with which Newton had been pleased to confuse his successors'.

*

It seems a small thing, and yet it is a great one, which Goethe, as the above description shows, discovered almost by chance. This is shown by the conclusions to which he was led in the systematic prosecutions of his discovery. An account of them is given in his *Beiträge zur Optik*,[1] published in 1791, the year in which Galvani came before the public with his observations in the sphere of electricity.

Goethe describes in this book the basic phenomena of the creation of the prismatic colours, with particulars of a number of experiments so arranged that the truth he had discovered, contrary to Newton's view, comes to light through the very phenomena themselves. Only much later, in the year 1810, and after he had brought to a certain conclusion four years previously the researches which he had pursued most carefully the whole time, did he make public the actual masterpiece, *Entwurf einer Farbenlehre*.[2] (An English translation of the didactic part appeared about ten years after Goethe's death.)

While leaving a more detailed description of the composition of Goethe's *Entwurf* for our next chapter, we shall here deal at once with some of the essential conclusions to which the reader is led in this book. As already mentioned, Goethe's first inspection of the colour-phenomenon produced by the prism had shown him that the phenomenon depended on the presence of a boundary between light and darkness. Newton's attempt to explain the spectrum out of light alone appeared to him, therefore, as an inadmissible setting aside of one of the two necessary conditions. Colours, so Goethe gleaned directly from the prismatic phenomenon, are caused by both light and its counterpart, darkness. Hence, to arrive at an idea of the nature of colour, which was in accord with its actual appearance, he saw himself committed to an investigation of the extent to which the qualitative differences in our experience of colours rests upon their differing proportions of light and darkness.

It is characteristic of Goethe's whole mode of procedure that he at once changed the question, 'What is colour?' into the question, 'How does colour arise?' It was equally characteristic that he did not, as Newton did, shut himself into a darkened room, so as to get hold

[1] *Contributions to Optics.* [2] *Outline of a Theory of Colour.*

of the colour-phenomenon by means of an artificially set-up apparatus. Instead, he turned first of all to nature, to let her give him the answer to the questions she had raised.

It was clear to Goethe that to trace the law of the genesis of colour in nature by reading her phenomena, he must keep a look-out for occurrences of colours which satisfied the conditions of the *Urphänomen,* as he had learned to know it. This meant that he must ask of nature where she let colours arise out of light and darkness in such a way that no other conditions contributed to the effect.

He saw that such an effect was presented to his eye when he turned his gaze on the one hand to the blue sky, and on the other to the yellowish luminous sun. Where we see the blue of the heavens, there, spread out before our eyes, is universal space, which as such is dark. Why it does not appear dark by day as well as by night is because we see it through the sun-illumined atmosphere. The opposite role is played by the atmosphere when we look through it to the sun. In the first instance it acts as a lightening, in the second as a darkening, medium. Accordingly, when the optical density of the air changes as a result of its varying content of moisture, the colour-phenomenon undergoes an opposite change in each of the two cases. Whilst with increasing density of the air the blue of the sky brightens up and gradually passes over into white, the yellow of the sun gradually darkens and finally gives way to complete absence of light.

The ur-phenomenon having once been discovered in the heavens, could then easily be found elsewhere in nature on a large or small scale—as, for instance, in the blue of distant hills when the air is sufficiently opaque, or in the colour of the colourless, slightly milky opal which looks a deep blue when one sees it against a dark background, and a reddish yellow when one holds it against the light. The same phenomenon may be produced artificially through the clouding of glass with suitable substances, as one finds in various glass handicraft objects. The aesthetic effect is due to the treated glass being so fashioned as to present continually changing angles to the light, when both colour-poles and all the intermediate phases appear simultaneously. It is also possible to produce the ur-phenomenon experimentally by placing a glass jug filled with water before a black background, illuminating the jug from the side, and gradually clouding the water by the admixture of suitable substances. Whilst the brightness appearing in the direction of the light goes over from yellow and orange to an increasingly red shade, the darkness of the black background brightens to blue, which increases and passes over to a milky white.

It had already become clear to Goethe in Italy that all colour-experience is based on a polarity, which he found expressed by painters as the contrast between 'cold' and 'warm' colours. Now that the *coming-into-being* of the blue of the sky and of the yellow of the sun had shown themselves to him as two processes of opposite character, he recognized in them the objective reason why both colours are subjectively experienced by us as opposites. 'Blue is illumined darkness—yellow is darkened light'—thus could he assert the ur-phenomenon, while he expressed the relation to Light of colours in their totality by saying: 'Colours are Deeds and Sufferings of Light.'

With this, Goethe had taken the first decisive step towards his goal—the tracing of man's aesthetic experience to objective facts of nature.

If we use the expressions of preceding chapters, we can say that Goethe, in observing the coloured ur-phenomenon, had succeeded in finding how from the primary polarity, Light—Dark, the opposition of the yellow and blue colours arises as a secondary polarity. For such an interplay of light and darkness, the existence of the air was seen to be a necessary condition, representing in the one case a lightening, in the other, a darkening element. That it was able to play this double role arose from its being on the one hand pervious to light, while yet possessing a certain substantial density. For a medium of such a nature Goethe coined the expression *trübes Medium.*

There seems to be no suitable word in English for rendering the term *trübe* in the sense in which Goethe used it to denote the optical resistance of a more or less transparent medium. The following remarks of Goethe's, reported by his secretary Riemer, will give the reader a picture of what Goethe meant by this term, clear enough to allow us to use the German word. Goethe's explanation certainly shows how inadequate it is to translate *trübe* by 'cloudy' or 'semi-opaque' as commentators have done. 'Light and Dark have a common field, a space, a vacuum in which they are seen to appear. This space is the realm of the transparent. Just as the different colours are related to Light and Dark as their creative causes, so is their corporeal part, their medium, *Trübe,* related to the transparent. The first diminution of the transparent, i.e. the first slightest filling of space, the first disposition, as it were, to the corporeal, i.e. the non-transparent—this is *Trübe.*'[1]

[1] See Rudolf Steiner's edition of Goethe's *Farbenlehre* under *Paralipomena zur Chromatik,* No. 27.

After Goethe had once determined from the macrotelluric phenomenon that an interplay of light and darkness within *Trübe* was necessary for the appearance of colour in space, he had no doubt that the prismatic colours, too, could be understood only through the coming together of all these three elements. It was now his task to examine in what way the prism, by its being *trübe,* brings light and darkness, or, as he also expressed it, light and shadow, into interplay, when they meet at a boundary.

We must remember that on first looking through the prism Goethe had immediately recognized that the appearance of colour is always dependent on the existence of a boundary between light and darkness —in other words, that it is a border phenomenon. What colours appear on such a border depends on the position of light and darkness in relation to the base of the prism. If the lighter part is nearer to the base, then blue and violet tints are seen at the border, and with the reverse position tints of yellow and red (Plate B, Fig. i). Along this path of study Goethe found no reason for regarding the spectrum-phenomenon as complete only when both kinds of border-phenomena appear simultaneously (let alone when—as a result of the smallness of the aperture through which the light meets the prism—the two edges lie so close that a continuous band of colour arises). Hence we find Goethe—unlike Newton—treating the two ends of the spectrum as two separate phenomena.

In this way, the spectrum phenomenon gave Goethe confirmation that he had succeeded in expressing in a generally valid form the law of the origin of the blue and the yellow colours, as he had read it from the heavens. For in the spectrum, too, where the colour blue appears, there he saw darkness being lightened by a shifting of the image of the border between light and dark in the direction of darkness; where yellow appears, he saw light being darkened by a shifting of the image in the direction of light. (See the arrow in Fig. i.)

In the colours adjoining these—indigo and violet on the blue side, orange and red on the yellow side—Goethe recognized 'heightened' modifications of blue and yellow. Thus he had learnt from the macrotelluric realm that with decreasing density of the corporeal medium, the blue sky takes on ever deeper tones, while with increasing density of the medium, the yellow of the sunlight passes over into orange and finally red. Prismatic phenomenon and macrotelluric phenomenon were seen to correspond in this direction, too.

Faithful to his question, 'How does colour arise?' Goethe now proceeded to investigate under what conditions two borders, when placed opposite each other, provide a continuous band of colour—that is, a colour-band where, in place of the region of uncoloured light, green appears. This, he observed, came about if one brought one's eye, or the screen intercepting the light, to that distance from the prism where the steadily widening yellow-red and the blue-violet colour-cones merge (Fig. ii).[1] Obviously, this distance can be altered by altering the distance between the two borders. In the case of an extremely narrow light-space, the blue and yellow edges will immediately overlap. Yet the emergence of the green colour will always be due to a union of the blue and yellow colours which spread from the two edges. This convinced Goethe that it is inadmissible to place the green in the spectrum in line with the other colours, as is customary in the explanation of the spectrum since Newton's time.

This insight into the relation of the central colour of the continuous spectrum to its other colours still further strengthened Goethe's conviction that in the way man experiences nature in his soul, objective laws of nature come to expression. For just as we experience the colours on the blue side of the spectrum as cold colours, and those on the yellow side as warm colours, so does green give man the impression of a neutral colour, influencing us in neither direction. And just as the experience of the two polar colour-ranges is an expression of the objective natural law behind them, so too is the experience of green, the objective conditions of whose origin give it a neutral position between the two. With this it also became clear why the vegetative part of the plant organism, the region of leaf and stem formation, where the light of the sun enters into a living union with the density of earthly substance, *must* appear in a garment of green.

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Having in this way found the clue to the true genesis of the spectrum, Goethe could not fail to notice that it called for another—a 'negative' spectrum, its polar opposite—to make the half into a whole. For he who has once learnt that light and darkness are two equally essential factors in the birth of colour, and that the opposing of two borders of darkness so as to enclose a light is a 'derived' *(abgeleitet)* experimental arrangement, is naturally free to alter the arrangement

[1] Goethe's own representation of the phenomenon. (The diagram is simplified by omitting one colour on each side.)

and to supplement it by reversing the order of the two borders, thus letting two lights enclose a darkness between them.

If one exposes an arrangement like this to the action of the prism, whose position has remained unchanged, colours appear on each of the two edges, as before, but in reverse order (Fig. iii). The spectral phenomenon now begins at one side with light blue and passes into indigo and violet, with uncoloured darkness in the centre. From this darkness it emerges through red and passes through orange to yellow at the other end.

Again, where the two interior colour-cones merge, there an additional colour appears. Like green, it is of a neutral character, but at the same time its quality is opposite to that of green. In Newtonian optics, which assumes colour to be derived from light only, this colour has naturally no existence. Yet in an optics which has learnt to reckon with both darkness and light as generators of colour, the complete spectrum phenomenon includes this colour equally with green. For lack of an existing proper name for it, Goethe termed it 'pure red' (since it was free from both the blue tinge of the mauve, and the yellow tinge of the red end of the ordinary spectrum), or 'peach-blossom' *(pfirsichblüt),* or 'purple' (as being nearest to the dye-stuff so called by the ancients after the mollusc from which it was obtained).[1]

It needs only a glance through the prism into the sunlit world to make one convinced of the natural appearing of this delicate and at the same time powerfully luminous colour. For a narrow dark object on a light field is a much commoner occurrence in nature than the enclosing by two broad objects of a narrow space of light, the condition necessary for the emergence of a continuous colour-band with green in the middle. In fact, the spectrum which science since the time of Newton regards as the only one, appears much more rarely among natural conditions than does Goethe's counter-spectrum.

With the peach-blossom a fresh proof is supplied that what man experiences in his soul is in harmony with the objective facts of nature. As with green, we experience peach-blossom as a colour that leaves us in equilibrium. With peach-blossom, however, the equilibrium is of a different kind, owing to the fact that it arises from the union of the colour-poles, not at their original stage but in their 'heightened' form. And so green, the colour of the plant-world harmony given by nature,

[1] This is not to be confused with the meaning of 'purple' in modern English usage.

stands over against 'purple', the colour of the human being striving towards harmony. By virtue of this quality, purple served from antiquity for the vesture of those who have reached the highest stage of human development for their time. This characteristic of the middle colours of the two spectra was expressed by Goethe when he called green 'real totality', and peach-blossom 'ideal totality'.

From this standpoint Goethe was able to smile at the Newtonians. He could say that if they persisted in asserting that the colourless, so-called 'white' light is composed of the seven colours of the ordinary spectrum—red, orange, yellow, green, blue, indigo, violet—then they were in duty bound to maintain also that the colourless, 'black' darkness is composed of the seven colours of the inverted spectrum—yellow, orange, red, purple, violet, indigo, blue.

Despite the convincing force of this argument, the voice of the Hans Andersen child speaking through Goethe failed to gain a hearing among the crowd of Newtonian faithful. So has it been up to the present day—regardless of the fact that, as we have shown, modern physics has reached results which make a contradiction of the Newtonian concept of the mutual relation of light and colour no longer appear so heretical as it was in Goethe's time.

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When we compare the way in which Goethe, on the one hand, and the physical scientist, on the other, have arrived at the truth that what Newton held to be 'discovery' was in actual fact 'manufacture', we find ourselves faced with another instance of a fact which we have encountered before in our study of electricity. It is the fact that a truth, which reveals itself to the spectator-scientist only as the result of a highly advanced experimental research, can be recognized through quite simple observation when this observation is carried out with the intention of letting the phenomena themselves speak for their 'theory'.

Furthermore, there is a corresponding difference in the effect the knowledge of such truth has on the human mind. In the field of electricity we saw that together with the scientist's recognition of the absolute qualities of the two polar forms of electricity a false semblance of reality was lent to the hypothesis of the atomic structure of matter. Something similar has occurred in the field of optics. Here, after having been forced to recognize the fallacy of Newton's theory, the spectator's mind has been driven to form a concept of the nature of light which is further than ever from the truth. For what then remains of light is—in Eddington's words—a 'quite irregular disturbance, with no tendency to periodicity', which means that to light is assigned the quality of an undefined chaos (in the negative sense of this word) sprung from pure chance.

Moreover, as Eddington shows, the question whether the optical contrivance 'sorts out' from the chaotic light a particular periodicity, or whether it 'impresses' this on the light, becomes just 'a matter of expression'.[1] So here, too, the modern investigator is driven to a resigned acknowledgment of the principle of Indeterminacy.

No such conclusions are forced upon the one who studies the spectrum phenomenon with the eyes of Goethe. Like the modern experimenter, he, too, is faced with the question 'Discovery or Manufacture?' and he, too, finds the answer to be 'Manufacture'. But to him nature can disclose herself as the real manufacturer, showing him how she goes to work in bringing about the colours, because in following Goethe he is careful to arrange his observations in such a way that they do not veil nature's deeds.

[1] This follows from the application of Fourier's Theorem, according to which every vibration of any kind is divisible into a sum of periodic partial vibrations, and therefore is regarded as compounded of these.

CHAPTER XV

Seeing as 'Deed'—I

Having made ourselves so far acquainted with the fundamentals of Goethe's approach to the outer phenomena of colour involved in the spectrum, we will leave this for a while to follow Goethe along another no less essential line of inquiry. It leads us to the study of our own process of sight, by means of which we grow aware of the optical facts in outer space.

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The importance which Goethe himself saw in this aspect of the optical problem is shown by the place he gave it in the didactic part of his *Farbenlehre.* The first three chapters, after the Introduction, are called 'Physiological Colours', 'Physical Colours', and 'Chemical Colours'. In the first chapter, Goethe summarizes a group of phenomena which science calls 'subjective' colours, since their origin is traced to events within the organ of sight. The next chapter deals with an actual physics of colour—that is, with the appearance of colours in external space as a result of the refraction, diffraction and polarization of light. The third chapter treats of material colours in relation to chemical and other influences. After two chapters which need not concern us here comes the sixth and last chapter, entitled 'Physical-Moral Effect of Colour' (*'Sinnlich-sittliche Wirkung der Farben'),* which crowns the whole. There, for the first time in the history of modern science, a bridge is built between Physics, Aesthetics and Ethics. We remember it was with this aim in view that Goethe had embarked upon his search for the solution of the problem of colour.

In this chapter the experiencing of the various colours and their interplay through the human soul is treated in many aspects, and Goethe is able to show that what arises in man's consciousness as qualitative colour-experience is nothing but a direct 'becoming-inward' of what is manifested to the 'reader's' eye and mind as the objective nature of colours. So, in one realm of the sense-world, Goethe succeeded in closing the abyss which divides existence and consciousness, so long as the latter is restricted to a mere onlooker-relationship towards the sense-world.

If we ask what induced Goethe to treat the physiological colours before the physical colours, thus deviating so radically from the order customary in science, we shall find the answer in a passage from the Introduction to his *Entwurf.* Goethe, in giving his views on the connexion between light and the eye, says: 'The eye owes its existence to light. Out of indifferent auxiliary animal organs the light calls forth an organ for itself, similar to its own nature; thus the eye is formed by the light, for the light, so that the inner light can meet the outer.' In a verse, which reproduces in poetic form a thought originally expressed by Plotinus, Goethe sums up his idea of the creative connexion between eye and light as follows:

' *Unless our eyes had something of the sun,*
How could we ever look upon the light?
Unless there lived within us God's own might,
How could the Godlike give us ecstasy?[1]

(Trans. Stawell-Dickinson)

By expressing himself in this way in the Introduction to his *Farbenlehre*, Goethe makes it clear from the outset that when he speaks of 'light' as the source of colour-phenomena, he has in mind an idea of light very different from that held by modern physics. For in dealing with optics, physical science turns at once to phenomena of light found outside man—in fact to phenomena in that physical realm from which, as the lowest of the kingdoms of nature, the observations of natural science are bound to start. Along this path one is driven, as we have seen, to conceive of light as a mere 'disturbance' in the universe, a kind of irregular chaos.

In contrast to this, Goethe sees that to gain an explanation of natural physical phenomena which will be in accord with nature, we must approach them on the path by which nature brings them into

[1] *Wär' nicht das Auge sonnenhaft,*
Wie könnten wir das Licht erblicken?
Lebt' nicht in uns des Gottes eigne Kraft,
Wie könnt' uns Göttliches entzucken!

being. In the field of light this path is one which leads from light as creative agent to light as mere phenomenon. The highest form of manifestation of creative light most directly resembling its *Idea* is within man. It is there that light creates for itself the organ through which, as manifest light, it eventually enters into human consciousness. To Goethe it was therefore clear that a theory of light, which is to proceed in accord with nature, should begin with a study of the eye: its properties, its ways of acting when it brings us information of its deeds and sufferings in external nature.

The eye with its affinity to light comes into being in the apparently dark space of the mother's womb. This points to the possession by the human organism of an 'inner' light which first forms the eye from within, in order that it may afterwards meet the light outside. It is this inner light that Goethe makes the starting-point of his investigations, and it is for this reason that he treats physiological colours before physical colours.

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Of fundamental significance as regards method is the way in which Goethe goes on from the passage quoted above to speak of the activity of the inner light: 'This immediate affinity between light and the eye will be denied by none; to consider them identical in substance is less easy to comprehend. It will be more intelligible to assert that a dormant light resides in the eye, and that this light can be excited by the slightest cause from within or from without. In darkness we can, by an effort of imagination, call up the brightest images; in dreams, objects appear to us as in broad daylight; if we are awake, the slightest external action of light is perceptible, and if the organ suffers a mechanical impact light and colours spring forth.'

What Goethe does here is nothing less than to follow the development of sight to where it has its true origin. Let us remember that a general source of illusion in the modern scientific picture of the world lies in the fact that the onlooker-consciousness accepts itself as a self-contained ready-made entity, instead of tracing itself genetically to the states of consciousness from which it has developed in the course of evolution. In reality, the consciousness kindled by outer sense-perception was preceded by a dreaming consciousness, and this by a sleeping consciousness, both for the individual and for humanity as a whole. So, too, outer vision by means of the physical apparatus of the eye was preceded by an inner vision. In dreams we still experience this inner vision; we use it in the activity of our picture-forming imagination; and it plays continuously upon the process of external sight. Why we fail to notice this when using our eye in the ordinary way, is because of that dazzling process mentioned earlier in this book. Goethe's constant endeavour was not to become the victim of this blindness—that is, not to be led by day-time experience to forget the night-side of human life. The passage quoted from the Introduction to his *Farbenlehre* shows how, in all that he strove for, he kept this goal in view.

How inevitably a way of thinking that seeks an intuitive understanding of nature is led to views like those of Goethe is shown by the following quotations from Reid and Ruskin, expressing their view of the relationship between the eye, or the act of seeing, and external optical phenomena. In his *Inquiry,* at the beginning of his review of visual perceptions, Reid says:

'The structure of the eye, and of all its appurtenances, the admirable contrivances of nature for performing all its various external and internal motions and the variety in the eyes of different animals, suited to their several natures and ways of life, clearly demonstrate this organ to be a masterpiece of nature's work. And he must be very ignorant of what hath been discovered about it, or have a very strange cast of understanding, who can seriously doubt, whether or not *the rays of light and the eye were made for one another with consummate wisdom, and perfect skill in optics.*'[1]

The following passage from Ruskin's *Ethics of the Dust* (Lecture X) brings out his criticism of the scientific way of treating of optical phenomena:

'With regard to the most interesting of all their [the philosophers'] modes of force—light; they never consider how far the existence of it depends on the putting of certain vitreous and nervous substances into the formal arrangement which we call an eye. The German philosophers began the attack, long ago, on the other side, by telling us there was no such thing as light at all, unless we choose to see it.[2] Now, German and English, both, have reversed their engines, and insist that light would be exactly the same light that it is, though nobody could ever see it. The fact being that the force must be there, and the eye there, and 'light' means the effect of the one on the other—

[1] *Inquiry*, VI, 1. The italics are Reid's.

[2] Presumably Kant and his school. Schopenhauer was definitely of this opinion.

and perhaps, also—(Plato saw farther into that mystery than anyone has since, that I know of)—on something a little way within the eyes.'

Remarks like these, and the further quotation given below, make it seem particularly tragic that Ruskin apparently had no knowledge of Goethe's *Farbenlehre.* This is the more remarkable in view of the significance which Turner, with whom Ruskin stood in such close connexion, ascribed to it from the standpoint of the artist. For the way in which Ruskin in his *Modern Painters* speaks of the effect of the modern scientific concept of colours upon the ethical-religious feeling of man, shows that he deplores the lack of just what Goethe had long since achieved in his *Farbenlehre* where, starting with purely physical observations, he had been able to develop from them a 'physical-moral' theory of colour.

Ruskin's alertness to the effect on ethical life of a scientific world-picture empty of all qualitative values led him to write:

'It is in raising us from the first state of inactive reverie to the second of useful thought, that scientific pursuits are to be chiefly praised. But in restraining us at this second stage, and checking the impulses towards higher contemplation, they are to be feared or blamed. They may in certain minds be consistent with such contemplation, but only by an effort; in their nature they are always adverse to it, having a tendency to chill and subdue the feelings, and to resolve all things into atoms and numbers. For most men, an ignorant enjoyment is better than an informed one, it is better to conceive the sky as a blue dome than a dark cavity, and the cloud as a golden throne than a sleety mist. I much question whether anyone who knows optics, however religious he may be, can feel in equal degree the pleasure and reverence an unlettered peasant may feel at the sight of a rainbow.'

What Ruskin did not guess was that the rudiments of the 'moral theory of light' for which he craved, as this passage indicates, had been established by Goethe long before.

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In the section of his *Farbenlehre* dealing with 'physiological colours', Goethe devotes by far the most space to the so-called 'after-images' which appear in the eye as the result of stimulation by external light, and persist for some little time. To create such an after-image in a simple way, one need only gaze at a brightly lit window and then at a faintly lit wall of the room. The picture of the window appears there, but with the light-values reversed: the dark cross-bar appears as light, and the bright panes as dark.

In describing this phenomenon Goethe first gives the usual explanation, that the part of the retina which was exposed to the light from the window-panes gets tired, and is therefore blunted for further impressions, whereas the part on which the image of the dark frame fell is rested, and so is more sensitive to the uniform impression of the wall. Goethe, however, at once adds that although this explanation may seem adequate for this special instance, there are other phenomena which can be accounted for only if they are held to derive from a 'higher source'. Goethe means experiences with coloured after-images. This will be confirmed by our own discussion of the subject.

What we first need, however, is a closer insight into the physiological process in the eye which causes the after-images as such. Wherever Goethe speaks of a simple activity of the retina, we are in fact concerned with a co-operation of the retina with other parts of our organ of sight. In order to make this clear, let us consider how the eye adapts itself to varying conditions of light and darkness.

It is well known that if the eye has become adjusted to darkness it is dazzled if suddenly exposed to light, even though the light be of no more than quite ordinary brightness. Here we enter a border region where the seeing process begins to pass over into a pathological condition.[1] A 'secret' of the effect of light on the eye is here revealed which remains hidden in ordinary vision, for normally the different forces working together in the eye hold each other in balance, so that none is able to manifest separately. This equilibrium is disturbed, however, when we suddenly expose the eye to light while it is adapted to darkness. The light then acts on the eye in its usual way, but without the immediate counter-action which normally restores the balance. Under these conditions we notice that the sudden dazzling has a painful influence on the eye—that is, an influence in some way destructive. This will not seem surprising if we remember that when light strikes on the background of the eye, consciousness is quickened, and this, as we know, presupposes a breaking down of substance in some part of the nervous system. Such a process does in fact

[1] As regards the principle underlying the line of consideration followed here, see the remark made in Chapter V in connexion with Goethe's study of the 'proliferated rose' (p. 76*f*.).

occur in the retina, the nerve-part of the eye, when external light falls upon it. If the eye were solely a structure of nerves, it would be so far destroyed by the impact of light that it could not be restored even by sleep, as are the more inward parts of the nervous system. But the eye receives also a flow of blood, and we know that throughout the threefold human organism the blood supplies the nervous system with building-up forces, polarically opposite to the destructive ones. In sleep, as we have already seen, the interruption of consciousness allows the blood to inundate the nervous system, as it were, with its healing, building-up activity. It is not necessary, however, for the whole of the body to pass into a condition of sleep before this activity can occur. It functions to some extent also in the waking state, especially in those parts of the organism which, like the eye, serve in the highest degree the unfolding of consciousness.

Having established this, we have a basis for an understanding of the complete process of vision. We see that it is by no means solely the nerve part of the eye which is responsible for vision, as the spectator-physiology was bound to imagine. The very fact that the place where the optic nerve enters the eye is blind indicates that the function of mediating sight cannot be ascribed to the nerve alone. What we call 'seeing' is far more the result of an interplay between the retina carrying the nerves, and the choroid carrying the blood-vessels. In this interplay the nerves are the passive, receptive organ for the inworking of external light, while the blood-activity comes to meet the nerve-process with a precisely correlated action. In this action we find what Goethe called the 'inner light'.

The process involved in adaptation now becomes comprehensible. The cause of the dazzling effect of light of normal intensity on an eye adapted to the dark, is that in such an eye the blood is in a state of rest, and this prevents it from exercising quickly enough the necessary counter-action to the influence of the light. A corresponding effect occurs when one suddenly exposes to darkness the eye adapted to light. One can easily observe what goes on then, if, after looking for a time at an undifferentiated light surface such as the evenly luminous sky, one covers the opened eyes with the hollowed hands. It will then be found that the space before the eyes is filled by a sort of white light, and by paying close attention one recognizes that it streams from the eyes out into the hollowed space. It may even be several minutes before the field of vision really appears black, that is, before the activity of the inner light in the choroid has so far died away that equilibrium prevails between the non-stimulated nerves and the non-stimulated blood.

With this insight into the twofold nature of the process of vision we are now able to describe more fully the negative after-image. Although in this case, as Goethe himself remarked, the ordinary explanation seems to suffice, yet in view of our later studies it may be well to bring forward here this wider conception.

On the basis of our present findings it is no longer enough to trace the appearing of the after-image solely to a differential fatigue in the retina. The fact is that as long as the eye is turned to the bright window-pane a more intensive blood-activity occurs in the portions of the eye's background met by the light than in those where the dark window-bar throws its shadow on the retina. If the eye so influenced is then directed to the faintly illumined wall of the room, the difference in the activity of the blood persists for some time. Hence in the parts of the eye adapted to darkness we experience the faint brightness as strongly luminous, even dazzling, whereas in the parts more adapted to light we feel the same degree of brightness to be dark. That the action of the inner light is responsible for the differences becomes clear if, while the negative after-image is still visible, we darken the eye with the hollowed hands. Then at once in the dark field of vision the positive facsimile of the window appears, woven by the activity of the blood which reproduces the outer reality.

Having traced the colourless after-image to 'higher sources'—that is, to the action of the blood—let us now examine coloured after-images. We need first to become conscious of the colour-creating light-activity which resides in the blood. For this purpose we expose the eyes for a moment to an intense light, and then darken them for a sufficient time. Nothing in external nature resembles in beauty and radiance the play of colour which then arises, unless it be the colour phenomenon of the rainbow under exceptionally favourable circumstances.

The physiological process which comes to consciousness in this way as an experience of vision is exactly the same as the process which gives us experiences of vision in dreams. There is indeed evidence that when one awakens in a brightly lit room out of vivid dreaming, one feels less dazzled than on waking from dreamless sleep. This indicates that in dream vision the blood in the eye is active, just as it is in waking vision. The only difference is that in waking consciousness the stimulus reaches the blood from outside, through the eye, whereas in dreams it comes from causes within the organism. The nature of these causes does not concern us here; it will be dealt with later. For the moment it suffices to establish the fact that our organism is supplied with a definite activity of forces which we experience as the appearance of certain images of vision, no matter from which side the stimulus comes. All vision, physiologically considered, is of the nature of dream vision; that is to say, we owe our day-waking sight to the fact that we are able to encounter the pictures of the outer world, brought to us by the light, with a dreaming of the corresponding after-images.

Just as the simple light-dark after-image shows a reversal of light-values in relation to the external picture, so in the coloured after-images there is a quite definite and opposite relationship of their colours to those of the original picture. Thus, if the eyes are exposed for some time to an impression of the colour red, and then directed to a neutral surface, not too brightly illuminated, one sees it covered with a glimmering green. In this way there is a reciprocal correspondence between the colour-pairs Red-Green, Yellow-Violet, Blue-Orange. To whichever of these six colours one exposes the eye, an after-image always appears of its contrast colour, forming with it a pair of opposites.

We must here briefly recall how this phenomenon is generally explained on Newtonian lines. The starting-point is the assumption that the eye becomes fatigued by gazing at the colour and gradually becomes insensitive to it. According to Newton's theory, if an eye thus affected looks at a white surface, the sum of all the colours comes from there to meet it, while the eye has a reduced sensitivity to the particular colour it has been gazing at. And so among the totality of colours constituting the 'white' light, this one is more or less non-existent for the eye. The remaining colours are then believed to cause the contrasting colour-impression.

If we apply the common sense of the Hans Andersen child to this, we see where it actually leads. For it says no less than this: as long as the eye is in a normal condition, it tells us a lie about the world, for it makes white light seem something that in reality it is not. For the truth to become apparent, the natural function of the eye must be reduced by fatigue. To believe that a body, functioning in this way, is the creation of God, and at the same time to look on this God as a Being of absolute moral perfection, would seem a complete contradiction to the Hans Andersen child. In this contradiction and others of the same kind to which nowadays every child is exposed repeatedly and willy-nilly in school lessons and so on—we must seek the true cause of the moral uncertainty so characteristic of young people to-day. It was because Ruskin felt this that he called for a 'moral' theory of light.

Since Goethe did not judge man from artificially devised experiments, but the latter from man, quite simple reflexions led him to the following view of the presence of the contrasting colour in the coloured after-images. Nature outside man had taught him that life on all levels takes it course in a perpetual interplay of opposites, manifested externally in an interplay of diastole and systole comparable to the process of breathing. He, therefore, traced the interchange of light-values in colourless after-images to a 'silent resistance which every vital principle is forced to exhibit when some definite condition is presented to it. Thus, inhalation presupposes exhalation; thus every systole, its diastole. When darkness is presented to the eye, the eye demands brightness, and vice versa: it reveals its vital energy, its fitness to grasp the object, precisely by bringing forth out of itself something contrary to the object.'

Consequently he summarizes his reflexions on coloured after-images and their reversals of colour in these words: 'The eye demands actual completeness and closes the colour-circle in itself.' How true this is, the law connecting the corresponding colours shows, as may be seen in the following diagram. Here, red, yellow and blue as three primary colours confront the three remaining colours, green, violet and orange in such a way that each of the latter represents a mixture of the two other primary colours. (Fig. 10.)

Colour and contrast-colour are actually so related that to whatever colour the eye is exposed it produces a counter-colour so as to have the sum-total of all the three primary colours in itself. And so, in consequence of the interplay of outer and inner light in the eye, there is always present in it the totality of all the colours.

It follows that the appearance of the contrast-colour in the field of vision is not, as the Newtonian theory asserts, the result of fatigue, but of an intensified activity of the eye, which continues even after the colour impression which gave rise to it has ceased. What is seen on the neutral surface (it will be shown later why we studiously avoid speaking of 'white light') is no outwardly existing colour at all. It is the activity of the eye itself, working in a dreamlike way from its blood-vessel system, and coming to our consciousness by this means.

Here again, just as in the simple opposition of light and dark, the perception of coloured after-images is connected with a breaking-down process in the nerve region of the eye, and a corresponding building-up activity coming from the blood. Only in this case the eye is not affected by simple light, but by light of a definite colouring. The specific destructive process caused by this light is answered with a specific building-up process by the blood. Under certain conditions we can become dreamily aware of this process which normally does not enter our consciousness. In such a case we see the contrasting colour as coloured after-image.

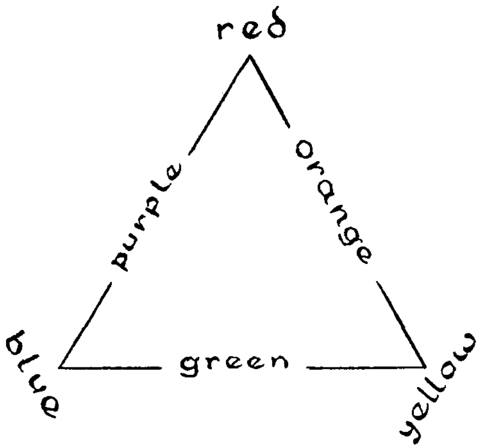

FIG. 10.

Only by representing the process in this way do we do justice to a fact which completely eludes the onlooker-consciousness—namely, that the eye produces the contrasting colour even while it is still exposed to the influence of the outer colour. Since this is so, all colours appearing to us in ordinary vision are already tinged by the subdued light of the opposite colour, produced by the eye itself. One can easily convince oneself of this through the following experiment. Instead of directing the eye, after it has been exposed to a certain colour, to a neutral surface, as previously, gaze at the appropriate contrasting colour. (The first and second coloured surfaces should be so arranged that the former is considerably smaller than the latter.) Then, in the middle of the second surface (and in a field about the size of the first), its own colour appears, with a strikingly heightened intensity.

Here we find the eye producing, as usual, a contrast-colour from out of itself, as an after-image, even while its gaze is fixed on the same colour in the outer world. The heightened brilliance within the given field is due to the addition of the after-image colour to the external colour.

The reader may wonder why this phenomenon is not immediately adduced as a decisive proof of the fallacy of the whole Newtonian theory of the relation of 'white' light to the various colours. Although it does in fact offer such a proof, we have good reason for not making this use of it here. Throughout this book it is never our intention to enter into a contest of explanations, or to defeat one explanation by another. How little this would help will be obvious if we realize that research was certainly not ignorant of the fact that the opposite colour arises even when the eye is not turned to a white surface. In spite of this, science did not feel its concept of white light as the sum of all the colours to be an error, since it has succeeded in 'explaining' this phenomenon too, and fitting it into the prevailing theory. To do so is in thorough accord with spectator-thinking. Our own concern, however, as in all earlier cases, is to replace this thinking with all its 'proofs' and 'explanations' by learning to *read* in the phenomena themselves. For no other purpose than this the following facts also are now brought forward.

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Besides Rudolf Steiner's fundamental insight into the spiritual-physical nature of the growing human being, through which he laid the basis of a true art of education, he gave advice on many practical points. For example, he indicated how by the choice of a suitable colour environment one can bring a harmonizing influence to bear on extremes of temperament in little children. To-day it is a matter of practical experience that excitable children are quietened if they are surrounded with red or red-yellow colours, or wear clothes of these colours, whereas inactive, lethargic children are roused to inner movement if they are exposed to the influence of blue or blue-green colours.

This psychological reaction of children to colour is not surprising if one knows the role played by the blood in the process of seeing, and how differently the soul-life of man is connected with the blood-nerve polarity of his organism in childhood and in later life. What we have described as the polar interplay of blood and nerve in the act of sight is not confined to the narrow field of the eye. Just as the nerve processes arising in the retina are continued to the optic centre in the cerebrum, so must we look for the origin of the corresponding blood process not in the choroid itself, but in the lower regions of the organism. Wherever, therefore, the colour red influences the whole nerve system, the blood system as a whole answers with an activity of the metabolism corresponding to the contrasting colour, green. Similarly it reacts as a whole to a blue-violet affecting the nerve system, this time with a production corresponding to yellow-orange.

The reason why in later years we notice this so little lies in a fact we have repeatedly encountered. The consciousness of the grown man to-day, through its one-sided attachment to the death-processes in the nerve region, pays no attention to its connexion with the life-processes centred in the blood system. In this respect the condition of the little child is quite different. Just as the child is more asleep in its nerve system than the grown-up person, it is more awake in its blood system. Hence in all sense-perceptions a child is not so much aware of how the world works on its nerve system as how its blood system responds. And so a child in a red environment feels quietened because it experiences, though dimly, how its whole blood system is stimulated to the green production; bluish colours enliven it because it feels its blood answer with a production of light yellowish tones.

From the latter phenomena we see once more the significance of Goethe's arrangement of his *Farbenlehre.* For we are now able to realize that to turn one's attention to the deeds and sufferings of the *inner* light means nothing less than to bring to consciousness the processes of vision which in childhood, though in a dreamlike way, determine the soul's experience of seeing. Through placing his examination of the physiological colours at the beginning of his *Farbenlehre,* Goethe actually took the path in scientific research to which Thomas Reid pointed in philosophy. By adapting Reid's words we can say that Goethe, in his *Farbenlehre,* proclaims as a basic principle of a true Optics: that we must become again as little children if we would reach a philosophy of light and colours.

CHAPTER XVI

Seeing as **'Deed'—II**

The observation of our own visual process, which we began in the last chapter, will serve now to free us from a series of illusory concepts which have been connected by the onlooker-consciousness with the phenomena brought about by light.

There is first the general assumption that light as such is visible. In order to realize that light is itself an invisible agent, we need only consider a few self-evident facts—for instance, that for visibility to arise light must always encounter some material resistance in space. This is, in fact, an encounter between light, typifying levity, and the density of the material world, typifying gravity. Accordingly, wherever visible colours appear we have always to do with light meeting its opposite.

Optics, therefore, as a science of the physically perceptible is never concerned with light-alone, but always with light and its opposite together. This is actually referred to in Ruskin's statement, quoted in the last chapter, where he speaks of the need of the 'force' and of the intercepting bodily organ before a science of optics can come into existence. Ruskin's 'light', however, is what we have learnt with Goethe to call 'colour', whereas that for which we reserve the term 'light' is called by him simply 'force'.

All this shows how illusory it is to speak of 'white' light as synonymous with simple light, in distinction to 'coloured' light. And yet this has been customary with scientists from the time of Newton until today, not excluding Newton's critic, Eddington. In fact, white exists visibly for the eye as part of the manifested world, and is therefore properly characterized as a colour. This is, therefore, how Goethe spoke of it. We shall see presently the special position of white (and likewise of black), as a colour among colours. What matters first of all is to realize that white must be strictly differentiated from light as such, for the function of light is to make visible the material world without itself being visible.

To say that light is invisible, however, does not mean that it is wholly imperceptible. It is difficult to bring the perception of light into consciousness, for naturally our attention, when we look out into light-filled space, is claimed by the objects of the illuminated world, in all their manifold colours and forms. Nevertheless the effect of pure light on our consciousness can be observed—during a railway journey, for instance, when we leave a tunnel that has been long enough to bring about a complete adaptation of the eyes to the prevailing darkness. Then, in the first moments of the lightening of the field of vision, and before any separate objects catch the attention, we can notice how the light itself exercises a distinctly expanding influence on our consciousness. We feel how the light calls on the consciousness to participate, as it were, in the world outside the body.

It is possible also to perceive directly the opposite of light. This is easier than the direct perception of light, for in the dark one is not distracted by the sight of surrounding objects. One need only pay attention to the fact that, after a complete adapting of the eyes to the dark, one still retains a distinct experience of the extension of the field of vision of both eyes. We find here, just as in the case of light, that our will is engaged within the eye in a definite way; a systolic effect proceeds from dark, a diastolic effect from light. We have a distinct perception of both, but not of anything 'visible' in the ordinary sense.

With regard to our visual experience of white and black, it is quite different. We are concerned here with definite conditions of corporeal surfaces, just as with other colours, although the conditions conveying the impressions of white or black are of a special character. A closer inspection of these conditions reveals a property of our act of seeing which has completely escaped scientific observation, but which is of fundamental importance for the understanding of optical phenomena dynamically.

It is well known that a corporeal surface, which we experience as white, has the characteristic of throwing back almost all the light that strikes it, whereas light is more or less completely absorbed by a surface which we experience as black. Such extreme forms of interplay between light and a corporeal surface, however, do not only occur when the light has no particular colour, but also when a coloured surface is struck by light of the same or opposite colour. In the first instance complete reflexion takes place; in the second, complete absorption. And both these effects are registered by the eye in precisely the same manner as those mentioned before. For example, a red surface in red light looks simply white; a green surface in red light looks black.

The usual interpretation of this phenomenon, namely, that it consists in a subjective 'contrast' impression of the eye—a red surface in red light looking brighter, a green surface darker, than its surroundings, and thereby causing the illusion of white or black—is a typical onlooker-interpretation against which there stands the evidence of unprejudiced observation. The reality of the 'white' and the 'black' seen in such cases is so striking that a person who has not seen the colours of the objects in ordinary light can hardly be persuaded to believe that they are not 'really' white or black. The fact is that the white and the black that are seen under these conditions are just as real as 'ordinary' white and black. When in either instance the eye registers 'white' it registers exactly the same event, namely, the total reflexion of the light by the surface struck by it. Again, when the eye registers 'black' in both cases it registers an identical process, namely, total absorption of the light.[1]

Seen thus, the phenomenon informs us of the significant fact that our eye is not at all concerned with the colour of the light that enters its own cavity, but rather with what happens between the light and the surface on which the light falls. In other words, the phenomenon shows that our process of seeing is not confined to the bodily organ of the eye, but extends into outer space to the point where we experience the visible object to be.[2]

This picture of the visual process, to which we have been led here by simple optical observation, was reached by Thomas Reid through his own experience of how, in the act of perceiving the world, man is linked intuitively with it. We remember that he intended in his philosophy to carry *ad absurdum* the hypothesis that 'the images of the external objects are conveyed by the organs of sense to the brain and are there perceived by the mind'. Common Sense makes Reid speak as follows: 'If any man will shew how the mind may perceive images of the brain, I will undertake to shew how it may perceive the most

[1] It will be well to remember here the discussion of our experience of temperature through the sense of warmth in Chapter VIII (p. 134*f*.).

[2] Along these lines the true solution of the problem of the so-called coloured shadows will be found, Goethe studied this without finding, however, a satisfactory answer.

distant objects; for if we give eyes to the mind, to perceive what is transacted at home in its dark chamber, why may we not make the eyes a little longer-sighted? And then we shall have no occasion for that unphilosophical fiction of images in the brain.' *(Inq.,* VI, 12.) Reid proceeds to show this by pointing out, first, that we must only use the idea of 'image' for truly visual perceptions; secondly, that the sole place of this image is the background of the eye, and not any part of the nervous system lying beyond; thirdly, that even this retina-image, as such, does not come to our consciousness, but serves only to direct the consciousness to the cause of the image, namely, the external object itself. In what follows we shall deal with an observation which will show how right Reid was in this respect.

Those familiar with this observation (well known indeed to those living in the hilly and mountainous districts both here and on the Continent) know that when distant features of the landscape, in an otherwise clear and sunlit atmosphere, suddenly seem almost near enough to touch, rainy weather is approaching. Likewise a conspicuous increase in distance, while the sky is still overcast, foreshadows fine weather.

This effect (the customary 'explanation' of which is, as usual, of no avail to us and so need not concern us here) ranks with phenomena described in optics under the name of 'apparent optical depth', a subject we shall discuss more fully in the next chapter. It suffices here to state that it is the higher degree of humidity which, by lending the atmosphere greater optical density (without changing its clarity), makes distant objects seem to be closer to the eye, and vice versa. (If we could substitute for the air a much lighter gas—say, hydrogen—then the things we see through it would look farther off than they ever do in our atmosphere.)

Observations such as these show us that *(a)* when external light strikes the retina of our eye, our inner light is stimulated to move out of the eye towards it; (*b*) in pressing outward, this inner light meets with a certain resistance, and the extent of this determines at what distance from the eye our visual ray comes to rest as the result of a kind of exhaustion. Just as the outer light reaches an inner boundary at our retina, so does the inner light meet with an outer boundary, set by the optical density of the medium spread out before the eye, Outer and inner light interpenetrate each other along the whole tract between these two boundaries, but normally we are not conscious of this process. We first become conscious of it where our active gaze—

that is, the inner light sent forth through the eye—reaches the limit of its activity. At that point we become aware of the object of our gaze. So here we find confirmed a fact noted earlier, that consciousness—at least at its present state of evolution—arises where for some reason or other our volition conies to rest.

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The foregoing observations have served to awaken us in a preliminary way to the fact that an essential part of our act of seeing takes place outside our bodily organ of vision and that our visual experience is determined by what happens out there between our gaze and the medium it has to penetrate. Our next task will be to find out how this part of our visual activity is affected by the properties of the different colours. We shall thereby gain a further insight into the nature of the polarity underlying all colour-phenomena, and this again will enable us to move a step further towards becoming conscious of what happens in our act of seeing.

We shall start by observing what happens to the two sides of the colour-scale when the optical medium assumes various degrees of density.

For the sky to appear blue by day a certain purity of the atmosphere is needed. The more veiled the atmosphere becomes the more the blue of the sky turns towards white; the purer and rarer the atmosphere, the deeper the blue, gradually approaching to black. To mountain climbers and those who fly at great heights it is a familiar experience to see the sky assume a deep indigo hue. There can be no doubt that at still higher altitudes the colour of the sky passes over into violet and ultimately into pure black. Thus in the case of blue the field of vision owes its darkening to a decrease in the resistance by which our visual ray is met in the optical medium. It is precisely the opposite with yellow. For here, as the density of the medium increases, the colour-effect grows darker by yellow darkening first to orange and then to red, until finally it passes over into complete darkness.

This shows that our visual ray is subject to entirely different dynamic effects at the two poles of the colour-scale. At the blue pole, the lightness-effect springs from the resistant medium through which we gaze, a medium under the influence of gravity, while the darkness is provided by the anti-gravity quality of cosmic space, which as a 'negative' resistance exercises a suction on the eye's inner light. At the yellow pole it is just the reverse. Here, the resistant medium brings about a darkening of our field of vision, while the lightness-effect springs from a direct meeting of the eye with light, and so with the suctional effect of negative density.

Our pursuit of the dynamic causes underlying our apperception of the two poles of the colour-scale has led us to a point where it becomes necessary to introduce certain new terms to enable us to go beyond Goethe's general distinction between *Finsternis* (darkness) and *Licht* (light). Following Goethe, we have so far used these two terms for what appears both in blue and yellow as the respective light and dark ingredients. This distinction cannot satisfy us any more. For through our last observations it has become clear that the *Finsternis* in blue and the *Licht* in yellow are opposites only in appearance, because they are both caused by Levity, and similarly that the lightening effect in blue and the darkening effect in yellow are both effected by Gravity. Therefore, to distinguish between what appertains to the primary polarity, Levity-Gravity, on the one hand, and their visible effects in the secondary polarity of the colours, on the other, we shall henceforth reserve the term *darkness* and, with it, *lightness* for instances where the perceptible components of the respective colours are concerned, while speaking of *Dark* and *Light* where reference is made to the generating primary polarity.

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If we are justified in thus tracing the colour-polarity to a polarically ordered interplay between levity and gravity, we may then pursue the following line of thought. We know from earlier considerations that wherever such an interplay between the poles of the primary polarity takes place, we have to do, in geometric terms, with the polarity of sphere and radius. We may therefore conclude that the same characteristics will apply to the way in which the blue of the sky and the yellow of the sunlight are encountered spatially. Now we need only observe how the blue heavens arch over us spherically, on the one hand, and how the yellow brightness of the sun penetrates the air raywise, on the other, in order to realize that this really is so.

Having thus established the connexion of the two poles of the colour-scale with the spherical and radial structure of space, we are now able to express the Goethean ur-phenomenon in a more dynamic way as follows: On the one hand, we see the blue of the heavens emerging when levity is drawn down by gravity from its primal in-visibility into visible, spherical manifestation. In the yellow of the sunlight, on the other hand, we see gravity, under the influence of the sun's levity, gleaming up radially into visibility. The aspect of the two colour-poles which thus arises before us prompts us to replace Goethe's 'lightened Dark' by *Earthward-dawning-Levity*, and his 'darkened Light' by *Heavenward-raying-Gravity.*

We have now to show that this picture of the dynamic relationship which underlies the appearance of the colour-polarity in the sky is valid also for other cases which are instances of the ur-phenomenon of the generation of colour in Goethe's sense, but seem not to lend themselves to the same cosmic interpretation. Such a case is the appearance of yellow and blue when we look through a clouded transparent medium towards a source of light or to a black background. There is no special difficulty here in bringing the appearance of yellow into line with its macrotelluric counterpart, but the appearance of blue requires some consideration.

We have seen that a corporeal surface appears as black if light striking it is totally absorbed by it. Thus, wherever our eye is met by the colour black, our visual ray is engaged in a process whereby light disappears from physical space. Now we need only bring this process into consciousness—as we have tried to do before in similar instances—to realize that what happens here to the visual ray is something similar to what it undergoes when it is directed from the earth into cosmic space.

Note, in this respect, the principle of the mirror as another instance of the fact that the interplay between light and an illumined surface can have on the visual ray an effect similar to that of external space. For the optical processes which occur on the surface of a mirror are such that, whilst taking place on a two-dimensional plane, they evoke in our consciousness pictures of exactly the same nature as if we were looking through the mirror into the space behind it.

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The value of our picture of the colour-polarity is shown further if we observe how natural phenomena based on the same kind of polarity in other realms of nature fit in with it. We remember that one of Goethe's starting-points in his investigation of the riddle of colour was the observation that of the totality of colours one part is experienced as 'warm' and the other as 'cold'. Now we can go further and say that the colours of the spherical pole are experienced as cold, those of the radial pole as warm. This corresponds precisely to the polarity of snow-formation and volcanic activity. The former, being the spherically directed process, requires physically low temperatures; the latter, being the radially directed process, requires high temperatures. Here, once more, we see with what objectivity the human senses register the facts of the outer world.

Another realm of phenomena based on a similar polar order is that of electricity. When we studied the negative and positive poles of the vacuum tube, with regard to the polar distribution of radius and sphere, our attention was drawn to the colours appearing on the two electrodes—red at the (positive) anode, blue at the (negative) cathode. Again we find a coincidence with the natural order of the colours.

Note how the qualitative dynamic method employed here brings into direct view the relationship between light and electricity, while it precludes the mistake of tracing light processes to those of electricity, as modern science does. Nor are electric processes 'explained' from this point of view merely as variations of light processes. Rather is the relation between light and electricity seen to be based on the fact that all polarities arising perceptibly in nature are creations of the same primeval polarity, that of Levity and Gravity. The interplay of Levity and Gravity can take on many different forms which are distinguished essentially by differences in cosmic age. Thus the colour-polarity in its primal form, made manifest by the heavens, differs as much from the corresponding polarity shown by the vacuum tube, as does the lightning in the heights from the electric spark.

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With the aid of what we have learnt here concerning outer light-processes we shall turn once more to the activity of our own inner light.

We may expect by now that our eye is fitted with two modes of seeing activity, polar to each other, and that the way in which they come into operation depends on whether the interplay of positive and negative density outside the eye leads to the appearance of the blue-violet or of the yellow-red side of the colour-scale. Such a polarity in the activity of the eye can indeed be established. Along with it goes a significant functional difference between the two eyes (not unlike that shown of the two hands).

To observe this we need simply to compare the two eyes of a person in a photograph by covering alternately the right and the left half of the face. Nearly always it will be found that the right eye looks out clearly into the world with an active expression, and the left eye with a much gentler one, almost held back. Artists are well aware of this asymmetry, as of others in the human countenance, and are careful to depict it. An outstanding example is Raphael's Sistine Madonna, where in the eyes and whole countenance both of Mother and Child this asymmetry can be studied in a specially impressive way.

Inner observation leads to a corresponding experience. A convenient method is to exercise the two eyes in complete darkness, in the following way. One eye is made to look actively into the space in front of it, as if it would pierce the darkness with its visual ray, while the activity of the other eye is held back, so that its gaze rests only superficially, as it were, on the darkness in front of it. Experience shows that most people find it natural to give the active note to the right eye, and the passive note to the left.

Once one has grown conscious of this natural difference between the two eyes, it is quite easily detected while one is looking normally into the light-filled environment. We thereby realize that for the two eyes to act differently in this way is the usual thing.

As an instance where this fact is well observed and effectively made use of, that of shooting may be mentioned here, especially shooting at flying game. Those who train in this sport learn to make a completely different use of the two eyes in sighting the target. The naturally more active eye—only once in about fifty cases is it the left—is called by them the 'master-eye'. Whilst the less actively gazing eye is usually employed for surveying the field as a whole into which the target is expected to enter, the master-eye is used for making active contact with the target itself ('throwing' oneself on the target 'through' the eye).

One further observation may be added. If one looks with rested eyes and in very faint daylight (perhaps in the early morning on awakening) at a white surface, while opening and closing the eyes alternately, then the white surface looks faintly reddish to the 'master-eye', and faintly bluish to the other.

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Following the lines of our treatment of after-images in the last chapter, we will next inquire into the anatomical and physiological basis of the two opposite sight-activities. In the previous instance we found this in the polarity of nerve and blood. This time we must look for it in a certain twofold structure of the eye itself. We shall best perceive this by watching the 'becoming' of the eye, thus again following a method first shown by Goethe.

Fig. 11 shows the human eye in different stages of its embryonic formation. The eye is clearly seen to consist of two parts essentially different in origin. Growing out from the interior of the embryonic organism is a structure that is gradually pushed in, and in its further development becomes the entire posterior part of the eye, destined to carry its life-imbued functions. A second independent part grows towards this from outside; this is at first a mere thickening of the

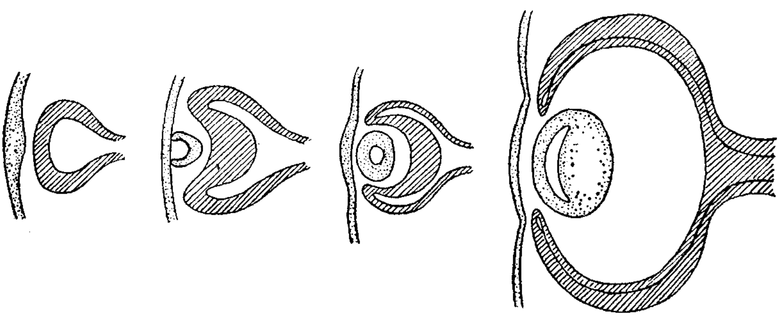

FIG. 11.

embryonic skin formation, but later it loosens itself and presses forward into the interior of the cup-shaped structure. It is gradually enclosed by this, and evolves finally into that part of the finished eye which embodies the optical apparatus functioning according to purely physical laws.

This series of forms shows that in the embryonic formation of the eye we are confronted with two processes, one of spherical, and the other of radial orientation. Consequently the two parts of the eye are differentiated in such a way that the posterior part, which has grown forth radially from the embryonic organism, as the life-filled element represents the *sulphur-pole* of the total eye, while the anterior part, with its much more crystalline nature, having grown spherically towards the organism, represents the eye's *salt-pole.*

Closer inspection into the connexion of the two visual activities of the eye with its basic corporeal parts reveals that here, at the outermost boundary of the human organism, we encounter once more that peculiar reversal of functions which we have already several times met in various realms of nature. For the anterior part of the eye—its salt-pole—which has come into being through a spherically directed formative process, seems to be the one through which we exercise the perceptive activity streaming out radially from the eye, whilst the posterior part—the eye's sulphur-pole—which has come into being through radially directed formative action, serves that form of seeing which is more receptive and is carried out in a plane-wise manner.

Considerations of this kind, and they alone, enable us also to draw true comparisons between the different sense-organs. Take the organ of hearing. Usually the ear is assumed to fill the same role in the field of hearing as does the eye in the field of seeing. In fact the ear corresponds to only one half of the eye; the other half must be looked for in the larynx. In other words, the two parts of the eye are represented in the realm of hearing by two separate organs, ear and larynx. Speaking from the aspect of metamorphosis, the vital part of our eye may be regarded as our 'light-ear'; the crystalline part, as our 'light-larynx'. In order to come consciously to a perception of sight we must 'listen' to the 'deeds and sufferings' of light, while at the same time we meet them with the help of the 'speaking' of our inner light. Something similar holds good for hearing. In fact, observation reveals that we take in no impression of hearing unless we accompany it with an activity of our larynx, even though a silent one. The significance of this fact for the total function of hearing will occupy us more fully later.

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Our insight into the polar nature of visual activity will enable us now to link the external interplay of Light and Dark—to which the physical colours owe their existence—to that play of forces which we ourselves set in motion when our eye meets the world of colours in their polar differentiation.

We established earlier that in the cold colours the role of darkness belongs to the pole of levity or negative density, and the role of lightness to the pole of gravity or positive density, whereas in the case of the warm colours the roles are reversed. Let us now unite with this the insight we have meanwhile gained into the two kinds of activity in seeing—the receptive, 'left-eyed' and the radiating, 'right-eyed'—

which mediate to us the experience of the positive or negative density of space spread out before our eyes. Taking together the results of outer and inner observation, we can express the polarity ruling in the realm of colour as follows.

If lightness and darkness as elements of colour, meet us in such a way that lightness, by reason of its positive density, calls forth 'left-eyed' activity, and darkness, by reason of its negative density, 'right-eyed' activity, then our soul receives the impression of the colour blue and colours related to blue. If lightness and darkness meet us so that we see the former in a 'right-eyed', and the latter in a 'left-eyed' way, then we experience this as the presence of yellow and the colours related to it.

The reason why we usually fail to observe the different kinds of interplay of the two modes of seeing, when we perceive one or other of the two categories of colour, is because in ordinary sight both eyes exercise each of the two activities without our becoming aware which is the leading one in a particular eye. If, however, one has come to a real experience of the inner polarity of the visual act, one needs only a little practice to realize the distinction. For example, if one looks at the blue sky, notably at noon-time, on the side away from the sun, or at the morning or evening sky, shining yellow and red, one quickly becomes conscious of how our eyes take hold of the particular contribution which Light and Dark make to one or other of the two colour appearances.

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In the natural course of our argument we had to keep at first to the appearance of colours as they come freely before us in space. The results we have obtained, however, hold good equally well for the permanent tints of material objects, as the following example will show.

A fact known to science is that red and blue surface colours, when illumined by light of steadily diminishing intensity, are seen to reverse their normal ratio of brightness. This phenomenon can be seen in nature, if, for instance, one observes a bed of blue and red flowers in the fading evening light and compares the impression with that which the same flowers make in bright daylight. If the phenomenon is reproduced artificially, the actual transition from one state to the other can be clearly observed. The easiest way is to place a red and a blue surface side by side under an electric light whose intensity can be gradually lessened by means of a sliding resistance. Here, as much as in the natural phenomenon, our reason finds it difficult to acknowledge that the surface gleaming in a whitish sheen should be the one which ordinarily appears as darkling blue, and that the one disappearing into darkness should be the surface which normally presents itself as radiant red.

This riddle is readily solved if we apply what we have learnt about the particular shares of lightness and darkness in these two colours, and if we link this up with the respective forms of seeing exercised by our two eyes. To the dim light, clearly, our eyes will respond more with the 'left-eyed' than with the 'right-eyed' form of vision. Now we know that it is 'left-eyed' vision which is roused by the lightness-component in blue and the darkness-component in red. It is only to be expected, therefore, that these elements should become conspicuous when in the dim light our seeing is mainly 'left-eyed'. This solution of the problem makes us realize further, that the laws which Goethe first found for the coming into appearance of colours freely hovering in space are indeed applicable to the fixed material colours as well.

CHAPTER XVII

Optics of the Doer

Three basic concepts form the foundation for the present-day scientific description of a vast field of optical phenomena, among them the occurrence of the spectral colours as a result of light passing through a transparent medium of prismatic shape. They are: 'optical refraction', 'light-ray', and 'light-velocity'—the latter two serving to explain the first. In a science of optics which seeks its foundation in the intercourse between man's own visual activity and the doings and sufferings of light, these three concepts must needs undergo a decisive change, both in their meaning and in their value for the description of the relevant optical phenomena. For they are all purely kinematic concepts typical of the onlooker-way of conceiving things—concepts, that is, to which nothing corresponds in the realm of the actual phenomena.

Our next task, therefore, will be, where possible, to fill these concepts with new meaning, or else to replace them by other concepts read from the actual phenomena. Once this is done the way will be free for the development of the picture of the spectrum phenomenon which is in true accord with the Goethean conception of Light and Colour.

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The first to be brought in this sense under our examination is the concept of the 'light-ray'.

In present-day optics this concept signifies a geometrical line of infinitely small width drawn, as it were, by the light in space, while the cone or cylinder of light actually filling the space is described as being composed of innumerable such rays. In the same way the object producing or reflecting light is thought of as composed of innumerable single points from which the light-rays emerge. All descriptions of optical processes are based upon this conception.

Obviously, we cannot be satisfied with such a reduction of wholes into single geometrically describable parts, followed by a reassembling of these parts into a whole. For in reality we have to do with realms of space uniformly filled with light, whether conical or cylindrical in form, which arise through certain boundaries being set to the light. In optical research we have therefore always to do with *pictures*, spatially bounded. Thus what comes before our consciousness is determined equally by the light calling forth the picture, and by the unlit space bordering it.

Remembering the results of our earlier study, we must say further of such a light-filled realm that it lacks the quality of visibility and therefore has no colour, not even white. Goethe and other 'readers', such as Reid and Ruskin, tried continually to visualize what such a light-filled space represents in reality. Hence they directed their attention first to those spheres where light manifests its form-creative activity, as in the moulding of the organ of sight in animal or man, or in the creation of the many forms of the plant kingdom—and only then gave their mind to the purely physical light-phenomena. Let us use the same method to form a picture of a light-filled space, and to connect this with the ideas we have previously gained on the co-operation in space of levity and gravity.

Suppose we have two similar plant-seeds in germ; and let one lie in a space filled with light, the other in an unlit space. From the different behaviour of the two seeds we can observe certain differences between the two regions of space. We note that within the light-filled region the spiritual archetype of the plant belonging to the seed is helped to manifest itself physically in space, whereas in the dark region it receives no such aid. For in the latter the physical plant, even if it grows, does not develop its proper forms. This tells us, in accordance with what we have learnt earlier, that in the two cases there is a different relation of space to the cosmically distant, all-embracing plane. Thus inside and outside the light-region there exists a quite different relation of levity and gravity—and this relation changes abruptly at the boundaries of the region. (This fact will be of especial importance for us when we come to examine the arising of colours at the boundary of Light and Dark, when light passes through a prism.)

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After having replaced the customary concept of the light-bundle composed of single rays by the conception of two dynamically polar realms of space bordering each other, we turn to the examination of what is going on dynamically inside these realms. This will help us to gain a proper concept of the propagation of light through space.

In an age when the existence of a measurable light-velocity seems to belong to the realm of facts long since experimentally proved; when science has begun to measure the universe, using the magnitude of this velocity as a constant, valid for the whole cosmos; and when entire branches of science have been founded on results thus gained, it is not easy, and yet it cannot be avoided, to proclaim that *neither has an actual velocity of light ever been measured, nor can light as such ever be made subject to such measurement by optical means*—and that, moreover, light, by its very nature, forbids us to conceive of it as possessing any finite velocity.

With the last assertion we do not mean to say that there is nothing going on in connexion with the appearance of optical phenomena to which the concept of a finite velocity is applicable. Only, what is propagated in this way is not the entity we comprise under the concept of 'light'. Our next task, therefore, will be to create a proper distinction between what moves and what does not move spatially when light is active in the physical world. Once more an historical retrospect will help us to establish our own standpoint with regard to the existing theories.

The first to think of light as possessing a finite velocity was Galileo, who also made the first, though unsuccessful, attempt to measure it. Equally unsuccessful were attempts of a similar nature made soon afterwards by members of the Accademia del Cimento. In both cases the obvious procedure was to produce regular flashes of light and to try to measure the time which elapsed between their production and their observation by some more or less distant observer. Still, the conviction of the existence of such a velocity was so deeply ingrained in the minds of men that, when later observations succeeded in establishing a finite magnitude for what seemed to be the rate of the light's movement through space, these observations were hailed much more as the quantitative value of this movement than as proof of its existence, which was already taken for granted.

A clear indication of man's state of mind in regard to this question is given in the following passage from Huygens's famous *Traité de la Lumière*, by which the world was first made acquainted with the concept of light as a sort of undulatory movement.

'One cannot doubt that light consists in the movement of a certain substance. For if one considers its production one finds that here on the earth it is chiefly produced by fire and flame, which without doubt contain bodies in rapid motion, for they dissolve and melt numberless other bodies. Or, if one considers its effects, one sees that light collected, for instance, by a concave mirror has the power to heat like fire, i.e. to separate the parts of the bodies; this assuredly points to movement, at least in true philosophy in which one traces all natural activity to mechanical causes. In my opinion one must do this, or quite give up all hope of ever grasping anything in physics.'

In these words of Huygens it must strike us how he first provides an explanation for a series of phenomena as if this explanation were induced from the phenomena themselves. After he has drawn quite definite conclusions from it, he then derives its necessity from quite other principles—namely, from a certain method of thinking, accepting this as it is, unquestioned and unalterably established. We are here confronted with an 'unlogic' characteristic of human thinking during its state of isolation from the dynamic substratum of the world of the senses, an unlogic which one encounters repeatedly in scientific argumentation once one has grown aware of it. In circles of modern thinkers where such awareness prevails (and they are growing rapidly to-day) the term 'proof of a foregone conclusion' has been coined to describe this fact.[1]

'Proof of a foregone conclusion' is indeed the verdict at which one arrives in respect of all the observations concerned with the velocity of light—whether of existing phenomena detectable in the sky or of terrestrial phenomena produced artificially—if one studies them with the attitude of mind represented by the child in Hans Andersen's story. In view of the seriousness of the matter it will not be out of place if we discuss them here as briefly as possible, one by one.[2]

The relevant observations fall into two categories: observations of certain astronomical facts from which the existence of a finite velocity of light and its magnitude as an absolute property of it has been inferred; and terrestrial experiments which permitted direct observa-

[1] Compare with this our account in Chapter X of the rise of the atomistic-kinematic interpretation of heat.

[2] The following critical study leaves, of course, completely untouched our recognition of the devotion which guided the respective observers in their work, and of the ingenuity with which some of their observations were devised and carried out.

tion of a process of propagation connected with the establishment of light in space resulting in the measurement of its speed. To the latter category belong the experiments of Fizeau (1849) and Foucault (1850) as well as the Michelson-Morley experiment with its implications for Einstein's Theory of Relativity. The former category is represented by Roemer's observations of certain apparent irregularities in the times of revolution of one of Jupiter's moons (1676), and by Bradley's investigation into the reason for the apparent rhythmic changes of the positions of the fixed stars (1728).

We shall start with the terrestrial observations, because in their case alone is the entire path of the light surveyable, and what is measured therefore is something appertaining with certainty to every point of the space which spreads between the source of the light and the observer. For this reason textbooks quite rightly say that only the results drawn from these terrestrial observations have the value of empirically observed facts. (The interpretation given to these facts is another question.)

Now, it is a common feature of all these experiments that by necessity they are based on an arrangement whereby a light-beam can be made to appear and disappear alternately. In this respect there is no difference between the first primitive attempts made by Galileo and the Academicians, and the ingeniously devised experiments of the later observers, whether they operate with a toothed wheel or a rotating mirror. It is always a *flash of light*—and how could it be otherwise?—which is produced at certain regular intervals and used for determining the speed of propagation.

Evidently what in all these cases is measured is the speed with which a beam of light establishes itself in space. *Of what happens within the beam, once it is established, these observations tell nothing at all.* The proof they are held to give of the existence of a finite speed of light, as such, is a 'proof of a foregone conclusion'. All they tell us is that the beam's front, at the moment when this beam is first established, travels through space with a finite velocity and that the rate of this movement is such and such. And they tell us nothing at all about other regions of the cosmos.

That we have to do in these observations with the speed of the light-front only, and not of the light itself, is a fact fully acknowledged by modern physical optics. Since Lord Rayleigh first discussed this matter in the eighties of the last century, physicists have learnt to distinguish between the 'wave-velocity' of the light itself and the velocity of an 'impressed peculiarity', the so-called 'group-velocity', and it has been acknowledged that only the latter has been, and can be, directly measured. There is no possibility of inferring from it the value of the 'wave-velocity' unless one has a complete knowledge of the properties of the medium through which the 'groups' travel. Nevertheless, the modern mind allows itself to be convinced that light possesses a finite velocity and that this has been established by actual measurement. We feel reminded here of Eddington's comment on Newton's famous observations: 'Such is the glamour of a historical experiment.' (Chapter XIV.)[1]

Let us now turn to Roemer and Bradley. In a certain sense Roemer's observations and even those of Bradley rank together with the terrestrial measurements. For Roemer used as optical signals the appearance and disappearance of one of Jupiter's moons in the course of its revolution round the planet; thus he worked with light-*flashes,* as the experimental investigations do. Hence, also, his measurements were concerned—as optical science acknowledges—with group-velocity only. In fact, even Bradley's observations, although he was the only one who operated with continuous light-phenomena, are exposed to the charge that they give information of the group-velocity of light, and not of its wave-velocity. However, we shall ignore these limitations in both cases, because there are quite other factors which invalidate the proofs they are held to give, and to gain a clear insight into these factors is of special importance for us.

Roemer observed a difference in the length of time during which a certain moon of Jupiter was occulted by the planet's body, and found that this difference underwent regular changes coincident with the changes in the earth's position in relation to Jupiter and the sun. Seen from the sun, the earth is once a year in conjunction with Jupiter, once in opposition to it. It seemed obvious to explain the time-lag in the moon's reappearance, when the earth was on the far side of the sun, by the time the light from the moon needed to cover the distance marked by the two extreme positions of the earth—that is, a distance equal to the diameter of the earth's orbit. On dividing the observed interval of time by the accepted value of this distance, Roemer obtained for the velocity of light a figure not far from the one found later by terrestrial measurements.

We can here leave out of account the fact that Roemer's reasoning

[1] The assumption is that the wave-velocity differs from the group-velocity, if at all, by a negligible amount.

is based on the assumption that the Copernican conception of the relative movements of the members of our solar system is *the* valid conception, an assumption which, as later considerations will show, cannot be upheld in a science which strives for a truly dynamic understanding of the world. For the change of aspect which becomes necessary in this way does not invalidate Roemer's observation as such; it rules out only the customary interpretation of it. Freed from all hypothetical by-thought, Roemer's observation tells us, first, that the time taken by a flash of light travelling from a cosmic light-source to reach the earth varies to a measurable extent, and, secondly, that this difference is bound up with the yearly changes of the earth's position in relation to the sun and the relevant planetary body.

We leave equally out of account the fact that our considerations of the nature of space in Chapter XII render it impermissible to conceive of cosmic space as something 'across' which light (or any other entity) can be regarded as travelling this or that distance in this or that time. What matters to us here is the validity of the conclusions drawn from Roemer's discovery within the framework of thought in which they were made.

Boiled down to its purely empirical content, Roemer's observation tells us solely and simply that *within the earth's cosmic orbit* light-flashes travel with a certain measurable speed. To regard this information as automatically valid, firstly for light which is continuously present, and secondly for everywhere in the universe, rests again on nothing but a foregone conclusion.

Precisely the same criticism applies to Bradley's observation, and to an even higher degree. What Bradley discovered is the fact that the apparent direction in which we see a fixed star is dependent on the direction in which the earth moves relatively to the star, a phenomenon known under the name of 'aberration of light'. This phenomenon is frequently brought to students' understanding by means of the following or some similar analogy.

Imagine that a machine-gun in a fixed position has sent its projectile right across a railway-carriage so that both the latter's walls are pierced. If the train is at rest, the position of the gun could be determined by sighting through the shot-holes made by the entrance and exit of the bullet. If, however, the train is moving at high speed, it will have advanced a certain distance during the time taken by the projectile to cross the carriage, and the point of exit will be nearer the rear of the carriage than in the previous case. Let us now think of an observer in the train who, while ignorant of the train's movement, undertook to determine the gun's position by considering the direction of the line connecting the two holes. He would necessarily locate the gun in a position which, compared with its true position, would seem to have shifted by some distance in the direction of the train's motion. On the other hand, given the speed of the train, the angle which the line connecting the two holes forms with the true direction of the course of the projectile—the so-called angle of aberration—provides a measure of the speed of the projectile.

Under the foregone conclusion that light itself has a definite velocity, and that this velocity is the same throughout the universe, Bradley's observation of the aberration of the stars seemed indeed to make it possible to calculate this velocity from the knowledge of the earth's own speed and the angle of aberration. This angle could be established by comparing the different directions into which a telescope has to be turned at different times of the year in order to focus a particular star. But what does Bradley's observation tell us, once we exclude all foregone conclusions?

As the above analogy helps towards an understanding of the concept of aberration, it will be helpful also to determine the limits up to which we are allowed to draw valid conclusions from the supposed occurrence itself. A mind which is free from all preconceived ideas will not ignore the fact that the projectile, by being forced to pierce the wall of the carriage, suffers a considerable diminution of its speed. The projectile, therefore, passes through the carriage with a speed different from its speed outside. Since, however, it is the speed from hole to hole which determines the angle of aberration, no conclusion can be drawn from the latter as to the original velocity of the projectile. Let us assume the imaginary case that the projectile was shot forth from the gun with infinite velocity, and that the slowing-down effect of the wall was great enough to produce a finite speed of the usual magnitude, then the effect on the position of the exit hole would be precisely the same as if the projectile had moved all the time with this speed and not been slowed down at all.

Seeing things in this light, the scientific Andersen child in us is roused to exclaim: 'But all that Bradley's observation informs us of with certainty is a finite velocity of the optical process going on *inside the telescope!'* Indeed, if someone should claim with good reason (as we shall do later on) that light's own velocity is infinite, and (as we shall *not* do) that the dynamic situation set up in the telescope had the effect of slowing down the light to the measured velocity—there is nothing in Bradley's observation which could disprove these assertions.

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Having thus disposed of the false conclusions drawn by a kinematically orientated thinking from the various observations and measurements of the velocity which appears in connexion with light, we can carry on our own studies undisturbed. Two observations stand before us representing empirically established facts: one, that in so far as a finite velocity has been measured or calculated from other observations, nothing is known about the existence or magnitude of such a velocity except within the boundaries of the dynamic realm constituted by the earth's presence in the universe; the other, that this velocity is a 'group'—velocity, that is, the velocity of the front of a light-beam in process of establishment. Let us see what these two facts have to tell us when we regard them as letters of the 'word' which light inscribes into the phenomenal world as an indication of its own nature.

Taking the last-named fact first, we shall make use of the following comparison to help us realize how little we are justified in drawing from observations of the front speed of a light-beam any conclusions concerning the kinematic conditions prevailing in the interior of the beam itself. Imagine the process of constructing a tunnel, with all the efforts and time needed for cutting its passage through the resisting rock. When the tunnel is finished the activities necessary to its production are at an end. Whereas these continue for a limited time only, they leave behind them permanent traces in the existence of the tunnel, which one can describe dynamically as a definite alteration in the local conditions of the earth's gravity. Now, it would occur to no one to ascribe to the tunnel itself, as a lasting quality, the speed with which it had been constructed. Yet something similar happens when, after observing the velocity required by light to lay hold on space, this velocity is then attributed to the light as a quality of its own. It was reserved for a mode of thought that could form no concept of the real dynamic of Light and Dark, to draw conclusions as to the qualities of light from experiences obtained through observing its original spreading out into space.

To speak of an independently existing space within which light could move forward like a physical body, is, after what we have learnt about space, altogether forbidden. For space in its relevant structure is itself but a result of a particular co-ordination of levity and gravity or, in other words, of Light and Dark. What we found earlier about the qualities of the two polar spaces now leads us to conceive of them as representative of two limiting conditions of velocity: absolute contraction representing zero velocity; absolute expansion, infinite velocity (each in its own way a state of 'rest'). Thus any motion with finite velocity is a mean between these two extremes, and as such the result of a particular co-ordination of levity and gravity. This makes it evident that to speak of a velocity taking its course *in* space, whether with reference to light or to a physical body in motion, is something entirely unreal.

Let us now see what we are really told by the number 186,000 miles a second, as the measure of the speed with which a light-impulse establishes itself spatially. In the preceding chapter we learnt that the earth's field of gravity offers a definite resistance to our visual ray. What is true for the inner light holds good equally for the outer light. Using an image from another dynamic stratum of nature we can say that light, while appearing within the field of gravity, 'rubs' itself on this. On the magnitude of this friction depends the velocity with which a light-impulse establishes itself in the medium of the resisting gravity. Whereas light itself as a manifestation of levity possesses infinite velocity, this is forced down to the known finite measure by the resistance of the earth's field of gravity. Thus the speed of light which has been measured by observers such as Fizeau and Foucault reveals itself as a function of the gravitational constant of the earth, and hence has validity for this sphere only.[1] The same is true for Roemer's and Bradley's observations, none of which, after what we have stated earlier, contradicts this result. On the contrary, seen from this viewpoint, Roemer's discovery of the light's travelling with finite speed within the cosmic realm marked by the earth's orbit provides an important insight into the dynamic conditions of this realm.

*

Among the experiments undertaken with the aim of establishing the properties of the propagation of light by direct measurements,

[1] Once this is realized there can be no doubt that with the aid of an adequate mathematical calculus (which would have to be established on a realistic understanding of the respective properties of the fields of force coming into play) it will become possible to derive by calculation the speed of the establishment of light within physical space from the gravitational constant of the earth.

quoted earlier, we mentioned the Michelson-Morley experiment as having a special bearing on Einstein's conceptual edifice. It is the one which has formed the foundation of that (earlier) part of Einstein's theory which he himself called the Special Theory of Relativity. Let us see what becomes of this foundation—and with it the conceptual edifice erected upon it—when we examine it against the background of what we have found to be the true nature of the so-called velocity of light.

It is generally known that modern ideas of light seemed to call for something (Huygens's 'certain substance') to act as bearer of the movement attributed to light. This led to the conception of an imponderable agency capable of certain movements, and to denote this agency the Greek word *ether* was borrowed. (How this word can be used again to-day in conformity with its actual significance will be shown in the further course of our discussions.) Nevertheless, all endeavours to find in the existence of such an ether a means of explaining wide fields of natural phenomena were disappointed. For the more exact concepts one tried to form of the characteristics of this ether, the greater the contradictions became.

One such decisive contradiction arose when optical means were used to discover whether the ether was something absolutely at rest in space, through which physical bodies moved freely, or whether it shared in their movement. Experiments made by Fizeau with running water seemed to prove the one view, those of Michelson and Morley, involving the movement of the earth, the other view. In the celebrated Michelson-Morley experiment the velocity of light was shown to be the same, in whatever direction, relative to the earth's own motion, it was measured. This apparent proof of the absolute constancy of light-velocity—which seemed, however, to contradict other observations—induced Einstein to do away with the whole assumption of a bearer of the movement underlying light, whether the bearer were supposed to be at rest or itself in motion. Instead, he divested the concepts of space and time, from which that of velocity is usually derived, of the absoluteness hitherto attributed to them, with the result that in his theory time has come to be conceived as part of a four-dimensional 'space-time continuum'.

In reality the Michelson-Morley experiment presents no problem requiring such labours as those of Einstein for its solution. For by this experiment nothing is proved beyond what can in any event be known—namely, that the velocity of the propagation of a light-

impulse is constant in all directions, so long as the measuring is confined to regions where the density of terrestrial space is more or less the same. With the realization of this truth, however, Einstein's Special Theory loses its entire foundation. All that remains to be said about it is that it was a splendid endeavour to solve a problem which, rightly considered, does not exist.[1]

*

Now that we have realized that it is inadmissible to speak of light as consisting of single rays, or to ascribe to it a finite velocity, the concept of the refraction of light, as understood by optics to-day and employed for the explanation of the spectrum, also becomes untenable. Let us find out what we must put in its place.

The phenomenon which led the onlooker-consciousness to form the idea of optical refraction has been known since early times. It

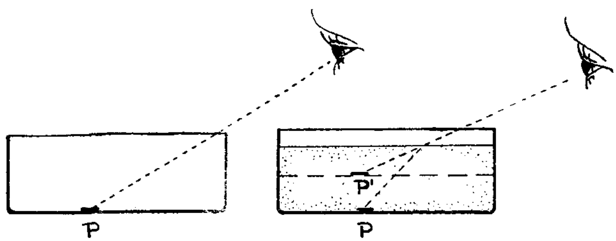

FIG. 12.

consists in the fact, surprising at first sight, that an object, such as a coin, which lies at the bottom of a vessel hidden from an observer by the rim, becomes visible when the vessel is filled with water. Modern optics has explained this by assuming that from the separate points of the floor of the vessel light-rays go out to all sides, one ray falling in the direction of the eye of the observer. Hence, because of the positions of eye and intercepting rim there are a number of points from which no rays can reach the eye. One such point is represented by the coin (P in Fig. 12a). Now if the vessel is filled with water, light-rays emerging from it are held to be refracted, so that rays from the points hitherto invisible also meet the eye, which is still in its original position. The eye itself is not conscious of this 'break' in the light-rays,

[1] The grounds of Einstein's General Theory were dealt with in our earlier discussions.

because it is accustomed to 'project' all light impressions rectilinearly out into space (Fig. 12b.). Hence, it sees P in the position of P'. This is thought to be the origin of the impression that the whole bottom of the vessel is raised.

This kind of explanation is quite in line with the peculiarity of the onlooker-consciousness, noted earlier, to attribute an optical illusion to the eye's way of working, while charging the mind with the task of clearing up the illusion. In reality it is just the reverse. Since the intellect can form no other idea of the act of seeing than that this is a passive process taking place solely within the eye, it falls, itself, into illusion. How great is this illusion we see from the fact that the intellect is finally obliged to make the eye somehow or other 'project' into space the impressions it receives—a process lacking any concrete dynamic content.

Once more, it is not our task to replace this way of 'explaining' the phenomenon by any other, but rather to combine the phenomenon given here with others of kindred nature so that the theory contained in them can be read from them direct. One other such phenomenon is that of so-called apparent optical depth, which an observer encounters when looking through transparent media of varying optical density. What connects the two is the fact that the rate of the alteration of depth, and the rate of change of the direction of light, are the same for the same media.

In present-day optics this phenomenon is explained with reference to the former. In proceeding like this, optical science makes the very mistake which Goethe condemned in Newton, saying that a complicated phenomenon was made the basis, and the simpler derived from the complex. For of these two phenomena, the simpler, since it is independent of any secondary condition, is the one showing that our experience of depth is dependent on the density of the optical medium. The latter phenomenon we met once before, though without reference to its quantitative side, when in looking at a landscape we found how our experiences of depth change in conformity with alterations in atmospheric conditions. This, then, served to make us aware that the way we apprehend things optically is the result of an interplay between our visual ray and the medium outside us which it meets.

It is exactly the same when we look through a vessel filled with water and see the bottom of it as if raised in level. This is in no sense an optical illusion; it is the result of what takes place objectively and dynamically within the medium, when our eye-ray passes through it.

Only our intellect is under an illusion when, in the case of the coin becoming visible at the bottom of the vessel, it deals with the coin as if it were a point from which an individual ray of light went out.. .. etc., instead of conceiving the phenomenon of the raising of the vessel's bottom as one indivisible whole, wherein the coin serves only to link our attention to it.

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Having thus cleared away the kinematic interpretation of the coin-in-the-bowl phenomenon, we may pass on to discuss the optical effect through which the so-called law of refraction was first established in science. Instead of picturing to ourselves, as is usually done, light-rays which are shifted away from or towards the perpendicular at the border-plane between two media of different optical properties, we shall rather build up the picture as light itself designs it into space.

We have seen that our inner light, as well as the outer light, suffers a certain hindrance in passing through a physical medium—even such as the earth's gravity-field. Whilst we may not describe this retardation, as is usually done, in terms of a smaller velocity of light itself within the denser medium, we may rightly say that density has the effect of lessening the intensity of the light. (It is the time required for the initial establishment of a light-filled realm which is greater within such a medium than outside it.) Now by its very nature the intensity of light cannot be measured in spatial terms. Yet there is a phenomenon by which the decrease of the inner intensity of the light becomes spatially apparent and thus spatially measurable. It consists in the alteration undergone by the aperture of a cone of light when passing from one optical medium to another.

If one sets in the path of a luminous cone a glass-walled trough filled with water, then, if both water and surrounding air are slightly clouded, the cone is seen to make a more acute angle within the water than outside it (Fig. 13). Here in an external phenomenon we meet the same weakening in the light's tendency to expand that we recognized in the shortening of our experience of depth on looking through a dense medium. Obviously, we expect the externally observable narrowing of the light-cone and the subjectively experienced change of optical depth to show the same ratio.

In order to compare the rate of expansion of a luminous cone inside and outside water, we must measure by how much less the width of the cone increases within the water than it does outside. (To be comparable, the measurements must be based upon the same distances on the edge of the cone, because this is the length of the way the light actually travels.) In Fig. 13 this is shown by the two distances, a-b and a'-b'. Their ratio is the same as that by which the bottom of a vessel appears to be raised when the vessel is filled with water (4: 3).

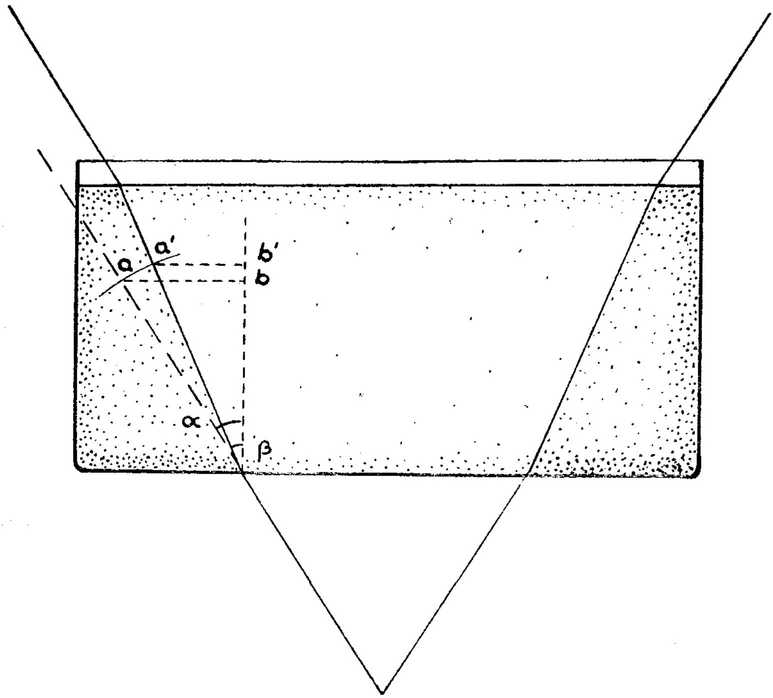

FIG. 13.

Thus by means of pure observation we have arrived at nothing less than what is known to physical optics as Snell's Law of Refraction. This law was itself the result of pure observation, but was clothed in a conceptual form devoid of reality. In this form it states that a ray of light in transition between two media of different densities is refracted at their boundary surface so that the ratio of the angle which is formed by the ray in either medium with a line at right angles to the boundary surface is such that the quotient of the sines of both angles is for these media a constant factor. In symbols $\frac{\sin \alpha}{\sin \beta} = c$.

It will be clear to the reader familiar with trigonometry that this ratio of the two sines is nothing else but the ratio of the two distances which served us as a measure for the respective apertures of the cone. But whereas the measurement of these two distances is concerned with something quite real (since they express an actual dynamic alteration of the light), the measuring of the angle between the ray of light and the perpendicular is founded on nothing real. It is now clear that the concept of the ray, as it figures in the usual picture of refraction, is in reality the boundary between the luminous space and its surroundings. Evidently the concept of the perpendicular on the boundary between the two media is in itself a complete abstraction, since nothing happens dynamically in its direction.

To a normal human understanding it is incomprehensible why a ray of light should be related to an external geometrical line, as stated by the law of refraction in its usual form. Physical optics, in order to explain refraction, had therefore to resort to light-bundles spatially diffused, and by use of sundry purely kinematic concepts, to read into these light-bundles certain processes of motion, which are not in the least shown by the phenomenon itself. In contrast to this, the idea that the boundary of a luminous cone is spatially displaced when its expansion is hindered by an optical medium of some density, and that the measure of this displacement is equal to the shortening of depth which we experience in looking through this medium, is directly evident, since all its elements are taken from observation.

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From what we have here found we may expect that in order to explain the numerical relationships between natural phenomena (with which science in the past has been solely concerned), we by no means require the artificial theories to which the onlooker in man, confined as he is to abstract thinking, has been unavoidably driven. Indeed, to an observer who trains himself on the lines indicated in this book, even the *quantitative* secrets of nature will become objects of intuitive judgment, just as Goethe, by developing this organ of understanding, first found access to nature's *qualitative* secrets. (The change in our conception of number which this entails will be shown at a later stage of our discussions.)

CHAPTER XVIII

The Spectrum as a Script of the Spirit

The realization that Newton's explanation of the spectrum fails to meet the facts prompted Goethe to engage in all those studies which made him the founder of a modern optics based on intuitive participation in the phenomena. In spite of all that he achieved, however, he never reached a real solution of the riddle of the colour-phenomenon produced when light passes through a transparent body of prismatic shape. For his assumption of certain 'double images', which are supposed to appear as a result of the optical displacement of the boundaries between the Light-filled and the Dark-filled parts of space and the mutual superposition of which he believed to be responsible for the appearance of the respective colours, does not solve the problem.[1]

What hindered Goethe in this field was his limited insight into the nature of the two distinct kinds of forces which, as we have noted in the course of our own inquiries, correspond to his concepts of *Licht* and *Finsternis.*

With the aid of this distinction—which we have indeed established through a consistent application of Goethe's method—we shall now be able to develop precisely that insight into the coming-into-being of the spectral colours which Goethe sought.[2]

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Dynamically, the process of the formation of the spectrum by light that passes through a prism divides into two clearly distinguishable parts. The first consists in the influence which the light undergoes

[1] See, in Rudolf Steiner's edition of Goethe's scientific writings, his footnote to Goethe's criticism of Nuguet's theory of the spectrum in the historical part of the *Farbenlehre* (Vol. IV, p. 248, in Kürschner's edition).

[2] It is obvious that the reader who wishes to appreciate fully the significance of the observations described in the following paragraphs, must, as in previous cases, carry out these observations himself.

inside the prism as a result of the latter's special shape, the other, in what happens outside the prism at the boundary between the Light-space—influenced by the shape of the prism—and the surrounding Dark-space. Accordingly, we shall study these two parts of the process separately.

As an aid to distinguishing clearly one process from the other, we shall suppose the prism experiment to be so arranged that the light area is larger than the width of the prism, which will then lie completely within it. We shall further suppose the dimensions of the whole to be such that the part observable on the screen represents only a portion of the total light-realm situated between the boundaries of the prism. The result is that the screen depicts a light-phenomenon in which there is no trace of colour. For normal eyesight, the phenomenon on the screen differs in no way from what it would be if no prism intervened in the path of the light.

These two seemingly identical light-phenomena reveal at once their inner dynamic difference if we narrow the field of light from either side by introducing into it an object capable of casting shadow. If there is no prism we see simply a black shadow move into the illumined area on the screen, no matter from which side the narrowing comes. If, however, the light has come through a prism (arranged as described above) certain colours appear on the boundary between the regions of light and shadow, and these differ according to the side from which the darkening is effected. The same part of the light area may thus be made to display either the colours of the blue pole of the colour-scale, or those of the yellow pole. This shows that the inner dynamic condition of the light-realm is altered in some way by being exposed to an optically resistant medium of prismatic shape. If we are to find the cause and nature of this alteration we must revert to the prism itself, and inquire what effect it has on light in the part of space occupied by it. By proceeding in this way we follow Goethe's model: first, to keep the two border-phenomena separate, and, secondly, not to ascribe to the light itself what is in fact due to certain boundary conditions.

In order to realize what happens to the light in passing through the prism, let us remember that it is a characteristic of an ordinary light-beam to direct itself through space in a straight line if not interfered with, and to illuminate equally any cross-section of the area it fills. Both these features are altered when the light is exposed to a transparent medium of prismatic shape—that is, to an optically resistant medium so shaped that the length of the light's passage through it changes from one side of the beam to the other, being least at the so-called refracting edge of the prism, greatest at the base opposite to that. The dimming effect of the medium, therefore, has a different magnitude at each point of the width of the beam. Obviously, the ratio between levity and gravity inside such a light-realm, instead of being constant, varies from one side to the other. The result is a transverse dynamic impulse which acts from that part of the light-realm where the weakening influence of the prism is least towards the part where it is strongest (see long arrow in Plate C, Fig. i). This impulse manifests in the deflection of the light from its original course. Apart from this, nothing is noticeable in the light itself when caught by an observation screen, the reason being that the transverse impulse now immanent in the light-realm has no effect on the reflecting surface.

The situation changes when the light-realm is narrowed down from one side or the other—in other words, when an abrupt change of the field-conditions, that is, a sudden leap from light to dark or from dark to light, is introduced within this realm. In this case, clearly, the effect of the transverse field-gradient on such a leap will be different, depending on the relation between the directions of the two (see small arrows in Fig. i). Our eyes witness to this difference by seeing the colours of the *blue* pole of the colour-scale appear when the field-gradient is directed *towards* the leap (a), and the colours of the *yellow* pole when the gradient is directed *away* from it (b).

For our further investigation it is very important to observe how the colours spread when they emerge at the edge of the shadow-casting object thus introduced into the light-realm from the one side or the other. Figs, ii and iii on Plate C show, closely enough for our purpose, the position of the colour-bearing areas in each case, with the dotted line indicating the direction which the light would have at the place of origin of the colours if there were no object interfering with its free expansion.[2] We observe a distinct difference in the widening

[1] In this and the two following diagrams the light-realm has been represented as being less wide than the space obtained by the prism. To avoid unnecessary complexity the colours which, in such a case, actually appear at the border of the light-realm where it emerges from the prism are not shown in any of the diagrams.

[2] This direction can be established with sufficient exactitude by holding a very thin object right in front of the prism and marking with a stretched thread the direction which leads from the object to its shadow on the screen. The colour-producing edge must then be introduced from either side so that it just touches the thread.

out of the two colour-areas on both sides of the original direction of the light: in each case the angle which the boundary of the colour-area forms with this direction is smaller on the side of the colours nearest the light-realm (blue and yellow respectively) than on the opposite side (violet and red).

Remembering what we have learnt about the dynamic characteristics of the two colour-poles, we are now in a position to state the following. When a light-area subject to a lateral gradient is narrowed down, so that the gradient is directed towards the narrowing object, colours arise in which the interaction between the two polarically opposite forms of density is such that positive density makes for lightness, and negative density for darkness. Whereas, when the border is so situated that the gradient is directed away from it, the interaction is such that positive density makes for darkness, and negative density for lightness. Further, the fact that on both occasions the darkness element in the colour-band increases in the outward direction tells us that in this direction there is on the blue-violet side a gradual decrease in positive, and increase in negative, density, while on the opposite side we find just the reverse. We note again that both processes occupy a considerable part of the space originally outside the boundaries of the light-area—that is, at the violet end the part towards which the light-beam is deflected, and at the red end the part from which it turns away.

The visual ray, when penetrating actively into the two colour-phenomena thus described, receives evidence of a dynamic happening which may be expressed as follows.

Where the transverse impulse, which is due to the varying degree of *Trübung* in the light-realm, is directed towards the latter's edge, the intermingling of the Dark-ingredient and the Light-ingredient, contained in that realm, is such that Dark *follows* Light along its already existing gradient, thereby diminishing steadily. Hence our visual ray, meeting conditions quite similar to those occurring when we look across the light-filled atmosphere into universal space, notifies us of the presence of the blue-violet colour-pole. If, on the other hand, the edge is in the wake of the transverse impulse, then a kind of dynamic vacuum arises in that part of space from which the beam is deflected, with the effect that the Dark-ingredient, imprinted on the light within the prism, is drawn into this vacuum by following a kind of suctional influence. Consequently Dark and Light here come to oppose one another, and the former, on its way out of the light-area, gains in relative strength. On this side our visual ray meets conditions resembling those which occur when we look across the darkening atmosphere into the sun. Accordingly our optical experience tells us of the presence of the yellow-red colour-pole.

From our description of the two kinds of dynamic co-ordination of positive and negative density at the two ends of the spectrum it follows that the spatial conditions prevailing at one end must be quite different from those at the other. To see this by way of actual perception is indeed not difficult. In fact, if we believe that we see both ends of the spectrum lying, as it were, flatly on the surface of the observation screen, this is merely an illusion due to our superficial way of using our eyes. If we gaze with our visual ray (activated in the manner previously described) into the two sides of the spectrum, while turning our eyes alternately in one or other direction, we soon notice that the colours of the yellow-red rise towards the eye so as to give the impression of protruding almost corporeally from the surface of the screen. We feel: Density obtains here in a state of fiery radiation. When turning to the other side we feel our visual ray, instead of being as before caught up in the colours, passing freely across the colours as if carried by them into the infinite. On the blue-violet side, space itself seems to fluoresce mysteriously[1]. Following Goethe's conception of the physical-moral effect of colours, we may describe the experience received thus from the two poles of the spectrum by saying that an 'other-worldly' character belongs to the colours of the blue-violet pole; an 'earthly' character to those of the yellow-red; while that of green, which appears when both sides are made to overlap, witnesses to its mediating nature between the two.

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In our endeavour to view the fundamental experiment of Newtonian optics with the eyes of Goethe we have been led from the wide expanse of the earth's sunlit periphery into the confines of the darkened experimental chamber. With the aid of the results gained from studying the artificially produced spectrum phenomenon, we shall now return to our original field of observation in order to study the same

[1] The difference in character of the various parts of the spectrum, as described above, comes out particularly impressively if for capturing the colour-phenomenon one uses instead of a flat white surface, a clear crystal of not too small size, or else a cluster of crystals—moving it slowly along the coloured band from one end to the other. (I am indebted to Fr. Julius, teacher of Natural Science at the Free School in The Hague, for this suggestion.)

phenomenon in nature. There it meets us in the form of the rainbow, which we shall now be able to read as a chapter in the great book of nature.

From what we have learnt already we can say at once that the rainbow must represent some sort of border-phenomenon, thus pointing to the existence of a boundary between two space-regions of differing illumination. Our question therefore must be: what is the light-image whose boundary comes to coloured manifestation in the phenomenon of the rainbow? There can be no doubt that the image is that of the sun-disk, shining in the sky. When we see a rainbow, what we are really looking at is the edge of an image of the sun-disk, caught and reflected, owing to favourable conditions, in the atmosphere. (Observe in this respect that the whole area inside the rainbow is always considerably brighter than the space outside.)

Once we realize this to be the true nature of the rainbow, the peculiar order of its colours begins to speak a significant language. The essential point to observe is that the blue-violet part of the spectrum lies on the inner side of the rainbow-arch—the side immediately adjoining the outer rim of the sun-image—while the yellow-red part lies on the outer side of the arch—the side turned away from the sun-image. What can we learn from this about the distribution of positive and negative density inside and outside the realm occupied by the sun-disk itself in the cosmos?

We remember that along the gradient from blue to violet, negative density (Light) increases and positive density (Dark) decreases, while from yellow to red it is just the reverse—positive density increases and negative density decreases. The rainbow therefore indicates a steady increase of Dark towards the outer rim, and of Light towards the inner. Evidently, what the optical image of the sun in the atmosphere thus reveals concerning the gradation of the ratio between Light and Dark in the radial direction, is an attribute of the entire light-realm which stretches from the sun to that image. And again, the attribute of this realm is but an effect of the dynamic relation between the sun itself and the surrounding cosmic space.

The rainbow thus becomes a script to us in which we read the remarkable fact that the region occupied by the sun in the cosmos is a region of negative density, in relation to which the region surrounding the sun is one of positive density. Far from being an accumulation of ponderable matter in a state of extremely high temperature, as science supposes, the sun represents the very opposite of ponderability. (It would be beyond the scope of this book to show how in the light of this fact one learns to re-read the various solar phenomena known to science.)

Once we realize this, our judgment of all that our terrestrially devised optical instruments, such as the telescope and spectroscope, tell us about the nature of the sun and its surroundings, will change accordingly. For it becomes clear that for the interpretation of solar phenomena shown by these instruments we cannot properly use concepts derived from observations within the earth's realm of positive density.

To compare adequately solar and terrestrial phenomena, we must keep in mind that they are in every respect polar opposites. For instance, the fact that the spectroscope reveals phenomena in the sun's light which are strikingly similar to others occurring when earthly matter is first caused to emit light—that is, brought near the upper border of its ponderable existence—and then studied spectroscopically, should not impose on us the illusion that the sun consists of matter in this same condition. On the contrary, the similarity should tell us that imponderable substance, while on its way between sun and earth to ponderable existence, assumes, at the point of transition, aspects exactly like those revealed by ponderable substance at the corresponding point in its upward transformation.

What we observe, when we study the sun through a spectroscope, is not the sun itself, but the conditions obtaining in this border-region, where imponderable substance enters the earth-realm.

The rainbow, directly we learn to see it as the border-phenomenon that it is, tells us something of itself which revives in modern form a conception held generally in former ages, when it was seen as a mediator between the cosmic-divine and the earthly-human worlds. Thus the Bible speaks of it as a symbol of God's reconciliation with the human race after the great Flood. Thus the Greeks beheld it when they saw it as the bridge of Iris, messenger of the Gods; and similarly the Germanic mythology speaks of it as the pathway along which the souls of the fallen warriors draw near to Valhalla. By recovering this old conception in a new and scientifically grounded form we are enabled also to rectify the misunderstanding from which the ancient bridge-conception of the rainbow has suffered in later days, when tradition had begun to replace direct insight into the truth.

When with the rise of man's onlooker-relation to the world of the senses, the rainbow could appear to him only as a form flattened against the sky, people began to think that the ancient picture of it as a bridge had been derived from its likeness to the latter's arched form. Representations of the rainbow from these times indeed show supersensible beings, such as the souls of the dead, moving upwards and downwards along the two halves of the arch. It is not in this abstract way that ancient man formed his cosmic imagery. What was seen going on between the upper and nether worlds when a rainbow appeared in the heights of the atmosphere was no traffic over the arch, but an interplay *across* the rainbow between the realm of levity, glimmering down in the rainbow's violet border, and the realm of gravity glowing up from the red. And this is how we have now learnt to see it again.

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At one point in our optical studies (page 259) we referred to some words of Ruskin in which he deplored the influence exerted on the soul-life of modern man by the world-conception of science. He illustrated this by showing how much less inspiration a man trained in the science of optics receives from the sight of a rainbow than does a 'simple peasant'. One lesson of our studies is that training in optics, if it proceeds on Goethean lines, has no such detrimental effect. There is, however, a further problem, outside Ruskin's scope, which we are now able to approach in the same healthy way.

Ruskin distinguishes between three possible stages in man's relation to the world of the senses. The first stage he calls that of 'inactive reverie'; the second—in a certain respect more advanced—that of 'useful thought', the stage of scientifically awakened man to whom all things disintegrate into countable and nothing but countable parts. Beyond this, Ruskin conceives of a third, still higher stage, in which man becomes capable of raising himself through 'higher contemplation' into an artistic-ethical relation to the content of the sense-world. Now, in the way Ruskin represents the second and third stages they seem to be exclusive of one another. That was as far as he could go, in his own day. Natural observation along Goethean lines leads to a form of higher contemplation which unites the second and third stages by nourishing man's ethical being and at the same time furnishing him with useful knowledge—knowledge, that is, which enables him to improve the conditions of the human race on the earth. The following is an example of the practical possibilities that open up in the field we are discussing if we apply the knowledge gained through our new approach to the forces working in nature.

We shall speak here of a task of experimental research which was mentioned by Rudolf Steiner in connexion with the renewal of natural science.

Rudolf Steiner felt the need for pioneers who, by advancing along the paths opened up by Goethe, would press forward into the realm of undiscovered phenomena on the upper border of nature, and this prompted him to give to those who were ready to listen various pointers towards new ways of experimental research. In so far as practical results have already been reached along these lines, they lie in the fields of biology and physiology (and of chemistry, in a certain respect) rather than in that of physics. Now, among the indications given in this latter field, and not yet worked out, there is one which deals with a way, unknown to-day, of influencing the spectrum by the magnet.

The possibility of a magnetic influence on the spectrum is, in itself, not unknown to modern physics. It was the Dutchman, Zeeman, who first observed a change in the appearance of certain spectral lines as a result of light passing through a magnetic field. This discovery, however, is in two respects typical of modern science. The Zeeman effect consists in the splitting up of certain spectral lines into other lines—hence, of a breaking up of a whole into parts. And by seemingly providing a decisive confirmation of contemporary views concerning the electromagnetic nature of light, Zeeman's discovery has formed one of the milestones in the progress of modern physical thought—with the usual result that an enlargement of man's knowledge of the behaviour of natural forces has served to entangle his conception of nature still more deeply in illusion.

Apart from the fact that our own way of combining observation and thought guards us against drawing theoretical conclusions from Zeeman's discovery, Rudolf Steiner's indication opens up the prospect of achieving quite practical results, opposite in character to those of the Zeeman effect. For in contradistinction to the use of a magnetic field for splitting the spectrum, Rudolf Steiner has made us aware of the possibility of uniting into a higher synthesis parts of the spectrum which normally appear in separated form. His indication points to nothing less than a leading over of the optically produced spectrum from its usual linear form, with two boundaries on either side, into a closed circular form, and of doing this by an adequate application—as yet undiscovered—of magnetic force. Further, according to his statement, the point where the two ends of the spectrum meet will prove to be a fountain-head of certain higher natural forces which otherwise are not directly accessible.

In order to understand how this is possible, we must remember that in two respects the spectrum is not a complete phenomenon. There is, to begin with, the fact that the colour-band visible on the observation screen is only apparently confined to the surface of the screen. For, as we have seen, because of the differing co-ordination of levity and gravity at the two ends of the spectrum, the conditions of space prevailing at each are polarically opposite. Negative space opens up spherically behind the blue-violet colours on one side, while positive space, filled by the radially shining yellow-red colours, arises on the other. So we see that what we found earlier for the two poles of magnetism and electricity holds good also for the spectrum. That is, the two processes bringing about the relevant phenomena are not confined to the part of space which these phenomena seem to occupy; for the whole positive and negative realms of the universe share in them. Hence the spectrum, though apparently bounded at its two ends, proves by its very nature to be part of a greater whole.

Once before we were led to recognize—though from a different aspect—that the spectrum is a phenomenon which, when rightly viewed, calls for a certain completion. In following Goethe's initial observations we realized that the known spectrum, extending from red via green to violet, has a counterpart extending from violet via peach-blossom to red. The reader may have wondered why we never returned to this other spectrum, in spite of the role it played in making Goethe aware of Newton's error. The reason was that in order to gain the understanding we needed of the spectrum, we had to observe the two border-phenomena independently—that is, without regard to their relative positions. Moreover, with ordinary optical means it is possible to produce only one type of spectrum at a time, so that each is left in need of being complemented by the other. In order to have both together in finite space, as part of one and the same phenomenon, space itself must be dynamically transformed in such a way that the continuation of the finite spectral band running through infinity enters into the finite as well.

Our understanding of magnetism as a specific representation of the polarity of the second order enables us to comprehend, at least in principle, how magnetism might influence—not light itself, as present-day physics erroneously believes—but the secondary polarity of the spectral colours formed out of the primary polarity Light and Dark. To see this in all necessary detail is a task of the future, beyond the scope of this book. We have here to continue our account of Rudolf Steiner's statement by communicating what he indicated concerning the particular nature of the new source of force which would appear in the normally infinite part of the spectrum, if this were brought into the region of the finite.

In order to understand the significance of this indication we must turn our attention to parts of the ordinary spectrum, well known in themselves, which we have purposely left out of our study so far. These are the regions of the ultra-violet and the infra-red, invisible in themselves, but forming part of the spectrum as a whole. The ultra-violet manifests through chemical effects, the infra-red through thermal effects. We have left them out of our considerations because these regions of the spectrum differ from the visible part not only quantitatively, as present-day science believes, but qualitatively also, and in a fundamental way. We must regard them as dynamic realms of particularly extreme spherical and radial activities. As such they represent metamorphoses, in the Goethean sense, of the levity-gravity interaction represented by the optically visible part of the spectrum. In this way the spectrum discloses a threefold differentiation of that region of force, which up to now we have called simply levity, into activities producing chemical, optical and thermal effects.

So far physical investigation is able to lead us, but no further. If, however, we let nature herself speak to us, while holding this differentiated concept of levity in mind, she tells us that beyond the three metamorphoses envisaged so far, there must be a fourth.

Let us remember that it was certain phenomena of life which first made us aware of the existence of a realm of forces with the attributes of anti-gravity, and that these forces revealed themselves first as creators of form. Now it is obvious that warmth, light and chemical energy, though they all play an essential part in living organisms, could never by themselves bring about that 'catching from chaos, carbon, water, lime and what not and fastening them into a given form' which Ruskin describes as the activity of the spirit in the plant. In order to be in this sense an instrument of the spirit active in nature, levity must be capable of yet another metamorphosis into an activity which controls the other three, so that through their action, definitely shaped organic structures may come into being.

The reason why this fourth and highest metamorphosis of Light does not appear in the ordinary spectrum is because it is of too spiritual a quality to be caught by the optical apparatus. In nature herself a creative life-process requires always the presence of a germ already imbued with life. And so, in order to call this fourth metamorphosis of Light into the spectrum, stronger means are needed than the mere optical transformation of light-filled spaces. This stronger agent, according to Rudolf Steiner, is magnetism. With the aid of this it will be possible to organize together round a common spatial centre that part of the activity of levity which escapes the optical instrument and thus remains cosmic, and that part which appears by itself in terrestrial space.

Once this is practically carried out, we may expect a complete colour-circle to appear as already divined by Goethe. The full circle consists of twelve discernible colours, with the Goethean *peach-blossom* diametrically opposite the green. It is in this region of the peach-blossom that—again according to Rudolf Steiner—we shall find a source of actively working life-forces, springing from the fourth metamorphosis of levity. Such is the prospect for research work guided on the new lines.

POSTSCRIPT

The fact of our having disclosed here one of Rudolf Steiner's indications concerning as yet undetected possibilities of scientific research, makes it necessary to deal with an objection which may be raised, particularly by some readers who already know this indication through their own relation to Rudolf Steiner's work. They may object to a discussion of the subject in a publication such as this, feeling it dangerous to hand over to the world information which in the economic battles of to-day might be used in a sense contrary to the social-moral aims to which the work of Rudolf Steiner was dedicated.

In reply it may be said that all we have gone through in this book has shown that concrete knowledge of the world cannot be gained without a certain ethical effort by the seeker. Therefore, anyone who receives such knowledge with a passive attitude of soul will find it meaningless, and will be quite unable to turn it to practical account.

We may therefore rest assured that the solution of the problem related here, as of any other experimental task set by Rudolf Steiner, will contain in itself a guarantee that no use will be made of it detrimental to the true progress of mankind.

On the other hand, the present world-situation, which to so high a degree is determined by the vast liberation of the sub-physical forces of the earth, makes one feel it is essential not to close the considerations of the fields of knowledge dealt with in these chapters, without a hint at the practical possibilities which arise from a continuation of Goethe's strivings in this field.

PART III

Towards a New Cosmosophy

CHAPTER XIX

The Country in which Man is *not a* Stranger

I question not my Corporeal or Vegetative Eye any more than I question a window concerning sight. I look through it and not with it.
WILLIAM BLAKE.

(a) INTRODUCTORY NOTE

A fundamental achievement along our path of study was the recognition that a force of levity exists, polar to that of gravity, and that these two together represent a primary polarity in nature which in turn is the source of nature's manifold secondary polarities.

In the last part of these studies a vista opened up of an inner differentiation of levity itself into warmth, light, chemical action and the formative activity of life. Our next task will be to develop a clearer conception of these four modes of action of levity.

In undertaking this task, however, we shall have to extend our observations of nature beyond the frontier that can be reached by using only what we can learn from Goethe. It is here that Rudolf Steiner comes to our aid by what he was able to impart through his researches in the realm of the supersensible itself.

This turning to information given by another mind, whose sources of knowledge are beyond our own immediate reach, seems at first sight to be incompatible with the principles guiding all our studies hitherto; for in gaining insight into the How and Whence of a phenomenon of the sense-world we have up to now admitted only what is yielded by an observation of the phenomenon *per se* (though with the aid of the 'eye of the spirit') and of other phenomena related to it. This is what we have called 'reading in the book of nature', and we have found it to be the method on which a science aspiring to overcome the onlooker-picture of the universe must be based. So we must first make sure that the step we now propose to take does not violate this principle.

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The assurance we want will be found in two characteristics of the communications made by Rudolf Steiner from his researches. The content of these communications was acquired by way of a 'reading' which is nothing but a higher metamorphosis of the reading first employed by Goethe; and the acceptance of this content by another mind is itself nothing but another act of reading, save that the direction of the reading gaze differs from the usual one.

In order to understand this we must go back to what we learnt in the course of our optical studies as to the two forms of vision arising from the activity of the eye's inner light—the dream-vision and the seeing of after-images. Of these two, seeing in dream is in a certain sense the purer form of inner seeing in that it arises without any outer stimulus exercised upon the physical organ of sight. On the other hand, it lacks that objective conformity to law characteristic of the after-images which mirror the order of the external world. There is an arbitrary, enigmatic element in dream-pictures, and their logic often seems to run counter to that of waking consciousness. A further characteristic of dream-perception is that we are tied to the level of consciousness prevailing in the dream. While we are dreaming we cannot awaken to the extent of being able to make the pictures the object of conscious observation.

With the after-images it is different. Although to begin with they are present in our consciousness with a clarity no greater than that of the dream-pictures, nevertheless we are able so to enhance our consciousness of them as to bring them under observation like any external phenomenon. As previously shown, it is possible, even while the eye is riveted on an impression from outside, to develop such awareness in the activity of the inner light called forth by this impression, that together with the results of the deeds and sufferings of the light we can perceive something of these deeds and sufferings themselves. Perception of the after-images thus turns into what we may call perception of simultaneous images. (This activity of the eye corresponds with what Goethe, in a different connexion, called an 'alliance of the eyes of spirit with the eyes of the body'.)

These two forms of visual perception—which we may briefly call: (1) perception of *post*-images, and (2) perception of co-images—represent successive rungs on a 'spiritual ladder' pointing beyond themselves to a further rung. By the logic of succession this may be expected to consist in some sort of seeing of *pre*-images, with the characteristic of being a still less physical mode of seeing than the two others. This seeing must be based on an activity of the inner light which will be similar to that in dream by its arising without any stimulus from external light-impressions, yet at the same time there must be no arbitrariness in the contents of this perception. Further, our consciousness in this perceptive activity must be such as to allow us to be in full control of it, as we are of ordinary day-waking seeing.

This kind of pure sense-free perception does indeed exist, and it can be aroused by means of a well-ordered training from the dormant state in which it is present in every human being. Anyone who learns to see in this way gains perception of the activity of cosmic light, contacting it directly with his own inner light—that is to say, without mediation of his corporeal eye which is subject to gravity. So this eye-of-the-spirit becomes capable of perceiving the levity-woven archetypes (ur-images), which underlie all that the physical eye discerns in the world of ordinary space.

In respect of the intrinsic character of the world-content thus perceived, Rudolf Steiner called this mode of perception, Imaginative perception, or, simply, Imagination. By so doing he invested this word with its due and rightful meaning.

From what we found in our optical studies concerning the nature of after-images (Chapter XV), it is clear that the acquisition of Imaginative perception rests on a re-awakening in the eye (and thus in the total organism behind the eye) of certain 'infant' forces which have grown dormant in the course of the growing up of the human being. It thus represents a fulfilment of Thomas Reid's philosophic demand. Consequently we find among the descriptions which Traherne gives of the mode of perception peculiar to man when the inner light, brought into this world at birth, is not yet absorbed by the physical eye, many helpful characterizations of the nature of Imaginative perception, some of which may be quoted here.

Consider, in this respect, the following passage from Traherne's poem *The Praeparative*, quoted earlier. In describing the state of soul at a time when the physical senses are not yet in operation, Traherne says:

'Then was my Soul my only All to me,
A living, endless Ey,
Whose Power, and Act, and Essence was to see:
I was an inward Sphere of Light
Or an interminable Orb of Sight,

Exceeding that which makes the Days,
A vital *sun that shed abroad its Rays:*
All Life, all Sense,
A naked, simple, pure Intelligence."

This is the condition of soul of which Traherne says in the same poem that through it a man is still a recipient of the 'true Ideas of all things'. In this condition the object of sight is not the corporeal world which reflects the light, but light itself, engaged in the weaving of the archetypal images. In a later passage of the same poem Traherne expresses this by saying:

'Tis not the Object, but the Light
That maketh Hev'n. . . .'

And more clearly still in the following part of his poem *An Infant Eye:*
'A simple Light from all Contagion free,
A Beam that's purely Spiritual, an Ey
Thai's altogether Virgin, Things doth see
Ev'n like unto the Deity;
That is, it shineth in an hevenly Sense,
And round about (Unmov'd) its Light dispense.

'The visiv Rays are Beams of Light indeed,
Refined, subtil, piercing, quick and pure;
And as they do the sprightly winds exceed,
Are worthy longer to endure;
They far out-shoot the Reach of Grosser Air,
With which such Excellence may not compare.
But being once debas'd, they soon becom
Less activ than they were before.'

How at this stage the soul experiences the act of perception in itself is shown in the following passage from the poem *Wonder:*

'A Nativ Health and Innocence
Within my Bones did grow
And while my God did all his Glories show
I felt a vigour in my Sense
That was all SPIRIT: I within did flow
With seas of Life like Wine.'

Utterances of this kind illustrate the fact that perception of the ur-images of the world consists in a reading with the eye-of-the-spirit, which has been rendered so strong that for its action no support from the physical eye is any longer required. This faculty of spiritual Imagination (which Rudolf Steiner was able to exercise in advance of other human beings) is acquired on a path of training which is the direct continuation of the Goethean path.[1]

It remains to show that acceptance of information obtained through spiritual Imagination, without ourselves being as yet in actual command of it, is not in contradiction with the principles of 'reading'. Let us, to this end, think of reading in the ordinary sense of this word, calling to mind that for the acquisition of this faculty we depend on someone who can teach it because he already has it. Exactly the same holds good for the reading with which we are here concerned. Here, too, a teacher already possessing this faculty is required. Thus Goethe became for us a teacher of reading, and it would be a mistake to imagine that he, for his part, needed no teacher. In his case this function was fulfilled partly by what he learned through his studies of the earlier fruits of man's spiritual activity, that is, from an epoch when vestiges at least of the original, instinctive faculty of spiritual Imagination were still extant. A similar function on our own path of study was performed by our occupation with the old doctrine of the four elements and the basic concepts of alchemy.

Indispensable as is such a training in reading by turning to past conceptions of man, it does not suffice to meet the present-day demands of a scientific understanding of the universe. For this, we need a 'technique' of reading that cannot be attained along these lines alone. Awareness of this fact led Rudolf Steiner to pursue his spiritual-scientific investigations and to communicate the results in such a way that they can be a 'school of reading' for those who study them.[2] In point of fact we have already made use in this sense of one of the results of Rudolf Steiner's researches, for at the very beginning of

[1] To avoid misunderstandings, it should be emphasized that spiritual Imagination is not attained by any exercise involving directly the sense of sight and its organ, the eye, but by purely mental exercises designed to increase the 'seeing' faculty of the mind.

[2] Indeed, it is a misunderstanding of the whole meaning of Anthroposophy when its contents are quoted—as they sometimes are even by adherents—in such a way as to suggest that by their help a better 'explanation' may be gained of matters for which there is otherwise no, or at least no satisfactory, explanation. The question: 'How does Anthroposophy explain this or that?' is quite wrongly put. We ought rather to ask: 'How does Anthroposophy help us to read more clearly this or that otherwise enigmatical chapter of the script of existence?'

this book his picture of the threefold psycho-physical organism of man was taken as the basis of our own investigations. The reason why the present remarks were not then included is that the relevant results of higher research were in that case of such a nature that, once known, they could be confirmed by the simplest kind of self-observation. The fact, however, remains that from the very beginning we have called upon one fully trained in reading, to help in deciphering certain facts of nature—in this case of human nature.

A similar need, though now in an amplified form, arises at the present stage of our studies. And here, out of the wealth of knowledge conveyed by Rudolf Steiner from the realm of supersensible Imagination, it is his characterization of the four modifications of levity which will now give the guidance necessary for our own observation. Adopting the terminology chosen by him for the description of this sphere, we shall in future speak of it as of the 'Ether' pervading the universe (thus using this word also in its true and original meaning). Accordingly, we shall refer to its fourfold differentiation as to the four kinds of ether: Warmth-Ether, Light-Ether, Chemical Ether and Life-Ether.

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(b) WARMTH

We begin with the warmth-ether as the only modification of ether which combines certain etheric with certain physical properties. Constituting as it does a border-condition between the two worlds, the warmth-ether has, on the one hand, the function of receiving the picture-weaving transmitted to it by the higher ethers, and, on the other, of bringing physical matter into the state where it becomes receptive to the working of the etheric forces. The warmth-ether achieves this by freeing matter from being controlled one-sidedly by the centre-bound forces of the earth. It thus calls forth, when acting physically, the processes of melting of solids and of evaporation of liquids: phenomena which yielded the initial observations for our introduction of the concept of levity. In processes of this kind we now recognize the physical manifestation of a universal function of the warmth-ether, namely, to divest matter of all form and to lead it over from the realm dominated by gravity into that of levity. Provided we attach the right meaning to the word, we may say that the function of the warmth-ether is to bring about *chaos* at the upper border of physical nature. It is thus that we have already found it working in the plant, when through the union of the pollen with the seed a state of chaos is produced within the seed, which enables the *type* to impress anew its form-principle into it.

Another instance of the warmth-ether's anti-gravitational effect, also discussed earlier, is the earth's seismic activity. True, it appears at first sight as if little were gained by speaking of warmth-ether, instead, as we did previously, of levity in general. But it must not be forgotten that in the ether-realm as a whole, warmth—that is, the overcoming of earthly gravity—is only one of the four modes of etheric action, albeit the one which enables the other three to work into the physical world. We shall see, later on, that only by taking into account the action of the higher modifications of the ether is it possible to gain insight into the true causes of the apparently so arbitrary occurrences of volcanic and kindred phenomena. Here, too, it is the function of the warmth-ether to produce in the physical sphere the chaos which is necessary to make the physical sphere receptive to the activities going on in higher spheres.

In view of this universal function of the warmth-ether, which distinguishes it from the other modifications of ether, we may give it as a second name that of 'chaoticizing ether'.

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(c) LIGHT

The function of the light-ether, the second of the four modes of ether, can best be envisaged by thinking of the difference between a plant growing in darkness (perhaps a potato sprouting in a cellar) and another of the same species exposed to the influence of the light. On Plates VII and VIII two kinds of unicellular organisms are shown, of one which—the green algae—is accustomed to live in light, the other—the bacilli—in darkness. These things are, of course, well-known facts. Our purpose here, however, is not merely to record them as 'fact', but, by re-creating them within ourselves, to use them to gain an experi-ence of the function of the light-ether.

The following passages from Goethe's *Metamorphosis of Plants* are a classical example of observation of the activity of the light-ether in the plant. They are taken from the second part of the essay, where Goethe is describing leaf-development:

'While the leaves owe their first nourishment principally to the more or less modified watery parts, which they draw from the stem, they are indebted for their increased perfection and refinement to the light and air. The cotyledons which are formed beneath the closed seed-sheath are charged, so to speak, with only a crude sap; they are scarcely and but rudely organized and quite undeveloped. In the same way the leaves are more rudely organized in plants which grow under water than in others which are exposed to the open air. Indeed, even the same species of plant develops smoother and less intricately formed leaves when growing in low damp places, whereas, if transplanted to a higher region, it will produce leaves which are rough, hairy and more delicately finished.'

'So it is also with the anastomosis of the vessels which spring forth from the larger veins, seeking each other with their ends and coalescing, and thus providing the necessary basis for the leaf-skin or cuticle. All this, if not entirely caused by subtle forms of air, is at least very much furthered by them. If the leaves of many water-plants are thread-like or assume the form of antlers, we are inclined to attribute it to lack of complete anastomosis. The growth of the water buttercup, *Ranunculus aquatilis,* shows this quite obviously, with its aquatic leaves consisting of mere thread-like veins, while in the leaves developed above water the anastomosis is complete and a connected plane is formed. Occasionally, indeed, in this plant, the transition may be still more definitely observed, in leaves which are half anastomosed and half thread-like.'

The second of these paragraphs describes the phenomenon of vascular anastomosis which, having already been more than once an object of our study, here reveals a new meaning. If, following Goethe's method, we re-create in our mind the repeated separations and re-unions of the sap-vessels, while keeping in view the fact that the leaf's outer form is the result of a purposive, many times repeated anastomosis, then the picture of the activity of weaving arises before our mind's eye. (Hence the word 'tissue' for the flesh of a living being.) In truth all nature's forms are woven of light, including the crystals.[1]

How clear a picture Goethe had of the conformity of man's act of thinking with nature's way of producing her forms—both being an act of supersensible weaving—is shown by the following two verses. That on the left is a passage from *Faust,* from the scene in which

[1] See *Space and the Light of Creation,* by G. Adams, where this 'weaving' is shown with the help of projective geometry.

Mephisto (disguised as Faust) instructs the young Scholar. The other is an altered version of it, written by Goethe at a later time to conclude an essay *(Bedenken und Ergebung)* in which he deals with the problem of the relation between Experience and Idea:

Truly, when men their thoughts conceive
'Tis as if some masterpiece they weave.
One thread, and a thousand strands take flight,
Swift to and fro the shuttles going,
All unseen the threads a-flowing,
One stroke, and a thousand close unite.[1]

So with a modest eye perceive
Her masterpiece Dame Nature weave.
One thread, and a thousand strands take flight,
Swift to and fro the shuttles going,
Each to the other the threads a-flowing,
One stroke, and a thousand close unite.[1] -

What Goethe wants to show here by applying to the activity of nature the same image which he used originally to depict the act of thinking, we can express to-day by saying that it is the identity of the activity of the light-ether in human thinking and in external nature which is responsible for the fact that the objective ideas operating in nature can become the content of man's consciousness in the form of thoughts.[2]

Following our previous procedure when we gave the warmth-ether a second name by calling it chaoticizing ether, we can denote the light-ether also as 'weaving ether'.

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If at this point in our discussion we revert once more to the realm of physical manifestations of light, dealt with in the preceding chapters, we do so because by studying them in the present context we shall gain further insight into the fact that one plane of nature provides illustrations of processes which on another plane remain more or less veiled. At the same time this will help us to learn more about the properties of levity-space. The optical phenomenon which we shall discuss in this sense is that of the *so-called pin-hole camera.* (The pinhole camera effect is easily produced by a keyhole in a closed door which on one side faces a window and on the other leads to a comparatively dark room.)

The usual explanation of the appearance of the optical image on the back inside wall of such a camera is that light-rays, emanating from every point outside, cross each other in the aperture of the camera and so—again point by point—create the inverted image. No such

[1] Translation by J. Darrell.
[2] We may recall here also the passage from Ruskin's *The Queen of the Air,* quoted earlier, p. 118).

explanation, clearly, is open to us. For the world of external objects is a whole, and so is its image appearing in the camera. Equally, the light entering the camera is not a sum of single rays. Pure observation leads to the following description of the optical process.

By surveying the path which the light takes from the illuminated surface of the outer objects via the pin-hole to the optical image inside the camera, we realize that the light-realm engaged in this process has the shape of a double cone, with its apex in the opening of the camera. Within this cone the light carries the image across the space stretching in front of the light-reflecting objects up to the point where the image becomes visible by being caught on the back wall of the camera.

Thus in every section of the cone the image is present in its totality—even in the very apex of the cone. There, too, the image in all its details is present as a whole, though without (ideally) any spatial extension. Seen thus, on this level of its action the light-ether reveals as one of its characteristics the faculty of making present in a spaceless point an image originally expanded in space, and of letting it emerge from this point in spatial expansion.

Further, there is the fact that, wherever we set up a pin-hole camera, the aperture in its front will cause the formation of an optical image inside it. This shows that each point in space filled with light is the bearer of an optical image, contracted to a point, of the entire world of light-reflecting objects surrounding it. All we do with such a camera is to select a particular image and bring it to separate visibility.

Through these observations we grow aware of light's faculty of communicating simultaneously to space as a whole, and to each point in it, a potential image of the light-reflecting object.

What we observe here in the sphere of physical light-activity is exactly what the light-ether performs on a higher level of nature when with its help the spiritual archetype of a plant takes on spatial appearance. For to this end the archetype, itself without spatial limitations, imprints its image into the tiny seed, whence the growing plant organism carries it again into space. And there is in principle no limitation to the number of such seeds, each of which will bear the complete image of the archetype.

*   *
*

(d) SOUND

The characteristics of the third modification of ether are such that they prompted Rudolf Steiner to give it as a second name, besides *chemical ether,* that of *sound-ether.* In view of the fact, stressed at the beginning of this chapter, that perception of the ether is achieved by a heightening of the power of the *spirit-eye,* it must cause surprise to learn that a certain mode of activity of the ether has a quality which makes appeal to aural experiences. The full answer to this riddle must await the discussion that follows this chapter. Two points, however, may be brought forward at once. Firstly, where gravity, with its tendency to individualize, is absent, no such sharp distinctions exist between one form of perception and another as are found in the sphere of the physical senses.[1] Secondly, even in ordinary sense-perception a certain overlapping of visual and aural experiences is known to us. We need only think how common it is to give musical attributes, such as 'consonant' and 'dissonant' to colours, and to describe tones as 'light' and 'dark'. The reason is that subconsciously we accompany visual experiences with tone-sensations, and vice versa. Cases are even known of human beings in whom the secondary sensation occurs with such intensity as to equal the primary one. Such people say that they 'see' sounds and 'hear' colours.

*

Everything that is true of the supersensible sphere we may expect to come to expression in some form in the world of sense-perception. The sphere of the ether is the sphere of the creative archetypes of the world, and when we learn that to one part of this world the character of sound is attributed, we must search for a phenomenon, perceptible to our senses, which reveals to us the secret of the sound's form-creating power. This we have in the so-called sound-figures, discovered by the German physicist Chladni (1756-1827) and called after him 'Chladni's sound-figures'. A short description of how they are produced will not be out of place.

A round or square plate of glass or brass, fixed at its centre so that it can vibrate freely at its edges, is required. It is evenly and not too

[1] That the ether, apart from being supersensibly seen, is also heard, was empirically known to Goethe. See the opening words of the 'Prologue in Heaven'' *(Faust,* I) and the call of the Spirit of the Elements in the first scene of the Second Part of the drama, which follow upon the stage direction: 'The sun announces his approach with overwhelming noise.'

thickly covered with fine sand or lycopodium powder and then caused to vibrate acoustically by the repeated drawing of a violin-bow with some pressure across the edge of the plate until a steady note becomes audible. Through the vibrations thus caused within the plate, the particles of sand or powder are set in movement and caused to collect in certain stationary parts of the plate, thereby creating

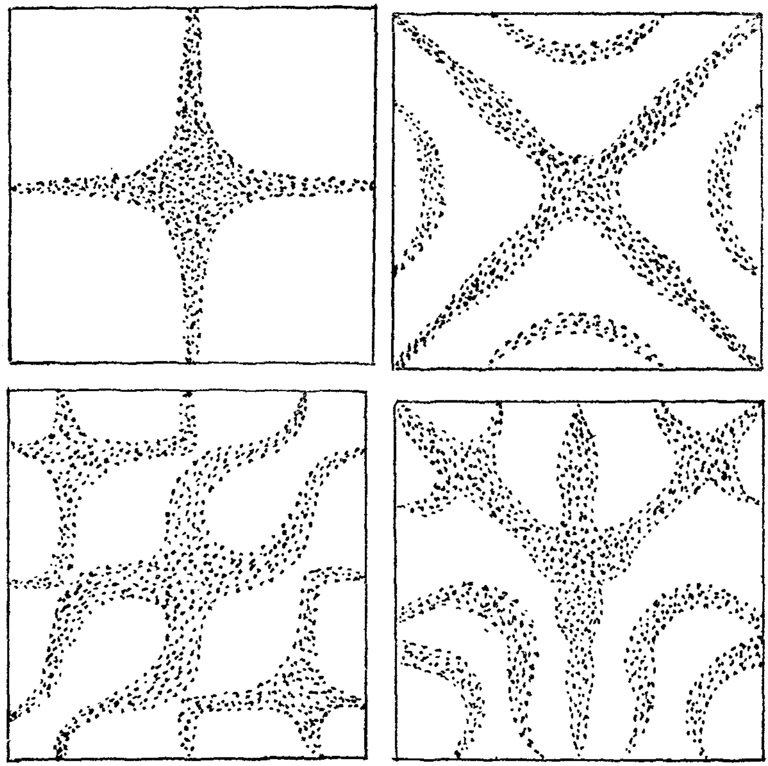

FIG. 14.

figures of very regular and often surprising form. By stroking the plate at different points on the edge, and at the same time damping the vibrations by touching the edge at other points with the finger, notes of different pitch can be produced, and for each of these notes a characteristic figure will appear (Fig. 14).[1]

[1] By attending Chladni's lectures on his discovery in Paris the French physicist Savart became acquainted with this phenomenon and devoted himself to its study. Chladni and Savart together published a great number of these figures.

The significance for us of Chladni's experiment will emerge still more clearly if we modify it in the following way. Instead of directly setting the plate with the powder into vibration by stroking it with the bow, we produce a corresponding movement on a second plate and let it be transmitted to the other by resonance. For this purpose the two plates must be acoustically tuned to each other and placed not too far apart. Let us imagine, further, that the whole experiment was arranged—as it well might be—in such a way that the second plate was hidden from a spectator, who also lacked the faculty of hearing. This gives us a picture of the situation in which we find ourselves whenever the higher kinds of ether by way of a tone-activity inaudible to our physical ear, cause shapeless matter to assume regularly ordered form.

*

This comparison of the activity of the sound-ether, as the form-creating element in nature, with Chladni's phenomenon is drawn correctly only if we recognize that the conception *of form,* as an expression of that which is called forth through the etheric forces in nature, comprises more than the external spatially bounded shape of an organic or inorganic entity. Apart from the fact already indicated, that for the formation of such entities the co-operation also of life-ether is necessary, we can judge the activity of sound-ether correctly only if we conceive it as a much more inward activity, compared with the formation in external space of Chladni's figures. In the latter case, the reason why the influence of sound causes nothing beyond the ordering of form in outer space is because on this plane of nature the only changes that can occur are changes in the positions of separate physical bodies. Where the forces of sound in ether-form are able to take hold of matter from within, they can produce changes of form of a quite different kind. This effect of the activity of sound-ether has given it its other name: chemical ether.

We have mentioned once before that our conception of 'form' in organically active nature must not be limited merely to that of a body's spatial outline. This was in connexion with Ruskin's definition of the spiritual principle active in plant-formation as 'the power that catches out of chaos charcoal, water, lime and what not, and fastens them down into a given form'. Besides the external order of nature revealed in space-form, there exists also an inner qualitative order expressed in a body's chemical composition. Upon this inner chemical order is based all that we encounter as colour, smell, taste, etc., of a substance, as well as its nourishing, healing or harmful properties. Accordingly, all these parts of an organism, both in the plant-kingdom and within the higher organisms, have a certain inner material order, apart from their characteristic space-structure. The one is never present without the other, and in some way they are causally connected.

In this inner order of substance we must see in the very first place the work of the sound or chemical ether. And we should be aware that by the word 'chemistry' in this connexion we mean something much more far-reaching than those chemical reactions which we can bring about by the reciprocal affinity of physical substances, however complicated these reactions may be. A few examples will illustrate the difference between chemical processes caused by direct influence of the chemical ether, and others in which only the physical consequences of the ether are effective.

In his book, *Man the Unknown,* Professor Carrel shows very impressively, by an example from the human organism, the difference of quantitative ratio in externally similar processes, one of which occurs within the domain of life, the other, outside it. He compares the quantity of liquid necessary to keep artificially alive a piece of living tissue which has been reduced to pulp, with the quantity of blood doing the same within the living organism. If all the tissues of a human body were treated in this way, it would take 45,000 gallons of circulating fluid to keep them from being poisoned in a few days by their own waste products. Within the living organism the blood achieves the same task with 1J gallons.

Very many chemical changes within living organisms are effected by the two polar processes of oxidation and reduction. We have discussed them repeatedly as hieroglyphs of much that occurs in nature by way of polarity. In accordance with the principle ruling the physical plane of nature, that differences of level tend to disappear, oxidation can occur by itself, whereas reduction requires the expenditure of energy. Let us from this point of view compare the transformation of oxidized into reduced iron, as it takes place inside and outside the realm of life.

An example of this process in its purely physical form is the reduction of iron-ore to metallic iron in blast-furnaces, where, with the help of high temperature and high pressure, carbon is made to combine with the oxygen ingredient of the ore and to impart to it its own imponderable energy. Precisely the same process is going on continuously and unobtrusively within the human body under normal bodily conditions of temperature and pressure, when the oxy-haemoglobin of the arterial blood changes over into the haemoglobin of the venous blood. A macrotelluric counterpart of this is the transformation of the red river-mud into the blue-black continental mud at the bottom of the sea, around the continental shores. Here, again, reduction takes place without those preliminaries that are necessary for carrying through the process by technical means.

Through examples of this kind we gain insight into the nature of the chemical ether as a 'magic' force (in the sense in which we have introduced this term at the beginning of the book). What the chemical ether is capable of effecting in a gentle manner, so to speak, in co-operation with the inertness-overcoming power of the warmth-ether, can be imitated physically only by an extraordinary concentration of external energy and the use of masses of material substance. At the same time the imitation is never complete. For to all that happens through the action of the chemical ether there belongs the quality of cosmic youth, while everything brought about in a purely physical manner is of necessity cosmically old.[1]

Of all the provinces of nature towards which man's exploring eye has turned since the dawn of the onlooker-consciousness, none has furthered his purely quantitative thinking more than chemistry, ever since the discovery that the chemical reactions of the various substances are conditioned by a quite definite and constant numerical relationship. It was these relationships which impelled the rise of the atomic conception of matter and all its consequences. For since the onlooker-consciousness is quite unable to conceive the existence of numerical relationships in the physical world except as sums of computable units in space, it was natural for this type of consciousness to reduce all empirically established numerical relationships to corre-

[1] Understanding the attributes of the chemical ether enables us to see in their right perspective Rudolf Steiner's suggestions to farmers for the preparation of the soil and for keeping healthy the crops growing on it. Attempts have been made to dismiss these suggestions by calling them 'mysticism' and 'mediaeval magic'. Both terms are titles of honour if we understand by the one the form of insight into the supersensible realm of nature acquired by the higher mode of reading, and by the other a faculty of nature herself, whose magic wand is the chemical or sound-ether.

spending relationships among quantities of the smallest possible material or matter-like units.

Scientific thinking, if guided by knowledge of the existence of etheric forces and their action, has no need of such an interpretation of the numerical relationships revealed in the physical world; for it knows them to be nothing but the last expression of the action of the chemical ether (hence occasionally also called 'number-ether' by Rudolf Steiner). To do justice to the appearance of measurable numerical relationships in nature, in whatever sphere, it is necessary to free ourselves from the abstract conception of number which governs modern scientific thought and to replace it by a more concrete one. We shall rind that for the existence of a certain number there may be two quite different reasons, although the method of establishing the number itself is the same in each case. A simple example will illustrate this.

Let us look at a number of similar objects, say a group of five apples. We observe that the relation of the number five to the group of objects in front of us is purely external and accidental. In applying to it the conception 'five' we combine the single objects into a group and give it a name, or numerical label, which has nothing to do with the nature of the items making up the group. This way of thinking, we may observe, is of exactly the kind which the nominalists of the Middle Ages attributed to every conception formed by the human mind. In fact, the process of counting is a process of pure abstraction. The more differentiated are the things which we want to combine into a group through the process of counting, the further this abstraction has to go. We can count apples and pears together under the collective conception of 'fruit'; if turnips are added, we must help ourselves out with the conception 'vegetable products'; until finally we deal only with 'things', without considering any qualitative differentiation. Thus the conception of number is created solely within the human mind, which applies it to things from outside.

From the moment when human consciousness was unable to attribute to itself any other than a purely nominalistic mode of comprehension it was inevitable that all explanations of natural phenomena would have two results: (1) the exclusion from observation of everything that could not be conceived in terms of numbers, and (2) an endeavour to find for every numerical relationship capable of empirical proof an explanation which could be interpreted as the result of taking qualitatively identical units and counting them. For this method of forming conceptions is the only one which nominalism can accept with a good conscience. The fact that in so doing it is led *ad absurdum* has only quite lately occurred to it. For if by the logical following of this path—as in modern theoretical physics—the whole universe is dissolved into units which can no longer be distinguished from each other, then it will become impossible to count these parts, for it cannot be established whether any given one of these hypothetical elemental particles has been counted or not. None the less, Eddington claimed to have found the exact number of particles composing the universe—a number with 80 figures—by using a special calculus, but this number is valid only on the supposition that the particles cannot be counted because they are indistinguishable![1]

However correct the nominalistic conception of number may be in such a case as that of numbering the five apples, it is wholly incorrect to restrict the concept of number itself to one valid for this kind of occurrence. We shall see this immediately if we take one of the apples and cut it across. There we find the number five confronting us in the well-known star-like figure, represented by the fivefold pericarp in the centre of the apple. What man, restricted as he was to the mode of understanding, has completely overlooked is this: although the act of counting, by which we establish the number five, is the same in both cases, the quality of the number five is totally different. For in the case of the five pericarps this number is a quality immanent in the apple, which it shares with the whole species of Rosaceae. The apple itself is just as much 'five' as it is 'round', 'sweet', etc. In the supersensible type which creates in the plant its own organ of manifestation, the creation of a number—in the apple the number five—is part of the form-creating activities characteristic of the type. The numerical relationships which appear between natural phenomena depend upon the way in which the chemical ether participates. This is true equally of those discovered by chemistry in the sphere of inorganic matter and used to-day with such great success.

Let us be quite clear that the relationship of unity to plurality in the case of the five apples is totally different from what it is in the fivefold pericarp. In the first case unity is the smallest quantity represented by each of the five apples. There, the step from one to two is

[1] See Eddington's humorous and at the same time serious treatment of this problem in his *Philosophy of Physical Science.*

made by joining together two units from outside. The path from one to many is by way of continuous addition. In the second case the unity is represented by the pericarp—i.e. by the one comprising the many, the latter appearing as parts of the whole. In such a case two is part of one and so are three, four, five, etc. Plurality arises from a continuous process of division of unity.

The ancient world knew the idea of number only in the last-mentioned form. There unity appeared as an all-embracing magnitude, revealed through the Universe. The world's manifoldness was felt to be not a juxtaposition of single things, externally connected, but the content of this unity, and therefore derived from it. This was expressed by the pre-Socratic Greek philosophers in the formula *έν και παν* (the One and the All).

With the appearance of the Arabs on the scene of history, human thought turned to the additive concept of number, and the original distributive concept receded gradually into oblivion. The acceptance of the new concept made it possible for the first time to conceive the zero. It is clear that by a continuous division of unity one is carried to a constantly growing number of constantly diminishing parts, but without ever reaching the nothing represented by the number zero. To-day we should say that in this way we can reach zero only by an infinite series of steps. Yet the idea of the infinite did not exist in this form for ancient man. On the other hand, in the arabic conception of number the steps necessary to reach zero are finite. For just as by the external addition of unities we can step forward from one number to the next, so we can also step back on the same path by repeated subtractions of unities. Having thus reached One, nothing can stop us from going beyond it by one more such step. The arabic numeral system, therefore, is the only one to possess its own symbol for zero.

It has been correctly noted that the penetration into European thought of this additive concept of number was responsible for developing the idea of the machine; for it accustomed human beings to think calmly of zero as a quantity existing side by side with the others. In ancient man the idea of nothingness, the absolute void, created fear; he judged nature's relation to the void accordingly, as the phrase 'natura abhorret vacuum' indicates. His capacity to think fearlessly of this vacuum and to handle it thus had to be developed in order to bring about the Machine Age, and particularly the development of efficient steam engines. Consider also the decisive part played by the vacuum in Crookes's researches, through which the path to the sub-physical realm of nature was laid open.

Yet nature makes use of number as a regulating factor in quite a different way from its appearance in the purely electrical and gravitational connexions of inorganic matter, namely where sound-ether from the upper boundary of nature so regulates nature's dynamic that the manifold sense-qualities appear in their time-and-space order. When we interpret the arrangement of numbers found there on a nominalistic basis, as is done when the axis- and angle-relationships of crystals are reduced to a mere propinquity of the atoms distributed like a grid in space, or when the difference in angle of the position of the various colours in the spectrum is reduced to mere differences in frequency of the electromagnetic oscillations in a hypothetical ether—then we bar the way to the comprehension not only of number itself, as a quality among qualities, but also of all other qualities in nature.

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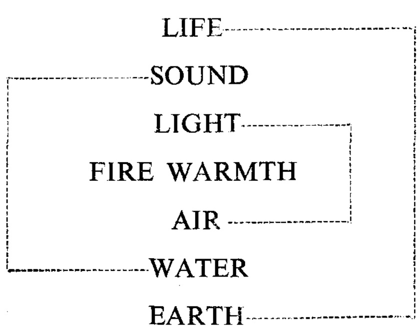
(e) LIFE

As already mentioned, the three kinds of ether, warmth, light and sound, are not sufficient in themselves to bring into existence what in its proper sense we call 'life' in nature, i.e. the formation of single living organisms. This requires the action of a fourth kind of ether, the life-ether, ranged above the other three. We can best comprehend the life-ether's contribution to the total activity of the ether in nature by considering the interaction of the four kinds of ether with the four physical elements.



We have seen that the warmth-ether has the double function of being at once the lowest ether and the highest physical element, thus acting as a sphere of reflexion for the other kinds of ether and the elements respectively. Each stage in the etheric has its reflexion in the physical, as the above table shows. Thus to the physical air the etheric light is related. (The affinity of light and air is best seen in the plant and its leaf-formation.) To bring about real changes in the material composition of the physical world requires the stronger powers of the chemical ether. Therefore it is also the first ether of which we had to speak as 'magical' ether. Its effects reach into the watery element which is already bound up with gravity, but by its own strength it cannot penetrate beyond that. The causation of material changes in the liquid sphere would in fact be all that these three kinds of ether could achieve together.

Only when the power of the life-ether is added to the three others can etheric action reach as far as the sphere of solid matter. Thus the life-ether is responsible for all solid formation in nature, both in her organic and inorganic fields (the latter—crystal-formation—being the effect of external ether-action).[1] It is to the action of the life-ether that nature owes the existence in her different realms of multitudes of separate solid forms. To mention an instance from our previous studies: in the same way as volcanic phenomena manifest the warmth-ether's gravity-overcoming power on a macrotelluric scale, so snow-formation illustrates the life-ether's matter-shaping might.

Through its power to bind flowing action into solid form, the life-ether is related to the sound-ether in the same way as the articulated word formed by human speaking is related to the mere musical tone. The latter by itself is as it were fluid. In human speech this fluidity is represented by the vowels. With a language consisting only of vowels man would be able to express feelings, but not thoughts. To let the word as carrier of thought arise out of sound, human speech possesses the consonants, which represent the solid element in it.

The emergence of the sense-bearing word from the merely ringing sound is an exact counterpart to what takes place in nature when the play of organic liquids, regulated by the chemical ether, is caused by the life-ether to solidify into outwardly perceptible form. By reading in this way the special function of the life-ether among the other three, we are led to the term '*Word-ether*' as an appropriate second

[1] Of the difference between external and internal ether-action more will be said in the concluding chapter.

name for it, corresponding to the term sound-ether for the chemical ether.

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Thus Levity presents itself to us as being engaged in the fourfold activity of Chaoticizing, Weaving, Sounding and, lastly, Speaking the form-creative Cosmic Word into the realm of Gravity.

CHAPTER XX

Pro Anima

Thy functions are ethereal,
As if within thee dwelt a glancing mind,
Organ of vision! And a Spirit aëreal
Informs the cell of Hearing, dark and blind.
W. WORDSWORTH

(a) THE WELL-SPRINGS OF NATURE'S DEEDS AND SUFFERINGS

As our observations have shown, gravity and levity not only exist side by side as a primary polarity; the manifold interaction of their fields gives rise to all sorts of secondary polarities. Obviously, this interaction must be brought about by a further kind of force to which gravity and levity are subordinate.

In what follows we shall try, so far as is possible within the scope of this book, to throw light on the nature of this force. Since the direct experience of the dynamic realm constituted by it is based on faculties of the mind other than those needed for the Imaginative perception of the etheric realm, we shall have to examine also the nature and origin of these faculties. This will lead us again to the study of one of man's higher senses, this time his sense of hearing, with the aim of finding the spiritual function that is hidden in it. But our order of procedure will have to differ from the one followed in the last chapter, because it will be necessary first to make ourselves acquainted with the nature of the new force and then to turn to an examination of the sense-activity concerned.

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Let our first object of observation be man himself in so far as he illustrates a polarity of the second order.

When studying man's nature with the idea of understanding the genesis of his onlooker-consciousness, it will be remembered, we had to examine the ordering of his consciousness into waking, dreaming and sleeping in the different members of his organism. We recognized three different organic systems, the sensory-nerve system, the rhythmic system and the metabolic-limb system, as the bodily foundation of three different soul activities. These are the thought-forming activity which belongs to waking consciousness; the feeling activity which belongs to dream consciousness; and the willing activity which belongs to sleep consciousness. We then saw in these three systems representatives of the three alchemical functions—'sulphurous' in the metabolic, 'saline' in the nervous, 'mercurial' in the mediating rhythmic system.

Regarded thus, man's nature reveals itself as being endowed with a physical organization, and an etheric organization, which are brought into different relationships by being acted upon by a third organization consisting of forces of the kind here to be studied. At his lower pole these forces co-ordinate the ether and physical organizations in a manner corresponding to the function of the 'sulphur'-pole of the alchemical triad. Here, therefore, the warmth-ether takes the lead and acts in such a way that the higher kinds of ether are able to come to expression in material processes of the body. At the upper pole corresponding forces co-ordinate the physical and ether organizations in a way characteristic of the 'salt'-pole. This gives the lead to the life-ether, so that the physical organism provides the foundation for the activity of the ether-forces without, however, being actually penetrated by them (at least after completion of the embryonic and first post-embryonic development). As a result, consciousness lights up in this part of the body. The rhythmic sphere, being the 'mercurial' middle, is distinguished by an alternation of the two conditions described. With each diastole it becomes more akin to the pole below, and with each systole more akin to the pole above. Here, therefore, the lighting up of consciousness is only partial.

By means of these observations we realize that the third type of force, in so far as it is active in man, has the capacity, by co-ordinating the physical and etheric parts of the organism in one way or another, to promote happenings either of a more corporeal or a more psychical nature—namely, motion at one pole, sensation at the other, and feeling in the middle between them.[1] Remembering Goethe's formula, 'colours are *deeds* and *sufferings* of light', we realize how

[1] We must here distinguish sensation from feeling proper, in which sensation and motion merge in mercurial balance.

deeply true the concepts were to which he was led by his way of developing observation and thought.

What we have now brought to our awareness by studying man, holds good in some sense also for the animal. The animal, too, is polarized into motion and sensation. (What makes the animal differ from man need not concern us here, for it belongs to a dynamic realm other than the one we are now studying. This other realm will come under consideration in the next chapter.) Quite a different picture arises when we turn to the plant. The plant, too, is characterized by a threefold structure, root, stem with leaves, and florescence, which in their way represent the three alchemical functions. Consequently, there is also motion in the plant, although this is confined to internal movements leading to growth and formation. And at the opposite pole there is sensation, though again very different from the sensation experienced by higher living beings. What we mean here by 'sensation' can be best expressed by quoting the following passage from Ruskin's *The Queen of the Air,* in which the dual activity of the dynamic which we seek to understand is brought out particularly clearly.

In describing the forming of blossom in the plant as the climax of the 'spirit' active in it, Ruskin says: 'Its (the plant's) form becomes invested with aspects that are chiefly delightful to our own human passions; namely, first, with the loveliest outlines of shape and, secondly, with the most brilliant phases of the primary colours, blue, yellow, red or white, the unison of all; and to make it more strange, this time of peculiar and perfect glory is associated with relations of the plants or blossoms to each other, correspondent to the joy of love in human creatures and having the same object in the continuance of the race.'[1]

If we wish to understand why the same dynamic action working on the physical and etheric organisms of the plant, on the one hand, and of man and the animal, on the other, brings about effects so different, we must turn to the realm whence this action originates in both cases. For the animal and for man this realm is situated within their organisms because in addition to their individual physical and etheric organizations they are endowed also with an individual organization of the higher kind. Not so with the plant. For the rhythms of its

[1] Note how for Ruskin the gulf which for the onlooker-consciousness lies between subject and object is bridged here—as it was for Goethe in his representation of the physico-moral effect of colour.

growth, the successive formation of its various organs, the production of its colours, etc., the plant depends on outer conditions.

What strikes us first in this respect is the plant's dependence on the succession of the seasons. These in turn are an outcome of the changing mutual positions of earth and sun. That which forms part of the individual organism in higher living beings is located in the cosmic surroundings of the plant. In fact, it is our planetary system which provides the forces that stir the etheric and physical forces of the earth to their various interactions, thus bringing about all the manifold secondary polarities.

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Before we embark on a description of further phenomena which testify to the cosmic nature of the forces with which we are here concerned, it will be well (following a principle applied before) to establish the historical antecedents of the conception of the universe we are about to develop.

We realize that the type of force with which we are here seeking to become familiar is the one responsible for the existence of what we commonly call 'soul'. The creation of a body-bound soul, however, is only one particular form of the activity of these forces. Another is the one which we have just seen manifest in the plant. In yet another way the same forces function as movers and stirrers of the macro-telluric processes of the earth, and beyond this of the happenings in the body of our planetary system, including the movements of the various planets.

This is an aspect which was by no means unfamiliar to ancient man. It was naturally lost when the onlooker-consciousness awoke. In this respect it is of historical significance that the same man, G. A. Borelli (1608-79), a member of the Florentine Academy, who was the first to inquire into the movements of the animal and human body from a purely mechanical point of view, made the first attempt to deduce the planetary movements from a purely physical cause.[1] Through this fact an impulse comes to expression which we may term *Contra Animam,* and against which we have to put our *Pro Anima,* in much the same way that we put our *Pro Levitate* against the *Contra Levitatem* call of the Florentine Academicians.

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[1] *De motu animalium* and *Theoria mediceorum planetarum ex causis physicis deducta.*

It will help our further descriptions if we introduce at this point the name which Rudolf Steiner adopted for the type of forces we are concerned with here. In view of the fact that their origin lies in the extra-terrestrial realm of the universe, he called them 'astral' forces, thereby giving back to this term, also, its true and original meaning. It is under this name that we shall speak of them henceforth. To make ourselves more familiar with the character of the astral forces, it will be well to observe them first of all in their macrotelluric form of activity.

There is, as already mentioned, the rhythmic occurrence of the seasons in connexion with the varying relative positions of earth and sun. Alongside this we may put the rhythm of the tides, coincident with the phases of the moon. Just as the solar rhythm manifests in an alternating rise and fall of the saps in the plants, so also does the lunar rhythm.[1] (Note how this fact actually vitiates the usual explanation that the tidal rhythm of the sea is caused by a gravitational pull exerted by the moon's body on the oceanic water.) In neither instance is the change of position of the relevant cosmic body—in our examples that of the sun or moon in relation to the earth—the 'cause' of the corresponding rhythmic events on the earth. Together with all other rhythmic events of equal periodicity, it is itself the effect of the activity of a force-sphere constituting the cosmic realm to which the relevant planetary body belongs.

From this statement three major questions arise, which need to be answered before we can carry on our description of the astral forces themselves:

Firstly, by the way we have spoken of the varying relations of the sun and moon to the earth, seeing in them the effects of certain astral activities, we have treated them as if they were of like nature, namely, resulting from a movement of the relevant heavenly body round the earth. According to the Copernican conception, however, only the moon rotates round the earth, whereas the apparent yearly progression of the sun is actually caused by the earth's motion round the sun. This raises the question of how far the Copernican, heliocentric aspect is valid in a science which strives to embrace the astral realm of the universe in its inquiries.

[1] Knowledge of this biological rhythm is still preserved among native peoples to-day and leads them to take account of the phases of the moon in their treatment of plants. A cosmic nature-wisdom of this kind has been reopened for us in modern form by Rudolf Steiner, and has since found widespread practical application in agriculture. See L. Kolisko, *The Moon and Plant Growth*.

Secondly, what roles do the other members of our planetary system play as compared with those of the sun and the moon?

Thirdly, if it is true that the essential solar and lunar effects—and presumably the effects of the other planets—on the earth do not spring from physical influence exerted by the visible bodies of the planets concerned, but from certain astral force-fields of which these bodies themselves form part, what is the significance of such a body within the planet's dynamic whole?

Starting with the answer to the first question, we shall quote the following passage from a lecture on theoretical physics given by Professor Planck in 1909 at the Columbia University, New York:

'Only the hypothesis of the general value of the principle of Relativity in mechanics could admit the Copernican system into physics, since this principle guarantees the independence of all processes on the earth from the progressive motion of the earth. For, if we had to make allowance for this motion, then I should, for instance, have to reckon with the fact that the piece of chalk in my hand possesses the enormous kinetic energy corresponding to a velocity of about 30 km/sec.'

The implications for us of these remarks by an eminent physicist can be expressed as follows:

In a science which knows how to deal with movement as an event of absolute dynamic reality, the Copernican aspect loses its significance as the only valid aspect of our cosmic system. For its application as a means of describing the dynamic happenings within this system presupposes the acceptance of Einstein's relativistic conception of motion. Indeed, for the building up of a picture of the dynamic structure of our system, the Copernican view-point is inadequate.

This statement must not be taken to deny all justification to the heliocentric view-point. There is, after all, the fact that the orbits which the heavenly bodies appear to follow when viewed in this way, assume a particular geometrical character which cannot be accidental. And more than that, when the heliocentric aspect is seen in its true setting, it forms (as will be shown later) an extremely revealing part of the script which tells us of the nature of the astral forces. All that is required is that the heliocentric picture be taken for what it is, namely, a purely kinematic aspect of the true dynamic ordering of our cosmic system, which in itself calls for quite other means of conceptual representation.

From the point of view of the astral order of the universe, the earth appears in the centre of a number of force-fields which penetrate each other and in their peripheral region extend beyond one another in accordance with the respective orbits of the various planetary bodies. How many force-fields there are, and what is the respective character of each, will become clear from the following consideration, which will also provide the answer to the second of our three questions.

As the originator of the secondary polarities in earthly nature the astral realm must undoubtedly itself be structured polarically, one part of it forming the cause of all the happenings by which levity is brought into interaction with gravity, the other of all the happenings by which gravity is brought into interaction with levity. There must be a further part which is responsible for the establishment of the 'mercurial' mean between the two poles of the secondary polarity. This leads us to a threefold aspect of the astral realm.

Closer inspection reveals a repetition of this threefold order within each of the two polar regions. In Chapter XII we learnt to distinguish the material happenings at the two poles of the secondary polarity by observing their appearance in the plant as 'sublimation', on the one hand, and 'assimilation' on the other. Of the former process, by which matter is carried from its gravity-bound to its gravity-free condition, we know that it takes place in three stages, of which the first implies the lifting of matter from the solid to the liquid condition, the second from the liquid to the aeriform condition, and the third to the condition of pure heat. There are three corresponding stages by which ether becomes susceptible to gravity. It is in their nature that they are not in the same degree manifest as are their polar opposites. Still, properly guided observation is able to detect them and enables us to describe them as follows. At the first stage, ether, which in itself has a purely peripheral orientation, becomes linked to some all-relating point; at the second stage, the various ether-activities, already point-related, are brought into some characteristic interrelationship so as to become the cause of a particular formative action in the material realm; at the third stage, the etheric aggregate thus organized receives the impulse to link itself with some particular portion of ponderable matter.

In these six forms of astral activity, observation, if guided by modern spiritual science, recognizes the characteristics of the six planetary spheres, known as 'Moon', 'Mercury', 'Venus', on the one hand, 'Saturn', 'Jupiter', 'Mars', on the other. In the same way the dynamic sphere of the 'Sun' is found to provide the astral activity which mediates between the two groups of planetary spheres.[1] The following observations may help us to become familiar with the different modes of activity of the force-spheres.

Let us start with the astral forces corresponding to the three cosmic bodies nearest to the earth—Moon, Mercury, Venus. Their activity can be discerned, for example, by watching the successive stages of plant development—the formation of the sap-bearing parts; the flower-substance already partly transformed into aeriform condition; finally the propagating processes which belong essentially to the sphere of activity of the warmth-ether.[2] In the human organism we find the same sequence in the step-by-step transformation of nutriment right up to the moment when earthly form passes into chaos, as we learnt previously. The so-called enzyme action, ascribed by physiology to the various digestive juices, is in reality the product of an activity of the lower part of man's astral organization, for which the relevant juices exercise the function of physical 'carriers'. In the field of macrotelluric phenomena, the metamorphosis of the atmospheric moisture extending beyond the different cloud-stages up to the stage of pure warmth is an example of the activity of the same forces.

Within all three-stage transitions of this kind, the astral forces connected with the Moon preponderate during the first stage, those connected with Mercury during the second, those connected with Venus during the third. We have already come across some examples of the outstanding share taken by the Moon in the events of the earth's watery sphere. To these phenomena, which show by their rhythm their connexion with the Moon, we may add the fertility rhythm in the female human organism which coincides, not in phase but in duration, with the rhythm set by the Moon's course in the heavens. If we consider that the formation of a new human body in the womb needs the play of formative forces from out of the whole world environment, and that for this purpose matter must be brought into a receptive condition for these forces, then we can better under-

[1] In the order of names given above we follow the ancient usage for the two planets nearest to the sun, not the reversed order in which they are used to-day. This is necessary in a cosmology which aspires at a qualitative understanding of the universe, in view of the qualities represented by these names. Note also the absence of the three most distant planets, Uranus, Neptune and Pluto. They are not to be considered as parts of the indigenous astral structure of our cosmic system—any more than radioactivity is an original feature of the earth.

[2] Note the 'Venus' character of Ruskin's description of the plant's state of florescence quoted above (p. 336).

stand the preparatory part played by the Moon-forces. In order, however, that the substance of the female germ should reach that condition of chaos suitable for embryonic development, there is still necessary the influence of the supra-lunar astral forces. Entry for these is provided by the union of the germ-cell with the male sperm-cell.[1]

As the three sub-solar planetary spheres are responsible for events of a 'sulphurous' (radial) character, so are the three supra-solar spheres responsible for those of a 'saline' (spherical) character. For example, we meet with Saturn-activity in everything which radiates from the human head and brings about the hardening both of the head itself and of the entire skeleton. Observation has shown that, even if the human being, as usually happens, stops growing in the early twenties, so that the skeleton undergoes no further lengthening, it nevertheless reaches its final shape and its final hardening only between the twenty-eighth and thirtieth years. This is the time in man's life when Saturn returns for the first time to the position in which it stood relatively to the earth at his birth, or, more correctly, at his conception.

If the activity of the Saturn-force is most clearly manifest in the formation of the hard skull, that of Jupiter, the planet of 'Wisdom', is shown in the formation of the complicated structure of the brain, which enables it to co-ordinate the bodily and psychic functions of the entire man. In the realm of physical nature, man's brain is indeed the most perfect example of cosmic Intelligence at work in a manner resembling that activity of human intelligence which one usually understands by 'organizing'.

In order that Form should come about, the forces of Saturn are required; for the formative process to take place in Wisdom-filled order, Jupiter's forces are necessary. If form and order are to become manifest in the realm of earthly substance, both require the assistance of Mars. We can best form an idea of the part which Mars contributes to the coming into being of the world of Form in nature if we observe

[1] As to the time-scale of the processes brought about by Mercury and Venus respectively, experience shows that they reveal the cosmic rhythms less clearly than those for which the Moon-activity is responsible. The same is found at the opposite pole. There it is the Saturn-generated processes which show the cosmic rhythm more conspicuously than those engendered by Jupiter and Mars. To learn to recognize rhythmic events in nature and man as reflexions of corresponding planetary rhythms is one of the tasks which future scientific research has to tackle. A practical example of this kind will appear in the further course of this chapter.

what takes place when we make use of speech as a medium for expressing our thoughts. In order to be able to shape a thought we have to participate in the formative force of Saturn. We depend upon Jupiter to bring about logical connexion between the single thoughts. To announce them to the world, we need the motive force of Mars, which enables us so to set external matter in motion that it becomes a carrier and relayer of our thoughts. (We here touch upon the field of the acoustic movements of the air which will occupy us more closely later on.)

Many examples of the activity of the force-spheres represented by the three exterior planets are to be found also in nature external to man. From the realm of plant life we may take the woody and bark-like formation of the trees as representing the operation of Saturn-forces. Similarly, all that goes on in the organizing of the single leaf, and particularly in the organization of the countless separate leaves which make up the foliage of a tree into a unified whole, the characteristic crown of a tree, is an example of the work of Jupiter. Both activities are assisted by the force of Mars, which directs them from the cosmic periphery toward the single physical object.

Between the two groups of astral force operating in this manner, the Sun acts as a mediating element through its double function of supporting the activity of the three lower planets by means of its heat and of conveying to the earth, through its light, the forces of the three higher planets. In the human microcosm the Sun-forces accomplish a corresponding task by means of the influences which radiate from the heart through the body along the paths taken by the blood.

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In what follows we shall point to a group of phenomena which show the astral interconnexion between earth and universe; we owe our knowledge of them to Rudolf Steiner. It is due to him, also, that experimental research into the relevant facts became possible. They concern the reflexion of the various planetary movements, observable in the sky, in the behaviour of certain mineral substances of the earth.

In connexion with our discussion of electricity (Chapter XIII) we spoke of the special function of the metals as bearers of the 'mercurial' quality (in the alchemical sense of the term). As one of the characteristics which reveal this function we mentioned the peculiar capacity of metals to behave as 'solid fluids'. This exceptional place among the mineral substances of the earth, the metals owe to their close association with the extra-terrestrial astral forces of the world.

In this field, too, modern spiritual investigation has recovered something which was known to people of old—that among the metals there are seven which have a distinctive character, for each stands in a special relation to one of the seven planets (that is, the planetary force-spheres) of our cosmic system. This is shown in the following table:

Saturn	Lead
Jupiter	Tin
Mars	Iron
Sun	Gold
Venus	Copper
Mercury	Quicksilver
Moon	Silver

As compared with these seven, the other metals are products of combinations of various planetary forces. A comparison of the role of Saturn as the outermost planet of our cosmic system with the role played by its metal, lead, as a final product of radioactive disintegration, leads one to conceive of the radioactive sphere of the earth as being related especially to the planets outside the orbit of Saturn, namely, Uranus, Neptune, Pluto.

Thanks to the work of L. Kolisko who, in following Rudolf Steiner's indications, observed for many years the behaviour of the seven metals singly and in combination by submitting their salts to certain capillary effects, we know to-day that the" earth bears in her womb substances whose dynamic condition follows exactly the events in the planetary realm of the universe.[1]

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The picture of the universe which has thus arisen before our mind's eye is a startling one only so long as we keep comparing it with its heliocentric predecessor. How wrong it would be to regard it as something inconceivable for the modern mind, is shown by the fact that the modern physiologist has already been driven to form quite a similar picture of the human organism, as far as it concerns glandular action in this organism. His observations have taught him to distin-

[1] See L. Kolisko: *Working of the Stars in Earthly Substances,* and other publications by the same author.

guish between the gland as a spatially limited physical organ and the gland as a functional sphere, and to conceive of the latter as the essential gland. Seen thus, 'the spatial and temporal dimensions of each gland are equal to those of the entire organism' (A. Carrel). In this way we come to see the human organism as a realm of interpenetrating spheres of distinctive physiological activities. Each of these activities is anchored somewhere in the physical body by the anatomically discernible gland-body, and the latter's relationship to the functional sphere is such that a gland's 'physiological individuality is far more comprehensive than its anatomical individuality'.

We need only translate this statement into its macrocosmic counterpart to obtain another statement which expresses fittingly the relationship of the visible body of a planet to the functional (astral) sphere indicated by its orbit. Then we shall say that 'a planet's astral individuality is far more comprehensive than its astronomical individuality'.

It should be observed that the step we have here taken, by using a conception obtained through microcosmic observation to help us to find the answer to a question put to us by the macrocosm, complies with one of the fundamentals of our method of research, namely, to allow 'the heavens to explain the earth, and the earth the heavens' (R. St.).

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(*b*) HEARING AS DEED

In the introductory part of the last chapter we said that we have the right to employ results of investigation carried out by higher faculties of spiritual perception without contradicting our principle of seeking to understand the phenomenal world by reading it, provided our doing so helps to enhance our own reading activity, and provided it can be shown that the acquisition of the higher faculties of perception is a direct continuation of the training we have to apply to our mind and senses to make them capable of such reading. As regards the forces of astral character, the first of these two conditions has been fulfilled by the observations we have already worked through in this chapter. We have still to show that the second condition is equally fulfilled.

The faculty of the mind which permits direct investigation of the astral realm was called (spiritual) Inspiration by Rudolf Steiner, who thereby restored to this term, also, its proper meaning. We have already indicated that this faculty resides in the sense of hearing in the same way that the faculty of Imagination—as we have found—resides in the sense of seeing. In order to understand why it is this particular sense which comes into consideration here, we have to consider that the phenomena through which the astral world manifests most directly are all of a rhythmic nature. Now, the sense through which our soul penetrates with direct experience into some outer rhythmic activity is the sense of hearing, our aural perceptions being conveyed by certain rhythmic movements of the air. In what follows we shall see how the study of both the outer acoustic phenomena and our own psycho-physical make-up in the region of the acoustic sense, leads to an understanding of the nature of Inspiration and of how it can be trained.

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Among all our sense-perceptions, sound is unique in making itself perceptible in two quite different ways—via the ear as a direct sense experience and via the eye (potentially also via the senses of touch and movement) in the form of certain mechanical movements, such as those of a string or a tuning fork. Hence the world-spectator, as soon as he began to investigate acoustic phenomena scientifically, found himself in a unique position. In all other fields of perception, with the exception of the purely mechanical processes, the transition to non-stereoscopic colourless observation had the effect that the world-content of the naive consciousness simply ceased to exist, leaving the ensuing hiatus to be filled in by a pattern of imagined kinematic happenings—for example, colour by 'ether'-vibrations, heat by molecular movements. Not so in the sphere of acoustics. For here a part of the entire event, on account of its genuine kinetic character, remains a content of actual observation.

In consequence, the science of acoustics became for the scientific mind of man a model of the required division between the 'subjective' (that is, for scientific considerations non-existent) and the 'objective' (that is, the purely kinematic) part of observation. The field of aural perception seemed to justify the procedure of collecting a mass of phenomena, stripped of all that is experienced by man's soul in meeting them, and of assembling them under a purely abstract concept, 'sound'.

Professor Heisenberg, in his lecture (quoted at the beginning of

Chapter II) on the way in which the scientific interrogation of nature has deliberately limited itself, draws attention to the fact that a full knowledge of the science of optics in its present form might be acquired merely through theoretical study by one born blind, yet without his ever getting to know what *light* is. Heisenberg could, of course, have said the same of the science of acoustics in regard to one born deaf. But we can go a step further by asking how far a deaf and a blind person could get towards *establishing* the respective science. The answer must be that, whereas the person lacking sight would not of himself be in a position to establish a science of optics, it would be well within the scope of the deaf man to establish a science of acoustics. For all the processes essential to a physical acoustics are accessible to the eye and other senses.

In order to make our experience of hearing a finger-post pointing the way to an understanding of the faculty of Inspiration innate in man, we must first of all seek to transform acoustics from a 'deaf into a 'hearing' science, just as Goethe turned the theory of colour from a colour-blind into a colour-seeing science.

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Following our procedure in the case of optics, we select from the total field of acoustic phenomena a defined realm specially suited to our purpose. As it was then the spectrum, so it will be now the so-called *quality* of sound, or *tone-colour.*

By this term in acoustics is understood a property possessed by sound apart from pitch and volume, and dependent on the nature of the source from which a tone is derived. It is the tone-colour by which the tone of a violin, for instance, is distinguished from a tone of equal intensity and pitch produced by a flute. Similarly, two musical instruments of the same kind are distinguished from each other by tone-colour.

Tone-colour plays a specially significant part in human and animal voices. Not only has each individual voice its unique colour, but the colour varies in one and the same person or animal, according to the prevailing mood. Moreover, by uttering the various vowels of his language, man is able to impart varying colour to the sounds of his speech. For the difference we experience when a tone is sung on the vowel 'a' or the vowel 'e', etc., derives from the particular colour given by the vowel to that tone.

Among the discoveries of the last century in the realm of acoustics, there is one which especially helped to establish a purely kinematic conception of sound. Helmholtz showed that tones which to our ears seem to have a clear and definite pitch may be split up by a series of resonators into a number of different tones, each of them sounding at a different pitch. The lowest of these has the pitch which our ears attach to the entire tone. Thus in any ordinary tone there may be distinguished a 'fundamental' tone and a series of 'overtones'. Helmholtz further showed that the particular series of overtones into which a tone can be resolved is responsible for the colour of that tone as a whole. Naturally, this meant for the prevailing mode of thinking that the experience of the colour of a tone had to be interpreted as the effect of a kind of acoustical adding together of a number of single tone perceptions (very much as Newton had interpreted 'white' light as the outcome of an optical adding together of a certain number of single colour perceptions).

The picture becomes different if we apply to the aural experience Goethe's theorem that, in so far as we are deluded, it is not by our senses but by our own reasoning. For we then realize that sounds never occur of themselves without some tone-colour, whilst physically 'pure' tones—those that represent simple harmonic motions—exist only as an artificial laboratory product. The colour of a tone, therefore, is an integral part of it, and must not be conceived of as an additional attribute resulting from a summing up of a number of colourless tone experiences.

Further, if we compare our experiences of the two kinds of tone, they tell us that through the quality or colour of the natural tone something of a soul-nature, pleasant or unpleasant, speaks to us, whereas 'pure' tones have a soulless character.

Resolving normal tones by Helmholtz's method (useful as it is for certain purposes) amounts to something like dissecting a living, ensouled organism into its members; only the parts of the corpse remain in our hands.

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Having thus established that the psychic content of aural experience forms an integral part of the tone-phenomenon as such, we must seek to understand how the kinetic process which is indispensable for its appearance comes to be the vehicle for the manifestation of 'soul' in the manner described.

To this end we must first of all heed the fact that the movement which mediates aural sensation is one of alternating expansion and contraction. Expressed in the language of the four Elements, this means that the air thus set in vibration approaches alternately the condition of the watery element beneath it and of the element of fire (heat) above it. Thus, in a regular rhythm, the air comes near the border of its ponderable existence. Purely physical considerations make us realize that this entails another rhythmic occurrence in the realm of heat. For with each expansion of the air heat is absorbed by it and thereby rendered space-bound, while with every contraction of the air heat is set free and returns to its indigenous condition—that is, it becomes free from spatial limitations.

This picture of the complete happenings during an acoustic event enables us to understand how such a process can be the vehicle for conveying certain astral impulses in such a way that, when met by them, we grow aware of them in the form of a direct sensation. Taking as a model the expression 'transparent' for the perviousness of a substance to light, we may say that the air, when in a state of acoustic vibration, becomes 'trans-audient' for astral impulses, and that the nature of these vibrations determines which particular impulses are let through.

What we have here found to be the true role of the kinetic part of the acoustic process applies equally to sounds which are emitted by living beings, and to those that arise when lifeless material is set mechanically in motion, as in the case of ordinary noises or the musical production of tone. There is only this difference: in the first instance the vibrations of the sound-producing organs have their origin in the activity of the astral part of the living being, and it is this activity which comes to the recipient's direct experience in the form of aural impressions; in the second instance the air, by being brought externally into a state of vibration, exerts a kind of suction on the astral realm which pervades the air, with the result that parts of this realm become physically audible. For we are constantly surrounded by supersensible sounds, and the state of motion of the air determines which of them become perceptible to us in our present state of consciousness.

At this point our mind turns to a happening in the macrotelluric sphere of the earth, already considered in another connexion, which now assumes the significance of an ur-phenomenon revealing the astral generation of sound. This is the thunder-storm, constituted for our external perception by the two events: lightning and thunder.

Remembering what we have found earlier (Chapter X) to be the nature of lightning, we are now in a position to say: a supraterrestrial astral impulse obtains control of the earth's etheric and physical spheres of force in such a way that etheric substance is thrown into the condition of space-bound physical matter. This substance is converted by stages from the state of light and heat via that of air into the liquid and, in certain cases, into the solid state (hail). To this we now add that, while in lightning the first effect of the etheric-physical interference of the astral impulse appears before our eyes, our ears give us direct awareness of this impulse in the form of thunder. It is this fact which accounts for the awe-inspiring character of thunderstorms.

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The picture we have thus received of the outer part of the acoustic process has a counterpart in the processes inside the organ of hearing. Hearing, like seeing, depends upon the co-operation of both poles of the human organism—nerve and blood. In the case of hearing, however, they play a reversed role. In the eye, the primary effect of light-impressions is on the nervous part; a secondary response to them comes from the blood organization. In the ear, the receptive organ for the astral impulses pressing in upon it is a part which belongs to the body's limb system, while it is the nervous organization which functions as the organ of response. For in the ear the sound-waves are first of all taken over by the so-called ossicles, three small bones in the middle ear which, when examined with the Goethean eye, appear to be a complete metamorphosis of ah arm or a leg. They are instrumental in transferring the outer acoustic movements to the fluid contained in the inner ear, whence these are communicated to the entire fluid system of the body and lastly to the muscular system.[1] We shall speak of this in detail later on. Let it be stated here that the peculiar role played by the larynx in hearing, already referred to by us in Chapter XVI, is one of the symptoms which tells of the participation of the muscular system in the internal acoustic process.

Psychologically, the difference between ear and eye is that aural perceptions work much more directly on the human will—that is, on the part of our astral organization connected with the limb system. Whereas eye-impressions stimulate us in the first place to think, ear-

[1] The close connexion between the ear and the motor system of the body is shown in another way by the fact that part of the ear serves as an organ for the sense of balance.

impressions stimulate us to … dance. The whole art of dancing, from its original sacred character up to its degenerate modern forms, is based upon the limb system being the recipient of acoustic impressions.

In order to understand how the muscles respond to the outer astral impulses which reach us through our ear, we must first understand what happens in the muscles when our will makes use of them for bodily motion. In this case, too, the muscular system is the organ through which certain astral impulses, this time arising out of the body's own astral member, come to expression. Moreover, the movement of the muscles, though not outwardly perceptible, is quite similar to acoustic movements outside the body. For whenever a muscle is caused to alter its length, it will perform some kind of vibration—a vibration characterized even by a definite pitch, which differs in different people. Since throughout life our body is never entirely without movement, we are thus in a constant state of inward sounding. The muscular system is capable of this vibration because during the body's initial period of growth the bones increase in length to a much greater extent than do the sinews and muscles. Hence the latter arrive at a condition of elastic tension not unlike that of the strings of a musical instrument.[1]

In the case of bodily movement, therefore, the muscles are tone-producers, whereas in acoustic perceptions they are tone-receivers. What, then, is it that prevents an acoustic perception from actually setting the limbs in motion, and, instead, enables our sentient being to take hold of the astral impulse invading our muscles?

This impediment comes from the contribution made by the nervous system to the auditory process. In order to understand the nature of this contribution we must remember the role played by the blood in seeing. It was found by us to consist in the bringing about of that state of equilibrium without which we should experience light merely as a pain-producing agent. Similarly, the perception of sound requires the presence of a certain state of equilibrium between the nerve-system and the limb-system. In this case, however, a lack of

[1] The muscle-tone can be made audible by the following means. In a room guarded against noise, press the thumbs lightly upon the ears and tense the muscles of the hands and arms—say by pressure of the fingers against the palms or by contracting the muscle of the upper arms. If this is done repeatedly, the muscle-tone will be heard after some practice with increasing distinctness. It is easily distinguished from the sound of the circulating blood as it is much higher. (As an example: the author's muscular pitch, not a particularly high one, has a frequency of approx. 630 per sec., which puts it between Treble D sharp and E.)

equilibrium would result not in pain, but in ecstasy. For if acoustic impressions played directly into our limb-system, with nothing to hold them in check, every tone we encounter would compel us to an outward manifestation of astral activity. We should become part of the tone-process itself, forced to transform it by the volitional part of our astral organization into spatial movement. That this does not happen is because the participation of the nervous system serves to damp down the potential ecstasy. Hence it is more or less left to the sentient part of the astral organization—that is, the part free from the physical body—to partake in the astral processes underlying the tone occurrences.

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Our discussion has reached a point where we are able to answer a question which first arose in the course of our study of the four ethers, and which arises here anew.

In studying the chemical or sound ether we were faced with the fact that part of the etheric realm, although in itself accessible to the spiritual part of the sense of sight, offers supersensible experience comparable to the perception of sound. Conversely, we are now met by the fact that it is spiritual hearing which gives access to the immediate perception of a realm of forces which is not only the source of acoustic phenomena, but the origin of all that manifests in nature in the form of sulphurous, saline and mercurial events, such as the world of colours, electricity, magnetism, the manifold rhythmic occurrences on the earth (both taken as a whole .and in single organisms), etc.—all of which are taken hold of by quite other senses than that of hearing.

At our first encounter with this problem we remarked that in the supersensible no such sharp distinctions exist between different sense-spheres as are found in body-bound sense-perception. At the same time we remembered that even in physical perception we are inclined to attach acoustic attributes to colours and optical attributes to tones. In fact, it was precisely an instance of this kind of experience, namely, our conception of tone-colour, which gave us our lead in discussing the acoustic sphere in general. Our picture of the particular interaction of the two polar bodily systems in the acts of seeing and hearing now enables us to understand more clearly how these two spheres of perception overlap in man. For we have seen how the system which in seeing is the receiving organ, works in hearing as the responding one, and vice versa. As a result, optical impressions are accompanied by dim sensations of sound, and aural impressions by dim sensations of colour.

What we are thus dimly aware of in physical sense activity, becomes definite experience when the supersensible part of the senses concerned can work unfettered by the bodily organ. Clear testimony of this is again given to us by Traherne in a poem entitled *Dumnesse.* This poem contains an account of Traherne's recollection of the significant fact that the transition from the cosmic to the earthly condition of his consciousness was caused by his learning to speak. The following is a passage from the description of the impressions which were his before his soul was overcome by this change:

'Then did I dwell within a World of Light
Distinct and Seperat from all Mens Sight,
Where I did feel strange Thoughts, and such Things see
That were, or seemd, only reveald to Me . . .

'. . . A Pulpit in my Mind
A Temple, and a Teacher I did find,
With a large Text to comment on. No Ear,
But Eys them selvs were all the Hearers there.
And evry Stone, and Evry Star a Tongue,
And evry Gale of Wind a Curious Song.'[1]

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We have obtained a sufficiently clear picture of the organization of our sense of hearing to see where the way lies that leads from hearing with the ears of the body to hearing with the ears of the spirit, that is, to the inspirative perception of the astral world.

In the psycho-physical condition which is characteristic of our present day-consciousness, the participation of our astral organization in any happenings of the outer astral world depends on our corporeal motor system being stimulated by the acoustic motions of the air, or of some other suitable medium contacting our body. For it is only in this way that our astral organization is brought into the sympathetic vibrations necessary for perceiving outer astral happenings. In order that astral events other than those manifesting acoustically may become accessible to our consciousness, our own astral being

[1] Compare also the beginning of Traherne's poem *Wonder,* quoted in Chapter VI (p. 110), where he says that everything he saw 'did with me talk'.

must become capable of vibrating in tune with them, just as if we were hearing them—that is, we must be able to rouse our astral forces to an activity similar to that of hearing, yet without any physical stimulus. The way to this consists in training ourselves to experience the deeds and sufferings of nature as if they were the deeds and sufferings of a beloved friend.

It is thus that we shall learn to hear the soul of the universe directly speaking to us, as Lorenzo divined it, when his love for Jessica made him feel in love with all the world, and he exclaimed:

'There's not the smallest orb which thou behold'st
But in his motion like an angel sings,
Still quiring to the young-eyed cherubim,—
But whilst this muddy vesture of decay
Doth grossly close it in, we cannot hear it.'

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(c) KEPLER AND THE 'MUSIC OF THE SPHERES'

'One must choose one's saints .. . and so I have chosen mine, and before all others, Kepler. In my ante-room he has ever a niche of his own, with his bust in it.'

This opinion of Goethe's must surprise us in view of the fact that Kepler was the discoverer of the three laws called after him, one of which is supposed to have laid the foundation for Newton's mechanical conception of the universe. In what follows it will be shown how wrong it is to see in Kepler a forerunner of the mechanistic conception of the world; how near, in reality, his world-picture is to the one to which we are led by working along Goetheanistic lines; and how right therefore Goethe was in his judgment on Kepler.

Goethe possessed a sensitive organ for the historical appropriateness of human ideas. As an illustration of this it may be mentioned how he reacted when someone suggested to him that Joachim Jungius—an outstanding German thinker, contemporary of Bacon, Van Helmont, etc.—had anticipated his idea of the metamorphosis of the plant. This remark worried Goethe, not because he could not endure the thought of being anticipated (see his treatment of K. F. Wolff), but because this would have run counter to the meaning of man's historical development as he saw it. 'Why do I regard as essential the question whether Jungius conceived the idea of metamorphosis as we know it? My answer is, that it is most significant in the history of the sciences, *when* a penetrating and vitalizing maxim comes to be uttered. Therefore it is not only of importance that Jungius has not expressed this maxim; but it is of highest significance that he was positively unable to express it—as we boldly assert.'[1]

For the same reason Goethe knew it would be historically unjustified to expect that Kepler could have conceived an aspect of the universe implicit in his own conception of nature. Hence it did not disturb him in his admiration for Kepler, that through him the Copernican aspect of the universe had become finally established in the modern mind—that is, an aspect which, as we have seen, is invalid as a means of forming a truly dynamic conception of the world.

In forming his picture of the universe, it is true, Copernicus was concerned with nothing but the spatial movements of the luminous entities discernible in the sky, without any regard to their actual nature and dynamic interrelationships. Hence his world-picture—as befits the spectator-form of human consciousness which was coming to birth in his own time—is a purely kinematic one. As such it has validity for a certain sphere of human observation.

When Kepler, against the hopes of his forerunner and friend, Tycho Brahe, accepted the heliocentric standpoint and made it the basis of his observations, he did so out of his understanding of what was the truth for his own time. Kepler's ideal was to seek after knowledge through pure observation. In this respect Goethe took him as his model. Kepler's discoveries were a proof that man's searching mind is given insight into great truths at any stage of its development, provided it keeps to the virtue of practising pure observation.

It has been the error of Newton and his successors up to our own day, to try to conceive the world dynamically within the limits of their spectator-consciousness and thus to form a dynamic interpretation of the universe based on its heliocentric aspect. This was just as repellent to Goethe as Kepler's attitude was attractive.

But by so sharply distinguishing between Newton and Kepler, do we not do injustice to the fact that, as the world believes, Kepler's third law is the parent of Newton's law of gravitation? The following will show that this belief is founded on an illusory conception of the kind we met before. As we shall see, Kepler's discovery, when treated in a *Keplerian* way, instead of leading to Newton, is found to be in

[1] For the particular reasons by which Goethe justifies his assertion, see his essay *Leben und Verdienste des Doktor Joachim Jungius.*

full agreement with the very world-picture to which our own observations have led us.

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It is an established conviction of the mathematical scientist that, once an observed regularity in nature has been expressed as a mathematical equation, this equation may be transformed in any mathematically valid way, and the resulting formula will still apply to some existing fact in the world. On innumerable occasions this principle has been used in the expectation of providing further insight into the secrets of nature. We came across a typical instance of this in discussing the basic theorem of kinematics and dynamics (Chapter VIII). Another example is Newton's treatment of Kepler's third law, or—more precisely—the way in which Newton's law of gravitation has been held to confirm Kepler's observations, and vice versa,

It will be our task to analyse the Kepler-Newton case on the very lines of our treatment of the two parallelogram theorems. This analysis will give us insight into a truth which we have to regard as one of the basic maxims of the new science. It says that whether a given formula, derived mathematically from one that was first read from nature, still expresses some fact of nature, cannot be decided by pure mathematical logic, but only by testing it against truly observable phenomena.

Through Kepler's third law a certain relation is expressed between the spatial dimensions of the different planetary spheres and the time needed by the relevant planet to circle once round the circumference of its own sphere. It says: 'The squares of the periodic times of the planets are always in the same proportion as the cubes of their mean distances from the sun.'

In mathematical symbols this reads:

$$\frac{t_1^2}{t_2^2} = \frac{r_1^3}{r_2^3}$$

We shall see later how Kepler arrived at this law. The point is that there is nothing in it which is not accessible to pure observation. Spatial distances and lengths of time are measured and the results compared. Nothing, for instance, is said about the dynamic cause of the movements. The assertion is restricted—and this is true also of the first and second law—to a purely kinematic content, and so precisely to what the earthly onlooker can apprehend.

Now it is said that Kepler's third law is a necessary consequence of

Newton's law of gravitation, and that—since it is based on pure observation—it therefore establishes the truth of Newton's conception. In this assertion we encounter a misconception exactly like the one in the statement that the theorem of the parallelogram of forces follows by logical necessity from the theorem of the parallelogram of velocities. For:

(a) The law of gravitation itself derives from Newton's formula for the centripetal force acting at a point which moves along a circle, this formula being itself the result of an amplification of the formula for centripetal acceleration by the factor 'mass' (as if the latter were a pure number) :

Centripetal acceleration: $a = 4\pi^2 \frac{r}{t^2}$

Centripetal force: $P = am = 4\pi^2 m \frac{r}{t^2}$

(b) The formula for centripetal acceleration—and the concept of such acceleration itself—is the result of splitting circular movement into two rectilinear movements, one in the direction of the tangent, the other in the direction of the radius, and of regarding it—by a mode of reasoning typical of spectator-thinking—as composed of the two. This procedure, however, useful as it may be for the purpose of calculation, is contrary to observation. For, as we have pointed out earlier, observation tells us that all original movement—and what can be more original than the movements of the planetary bodies—is curvilinear. No insight into the dynamic reality of cosmic movement, therefore, can ever be gained by handling it mathematically in this way.

(c) The transformation of Kepler's formula which is necessary in order to give it a form representing the nucleus of Newton's formula, is one which, though mathematically justified, deprives Kepler's formula of any significance as expression of an observed fact. The following analysis will show this.

Kepler's formula— $\frac{r_1^3}{r_2^3} = \frac{t_1^2}{t_2^2}$

may be written also $\frac{r_1^3}{t_1^2} = \frac{r_2^3}{t_2^2}$

and this again in the generalized form: $\frac{r^3}{t^2} = c$

Obviously, by each of these steps we diminish the reality-value of the formula. In its original form, we find spatial extension compared with spatial extension, and temporal extension with temporal extension. Each of the two comparisons is a fully concrete one, because we compare entities of like nature, and only then test the ratios of the two—that is, two pure numbers against each other—to find that they are identical. To compare a spatial and a temporal magnitude, as is done by the formula in its second form, requires already a certain degree of abstraction. Still, it is all spectator's work, and for the spectator time is conceivable and measurable only as a rate of spatial displacement. Hence the constant number *c,* by representing the ratio between the spatial extension of the realm inside a planet's orbit and the time needed by it to perform one round on this orbit—a ratio which is the same for all planets—represents a definite structural element of our cosmic system.

By this last operation our equation has now achieved a form which requires only one more transformation to bring it into line with Newton's formula.

Instead of writing: $\frac{r^3}{t^2} = c$

we write: $\frac{r}{t^2} = c\,\frac{1}{r^2}$

All that now remains to be done amounts to an amplification of this equation by the factor $4\pi^2 m$, and a gathering of the constant product $4\pi^2 c$ under a new symbol, for which we choose the letter *f.* In this way we arrive at: $4\pi^2 m\,\frac{r}{t^2} = 4\pi^2 c\,\frac{m}{r^2}$

and finally: $P = \ldots = f\,\frac{m}{r^2}$

which is the expression of the gravitational pull believed to be exerted by the sun on the various planetary bodies.

Nothing can be said against this procedure from the point of view of mathematical logic. For the latter the equation $\frac{r}{t^2} = c\,\frac{1}{r^2}$ is still an expression of Kepler's observation. Not so for a logic which tries to keep in touch with concrete reality. For what meaning, relevant to the phenomenal universe as it manifests in space and time to physical perception, is there in stating—as the equation in this form does—

that: the ratio between a planet's distance from the sun and the square of its period is always proportional to the reciprocal value of the area lying inside its orbit?

*

Once we have rid ourselves of the false conception that Kepler's law implies Newton's interpretation of the physical universe as a dynamic entity ruled by gravity, and gravity alone, we are free to ask what this law can tell us about the nature of the universe if in examining it we try to remain true to Kepler's own approach.

To behave in a Keplerian (and thus in a Goethean) fashion regarding a mathematical formula which expresses an observed fact of nature, does not mean that to submit such a formula to algebraic transformation is altogether impermissible. All we have to make sure of is that the transformation is required by the observed facts themselves : for instance, by the need for an even clearer manifestation of their ideal content. Such is indeed the case with the equation which embodies Kepler's third law. We said that in its original form this equation contains a concrete statement because it expresses comparisons between spatial extensions, on the one hand, and between temporal extensions, on the other. Now, in the form in which the spatial magnitudes occur, they express something which is directly conceivable. The third power of a spatial distance (r^3) represents the measure of a volume in three-dimensional space. The same cannot be said of the temporal magnitudes on the other side of the equation (t^2). For our conception of time forbids us to connect any concrete idea with 'squared time'. We are therefore called upon to find out what form we can give this side of the equation so as to express the time-factor in a manner which is in accord with our conception of time, that is, in linear form.[1] This form readily suggests itself if we consider that we have here to do with a ratio of squares. For such a ratio may be resolved into a ratio of two simple ratios.

In this way the equation— $$\frac{r_1^3}{r_2^3} = \frac{t_1^2}{t_2^2}$$

assumes the form— $$\frac{r_1^3}{r_2^3} = \frac{t_1/t_2}{t_2/t_1}$$

[1] The natural question why Kepler himself did not take this step, will be answered later on.

The right-hand side of the equation is now constituted by the double ratio of the linear values of the periods of two planets, and this is something with which we can connect a quite concrete idea.

To see this, let us choose the periods of two definite planets—say, Earth and Jupiter. For these the equation assumes the following form ('J' and 'E' indicating 'Jupiter' and 'Earth' respectively):

$$\frac{r_J^3}{r_E^3} = \frac{t_J/t_E}{t_E/t_J}$$

Let us now see what meaning we can attach to the two expressions $\frac{t_J}{t_E}$ and $\frac{t_E}{t_J}$.

During one rotation of Jupiter round the sun the earth circles 12 times round it. This we are wont to express by saying that Jupiter needs 12 earth-years for one rotation; in symbols:

$$\frac{t_J}{t_E} = \frac{12}{1}$$

To find the analogous expression for the reciprocal ratio:

$$\frac{t_E}{t_J} = \frac{1}{12}$$

we must obviously form the concept 'Jupiter-year', which covers one rotation of Jupiter, just as the concept 'earth-year' covers one rotation of the earth (always round the sun). Measured in this time-scale, the earth needs for one of her rotations $\frac{1}{12}$ of a Jupiter-year.

With the help of these concepts we are now able to express the double ratio of the planetary periods in the following simplified way. If we suppose the measuring of the two planetary periods to be carried out not by the same time-scale, but *each by the time-scale of the other,* the formula becomes:

$$\frac{r_J^3}{r_E^3} = \frac{t_J/t_E}{t_E/t_J} = \frac{\textit{period of Jupiter measured in Earth-years}}{\textit{period of Earth measured in Jupiter-years.}}$$

Interpreted in this manner, Kepler's third law discloses an intimate interrelatedness of each planet to all the others as co-members of the same cosmic whole. For the equation now tells us that the solar times of the various planets are regulated *in* such a way that for any two of them the ratio of these times, *measured in their mutual time-units*, is the same as the ratio of the spaces swept out by their (solar) orbits.

Further, by having the various times of its members thus tuned to one another, our cosmic system shows itself to be ordered on a principle which is essentially musical. To see this, we need only recall that the musical value of a given tone is determined by its relation to other tones, whether they sound together in a chord, or in succession as melody. A 'C' alone is musically undefined. It receives its character from its interval-relation to some other tone, say, 'G', together with which it forms a Fifth. As the lower tone of this intveral, 'C' bears a definite character; and so does 'G' as the upper tone.

Now we know that each interval represents a definite ratio between the periodicities of its two tones. In the case of the Fifth the ratio is 2 : 3 (in the natural scale). This means that the lower tone receives its character from being related to the upper tone by the ratio 2 : 3. Similarly, the upper tone receives its character from the ratio 3 : 2. The specific character of an interval arising out of the merging of its two tones, therefore, is determined by the ratio of their ratios. In the case of the Fifth this is 4 : 9. It is this ratio, therefore, which underlies our experience of a Fifth.

The cosmic factor corresponding to the periodicity of the single tone in music is the orbital period of the single planet. To the musical interval formed by two tones corresponds the double ratio of the periods of any two planets. Regarded thus, Kepler's law can be expressed as follows: *The spatial ordering of our planetary system is determined by the interval-relation in which the different planets stand to each other.*

By thus unlocking the ideal content hidden in Kepler's third law, we are at the same time enabled to do justice to the way in which he himself announced his discovery. In textbooks and encyclopaedias it is usually said that the discovery of the third law was the surprising result of Kepler's fantastic attempt to prove by external observation what was once taught in the school of Pythagoras, namely, that (in Wordsworth's language):

> *'By one pervading spirit*
> *Of tones and numbers all things are controlled.'*

Actually, Kepler's great work, *Harmonices Mundi*, in the last part of which he announces his third law, is entirely devoted to proving the truth of the Pythagorean doctrine that the universe is ordered according to the laws of music. This doctrine sprang from the gift of spiritual hearing still possessed by Pythagoras, by which he could perceive the harmonies of the spheres. It was the aim of his school to keep this faculty alive as long as possible, and with its aid to establish a communicable world-conception. The Pythagorean teaching became the foundation of all later cosmological thinking, right up to the age which was destined to bring to birth the spectator-relationship of man's consciousness with the world. Thus it was left to Copernicus to give mankind the first truly non-Pythagorean picture of the universe.

When Kepler declared himself in favour of the heliocentric aspect, as indicated by Copernicus, he acknowledged that the universe had grown dumb for man's inner ear. Yet, besides his strong impulse to meet the true needs of his time, there were inner voices telling him of secrets that were hidden behind the veil woven by man's physical perceptions. One of these secrets was the musical order of the world. Such knowledge, however, could not induce him to turn to older world-conceptions in his search for truth. He had no need of them, because there was yet another voice in him which told him that the spiritual order of the world must somehow manifest itself in the body of the world as it lay open to physical perception. Just as a musical instrument, if it is to be a perfect means of bringing forth music, must bear in its build the very laws of music, so must the body of the universe, as the instrument on which the harmonies of the spheres play their spiritual music, bear in its proportions a reflexion of these harmonies. Kepler was sure that investigation of the world's body, provided it was carried out by means of pure observation, must needs lead to a re-establishment of the ancient truth in a form appropriate to the modern mind. Thus Kepler, guided by an ancient spiritual conception of the world, could devote himself to confirming its truth by the most up-to-date methods of research. That his search was not in vain, our examination of the third law has shown.

One thing, however, remains surprising—that Kepler announced his discovery in the form in which it has henceforth engraved itself in the modern mind, while refraining from that analysis of it which we have applied to it here. Yet, in this respect also Kepler proves to have remained true to himself. There is, on the one hand, the form in which Kepler pronounced his discovery; there is, on the other, the context in which he made this pronouncement. We have already pointed out that the third law forms part of Kepler's comprehensive work, *Harmonices Mundi.* To the modern critic's understanding it appears there like an erratic block. For Kepler this was different. While publishing his discovery in precisely the form in which it is conceived by a mind bent on pure observation, he gave it a setting by which he left no doubt as to his own conception of its ideal content. And as a warning to the future reader not to overlook the message conveyed by this arrangement, he introduced the section of his book which contains the announcement of the law, with the mysterious words about himself: 'I have stolen the golden vessels of the Egyptians from which to furnish for my God a holy shrine far from Egypt's confines.'

CHAPTER XXI

Know Thyself

Our inquiries have led us to a picture of man as a sensible-super-sensible organism composed of three dynamic aggregates—physical, etheric, astral. As three rungs of a spiritual ladder they point to a fourth, which represents that particular power in man by which he distinguishes himself from all other beings in nature. For what makes man differ from all these is that he is not only fitted, as they are, with a once-for-all given mode of spiritual-physical existence peculiar to himself, but that he is endowed with the possibility of transforming his existence by dint of his free will—that indeed his manhood is based on this capacity for self-willed Becoming.

To this fourth principle in man we can give no better name than that which every human being can apply to himself alone and to no other, and which no other can apply to him. This is the name, *I*. In truth, we describe man in his entirety only if we ascribe to him, in addition to a physical, etheric and astral body, the possession of an I (Ego).

Naturally, our previous studies have afforded many opportunities for observing the nature and mode of activity of the I. Still, at the conclusion of these studies it is not redundant to form a concise picture of this part of man's being, with particular regard to how it works within the three other principles as its sheaths. For in modern psychology, not excluding the branch of it where efforts are made to penetrate into deeper regions of man's being, nothing is less well understood than the true nature of man's egoity.

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In order to recognize the peculiar function of the I in man, we must first be clear as to how he differs from the other kingdoms of nature, and how they differ from one another with respect to the mode of action of the physical, etheric and astral forces.

The beings of all the kingdoms of nature are endowed with an aggregate of physical forces in the form of a material body subject to gravity. The same cannot be said of the etheric forces. Only where life is present as an inherent principle—that is, in plant, animal and man—is ether at work in the form of an individual etheric organization, while the mineral is formed by the universal ether from outside. Where life prevails, we are met by the phenomena of birth and death. When a living organism comes to birth, an individual ether-body is formed out of the general etheric substance of the universe.[1] The death of such an organism consists in the separation of the etheric from the physical body and the dissolution of both in their respective mother-realms. So long as an organism is alive, its form is maintained by the ether-body present in it.

Our studies have shown that the plant is not devoid of the operation of astral forces. In the plant's life-cycle this comes to clearest expression in its florescence. But it is a working of the astral forces from outside, very much as the ether works on the mineral. As a symptom of this fact we may recall the dependence of the plant on the various outer astronomical rhythms.

It is only in animal and man that we find the astral forces working in the form of separate astral bodies. This accounts for their capacity for sensation and volition. Besides the alternation of birth and death, they experience the rhythm of sleeping and waking. Sleep occurs when the astral body leaves the physical and etheric bodies in order to expand into its planetary mother-sphere, whence it gathers new energy. During this time its action on the physical-etheric aggregate remaining upon earth is similar to that of the astral cosmos upon the plant.

Again, in the animal kingdom the ego-principle works as an external force in the form of various group-soul activities which control and regulate the life of the different animal species. It is in the group-ego of the species that we have to look for the source of the wisdom-filled instincts which we meet in the single animals.

Only in man does the ego-principle enter as an individual entity

[1] The word 'body' is here used in a sense no different from our earlier use of it, when in connexion with our study of combustion (Chapter XI) we referred to the 'warmth-body' as a characteristic of the higher animals and man. Such a warmth-body is nothing else but the warmth-ether part of an ether-body. To use the word body for aggregations of etheric or astral forces is legitimate if one considers the fact that the physical body also is really a purely dynamic entity, that is, a certain aggregate of forces more or less self-contained.

into the single physico-etheric-astral organism. Here, however, the succession of stages we have outlined comes to a conclusion. For with the appearance of the I as an individual principle, the preceding evolutionary process—or, more correctly, the involutionary process—begins to be reversed. In moving up from one kingdom to the next, we find always one more dynamic principle appearing in a state of separation from its mother-sphere; this continues to the point where the I, through uniting itself with a thus emancipated physico-etheric-astral organism, arrives at the stage of self-consciousness. Once this stage has been reached, however, it falls to the I to reverse the process of isolation, temporarily sanctioned by the cosmos for the sake of man.

That it is not in the nature of the I to leave its sheaths in the condition in which it finds them when entering them at the beginning of life, can be seen from the activities it performs in them during the first period after birth. Indeed, in man's early childhood we meet a number of events in which we can perceive something like ur-deeds of the I. They are the acquisition of the faculties of walking, speaking and thinking. What we shall here say about them has, in essentials, already been touched upon in earlier pages. Here, however, we are putting it forward in a new light.

Once again we find our attention directed to the threefold structure of man's physical organism. For the faculty of upright walking is a result of the I's activity in the limb-system of the body; the acquisition of speech takes place in the rhythmic system; and thinking is a faculty based on the nerve-system. Consequently, each of the three achievements comes to pass at a different level of consciousness—sleeping, dreaming, waking. All through the struggle of erecting the body against the pull of gravity, the child is entirely unaware of the activities of his own I. In the course of acquiring speech he gains a dim awareness, as though in dream, of his efforts. Some capacity of thinking has to unfold before the first glimmer of true self-consciousness is kindled. (Note that the word 'I' is the only one that is not added to the child's vocabulary by way of imitation. Otherwise he would, as some mentally inhibited children do, call all other people 'I' and himself 'you'.)

This picture of the three ur-deeds of the I can now be amplified in the following way. We know that the region of the bodily limbs is that in which physical, etheric and astral forces interpenetrate most deeply. Consequently, the I can here press forward most powerfully into the physical body and on into the dynamic sphere to which the body is subject. Here the I is active in a way that is 'magic' in the highest degree. Moreover, there is no other action for which the I receives so little stimulus from outside. For, in comparison, the activity that leads to the acquisition of speech is much more of the nature of a reaction to stimuli coming from outside—the sounds reaching the child from his environment. And it is also with the first words of the language that the first thoughts enter the child's mind. Nothing of the kind happens at the first stage. On the contrary: everything that confronts the I here is of the nature of an obstacle that is to be overcome.

There is no learning to speak without the hearing of uttered sounds. As these sounds approach the human being they set the astral body in movement, as we have seen. The movements of the astral body flow towards the larynx, where they are seized by the I; through their help the I imbues the larynx with the faculty of producing these sounds itself. Here, therefore, the I is active essentially within the astral body which has received its stimulus from outside. In order to understand what impels the I to such action, we must remember the role played by speech in human life: without speech there would be no community among human individuals on earth.

An illustration of what the I accomplishes as it enters upon the third stage is provided by the following episode, actually observed. Whilst all the members of a family were sitting at table taking their soup, the youngest member suddenly cried out: 'Daddy spoon . . . mummy spoon. . . .' (everyone in turn spoon) '. . . *all* spoon!' At this moment, from merely designating single objects by names learnt through imitation, the child's consciousness had awakened to connective thinking. That this achievement was a cause of inner satisfaction could be heard in the joyful crescendo with which these ejaculations were made.

We know that the presence of waking consciousness within the nerves-and-senses organism rests upon the fact that the connexion between physical body and etheric body is there the most external of all. But precisely because this is so, the etheric body is dominated very strongly by *the forces* to which the physical head owes its formation. This, too, is not fundamentally new to us. What can now be added is that, in consequence, the physical brain and the part of the etheric body belonging to it—the etheric brain—assume a function comparable with that of a mirror, the physical organ representing the reflecting mass and the etheric organ its metallic gloss. When, within the head, the etheric body reflects back the impressions received from the astral body, the I becomes aware of them in the form of mental images (the 'ideas' of the onlooker-philosopher). It is also by way of such reflexion that the I first grows aware of itself—but as nothing more than an image among images. Here, therefore, it is itself least active.

If, once again, we compare the three happenings of learning to walk, to speak and to think, we find ourselves faced with the remarkable fact that the progressive lighting up of consciousness from one stage to the next, goes hand in hand with a retrogression in the activity of the I itself. At the first stage, where the I knows least of itself, it is alive in the most direct sense out of its own being; at the second stage, where it is in the dreaming state, it receives the impetus of action through the astral body; at the third stage, where the I wakens to clear self-consciousness, it assumes merely the role of onlooker at the pictures moving within the etheric body.

Compare with this the paths to higher faculties of knowledge, Imagination and Inspiration, as we learnt to know them in our previous studies. The comparison shows that exactly the same forces come into play at the beginning of life, when the I endeavours to descend from its pre-earthly, cosmic environment to its earthly existence, as have to be made use of for the ascending of the I from earthly to cosmic consciousness. Only, as is natural, the sequence of steps is reversed. For on the upward way the first deed of the I is that which leads to a wakening in the etheric world: it is a learning to set in motion the etheric forces in the region of the head in such a way that the usual isolation of this part of the etheric body is overcome. Regarded thus, the activity of the I at this stage reveals a striking similarity to the activity applied in the earliest period of childhood at the opposite pole of the organism. To be capable of imaginative sight actually means to be able to move about in etheric space by means of the etheric limbs of the eyes just as one moves about in physical space by means of the physical limbs.

Similarly, the acquisition of Inspiration is a resuming on a higher level of the activity exercised by the I with the help of the astral body when learning to speak. And here, too, the functions are reversed. For while the child is stimulated by the spoken sounds he hears to bring his own organ of speech into corresponding movements, and so gradually learns to produce speech, the acquisition of Inspiration, as we have seen, depends on learning to bring the supersensible forces of the speech-organ into movement in such a way that these forces become the organ for hearing the supersensible language of the universe.

Our knowledge of the threefold structure of man's organism leads us to seek, besides the stages of Imagination and Inspiration, a third stage which is as much germinally present in the body's region of movement, as the two others are in the regions of thought and speech. After what we have learnt in regard to these three, we may assume that the path leading to this third stage consists in producing a condition of wide-awake, tranquil contemplation in the very region where the I is wont to unfold its highest degree of initiative on the lowest level of consciousness.

In an elementary manner this attitude of soul was practised by us when, in our earlier studies, we endeavoured to become inner observers of the activity of our own limbs, with the aim of discovering the origin of our concept of mass. It was in this way that a line of observation opened up to us which led to the recognition of the physical substances of the earth as congealed spiritual functions or, we may say, congealed utterances of cosmic will.

Cosmic Will, however, does not work into our existence only in such a way that, in the form of old and therefore rigid Will, it puts up resistance against the young will-power of the I, so that in overcoming this resistance the I may waken to self-activity. Cosmic Will is also present in us in an active form. We point here to the penetration by the higher powers of the universe into the forming of the destiny of humanity and of individual man. And here Rudolf Steiner has shown that to a man who succeeds in becoming a completely objective observer of his own existence while actively functioning within it (as in an elementary way we endeavoured to become observers of our limb actions while engaged in performing them) the world begins to reveal itself as an arena of the activities of divine-spiritual Beings, whose reality and acts he is now able to apprehend through inner awareness. Herewith a third stage of man's faculty of cognition is added to the stages of Imagination and Inspiration. When Rudolf Steiner chose for it the word Intuition he applied this word, also, in its truest meaning.

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While through Imagination man comes to know of his ether-body as part of his make-up, and correspondingly through Inspiration of his astral body, and thereby recognizes himself as participant in the supersensible forces of the universe, it is through Intuition that he grows into full awareness of his I as a spirit-being among spirit-beings—

God-begotten, God-companioned,
for ever God-ward striving.

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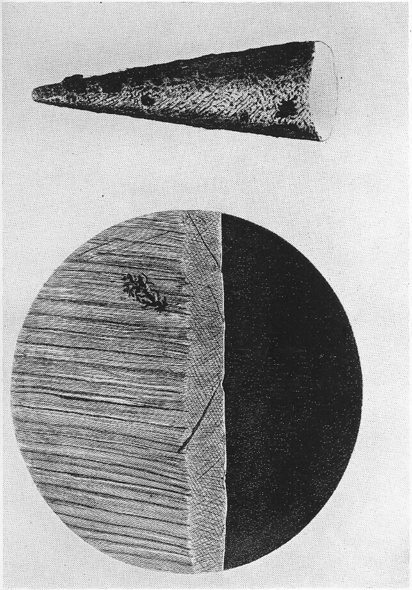
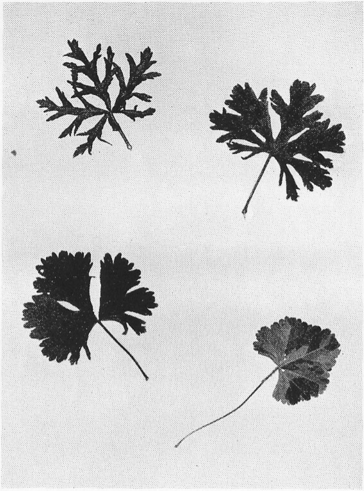
(See also the summary on pp. 7-11)



See page 40

Robert Hooke's 'proof' of the non-reality of human concepts: A needle ('point') and the edge of a knife ('line'), seen through the microscope

Plate II



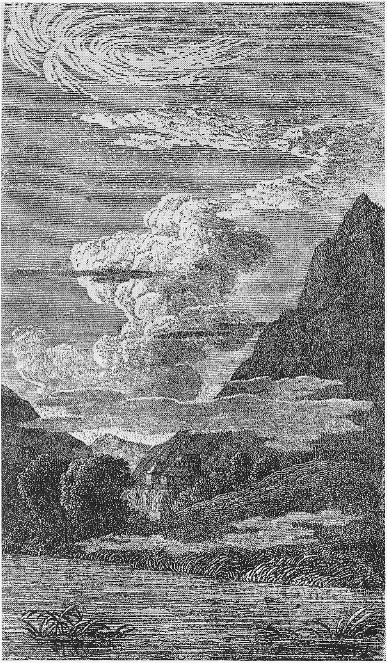
See page 70

Leaf-metamorphosis showing a step-wise appearing of the basic form of the leaf. After the achievement of the top leaf the plant 'leaps' into the calyx stage. (Compare with Plate III, facing page 76)

See page 70

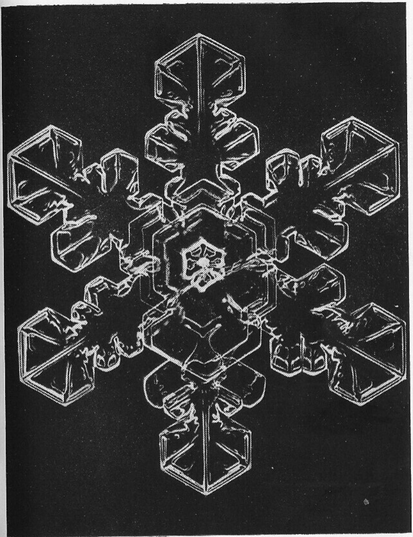
Leaf-metamorphosis showing a gradual withdrawal of the basic form after its full appearance in the first leaf. An instance of the plant's 'softly stealing into the calyx stage'.

Plate IV



See page 123

Goethe's sketch of a cloud-formation showing the entire scale of Howard's types in their order of succession, made after an actual observation during a journey in Bohemia



From O. Procknow, *Erdball und Weltall* *See page 203*

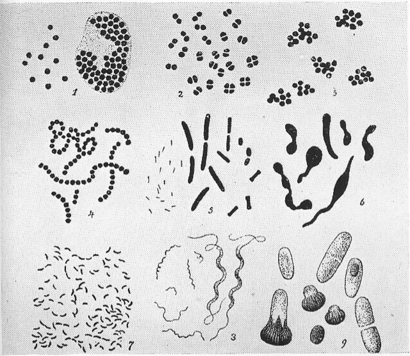
A single Snow-Crystal

Plate VI

See page 204

A cluster of calcite crystals showing the independence of crystal growth from the gradient of the gravitational field of the earth. (Note: the original position of the base of the cluster need not have been the one shown here)

Plate VII

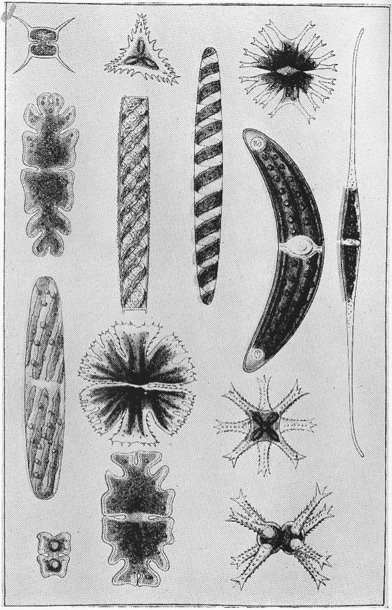


After Schottelius

See page 319

Various species of bacteria—illustrating the absence of form in unicellular organisms that grow in the dark

Plate VIII



After Migula and Haeckel

See page 319

Various species of fresh-water algae—illustrating the formative power of light displayed in chlorophyll-bearing unicellular organisms. (The green parts appear dark in this reproduction)

PLATE A

(i)

The coupling of levity and gravity at the two poles of the electrical polarity, revealed by the vacuum-tube and by their distribution in the human organism

(ii)

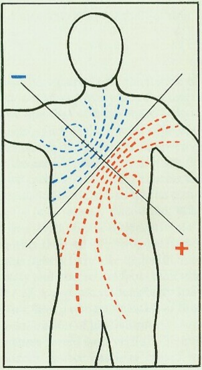
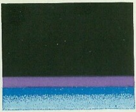


PLATE B

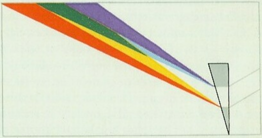
Reproduction of the spectrum in its primal form

(i)



as two independent border-phenomena

(ii)



Goethe's representation of the two polarically opposite spectral phenomena (simplified) showing the emergence of <u>green</u> and <u>peach blossom</u> respectively, where the two interior colours merge

(iii)

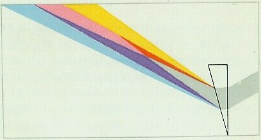
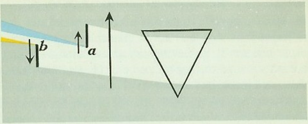


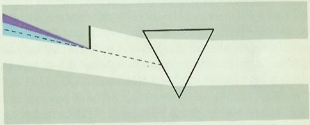
PLATE C

(i)



Emergence of the spectral colours as a result of the occurrence of a leap in the field conditions of a light-realm with a transverse field-gradient

(ii)



Position of the two colour-bearing areas in relation to the direction of the undisturbed light-realm. Note in both instances the difference of angle on the side of the light-realm and on the opposite side

(iii)