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The Chemical Basis of Medical Climatology

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FOREWORD

Our Living Chemistry Series was conceived by Editor and Publisher to advance the newer knowledge of chemical medicine in the cause of clinical practice. The interdependence of chemistry and medicine is so great that physicians are turning to chemistry, and chemists to medicine in order to understand the underlying basis of life processes in health and disease. Once chemical truths, proofs and convictions become sound foundations for clinical phenomena, key hybrid investigators clarify the bewildering panorama of biochemical progress for application in everyday practice, stimulation of experimental research and extension of postgraduate instruction. Each of our monographs thus unravels the chemical mechanisms and clinical management of many diseases that have remained relatively static in the minds of medical men for three thousand years. Our new Series is charged with the *nisus élan* of chemical wisdom, supreme in choice of international authors, optimal in standards of chemical scholarship, provocative in imagination for experimental research, comprehensive in discussions of scientific medicine, and authoritative in chemical perceptives of human disorders.

Dr. Piccardi of Florence, Italy, presents the physiochemical equilibria involved in the incessant interactions between macrocosm and microcosm, outer world and inner nature, climate and life, environment and man in health and disease. We are nothing but what we derive from the air we breathe, the sun we absorb, the water we drink, the food we consume, the climate we inhabit, the weather we withstand, the existence we foster, the hygiene we practice, the life we lead. External spacial and solar phenomena influence all physical and chemical processes of life, particularly the inanimate colloidal substrata of living organisms ever attaining thermodynamic equilibria. The author brings to light the newer knowledge of meteorological influences shown by Hippocrates 2000 years ago. Climate means slope, reflecting the early

PREFACE

When Dr. Kugelmass proposed that I write a monograph on the chemical basis of medical climatology, I asked myself about my competence to handle such a topic. Climatology is usually held to be outside of the field of traditional physical chemistry. On the other hand, my chemical-physical studies regarding some common inorganic processes introduced me into a very new field which, even if it was not climatology itself, it still had some points of contact with that science: the field of relationships between spacial and chemical-physical phenomena in which I worked for twenty-one years, the last ten of which were fruitful. With my possession of the relationships between spacial and chemical-physical phenomena, I thought that it would not be unreasonable to attempt this enterprise inasmuch as I had never before treated traditional climatology with any depth.

The monograph which I present mirrors my own situation. Some arguments are treated diffusely, or very minutely; and others are recapitulated briefly; still others skirted or not touched upon at all. Therefore the treatment is in part exhaustive, in part schematic, and in part elusive. But from the chemical point of view it is complete enough *for what we know today,* arranged according to a criterion different from the traditional one and brought up to date by a literature selected upon the basis of the non-traditional criterion adopted and therefore limited. It was not possible for me to act differently if I wanted to remain within the limits of the length of the monograph and within the limits of the time allotted to me and at the same time demonstrate something new.

I have based the chemical basis of medical climatology upon the structure of water, solutions and colloids, that is upon modern structural chemistry and the physical chemistry of natural phenomena. It was exactly to demonstrate this structural aspect that I overcame the doubts I had regarding my competence in traditional climatology. Notwithstanding its defects, quite visible

Greek correlation of the earth's declivity with weather changes. Actually, climate connotes long-term means of conditions in outer space; and weather, short-cycle changes in the atmosphere, dominant in the dynamic status of human existence. It is not constancy but deviation in climatic cycles that contribute to organic evolution, for an absolutely steady sun and earthy-crust for the past 400 million years might have left us living as Silurian ooze-browsers deprived of climatic stimulation. Our energetic emergence on this Earth still leaves us with soft answers for hard questions on medical climatology, but the rapid pace of scientific progress will unravel the solutions. Each chapter in this monograph is solid, sometimes solemn, and at all times authoritative, for Dr. Piccardi heeded Francis Bacon's dictum: *Si quis hujusmodi rebus ut nimium exilibus et minutis vacare nolit, imperium in naturam nec obtinere nec regere poterit.*

I. NEWTON KUGELMASS, M.D., Ph.D., Sc.D., *Editor* and inevitable, I hope that this monograph can be of some use to its readers, for it reveals the experience of a chemist, away from his traditional field, who has wandered into the field of natural phenomena trying to bridge the gap between the physics of space and biology. A gap of this kind could not be spanned except by physical chemistry.

Since the facts upon which I base my exposition came in large part from my experimental research or that of my collaborators, I must recognize and thank all of those who worked towards the satisfactory completion of the research. In Florence, the principal center of the experiments, it was necessary for them to be conducted with absolute regularity every day, and on holidays too, and fixed hours for a unlimited period. My assistants, teachers, students and holders of CNR fellowships took this work upon themselves for ten consecutive years. A multitude of young people worked on the chemical tests with admirable devotion. It would be impossible for me to name them all or to thank them enough.

I must express my gratitude to all the foreign experimenters: Mrs. Capel Boute, chef des travaux at the Université libre of Brussels (Institute of Electrochemistry and Metallurgy, directed by Prof. Decroly), who for eight years has studied the chemical tests under great difficulty, and M. Gittens, the technician who aided her faithfully in her hard task; Engineer Doat, director of the Wiental-Wasserleitung who conducted, at the expense of his own agency, chemical test in their experimental centers in Untertullnerbach (Nieder Oesterreich) and his technician Mr. Wachter who conducted impeccably the experiments assigned him for five consecutive years; Dr. Miss Mayer of the Astronomical Institute of the University of Tuebingen (directed by Prof. Siedentopf); Mr. Berger of the Auroral Obervatory of Tromsoe (directed by Prof. Toensberg).

My thanks go to Prof. Bossolasco, director of the Geophysical Institute of the University of Genoa; Prof. Morelli, director of the Geophysical Observatory of Trieste, and his assistant Dr. Mosetti; Prof. Picotti, director of the Istituto Talassografico of Trieste. Particular appreciation is extended to all those who promoted or organized studies on the chemical tests during the IGY and IGC in the southern hemisphere: M. Van de Elst, director of the Meteorological Service of the Congo and Ruanda Urundi; M. Viaut, chief of the WMO; M. Roulleau, chief of the l'Etablissement d'Etudes Météorogiques, Paris; M. Bost, chief of the Scientific Bureau of TAAF (Terres Australes et Antarctiques françaises), and the Belgian Committee of Antartic Research. A small part of this work was carried out with the contribution of the Consiglio Nazionale delle Ricerche Italiano.

I must also gratefully thank all the collaborators whom I have never known and who perhaps I shall never know personally. I allude to all those technicians and assistants who, during the IGY and IGC, carried out the research in Africa and in the Indian Ocean. How much we owe to these unknown workers! I remember them with gratitude.

Florence

G. P.

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Chapter I

INTRODUCTION

PREMISE

SOMEDAY IT MAY BE possible to speak with precision and depth of the chemical basis of medical climatology, but this is certainly not possible today. Indeed, medical climatology, like climatology, is a natural science of a general character, if we do not confine it to the restricted field of traditional meteorology. Since it is a natural science of a general character, there can be no progress in climatology if there is no progress in those branches of knowledge which lie on the boundaries between climatology and other sciences – astrophysics, geophysics, meteorology, physical chemistry, biophysics, biology—and above all, if these fields have no mutual contact and penetration.

Nonetheless, it is worthwhile to attempt the laying of some kind of foundation if for no other reason than to have an idea of the type of construction we may erect upon it. The field of bioclimatology holds many surprises for whoever should choose to venture there.

I am not able to present a complete picture of the studies carried out to date in the field of bioclimatology, nor analyse the criteria upon which they are based. Even if I were competent to do so, it would be exceedingly lengthy and would not serve our immediate purposes. I will therefore confine myself to presenting certain examples to characterise the situation and to serve as a connecting bridge leading, in a logical and rational manner, to the part of the work in which I am at home: chemistry.

Nor will I cite studies or authorities in the field of bioclimatology. We have a great international organization, the International Society of Bioclimatology, with its center at Oegstgeest (Leiden, Holland). In addition, the American Institute of Medical Climatology has recently been founded in the United States.

Others, much closer to the subject than I, could speak more diffusely on events taking place in bioclimatological studies.

I view the resurgence of bioclimatological studies in the United States, due to the efforts of the American Institute of Medical Climatology, with great pleasure. One of the pioneers in this field was actually an American, Petersen, who left us with a fundamental work, *The Patient and the Weather.* But after his death, these studies slackened off in America while they flourished in Europe due to the works of De Rudder, Duell and others; too, there were created here numerous institutes within the framework of the great meteorological organizations: Deutscher Wetterdienst, Zentralanstalt fuer Meteorologie und Geodynamik (Hohe Warte Wien), Station Centrale Suisse de Meteorologie, etc.

MEDICAL CLIMATOLOGY AND TRADITIONAL CLIMATIC FACTORS

If, when we refer to medical climatology, we mean only the study of the forces exerted by traditional climatic factors upon the human body, we shall not be able to say any more than physical chemistry and physiology have been telling us for some time.

The traditional climatic factors are almost exclusively meteorological factors: temperature, pressure, humidity, wind, air masses, fronts, precipitations, the state of the weather and the meteorological situation and its evolution.

Those traditional meteorological factors which are measurable and therefore capable of being quantitatively evaluated and thus reduceable to numbers, are very few. Among these are temperature, pressure, humidity, etc.

No more than a summary description of the others is possible and their characteristics cannot be numerically determined; the evaluation of these factors is only qualitative.

Temperature, pressure and humidity are measured, one might say, wherever the relevant data may be obtained without difficulty. For air masses, or the meteorological situation, etc., one can always turn to meteorological bulletins.

MEDICAL CLIMATOLOGY AND GEOPHYSICAL FACTORS

In addition to purely meteorological factors we should also consider geophysical, electrical, electromagnetic, magnetic and gravitational factors:

a) Atmospherical potential, spacial electrical charge, electrical conductivity of the air, vertical currents, radio-activity of the air;

b) Electromagnetic waves or general disturbances of the electro magnetic field, terrestrial magnetism;

c) Radiation of various types;

d) Gravitational variations, and the effects of tides.

The electrical geophysical factors are only measured in a few scattered stations, mainly in the northern hemisphere of the earth, and these measurements are not always taken with continuity. Disturbances in the electromagnetic field are also measured in few stations and these generally record wave scales which differ from station to station. The data gathered are therefore of no current use to biologists. In fact, a biologist cannot use data in his bioclimatological studies which have been obtained 500 or 1,000 Km away, since electrical and electromagnetic disturbances differ at any given moment, depending upon the locality. Except in fortunate circumstances, the biologist wishing to examine the more important geophysical factors must install a complete range of equipment in his observatory.

The impossibility of gathering adequate information regarding these highly important factors renders a bioclimatologist's situation quite unsatisfactory, and it does not favor any advancement in our knowledge of these factors. We will see later how important certain of these geophysical factors are with respect to the studies in question.

EXTERNAL FACTORS AFFECTING BIOCLIMATOLOGY-BIOTROPIC FACTORS

The correlation of temperature, pressure, humidity and other factors which are measurable and reducible to numbers, with physiochemical and biological phenomena, although valuable information from a general standpoint, does not lead us to any fact which has not been noted previously in either physical chemistry or physiology, as I pointed out earlier. Furthermore, these correlations would not provide us with a complete solution to the effects of climatic variations. A simple example will illustrate this affirmation:

There are meteoropathic persons who, for example, display grave disturbances at the approach of a cyclonic zone, or even merely a low pressure zone. At such times, the person will feel the effects of the zone, even remaining indoors at a constant temperature. Therefore temperature is not an important factor. On the other hand, if the meteorological disturbance is not approaching, the person remains unaffected and can go upon a hill or a skyscraper with no harm accruing. Yet going to the top of one of the tall New York skyscrapers results in a pressure drop of around 30 mm of mercury. Nothing less than a common cyclone is able to provoke a similar pressure drop. But since there is no cyclone, the person remains unaffected. Therefore pressure is not an important factor. The same can be said of humidity.

Temperature, pressure and humidity thus have nothing to do with meteoropathic disturbances.

Is it worthwhile to continue considering these traditional physical factors in connection with modern bioclimatology? Probably not, except in a subordinate and auxiliary rôle, as long as variations in these factors are not indications of other concomitant phenomena which are of importance from a bioclimatological point of view. The traditional factors are not sufficient in themselves to define a biotropic situation and, considered alone, are of very little interest.

However other general factors are at work in the field of meteorology, such as the weather situation, the evolution of the meteorological situation, fronts and so on. It is not my place to speak in detail of these, but, as I see it, to identify, define and classify the factors in question in a clear manner that would be useful in biology and medicine is a very difficult job.

At some Institutes, in order to establish relationships between the meteorological situation and biological and medical occurrences, they have attempted to distinguish meteorological situations in a rough way, without dealing in minute details. They concerned themselves with descriptions which were largely qualitative. For example:

Dr. Ungeheuer had distinguished the meteorological situation in six phases:

Weather phase 1. Half fine-weather.
Weather phase 2. Improvement in fine weather.
Weather phase 3. Full fine weather reinforced eventually from *foehn.*
Weather phase 4. Beginning of clouding (break-up of weather).
Weather phase 5. Sky completely overcast (complete break-up of weather).
Weather phase 6. Beginning of improvement.

He then distinguished nine points in each phase:

1. General impression and tendency to evolve toward other phase
2. Clouding
3. Visibility, transparency of the air
4. Temperature and humidity
5. Atmospheric pressure
6. Wind at ground level and at altitude
7. Distribution of the temperature at altitude, inversion of the temperature at ground level
8. Electromagnetic wave disturbances in the field
9. Meteorological peculiarities, local clouds in the morning, dew, etc.

This classification in six phases with a description of the nine points was greatly appreciated and served as a basis for various studies of a bioclimatological nature (Muecher and others). This naturalistic and almost picturesque description of weather phases in fact permitted the correlation of the frequency of the phases with the frequency of certain biological phenomena. Thus we now know that weather phases are not without effect (indifferent) with respect to living organisms, at least in a general sense. But, of the mass of phenomena that constitutes a phase, what actually reacts upon the organisms?

In referring to the measurable factors—temperature pressure, etc.—we are reverting to the study of factors that have nothing to do with the phenomena which we should wish to study. Dr. Reiter, Director of the Bioklimatische Forschungsstelle of Munich, Bavaria, adopted a different method:

Instead of more or less minutely describing the meteorological situation, he concentrated on particular meteorological elements, taken as *meteorological indicators.* These indicators were chosen at random, with no pretense of doing anything absolute, but merely something useful and practical. Reiter holds that there must be a single causal dependence, valid under any circumstances, between the weather and the reactions of living organisms. It means distinguishing, on the basis of the indicators, the *biotropic situation* of the weather from the *non-biotropic situation.* This method makes it possible to know whether on a given day there were external factors at work capable of producing biological reactions. The principal indicators adopted by Reiter were:

a) *Atmospherics* (Infralangwellenstoerungen der Atmosphaere; VLF, *very low frequencies);* atmospheric disturbances on very long wave lengths—or *infra waves.*

b) *Any peculiarity in the atmospheric electrical field.*

Temperature, pressure and the other traditional meteorological factors fade into insignificance when compared with the indicators of biotropic situations. Even the other great factors, fronts, air masses, etc., seem to demonstrate the existence of a biotropic meteorological situation with less sureness and precision than do atmospherics and the static electrical field.

The effective and direct biotropic reaction of atmospherics was discussed at great length; however, later, after a wealth of observational material had been examined, highly satisfactory correlations between electromagnetic disturbances and certain biological and psychic functions were established (Curry, Duell, Linke, Moerikofer, Reiter, Schulze, Zink and others).

The electromagnetic field thus was established as a direct cause, as the determining factor in biological phenomena.

It is not within the scope of my work to deal with these problems. The examples which have been set forth clearly show how scholars in the field of bioclimatology are abandoning the traditional, typical climatic meteorological elements—those whose existence is physically discernable in a direct manner, such as temperature and humidity—in order to adopt other elements, whose existence men cannot discern physically by the living organism, such as electromagnetic waves.

This is as to say that the climate will be modernly defined or, better, that the definition of climate will be enriched by new geophysical and astrophysical elemente.

THE CHEMICAL BASIS OF MEDICAL BIOCLIMATOLOGY IN THE PAST

If the basis that we wish to attribute to climatology is to be chemical, then before all else we should know what are the relationships between climatic and chemical phenomena. Once this is known, we should be able to transfer these relationships onto a biochemical plane and later onto a biological and medical plane.

Before going further I must point out that studies of this nature have only been carried out sporadically and have never been received with great favour.

Experimental chemists, analytical chemists and all those having to do with chemical operations, especially colloidal or any other type in a heterogeneous system, know that an indefinable *something* sometimes reacts on their operations. Even workers in certain branches of industry are aware of this. But these things are not discussed. Yet we are not speaking of negligible facts; for example, in some industries serious disruptions take place with frequency in correspondence with certain meteorological situations: in silk spinning, the making of some dyes, flotation and, in certain seasons, the application of magnesium cements. But these disruptions, which are truly inexplicable, are attributed either to chance errors (which is the handiest way of dismissing them) or to quirks in the system of handling, which lead to energetic measures to restore normal operations by modifying work conditions.

Colloidal arsenic trisulphide is widely considered as being sensitive to weather (*wetterempfindlich,* as the Germans say). E. Findeisen felt she had demonstrated the sensitivity of arsenic trisulphide using measurements of electrical conductivity, but Reiter sharply criticised this work. On the other hand, Wilke and Mueller showed that the sulphide in question is sensitive to an electromagnetic field. Recently, Neuwirth resumed the study of the influence of atmospheric phenomena on the *aging* of colloidal arsenic trisulphide by photometric means. The observations were conducted every day for two consecutive years and the author found that the discontinuities in the aging process were related to various atmospheric phenomena, among which were variations in the altitude of the stratum at 500 mb and cold fronts.

Calcium phosphate, precipitating from appropriate solutions, is also sensitive to external spacial factors and changes in appearance according to external conditions. It was Bortels who in 1951 first drew attention to this fact. Calcium phosphate from those particular solutions, in fact, precipitates in filaments and in flakes ~~in filaments~~ when the meteorological situation is anti-cyclonic, and in flakes when it is cyclonic, says Bortels. The manner of precipitation is influenced by a metal screen, for instance, a thin sheet of aluminum. It is even possible to observe the two types of precipitation in the same solution by covering the half of the vessel containing the solution with an aluminum sheet. From this it would seem that the modification in the appearance of the precipitate is due to disturbances in the electromagnetic field and that the appearance of filaments or flakes in correspondence with cyclonic or anti-cyclonic zones is still to be related with the electromagnetic phenomena which accompany the zones themselves.

The studies of the precipitation of calcium phosphate, begun in 1949, were carried out regularly each day at three fixed times, except for brief interruptions, for several years. Under the aluminum screen the precipitation occurs more often in the form of filaments than in the open. The explanation put forth by Bortels regarding this and other phenomena in which he referred to particular radiations or agents of low or high pressure (T-Agens and H-Agens), was strangely criticised; however, the facts which he presented are, in spite of the degree of uncertainty and the doubts to which they can give rise, the typical facts which are encountered by all those who wish to study these phenomena directly, relating the results of a given experiment to meteorological, geophysical or solar data. For this reason, Bortels' work is no less valid than that of other authors.

Bortels also studies a phenomenon of extreme importance from a general point of view: the freezing of over-cooled water. This phenomenon could not be more variable, and Bortels sought to link the frequency with which small samples of overcooled water freeze to the course of the weather.

An accurate statistical and critical analysis by Berg of the data presented by Bortels with respect to terrestrial magnetism and solar activity, came to the conclusion that the numerical data studied "barely succeeded in constituting a strong argument in favor of the 'pilotage' of the precipitation of calcium phosphate by terrestrial magnetism and solar activity." The results of Berg's highly acute criticism were, therefore, not negative, but sufficiently positive.

Bortels also studied the separation of water from agar gel, so-called *sineresis,* as related to external phenomena.

Bortels is to be highly credited for having indicated two typical phenomena as being sensitive to external factors: the precipitation of an inorganic compound and the transformation (passaggio di stato) of a pure substance. The pure substance is water, the home of the vital phenomena.

Neuwirth & Hummel studied the influence of meteorological factors on the dissipating power of colloidal solutions of Polyvinylpyrrolidon:

"Experiments on optical diffusion with a solution of Polyvinylpyrrolidon (Kolloidon k 30) have been carried out and have revealed exogen influence on the intensity of diffusion. The observed significant extremes were correlated with meteorological phenomena and shown to be in connection with fronts and horizontal shearing numbers. It followed also relation to the jet stream as to its position and time of arrival at the observation place. It seemed possible to use colloides as indicators for biometeorological or even for synoptical connection. The observed influence of weather on colloidal solutions may be explained by terrestrial or extraterrestrial electromagnetic radiation, more or less modified by weather influences. It could not yet be determined at which place in the wave spectrum the colloidal meteorological rays are situated, nor was it possible to find anything definite concerning the character and kind influencing the colloidal solution."

Caroli & Pichotka studied the influence of the weather on the results of titration of sodium thiosulphate. The condition of the experiments shows that the cause of the variation of titration results may consist in changes of electromagnetic undulatory radiation of high frequency or in radioactive radiation.

To the purely chemical studies listed above we must add a study that provided one of the most spectacular examples of spacial influence on a chemical-biological system: Takata's report, one which is well known in medical circles.

Since 1941, Takata & Murasugi have established that the flaking numbers of the blood serum of a healthy man (Takata's numbers) remain very constant over a period of time. But in certain periods these numbers can rise to very high values, suddenly or even tumultuously. The disturbed periods for Takata's reaction were those between the years 1938 and 1943 and between 1948 and 1950. These were not local phenomena; rather they were worldwide. Takata's reaction was in current use in clinical practice all over the world and, because of its wide adoption, it must be considered a wonderful test. Simultaneous disturbances and parallel behavior patterns were observed in localities as much as 1500 Km apart.

The disturbances in Takata's reaction were related not to meteorological phenomena, but to solar phenomena. The passage of a group of spots along the central meridian of the sun seemed to disturb Takata's reaction. But the phenomenology observed in great profusion in the years 1938-1943 and in lesser profusion in the years 1948-1950 was never again evidenced. The disturbed periods indicated by Takata's reaction correspond to the diminishing (or to part of it) of the two solar cycles which preceded the present one, whose maximums of activity were recorded in 1937 with an average of 114 spots, and in 1947 with an average of 150 spots daily. It would be extremely interesting to know what is taking place today, now that we once more find ourselves in the diminishing phase of the present solar cycle, which reached its maximum of activity in 1957 with an average of 190 spots, the highest ever registered!

The behaviour of Takata's reaction awoke great interest and many scholars studied it with a view to possible relationships with solar or geophysical phenomena. But in spite of all the studies that were carried out, it was not possible to clarify completely the situation. The problem remained open, but there was no doubt that the disturbances indicated by Takata's reaction are of spacial and, above all, solar origin.

These studies, in which a connection was sought between the the chemical and biochemical phenomena which take place in surrounding space, are extremely noteworthy. As far as I know, literature on the subject does not offer a great deal more. As one can see, the number of studies carried out has been scanty, even though some were very painstaking. This is not, unfortunately, a subject which interests chemists at this moment. The greater part of the studies outlined above are the work of persons outside the chemical field.

I do not wish to enter into an involved discussion of the results obtained by the various authors. It must be admitted that these results are acceptable as being more indicative than definitive. In fact, the simple and direct correlation of chemical or biological-chemical events with spacial events provides a glimpse of an appreciable interdependence between these two orders of phenomenon, without introducing new criteria or methods.

A MODERN CHEMICAL BASIS

However, we are still not coming to grips with the chemical problem. What external forces are at work, and how do they react upon a chemical system? What is the sensitive part of a chemical system?

These are the questions upon which I personally have concentrated during the past ten years.

In closing this introduction, I must of necessity mention the research which I began in 1935 and which has continued up to the present, on a particular phenomenon known as the "activation" of water. The term activation is exceedingly ill-chosen, but by now it has established itself in usage.

By means of particular physical procedures, it is possible to modify water physically without modifying its chemical composition or the traditional physical conditions in which it is found:

temperature, pressure, illumination etc. These procedures, all of them empirical, have been the subject of many industrial patents. These patents have been employed in the physical descaling of boilers, water reservoirs etc. The instruments for the activation of water do not give constant results over a period of time and often display anomalous behaviours.

In order to study the phenomenon of "activation," I conceived a differential method by means of which I was to compare the behaviour of one sample of water in an activated and in a non-activated state. I noted that the physically modified water did not always produce the same effects; the effects were of one sign during a given period of time, and of contrary sign during another period, without anything apparently having changed. This was the point upon which I concentrated, and in 1938 I became aware that *these changes were related to external phenomena,* not at that time clearly identified. In 1939, I announced that I had been correct in assuming that certain chemical phenomena were subject to the actions of spacial phenomena, and I invited chemists, biologists, meteorologists, to collaborate with me in this new research. But the proximity of the war interrupted my work and I was not able to resume it until 1950 at the Institute of Physical-Chemistry of Florence University.

Many chemical systems were studied during this period, all of them *heterogeneous systems in evolution:* precipitation of oxichloride of bismuth by means of hydrolisis; precipitation of colloidal arsenic trisulphite; precipitation of silver halide, of calcium sulphate, formation of colloidal gold by means of reduction of chloride etc., and also the simple deposition of inorganic compounds in water: graphite, mercury oxide etc.

During this long series of studies, which was highly promising but not very conclusive, I was able to ascertain at one point—in 1936—that a metal screen was sometimes capable of modifying the direction of activation: for example there was a passage from activation which accelerated precipitation to activation which retarded it.

This fact confirmed that water is a sensitive substance to external actions and that it is enough to modify these conditions with a metallic screen to note an effect. A thin metallic screen changes the electric field and the electromagnetic fields at least in part. But even these were only indications.

The work carried out from 1935 to 1940 is to be considered as a broad exploration in search of bridges to connect an extremely vast complex and general network of phenomena, so general that the chemical quality of the material involved *was not so important as the aggregate state of the material* and evolution of this aggregate state in the course of time. More than being merely chemical, the research was physical-chemical. The externally-acting phenomena could be studied using any material providing that material was in a suitable aggregate state which had not reached a state of equilibrium and was still in evolution. The basis of these phenomena seems structural.

Basically, these old studies still partially possessed characteristics of the research carried out later by other authors. *Heterogeneous systems which are not in equilibrium, especially colloidal systems, are the indicators of an external situation.*

The studies of "activation" showed that water is by itself an easily-influenced body. In fact, physical processes modify it in a semi-permanent manner, in the sense that the modification persists for a very long time. This permits the storage of industrial water after treatment and thus the utilization of instruments which are compared to the quantity of water treated.

Water is, therefore, a sensitive and modifiable body. I have shown that modification is possible in water prepared for conductance measurements (equilibrium water), in normal distilled water, in drinking water from a tap, as well as in dirty water from a brook or river. The behaviour of one of the reactions I have mentioned differs if normal or activated water is employed together with the same chemical reactive. There is no need to underline the importance of this fact: it is well known that life takes place in an aqueus and colloidal system—that is, in the type of system studied by myself and by the other authors.

For this reason, after having shown how external phenomena influence aqueous colloidal systems, I have concentrated on the study of the structure of water, which I shall shortly describe.

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Chapter II

STRUCTURE OF WATER

THE PROPERTIES OF WATER

WATER IS A LIQUID which displays properties differing greatly from those of other liquids that chemically should resemble it. Its behaviour is anomalous. In recent years, scholars have concentrated their attention on the properties of water and have found that the deeper they go and the more theory progresses and the finer the properties brought to light, the greater the anomalies. Strictly speaking, one may say that it is only recently that water has become recognised as a truly abnormal liquid. In order to realize the exceptional uniqueness of the most common of liquids we need only compare certain physical data which concern water with those of the hydrids of the elements which are close to water in the periodic system or else we can consider the same data in the homologous series: O, S, Se, Te (Table I).

TABLE I

	B_2H_6	CH_4	NH_3	OH_2	FH
Melting point	—169	—185	—77	0	—92
Boiling point	— 87	—161	—31	+100	+19

	OH_2	SH_2	SeH_2	TeH_2
Melting point	0	—82	—64	—48
Boiling point	+100	—60	—41	— 1

In melting, water contracts so that its density at 0° C is greater than that of ice, which is also at 0° C. As the temperature rises, water continues to contract until it reaches 4° C, at which temperature it is at its maximum density. Above 4° C, water expands at the temperature rises, The "physical scandal" of a body whose density rises with the temperature has provoked a great deal of thought among scholars since the years 1667, when the increase of density was noted by Florentine academicians of Cimento.

At 0° C, the density of ice is 0.9168 and that of water is 0.9999.

Water contracts by 8.3% as it melts and, on reaching 4° C, it further contracts by 0.12%.

The dielectric constant of water at 25° C is 78.30, a very high value which is greater than that of the dielectric constant of the common liquids with the exception of four; hydrogen cyanide (106.8 at 25°C), formamide (108.5 at 25°C), sulphuric acid (101 at 25°C) and hydrogen fluoride (83.6 at 0°C).

All other liquids present smaller dielectric constants of unity 10, 20 or even 50, if they are polar, and above unity 70 if they are non-polar. In general, the value of the dielectric constant of non-polar liquids is around 2.

The surface tension of water is remarkably higher than that of the other common liquids. Melted salts and melted metals are not included among the common liquids, because in these cases the surface tension values change their order of size. Only the surface tension of hydrogen peroxide has a value slightly greater than that of water (Table II).

TABLE II

	Surface tension dynes/c
Common liquids	0 — 65
Melted salts	90 — 230
Melted metals	360 — 1000
Water	73
Hydrogen peroxide	78

The latent heat of ice fusion is the greatest known, save for that of ammonia. And the latent heat of water vaporization is certainly the greatest known.

The specific heat of water is abnormally high. For example:

water	mercury	alcohol	benzene	carbondisulphide
1.000	0.033	0.547	0.397	0.235

and the difference between specific heat in the liquid state and in the solid state is also abnormally large. The specific heat of ice is 0.5026 cal/gr at 0°C and that of water is 1.008 at the same temperature. The difference is 0.4982 at 0°C. The differences revealed by other substances are not as high as that of water.

The specific heat of water is at a minimum at 35°C. This minimum was determined with great exactitude by Osborne, Stimson and Ginnings in 1939. The International Committee on Weights and Measures has approved a heat capacity table for international use in calorimetry which differs from the table of Osborne, Stimson and Ginnings by less than 0,005 joule/deg. mole. The date are thus completely dependable. The preceding measurements go back to the years 1874, 1893, 1900, 1905, 1910, 1911, 1912 and 1915. Revision and clarification were necessary.

I have insisted on the determination of the specific heat of water and on the precise establishment of the minimum point because the existence of this minimum is of greatest importance, as we will see later.

A study carried out by Bridgman concerning the viscosity of water at various pressures and various temperatures must be considered as being of fundamental importance. With a rise in temperature, the isotherm at 0°C reveals a minimum in correspondence with a pressure of 1000 kg/cm^2; the isotherm at 10°C reveals this minimum less markedly and the isotherm at 30°C no longer reveals a minimum. This means that below 30°C the viscosity presents an anomaly in correspondence with a pressure of 1000 kg/cm^2, as if something voluminous were "crushed" that the temperature destroys when it rises above 30°C.

On the other hand, it is best to note before going further that between 30 and 40°C many of water's properties reveal certain oddities, a sign that at that temperature something very important occurs with respect to the structure of water.

Magat, observing the disappearance of the intermolecular bands of the Raman spectrum of water at temperatures above 37°C, decided to determine whether the other properties of water presented anomalies at the same temperature.

He found that all the known properties reveal irregularities in the temperature interval between 30 and 40°C:

- *Compressibility of water* in function of the temperature (on the basis of data furnished by Magat, Tamman and Ruenenbeck).

- *Index of the refraction* of water for the line D in function of the temperature (on the basis of data furnished by Hall & Payne).
- *Second derivative of the viscosity* in function of the temperature (based on the average of all known values).
- *Molecular heat of water at constant pressure* in function of the temperature (based on the measurements of Dieterici). At that time there were as yet no Bureau of Standards measurements and divergences were noted between one author and another on the position of the minimum. Magat localized it between 35 and 45° C.
- *Molecular heat of water at constant volume* of the temperature, calculated by Magat on the basis of constant pressure data.
- *Derivative of the dilatation coefficient* in function of the temperature, based on the excellent measurements of Chappuis integrated with the measurements of the Phys. Techn. Reichsanstalt.
- *Solubility of water in benzene* (based on the data of Hill).
- *Solubility of water in a non-polar substance* (bromine).
- *Solubility of water in a polar substance,* but not strongly associated in the liquid state (ether).
- *Second maximum in the X diffraction spectrum.* This maximum begins to wane at 20° C and at 40° C it remains nothing but a point of inflection, according to the observation of Stewart, 1931.

It was evident that something very important was taking place in the structure of water around 35° C. Magat advanced a working hypothesis which held that the anomalies in question were linked to the transformation of a vibration in a rotation.

He immediately saw the *biological importance* of this general fact and affirmed: "Signalons enfin, qu'une variation des propriétés associatives de l'eau peut être d'une grande importance pour les processus biologiques, la région de temperatures correspondant à la transformation étant celle de l'organisme des animaux à sang chaud."

After some years Morgan and Warren studied x-ray diffraction patterns of water at five temperatures: 1,5, 13, 30, 62 and 83° C. "Radial distribution curves for water at the five temperatures were obtained by a Fourier analysis of the x-ray intensity curves. The results can be interpreted in terms of a structure. The change in the diffraction pattern of water with rise in temperature is evident. At 1.5°C exist a first peak and a second peak. With rising temperature the second peak becomes less sharply resolved from the first peak. At 83°C the two peaks have practically merged into a single peak. About the only conclusion that can be drawn from the intensity curves is that there is a change in the structure of water with rise in temperature."

In order to explain the unique properties of water which make it so different from all other liquids, Roentgen supposed that water is a mixture of two different types of molecule, which he called *ice molecules* and *water molecules*. The ice molecules form a mass which is less dense than that of the water molecules. As the temperature rises, the number of ice molecules diminishes and the number of water molecules increases. This hypothesis made possible the explanation of some of the anomalous properties of water; for example, the maximum of density at 4°C. It is important to note that until that time scholars had occupied themselves with the effect of melted substances on the lowering of temperature to the point where the maximum of density was observable, that is, in the destruction of the ice molecules.

Chemical analysis designated the composition of water as H_2O. But the density of steam was slightly greater than should have been the case if it were completely made up of H_2O molecules, and less than should have been the case if water were made up of H_4O_2 or $(H_2O)_2$ molecules. Thus steam is to be considered as a mixture of two molecular types. At 0°C the molecular ratio of H_4O_2 or $(H_2O)_2$ would be 2.6% (Bose).

But in order to explain the behaviour of water in a gaseous state at various temperatures, more complex hypotheses were necessary. There is nothing to be gained now by reviving those old hypotheses. It will suffice to point out that until the early years of this century the behaviour of water in a gaseous state made it necessary to assume the simultaneous presence of several types of molecule and, in addition, the possibility that one of these behaved in a special manner.

The properties of liquid water have to be explained by even more complex hypotheses.

Sutherland put forth the hypothesis that water was composed of *three molecular types: hydrol,* H_2O; *dihydrol,* $(H_2O)_2$ or H_4O_2; *trihydrol,* $(H_2O)_3$ or H_6O_3. Hydrol would exist only in water vapour, dihydrol and trihydrol would be the normal components of liquid water, together with a small percentage of hydrol.

According to Sutherland, liquid water at 0°C would be composed of 62.5% dihydrol and 37.5% trihydrol. Dihydrol would possess a greater density, 1.089 at 0°C, and trihydrol a lesser density, 0.88 at 0°C. High pressure would then reduce the quantity of trihydrol present.

This hypothesis made it possible to explain partially the unusual properties of liquid water, and between 1900 and 1933 there was no substantial change of thought. But in the meantime, general progress in spectroscopy and molecular physics led to some very precise notions regarding the isolated H_2O molecule in a gaseous state.

Even when thoroughly purified, water retains a slight electrical conductivity. Highly purified water, equilibrated with the surrounding air (equilibrated water) has a conductivity of $0{,}75.10^{-6}\,\text{ohm}^{-1}\text{cm}^{-1}$ at 18°C, attributable to a slight dissociation of the water in the hydrogen and hydroxil ions:

$$H_2O \rightleftarrows H^+ + OH^- \quad \text{or:} \quad 2.H_2O \rightleftarrows H_3O^+ + OH^-$$

The concentration of hydrogen and hydroxil ions is $0{,}8.10^{-7}$ equivalent per litre at 25°C.

Water is an ionizing liquid, and if one imagines it to be a homogeneous fluid with a given dielectric constant and a given viscosity, with the ions of the solute as little charged spheres subjected to resistance proportional to their velocity, modern theories of solutions substantiate the mobilities of the ions in a quite satisfactory manner. But until now no theory has been able to account for the mobility of the H^+ and OH^- ions water, a mobility that is unusually great compared with that of the other ions.

Here are some data, at 18°C (Kohlrausch):

$$H^+\ \underline{315,} \qquad OH^-\ \underline{174}$$

$$Na^+33,\ K^+65,\ NH_4{}^+64,\ Cl^-65,\ Br^-67,\ \tfrac{1}{2}SO_4\ {}^{-}68$$

The great anomaly displayed by the ions of water has led to modern theory's first general assault on the nature of liquid water.

THE SUBTLE PROPERTIES OF WATER

Establishing that water possesses exceptional properties compared with other liquids and that its behaviour is completely anomalous, has not yet solved the problem of the properties of water. What we have shown are the general, characteristic and easily-definable properties that determine the behaviour of water in a wide sense.

But beyond the easily-definable properties, water displays a quantity of other properties not so easily-defined and hardly predictable that evade all attempts at documentation or thorough study. Chemists and, to an even lesser degree, physicists never consider the possibility that water could display such subtle and evasive properties. But biologists, hydrologists, hydrobiologists and balneologists are quite aware of the existence of these properties and know that they are highly important despite the difficulty of coming to grips with them.

Why is it that natural water drunk at a spring is more effective from a medical point of view than the same water bottled and aged? Why is natural water so different from a medical point of view in spite of the fact that the difference in chemical composition reveals nothing in particular? It is certainly not the small variations in common salts content that justify the efficacy of this or that water. Even the existence of small traces of radioactivity does not justify the differences in properties at all. Today we are beginning to speak of changes in the biological properties of water due to the heating and subsequent cooling of the water, which does not return to its previous state from a biological standpoint, even if we replace the gases it had lost during the heating and return it to exactly the same conditions in which it was found previously. This is what is known as *fervourisation* of water (Vale Vouk); an operation that bestows different characteristics upon water in spite of the fact that nothing different has definitely taken place from a chemical or physical standpoint.

The biological effects of fervourisation seem to be evident.

Then there are other facts to keep in mind, in spite of the fact that the majority of physicists and chemists have refused to consider them: the so-called phenomena of "*activation*," which I mentioned in the introduction.

Water which is subjected to physical treatment, that puts minute quantities of energy in play, acquires some properties which last for quite some time, even for several days. Nothing has changed from a chemical standpoint. The properties that activated water acquires have been employed in the *physical descaling* of boilers and have been the subject of patents. Many of these patents have not served their purpose at all, but others have come into wide use and their results in industry are controllable. The effects of activation are changeable in the course of time and may only be evaluated statistically. But the effects do exist. The results can be good, and then suddenly turn bad. Why is this? In spite of the aleatoriability of its function, it has appeared convenient in many cases to attempt the use of physical descaling, which does not tie down specialized personnel, or consume chemical products and does not involve delicate chemical operations.

This is a subtle property of water that may be observed in the field of inorganic chemistry and in industry. It is a marvel that such a tiny quantity of energy is capable of such remarkable results, to say nothing of the economical aspects.

I will return to the subject of the activation of water in a subsequent chapter.

There are facts then which were considered a few years ago impossible to apprehend scientifically.

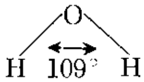
The study of natural phenomena may only be carried out when conditions are favorable. But to deny facts that are beginning to appear before our very eyes merely because they do not fall within the range of our standard knowledge is highly unscientific.

That these facts exist, at least with highly interesting frequency, is proved by industry which has spent and is still spending millions to make use of the very facts that many scientific scholars choose to ignore.

THE STRUCTURE OF WATER

In the midst of studies of the properties of water based on theoretical concepts and on previously established facts, atomic physics, molecular physics and spectroscopy we are able to proceed from well-defined ideas regarding the isolated H_2O molecule; that is, the molecule in a gaseous state. It would not have been possible to define these ideas earlier because the general theory would not have been sufficiently advanced.

The isolated H_2O molecule has the following form:



The bond angle is 105°, the tetrahedral angle almost 109°. The internuclear distance O—H is 0.97 A. The electrical dipole moment is $1{,}87.10^{-18}$c.s.u. The vector of dipole moment acts upon the bisector of the angle H-O-H.
The negative end is that nearest the oxygen.

The mechanical wave theory gives some information on electronic distribution. The water molecule has 10 electron wave functions which can, according to Mulliken, be designated thus:

$$(1s)^2[2s_1]^2[2p_z]^2[2p_y]^2[2p_x]^2$$

Z is oriented along the bisector of the angle H-O-H, Y lies in the plane H-O-H perpendicular to Z, and X is perpendicular to the plane H-O-H.

Z, Y and X pass through the nucleus of the atom O. The radius of the water molecule is about 1.4 A. This means that if water were made up of spherical molecules in disorderly arrangement and touching one another, the density of water should be 1.84. If we wish to ascribe to water its true density, imagining it to be composed of spherical molecules arranged as we have suggested, its radius should be 1.72 A. The water molecule would then have to undergo a remarkable change of dimension during the process of fusion, because in ice, as we know from roentgenographic studies, its radius is 1.4 A. The extreme dissymmetry between the water molecule and its electropolarity does not permit such a conclusion. Apart from this, the study of X-ray diffraction on liquid water provides us with an independent and conclusive argument. X diffraction indicates that the radius of the H_2O molecule in liquid water is 1.38 A.

The arrangement of the molecule cannot then be disordered as mentioned above, but must be of an entirely different order.

In 1933, Bernal and Fowler put forth a completely new idea, based on spectroscopic data, concerning the H_2O molecule in a gaseous state, its electric moment and its dimension even bearing in mind certain similarities to order chemical compounds. Their idea revolutionized concepts of the constitution of water.

"$[2p_z]^2$ gives a concentration of negative electricity in two regions at right angles to the plane H-O-H. The net distribution of electronic density will therefore resemble a *tetrahedron* with two corners of positive and two corners of negative charge. Also it is possible to find that water molecules arrange themselves in a tetrahedral co-ordination.

Each molecule is surrounded by four others, the binding being between the positive regions on one molecule to the negative regions on the next."

Barnes found tetrahedral co-ordination in ice.

Bernal and Fowler pointed out that in the case of solid silica $(SiO)_2$ there exists a similar fourfold co-ordination. The variations of the polymorphous forms of silica showed that tetrahedral co-ordination alone is however not sufficient to determine the structure completely. The forms are: cristobalite, tridymite and quartz. *Ice is isomorphous with tridymite.*

It seems likely that when ice melts the water molecules tend to join together, as ice in a *tridymite-like pseudo crystalline structure,* which is less dense, and that with rise in temperature the tridymite-like pseudo-structure tends to transform itself into a *quartz-like pseudo-structure,* which is denser.

The maximum of density at 4°C would thus be easily explained theoretically. Bernal and Fowler acknowledge three types of structure, corresponding to three types of water.

Water I: Ice and tridymite-like, light, viscous;
Water II: Quartz-like, heavy, semi-viscous;
Water III: Liquid ammonia-like, light, non viscous.

"The nature of the water is determined by different geometrical arrangements of the same molecules in small regions of the liquid, due to a different amount of molecular movement, imposed by the temperature. In each small region the arrangement is *pseudo-crystalline.* These regions have an appreciable electric moment, and are needed to account for the large dielectric constant of water which is practically identical with that of crystalline ice for low frequences."

These arguments were used quantitavely *to calculate the internal energy of ice and water from the water molecule model derived from spectra and dipole moment* ". . . It is possible to go further on the basis of the theory to find the real nature of the hydrogen ion in solution and provide a theory for the *abnormal mobilities of the hydrogen and hydroxil ions.*"

These are characteristic problems of water.

Thus Bernal and Fowler successfully confronted the most central problem of water.

It serves no purpose to probe deeply into the work of Bernal and Fowler, the two pioneers of the modern theory of the structure of water. A great deal has changed since then.

The revolutionary idea of the two authors was met by a lively reaction. The supporters of the theory which held that water had to be considered as a *mixture of aggregates*, according to traditional ideas, attacked the concepts of Bernal and Fowler. New ideas cannot be perfect at their birth and attacks are inevitable, both for their imperfections and for the uneasiness provoked by their appearance.

Eucken found that the properties of water can be satisfactorily explained by supposing that around a temperature of 0° there exist, in roughly equal quantities: simple, dimer, tetramer and octomer molecules.

The *octomers* occupy a large volume and for this reason behave like *ice molecules (Eisartig)* and to a certain degree substitute Bernal and Fowler's tridymitic structure. Eucken supposes that the hydrogen bonds are the forces which bind the H_2O water molecules in larger aggregates.

Gierer and Virtz found, however, that two conceptions, that of Eucken and that of Bernal and Fowler, although they differed, were capable of a certain mutual relationship. Eucken's mixture of aggregates may be interpreted as a quantitative representation of the equilibria among three forms of arrangement whose coexistence in a quasi-crystalline liquid reticule constitutes the starting point of Bernal and Fowler's theory. Gierer and Virtz considered the number of hydrogen bonds that the various molecular species were able to produce, and on this basis and on the basis of the effect of temperature on the rupture of hydrogen bonds, they sought to explain the properties of water.

The struggle between the *mixture of aggregates* exponents and the *pseudo-crystalline structure* exponents was even carried to certain bands of the Raman spectrum. There exist bands in the Raman liquid water spectrum which were interpreted as being intermolecular that is, due to molecules which are bound together. The bands in question disappear with the rise in temperature, as previously observed by Magat. Rao has consistently argued in favour of the classical concept: these bands had to be attributed to the H_2O molecules $(H_2O)_2$ and $(H_2O)_3$. Rao's immense authority on the subject of the Raman spectrum made itself felt. But it was later observed that the difference between the classical conception and Bernal and Fowler's theory, was more illusory than real.

In 1939, Hibben summed up the situation in the following manner:

"Rao has consistently ascribed the variation in the bands adjacent to $\Delta\nu$ 3400 as due to a change in the proportion in which the water polymers, i.e., H_2O, $(H_2O)_2$, $(H_2O)_3$, are present and he has ascribed to the frequency near $\Delta\nu$ 3600 the unpolymerised water. Bernal and Fowler have proposed a quasi-crystalline arrangement for water having respectively a tridymite, quartz and close-packed ideal structure as a function of increasing temperature. The difference between these concepts is more illusory than real. The essential fact is that there is a profound influence on the Raman spectrum of water as changes in the constitution of water take place . . .

". . . Rao has argued in favour of the classical concept of water and has pointed out the variation in intensity of the water bands with temperature. This concept appears to be somewhat too well defined. On the other hand it is often too easy to explain departures from the normal on the basis of hydrogen bonding or resonance. These explanations may err in the opposite extreme.

Neither concept is in contradiction to the experimental observations upon which ultimately any explication must be founded. In any case the formula H_2O given water or ice is undoubtedly incorrect. Other factors, which are due to intermolecular interaction and influence both the physical and chemical properties of water intervene. Evidence as to the nature of these factors and their magnitude obtained from Raman spectra illustrates an important application of this method of attack on the structure of liquids."

Here we see that the shift from opposition to the ideas of Bernal and Fowler to a reconciliation of the opposing theses has already been accomplished.

Pople brilliantly modified Bernal and Fowler's theory, overcoming the difficulties which it had encountered. Pople's theory is based on results of the study of molecular orbitals. The external electrons of the water molecule occupy four tetrahedrally-directed orbits, two of which are associated with O-H bonds, the remaining two with lone pairs of electrons. Each molecule then tends to *form four hydrogen bonds in tetrahedral directions.*

This concept of Pople's, so very new, met with great success.

Hydrogen bonds can stretch or bend without breaking, absorbing great amounts of energy and enthropy. Water differs from ice in that the hydrogen bonds of water *can bend independently instead of cooperatively*. The necessity of an over-extensive bond-breaking to explain the high heat capacity of water is thus eliminated.

Lennard-Jones and Pople hold that in water there exists a *network of bonds extending throughout the entire liquid which is, in a sense, one large molecule.*

The theory permits us to explain the properties of water determined by the various experimental techniques, both by x-rays, calorimetry and by electric conductivity.

On the basis of the Pople theory, Harris and Alder calculated the dielectric constant of water at various temperatures. The values determined by these calculations were *identical* to the experimental values. This striking success determined the fate of the new concept, which had by this time definitely won the day.

A quasi-crystalline structure implies the existence of a *quasi-Curie point,* observable either directly in first degree transformations or in those of the second or third. Magat, as I have mentioned, had listed those properties which reveal anomalies between 30 and 40° C. Certain of those anomalies are not strictly probatory, but at least two of them doubtless are: the specific heat minimum of water at 35° C and the behavior of viscosity at high pressure. With the old experiments of Bridgman, which I referred to in the first part of this chapter, the crushing of the tridymitic structure at a temperature below 30°C may be directly observed. The crushing is no longer observable above this temperature.

For this reason it is held that the *structure* of *water* melts at 35°C.

Thus *there exists in water below 35°C a tridimensional self-perpetuating structure.*

Now that our ideas have changed so greatly from those of times past, how are we to look upon the phenomenon of dissolution and how are we to deal with the problem of the solutions?

Frank, Frank and Evans studied the problem from a thermodynamic standpoint, which is the most general one, on the basis of new criteria. When a non-polar gas is released in a non-polar liquid, there is a diminution of enthropy. When a non-polar gas is released in water, the diminution of enthropy is more than double. The loss of enthropy in the first instance diminishes but little with the rise in temperature, while the loss of enthropy in the second instance diminishes rapidly with the variation in temperature. In other words, the enthropy that the dissolution of the non-polar substance *in a non-polar liquid* had caused to diminish slightly, increases slightly with the rise in temperature; but the enthropy that the dissolution of the non-polar substance *in water* had caused to diminish greatly, increases rapidly with the rise in temperature.

Since the diminution of enthropy is related to the establishment of a highly-ordered state, it must be concluded that the dissolution of a non-polar substance in water creates a greater order than in a non-polar solvent. The order has been conceived as the geometrically well-defined *fixation of the water molecules around the non-polar molecule of the solute.* Thus we have the formation of *ice particles,* or icebergs as they are now called. The rise in temperature brings about the fusion of the icebergs and thence a more rapid increase in the disarrangement and, thus, of enthropy.

This point of view is completely new, but it must be regarded as being dependable since it is in perfect harmony with the principles of thermodynamics.

The case of the dissolution of a substance which generates ions is presented in a highly complex manner. Even in the case of the interactions between ions and water the formation of the icebergs is taken into account; but here we must remember many other factors, such as the polarization of the molecules due to the electric fields of ions, the variation of the entire dielectric constant that goes with variation in concentration, and the variation of the microscopic dielectric constant that goes with the variation in the distance from an ion. New problems rise, and a new field is opened to study the solutions.

Molecules and ions, at least when they are in sufficient concentration, break down the structure of water to generate ice-like structural entities: icebergs. Since the high value of the thermic capacity of water is due to its structure, the breakdown of the structure, either by heating or by introduction of a soluble substance without heating produces a diminution of its thermic capacity.

The manner in which the various ions create their own icebergs and bind them in relation to the remainder of the water which does not adhere to them, is extremely interesting. But this is a special chapter, now under study.

This brief and summary review of the evolution of ideas on the structure of water was indispensable in order to demonstrate how the most common of liquids, the giver of life, is the most complex and has the richest properties of all liquids known. Water is an exceptional substance. Its visible and ascertainable properties have occupied the efforts of scholars for years; but these, as I said, do not complete our knowledge of water. There is much more. And it is upon this *much more* that, with all probability, the phenomena which interest us work.

Even aqueous systems must possess, at least within certain limits, similar possibilities of change and adaptation.

The existence of a structure so delicate and sensitive permits the assumption that appropriate actions are capable of modifying the structure itself in an infinite number of ways, and thus we may assume that water is sensitive to extremely delicate influences and is capable of adapting itself to the most varying circumstances to a degree attained by no other liquid. It may be that it is this infinity of possibilities that makes the existence of life possible.

Perhaps it is even by means of water and the aqueous system that external forces are able to react on living organisms.

It is opportune, at this point, to note how recently it was shown that water presents beyond the absorption bands in the far red and infra-red already known, absorption bands in the field of very low frequencies (VLF).

Freymann found in fact that *water in the solid state (ice)*, the *hydratation water* and the *water chemically absorbed by solids* presents wide absorption bands at the frequencies of 10kHz, that is for electromagnetic waves of 30 km length.

That demonstrates that electromagnetic fields of low frequency and therefore of very little energy are capable of acting upon water. That is extremely important from our point of view. Unfortunately the spectroscopy of VLF is still left to be done. An immense lacuna is before us and makes it difficult to follow our work.

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Chapter III

THE CHEMICAL TESTS

IN ORDER TO EXPLAIN what the chemical tests are I have decided to follow a course previously adopted with some success on occasion of the Brussels Symposium, October 1958.

When a chemical operation is performed and repeated several times, one will observe differences in the results obtained over a period. It is of course well known that our operations allow a margin of error that may be rather large or, on the other hand, rather small. This depends on the chemical system employed. The variations in the results are normally attributed to experimental errors; that is, to chance.

But the variations may be due, at least in part, to external causes, to conditions which have not been controlled and which exist and fluctuate independently of our wishes and about which we are generally unaware. How are we to determine their presence? The solution to this problem was attempted by devising an appropriate method, one capable of revealing how external phenomena influence our chemical operations.

Two possibilities were considered:

1) It is possible that, on modifying external conditions, the chemical system will react in a markedly different manner under the new conditions;

2) It is possible that, on modifying the chemical system, the system will react in a markedly different manner against the same external influences.

If the system reacts to one of these conditions, it is then possible to conduct a *differential experiment* by carrying out the same operation twice, simultaneously, using the same reactive agents and maintaining equal, at every moment, the common physical conditions of the two experiments at hand, (temperature, pressure, humidity, light, etc.), *but modifying* in an appropriate manner:

A) *The spacial conditions surrounding one of the two reacting systems,* or else:

B) *One of the reacting chemical systems.*

The results yielded by the two reacting systems will, as a rule, no longer be identical because of the imposed modification. It will be noticed, for example, that a more rapid sedimentation, a darker colour, a more abundant precipitation or some such effect will be evidenced by one of the two systems.

There will therefore be an observable difference, either *in one direction*—for example, a more rapid sedimentation in the modified system (or under modified conditions)—*or in the opposite direction.* It may also be that no difference whatever results but this case is extremely rare.

The case in which the sedimentation is produced more quickly in the modified system has been called *T*, while *R* is the name given to the inverse case. The case of perfect identity is known as *O*.

Experimental errors always play their part according to the chance involved (I am not considering the case of systematic errors) and superimpose themselves on the effects of external phenomena.

Pure chance, on a great number of experiments gives as results: 50%T. A result that on a great number of experiments is different from 50%, is always significant. Its value had to be that one observed or more different from 50%—that is to say—again better. *One derives from the differential experiment A RESULT THAT IS NOT DUE TO CHANCE, by effecting a large number of differential experiments (not less than 10) either simultaneously or within a very short space of time,* and by determining the relative number of the differences produced in direction T; that is, the percentage of T.

The percentage of T is the numerical result of the chemical test.

The result of the chemical test is therefore STATISTICAL and can vary from 0 to 100.

The principal feature of the chemical test is, therefore the following:

To provide a statistical numerical result, not by means of measurements, but by COUNTING the number of times, in a fixed *number of experiments, a given chemical operation behaves in a determined manner* with respect to another chemical operation of the same type.

The result of the chemical test is independent of temperature, pressure and so on; in short, it is *independent of all the common traditional variables.*

THE CHEMICAL TEST IN CASE A

External phenomena, far away or close at hand, manifest themselves in the space in which we live, as far as we know, by means of electromagnetic or corpuscular radiation or by field variations. Thus it is possible to modify the spacial conditions surrounding one of the two chemical systems in the differential experiment by enclosing the selected system in a metallic chamber or, at least, by placing a metal plate over it. The metal we have chosen is *copper.* The system is thus screened, either wholly (as in the case of the chamber) or in part (as in the case of the plate).

The copper screens, or at least partially screens, certain radiations and modifies the electrical and electromagnetic field.

If there are no forces acting in the surrounding space, or only those forces which are not modified by the copper, the response to the chemical test will be that due to chance: *50* (50% T).

But if in the surrounding space forces are acting that are modified by the copper, then underneath the plate (or within the chamber) the conditions will differ compared with those on the outside.

A sensitive chemical system will react to the difference in conditions during its evolution before reaching the equilibrium.

In this regard I will give two highly significant examples.

1) Polymerisation of Acrilonytrile

A solution of monomer acrilonytrile in water was divided and placed into several identical glass flasks. The flasks were enclosed in a small chamber or in a wooden chest, well protected against temperature variations. Half of the chest containing the half of the flasks was covered with a thin copper screen, 0.1 mm in thickness. After a sufficient length of time the flasks were taken out and the solid polymer that had formed was filtered, dried and weighed. From December 1951 to April 1954, 108 experiments were carried out and it was established that the weight of the polymer was *less under the screen* 80 times out of 108; that is, in 75% of the cases (Table III).

TABLE III

THE NUMBER OF EXPERIMENTAL GROUPS
YIELDING A GREATER WEIGHT OF POLYMER

		Outside the screen	*Under the screen*
1951	December	7	2
1952	February	5	1
"	March	14	6
"	April	14	4
"	May	5	1
"	June	3	3
"	July	3	3
"	October	2	0
"	November	2	0
"	December	4	0
1953	January	8	4
"	February	10	0
1954	March	1	4
"	April	2	0
	Total	80	28
	%	74	26

From a statistical point of view, therefore, the effect of the screen was easily observable. The effect was *not constant either in sign or in size,* all of which is quite natural since spatial properties fluctuate incessantly.

2) Precipitation and Sedimentation of Oxychloride of Bismuth

a) 1000 Blank Tests

We hydrolised identical quantities of the same solution of trichloride of bismuth, with the same quantity of water, in two sets of beakers, designated by the colours red and blue. The hydrolisis was effected in pairs, one red beaker with one blue beaker, simultaneously and under identical conditions, 10 pairs at a time.

From October 15 to November 6, 1954, a total of 1000 paired tests was carried out.

In each group of 10 pairs, we recorded how many times the sedimentation of oxychloride of bismuth had proceeded more rapidly in the red beakers, and the percentage was calculated. This percentage constituted the numerical response to the blank test.

Distributing the different responses according to their values, between 0 and 100, a curve was obtained much like that of Gauss

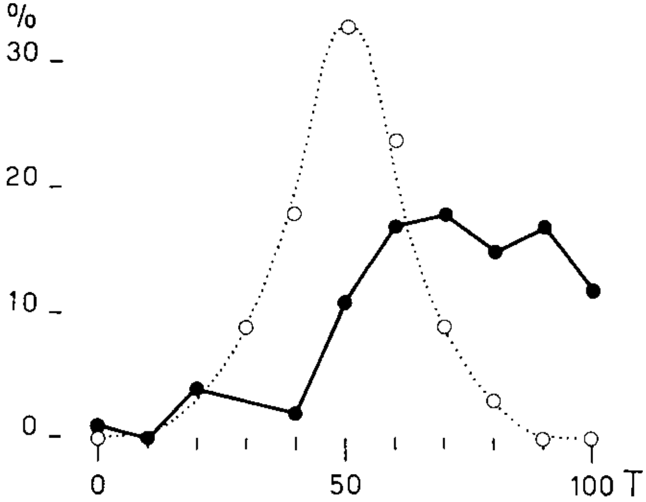

FIG. 1. One thousand *blank tests (dotted line)* and one thousand tests P *(black line)* effected in groups of ten, distributed according to the percentage T given by each group. On the abscissa: the values of percentage T; on the ordinate: the frequency of percentage T. Note the perfect symmetry of the distribution about value 50% in the case of the blank test and the dissymmetry of the distribution in the case of test P.

(Fig. 1), in symmetrical ratio to the ordinate 50. The general average of the 1000 results was 50.4%.

The blank test thus rendered the result due to chance.

b) 1000 P—Tests

Simultaneously with the blank tests, 1000 tests were carried out that were identical to those previous, *but the red beakers were covered with a copper screen.* This constituted *test P.*

Distributing the various results according to their values, between 0 and 100 a curve was obtained that was quite different from that of Gauss, showing an asymmetrical rapport with the ordinate 50. The general average of the results was 70.1%.

Test P therefore rendered a result quite different from that of the blank test. *This was no longer chance playing its part, but the influence of exterior actions.*

THE CHEMICAL TEST IN CASE B

One of the chemical systems may be modified by chemical or physical means. We have chosen, for practical reasons, a very simple physical means. Since the precipitation of oxychloride of bismuth, provoked by the hydrolysis of trichloride, was adopted for our routine tests, we modified the water by means of *physical activation.*

A bulb of mercury, that is, a closed glass globe containing a drop of mercury and neon at reduced pressure was gently stirred in the water. On moving the bulb, the mercury slides upon the glass; the double electric layer between the mercury and the glass is stripped and an electrical discharge is produced in the interior of the globe. The water which is in contact with the bulb is thus activated. Mercury bulbs as well as other devices, have been employed in industry for the "physical" descaling of boilers.

The mercury bulb has been the subject of a study by Halla and Novotny. The sliding of the mercury upon the glass produced an *electromagnetic emission.* This emission has not been found at high frequencies, but *only at low frequencies,* 3-4 KHz. But the low-frequency emission is modulated at an extremely small frequency, 10 Hz—that is to say, the 3-4 KHz emission appears in *packages* of 10 Hz. It is useless at this point to speak of the physical-chemical problems that activation presents: the structure of water etc. It is enough to know now that it is possible to prepare two lots of water, chemically identical (of the same centesimal chemical composition), but physically different.

With *normal water* and *activated water* we are able to conduct a *differential experiment* as in case B and to use it as a chemical test.

Such a test may be conducted *out of doors,* in the open air; that is to say, in a location where there is no metal present. This constitutes test *F*. On the other hand, the test may be conducted *indoors,* within an area shielded by copper (or underneath a screen). This constitutes test *D.*

THREE CHEMICAL TESTS

The three types of chemical test which we have employed up to the present are collected in the Table IV.

TABLE IV

(I is compared with II)

	Condition I	*Condition II*
Test P	normal water spacial conditions unmodified: open air	normal water spacial conditions *modified:* under copper
Test F	normal water spacial conditions unmodified: open air	*activated* water spacial conditions unmodified: open air
Test D	normal water spacial conditions *modified:* under copper	*activated* water spacial conditions *modified:* under copper

RESEARCH ON THE CHEMICAL TESTS

With regard to the chemical tests, two types of research were carried out:

a) *Special research,* designed to improve our knowledge of the chemical tests.

b) *Routine research,* given to the study of exterior actions, with which we deal later.

Special Research

1) Closed and Open Metal Screen (Completely Sealed Copper Chamber and Horizontal Copper Plate)

It was very important to know if, instead of working within a completely sealed copper chamber, we could obtain results that did not differ too greatly by working under a copper plate. This was necessary since we had to conduct routine tests in places where it was impossible to employ a sealed metal chamber.

Test D—Three series of 200 differential precipitations (normal water-activated water) carried out in May 1953, one in the open air, one beneath a horizontal copper plate and one in a sealed copper chamber (thickness of the copper of the chamber and the plate: 0.1 mm), yielded the results collected in the Table V.

TABLE V

	% *T*
In open air	54.5
Beneath the plate	37.0
Within the chamber	37.5

Thus there was no great difference between the two tests D. We may safely assume that exterior forces fall downward upon the Earth from above. Therefore the "roof" would be the most important part of the chamber for the purposes of the chemical tests. All of this has only an indicative value since the tests were so few.

Test P—Five years later (1958) it was observed that test P followed a different behaviour pattern from that followed by test D. The results of test P obtained by using a horizontal metal plate showed a behaviour almost *reversed* to that shown by the results of test P obtained simultaneously using a completely sealed copper chamber.

This explains why the test P results obtained in Florence using the copper chamber have shown a positive and significant correlation with solar activity, while the results obtained in different stations during the IGY, when of necessity simple copper plates were employed, have shown a negative and significant correlation. The screen obviously plays a very important part in the chemical tests.

The problem of the screen is highly complicated and requires a separate study. On the other hand, how are we to compare the results of the experiments carried out in 1953, with a near-minimum of solar activity, with the results of the experiments carried out in 1958, with a near-maximum of solar activity? Variations in solar activity must be closely considered in this study.

2) *Nature of the Metal of the Screen*

Numerous series of tests were carried out, activating water and precipitating oxychloride of bismuth within small chambers of different metals—copper, aluminium, iron and lead—so as to determine whether the nature of the screen was of importance, that is to say if the action of the screen was merely electrostatic, or if it was comparable to the action of a filter or selective mirror.

The results of four series of 6,900 tests each (normal water-activated water) carried out between January 6, 1954 and March 26, 1955 are collected in the Table VI general averages.

TABLE VI

	% T	*Specific electrical conductance $ohms^{-1}\,cm^{-1}$*
In open air	46.4	0.10^4
Under Fe	45.4	10.
Under Al	42.2	35.
Under Cu	39.6	58.

It is evident that the nature of the metal plays an important rôle. We may conclude that the most important characteristic of metal, as far as the chemical tests are concerned, is its electrical conductivity. Unfortunately, physics has nothing to tell us on this subject. What we know regarding Faraday's cage is valid for electrostatic phenomena, but not for the phenomena which we are studying, where an entire range of electromagnetic waves falls on our screens.

3) *Structure of the Screen*

Since we have not only the nature of the metal to consider, but also the structure of the screen, we have carried out some orienting tests with a *compact screen*—a continuous metal plate—and a *discontinuous screen or powder screen*—a metallic paint: that is, a metallic powder bound by an insulating paint.

We have tried out an aluminum plate with a thickness of 0.7 mm and a piece of cardboard coated with a "*pure aluminium paint.*" Three series, each of 500 simple tests (three single precipitations): one in the open air, one beneath the painted cardboard and one beneath the plate, were carried out between April 7, 1955 and April 14, 1955. The three series were later compared, and give the results collected in the Table VII general average.

TABLE VII

	% T
Out of doors—with plate	76.8
Out of doors—with powder	72.6
With plate—with powder	45.6

It is evident that the screen formed by a metallic powder with isolated grains also produces a noteworthy effect, almost like that produced by the metal plate.

But this depends upon the radiation falling upon the screen. It was noticed much later that the aluminium plate screened to a noticeable extent the radioelectric emission of 10 KHz frequency, but that the cardboard presented hardly no obstacle to the same emission. So then, which rays are stopped by the discontinuous screen? This problem as well should be studied by the appropriate methods. It is a matter of experimenting with very different frequencies, above all with the very low frequencies (VLF), ones for which we can find no serviceable instrument, either transmitter or receiver. It would be necessary to build them all specially.

The problem of the screens is slowly being forced upon us.

4) Test D, Test P and Screen Thickness

In order to establish whether the screen played an important rôle in our tests, a long series of tests was carried out, activating water within lead boxes of different thickness: 0.3, 15 and 30 mm.

Between June 25, 1953 and April 10, 1954, 7130 tests were carried out using the chamber of 0.3 mm thickness, and 7130 with the chamber of 30 mm thickness. From January 26, 1954 to April 10, 1954, 1500 tests were carried out using the chamber of 15 mm thickness, contemporaneously with those for the 0.3 and 30 mm chambers. The results are collected in the Table VIII.

TABLE VIII

	Pb 0.3	*Pb 15*	*Pb 30*
Series of 7130 tests	39.7	....	42.9
Series of 1500 tests	40.4	42.9	41.4

The effect of thickness is not very remarkable for the thicknesses and metal in question, even though the thickness was varied from 1 to 100. The general pattern seems to follow Rossi's curve, because the 15 mm screen yielded results a bit greater than the 0.3 and 30 mm screen. But this does not help much in the study of our chemical tests. If that which was observed comes within the sphere of interactions between *cosmic radiation* and *dense screens* and becomes a problem of secondary radiation, then the dense screen, of great thickness, presents nothing but a useless complication, voluntarily introduced. We then attempted to discover if an *extremely thin screen* had an influence on the chemical tests, hoping to be able to establish a *minimum limit* for practical thickness.

Aluminium screens were placed on cellophane by sublimation in a vacuum, and were employed according to the test P technique. Very noteworthy effects were constantly obtained, even with screens which were so thin (800 angstrom) that they allowed the filtration of a weak blue light when held up to an electric lamp. This result agrees with those obtained by Bortels on biological tests. A very thin sheet of aluminium foil, like that from cigarette packages, was enough to produce notable effect on the microbiological system.

In addition, three series of 100 simple tests were carried out according to the test P technique, simultaneously precipitating oxychloride of bismuth in the *open air,* underneath a screen of *hammered gold* (gold leaf used for the gilding, 0.5 thousandths of a millimeter in thickness, applied to cardboard), and underneath a screen of *gold deposited by sublimation* on cellophane (8-10 gr. of gold for 10 square meters of surface, about 50 angstrom in thickness). The results which were obtained are collected in the Table IX.

TABLE IX

	% T (General averages)
Open air—deposited gold	45.0
Open air—hammered gold	71.0
Deposited gold—hammered gold	76.0

It is evident that the hammered gold shows a very noteworthy difference out of doors while the deposited gold reveals a slight and negative effect. Forty-five is not far from fifty, which would be the result due to chance. On the other hand, a mere 100 tests does not permit us to draw any definitive conclusions. All the same, it is obvious that a very noteworthy effect may yet be obtained with thicknesses less than one micron.

With regard to the chemical tests, it will be necessary to pursue the study of the effects of screens of very small thicknesses. This area is completely new, even from the point of view of the interaction of screens on electromagnetic fields.

5) *Electromagnetic Fields of Very Low Frequency (VLF) and the Chemical Tests*

Natural electromagnetic fields of radioelectric frequency present a rather particular point of interest, for they are capable of quite visibly influencing colloidal systems in evolution, if the frequency is sufficiently small. It would have been highly interesting to have correlated the results of my chemical tests with the intensity of *atmospherics* (VLF). But in Italy the intensity of atmospherics was not measured; to have made use of information from Munich or Hamburg and so forth, places very far from Florence, would not have made sense.

So two series of simple tests were carried out, one at a distance of 2m and the other at a distance of 20m from a transmitter with a strength of 10 W, regulated on a frequency of 10 KHz. At 20m the intensity of the electro-magnetic field, measured by a field meter, was a great deal weaker than at 2m. Ten simultaneous pairs of precipitations of oxychloride of bismuth were effected in the normal manner; we then counted how many times the sedimentation proceeded more rapidly far from the transmitter.

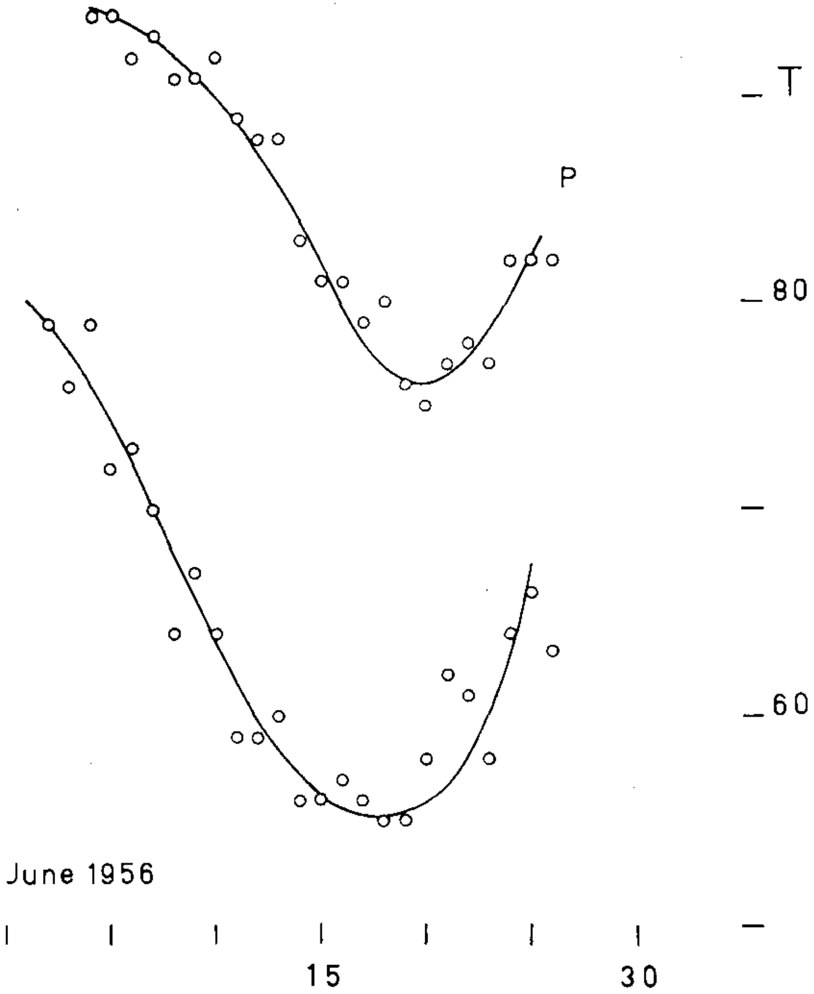

FIG. 2. *Above:* the behaviour of test P in June 1956 (screen effect). *Below:* the behaviour of the near-far chemical test under the influx of an electromagnetic field of 10 kHz frequency. Note the parallelism.

It was therefore a case of a *near-far test* perfectly analogous to test P, which is an *indoors-outdoors test*.

From September 11, 1955 to February 29, 1956 ten simultaneous pairs of precipitations were effected each morning at 9h 30, for a total of 1720 pairs.

At 20m, the sedimentation of oxychloride of bismuth proceeded more rapidly in 72.7% of the cases. The sedimentation was thus, on the average, retarded during the period in question by the effect of the electromagnetic field.

The tests were continued between June 1, 1956 and June 25, 1956 using two different frequencies: 10 and 120 KHz, and effecting 260 pairs of precipitations for each frequency. The two series of tests yielded practically the same results. The pattern of the near far response for both the 10 KHz and the 120 KHz frequencies, was almost parallel to that of test P (Fig. 2).

There is no doubt that electromagnetic fields play a very important rôle in the chemical tests.

6) *Effect of Altitude on the Chemical Tests*

It was rather necessary to know, from a general point of view, if the altitude of the location where tests were carried out was of any importance, so as to be able to compare results obtained in different places.

Prof. Fritsch of the Vienna Technical High School (Technische Hochschule Wien) organized studies, in collaboration with us, at Kaprun Mooserboden, altitude 2000 m, and Kaprun Werksiedlung, altitude 800 m, on the Hohentauern (Austria), during the construction of the great hydroelectric dams, from May to December 1954.

Other studies were carried out over a six-month period from October 1957 to March 1958 by the personnel of the Astronomical Institute of the University of Tuebingen, directed by Prof. Siedentopf, at Jungfraujoch (3578 m) and at Tuebingen (328 m). The total results are collected in the Table X.

TABLE X

	Altitude	*% T (General averages)*		
		F	*D*	*P*
Kaprun Werksiedlung	800	48.6	51.9	. .
Kaprun Mooserboden	2000	55.0	54.7	. .
Tuebingen	328	38.3	45.4	64.0
Jungfraujoch	3578	47.3	54.3	43.2

While at Kaprun very small differences were observed between the tests effected at 2000 m and at 800 m, the Jungfraujoch tests revealed much higher values for tests F and D and lower values for test P than was the case at Tuebingen.

It must, however, be kept in mind that the Kaprun tests were conducted in 1954—that is, during the *minimum* of solar activity—while the Jungfraujoch tests were conducted in 1957 and 1958, during the *maximum* of solar activity. Furthermore, we must remember that Jungfraujoch is 1,500 meters higher than Mooserboden. A perfect solution would demand being able to carry out still more tests, during both a minimum and a maximum of solar activity, in the same place and using identical methods.

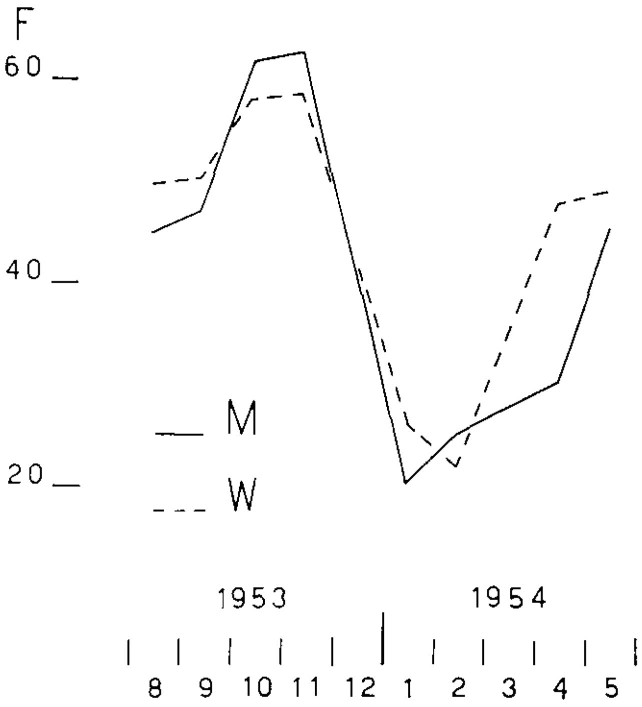

FIG. 3. Chemical test F at Vienna and at Kaprun Mooserboden from October 1953 to May 1954 (monthly averages). *Dotted line:* test F at Vienna Untertullnerbach (altitude 280 m). *Black line:* test F at Kaprun Mooserboden (altitude 2000 m). The distance betwen the two places about 290 km. Note the similarity of the behaviour.

It is interesting to note that the behaviour of the tests F and D at Kaprun Mooserboden and in Vienna was practically the same notwithstanding the distance between the two stations (300 km) and the difference in sea level (1800 m). The tests obeyed a general phenomena (Fig. 3).

7) *Diurnal Effect*

It seemed reasonable to wonder if there existed a diurnal effect, but because of the difficulties involved in carrying out continuous tests during the night (every night for several months), I have deferred such a study.

At the Tuebingen Astronomical Observatory, directed by Prof. Siedentopf, Dr. U. Mayer carried out tests at noon and at midnight during the months of May, June and July, 1958 for a total of 860 differential precipitations at noon and 780 at midnight. The results are collected in the Table XI.

TABLE XI

Tuebingen	*Day-night % T (Monthly averages)*					
	DAY			NIGHT		
1957	F	D	P	F	D	P
May	32.8	60.0	23.3	36.7	63.3	13.3
June	42.1	55.2	45.7	45.0	58.8	49.4
July	38.0	48.8	39.7	39.7	52.3	39.3
Averages	37.6	54.7	36.2	40.4	58.1	34.0
Brussels						
1958						
August-September (total averages)	59.6	54.3	56.3	56.0	55.0	47.1

I have obtained this data privately from Miss Mayer.

According to the Tuebingen results, it would seem that there is no noteworthy day-night effect. But the problem of diurnal variation must be studied further. It cannot be resolved with only two series of experiments a day. Madame Capel, who has conducted night-time tests at Uccle-Brussels, plans to resume this line of study at an opportune moment.

8) *Effect of Turbulence*

The attention of many scientists is today being drawn toward the *plasmas*—the fluids made up of electrically charged particles: positive ions and electrons. In the field of astrophysics, the atmospheres of stars, interstellar matter, nebulous gasses and comets are considered as being plasmas. In the fields of physics and physical-chemistry, metallic liquids and flames (above all salted flames, the flames of the electric arc etc.) are considered as being plasmas. It is not yet known if an electrolytic solution could be considered as being a plasma of a particular type.

Today a plasma theory has been developed (Alfven and others) which has also led to laboratory experiments which are opening up a new field: *Magnetohydrodynamics.* Magnetohydrodynamics is the study of the movement of an electrical conductor fluid in a magnetic field. The electrical currents resulting from the movement modify the field and, at the same time, as they flow in the magnetic field, produce mechanical forces which modify the movement of the fluid.

Since water, saline solutions and colloidal solutions are also fluids containing electrically-charged particles, it was expedient to establish whether the movement—the turbulence—of a liquid such as water was an important or an insignificant factor in our chemical tests.

To this end we effected, between March 19 and April 12, 1955, three hundred pairs of differential tests with water which had remained *motionless* for a long time, under a cardboard screen and under a copper screen. The precipitations were carried out in the open air. The general average was 50.0—the result due to chance.

Between March 19 and May 14, 1955, we carried out 350 pairs of differential tests with mechanically *stirred* water in two flasks, one inside a cardboard box and the other inside a copper box. The precipitations were carried out in the open air. The general average was 56.8. This was no longer chance. There had been a slight effect.

Between April 28 and July 15, 1956, we carried out a further 790 pairs of differential tests with water which was agitated by bubbling in two flasks, one inside a cardboard box and the other inside a copper box, both with the same modality. The general average was 54.4. Once again we were able to note an effect, slight but meaningful.

The daily data *smoothed out* over decades, vary between 45 and 55 and their fluctuations correspond perfectly with the fluctuations of test P (on another scale, of course). This demonstrated that the same factors that have influenced test P have influenced our experiment (Fig. 4).

Our experiments have thus revealed something highly unusual: *agitation—or turbulence—seems to be capable of determining the effect of the screen in the water.* But this is only the beginning. Unfortunately, the problem of the screens still has to be studied.

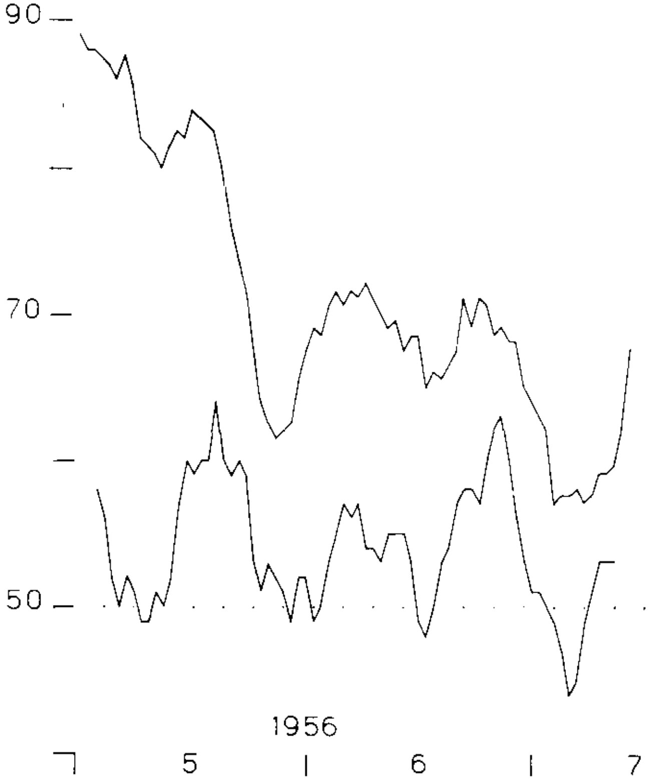

Fig. 4. *Above:* Test P. *Below:* test water stirred under cardboard—water stirred under copper. *On the abscissa:* the time. *On the ordinate:* the percentage of the two tests. Daily averages smoothed by ten.

The Routine Research

After having shown the results of studies specially conducted with the aim of understanding the properties of the chemical tests and of setting out the problems that will have to be resolved in the future, we may speak of the routine tests, conducted in Florence, at the Institute of Physical Chemistry of the University, with the particular aim of establishing whether the chemical tests respond to exterior actions and, in the affirmative case, whether it is possible to determine which are the external phenomena which influence the results of the chemical tests.

First I will set out the sum of the work carried out in this sphere (Table XII).

TABLE XII

NUMBER OF TESTS CONDUCTED BETWEEN MARCH 1, 1951 AND OCTOBER 31, 1960:

Florence	8^h30^m	14^h30^m or 12^h00^m	18^h30^m	*Total*
Test F	36035	35710	19350	91095
Test D	36038	35709	19350	91097
Test P	22150	22110	18110	62370
Test P IGY	....	12880	....	12880
			General total	257442

The figures concern the period from March 1, 1951, to October 31, 1960, a total of nine and a half years. The routine tests F, D and P were conducted every day, including holidays.

Beginning October 1, 1952, routine tests were initiated at Brussels by Madame Capel Boute, Chef des Travaux at the Institute of Electrochemistry and Metallurgy of the Université Libre, with the assent, assistance and advice of M. Decroly, Director of the Institute. Since July 1, 1957, studies have been carried out, thanks to the kindness of M. Bourgeois at the Belgian Royal Observatory, in a tiny wooden pavilion that has no metal constituents.

Beginning February 13, 1953, routine tests were carried out at Untertullnerbach, near Vienna, at the Wiental-Wasserleitung, thanks to the kind interest of engineer H. Doat, Director of the W. W. Society. The tests were interrupted on December 31, 1955, because the W. W. was taken over by the City of Vienna. It was truly unfortunate that a series of tests that had gone on for four years should be interrupted right in the middle of the IGY.

During the IGY and the subsequent IGC (International Geophysical Cooperation) routine tests were put into operation in several localities in the world (Table XIII).

TABLE XIII

Brussels (Uccle)—Observatoire Royal de Belgique.
Tuebingen—Astronomisches Institut der Universitaet.
Jungfraujoch—Meteorological Observatory.
Vienna (Untertullnerbach)—Wiental Wasserleitung.
Triest—Osservatorio Geofisico Sperimentale.
Genoa—Instituto Geofisico e Geodetico dell 'Università.
Bari (Castellana Grotte)—Distaccamento dell 'Istituto di Fisica dell 'Università.
Libreville—Service Météorologique du Gabon.
Leopoldville—Service Météorologique du Congo et de Ruanda Urundi.
Fort Dauphin—Services Météorologiques de Madagascar, des Comores et de la Réunion.
Kerguelen Islands—Etablissement Scientifique du Territoire des Terres Australes et Antarctiques Françaises (T.A.A.F.).

Sapporo—School of Medicine, Department of Physiology, Hokkaido University.
Kumamoto—Research Institute for Diathetic Medicine, Department of Physiology and Hygiene, Kumamoto University.
Nouvelle Amsterdam—Etablissement Scientifique du Territoire des Terres Australes et Antarctiques Françaises (T.A.A.F).
Base Roi Baudouin (Antarctica)—Etablissement du Centre National de Recherches Polaires de Belgique. 2. eme Expedition Antarctique.
Tromsoe—Nordlysobservatoriet.

The data gathered at Florence has been studied both by myself and by specialists: Prof. O. Burkard, University of Graz; Dr. Becker, Fraunofer Institute, Freiburg i/B; Dr. Mosetti, Geophysical Observatory, Trieste; Prof. Berg, University of Cologne; Dr. U. Mayer, University of Tuebingen.

The relationship between test D and solar activity immediately became evident. Nonetheless, it was necessary to establish statistically its degree of accuracy and to uncover any other relationships that might not appear so openly. It is in this area that the work of the above-named specialists has been so valuable. The following is a summary of the results they have attained.

TEST D

Secular Variation. The annual, monthly and daily averages reveal a secular variation, marked by a very low minimum in 1954, in perfect correspondence with the minimum of solar activity (Fig. 5). Becker has demonstrated that this correspondence is statistically valid.

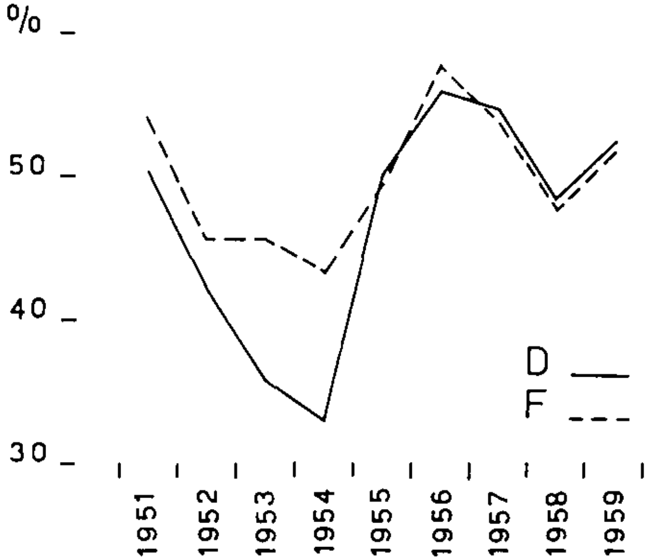

Fig. 5. Secular variation of test F (dotted line) and test D (black line). Annual averages. *On the abscissa:* time in years. *On the ordinate:* the percentages F and D. Note the minimum in 1954.

Annual Variation. One observes an annual variation marked by a very low minimum, corresponding to the month of March (Fig. 6). Also noticeable is a secondary minimum which corresponds with the month of August. Becker has demonstrated that the March minimum is real and that the August minimum is no longer so. We must wait until we have more information. But today, after ten years, the August minimum exists always and we can consider it. The existence of an annual rhythm leads one to envisage a relationship between the result of test D and the movement of the Earth. I will return to this point later.

Short-term Variation. These variations, often very marked, may be connected with different phenomena. During the long periods a parallelism was ascertained between the behaviour of test D and

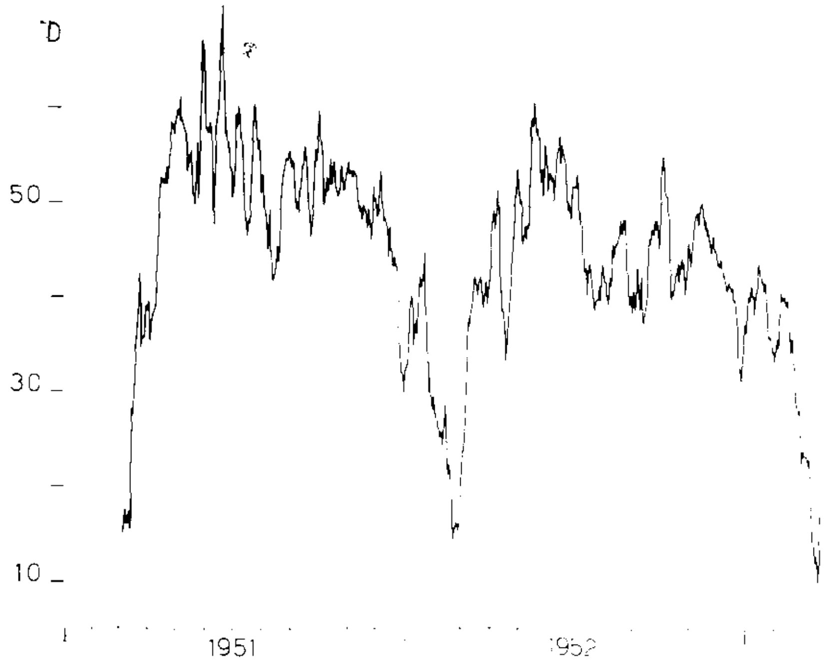

FIG. 6. Annual variation of test D. Daily averages smoothed by ten. *On the abscissa:* the time. *On the ordinate:* test D. Note the winter-spring minima.

the intensity of the cosmic radiation recorded by Prof. Steinmaurer at Hafelekar, near Innsbruck (Fig. 7). However, it has not been possible to pursue these studies at any length. The emission of particles from the sun is related to the solar activity.

TEST F

Secular Variation. Test F reveals a highly evident secular variation, although it is less marked than that of test D (Fig. 5). The variation also reveals a minimum which corresponds with 1954, but not as low as that of test D. The secular behaviour of test F appears disturbed. This should not be surprising, for test F is not protected, as is Test D, against natural electromagnetic fields. Becker has demonstrated that the general relationship between test F and solar activity is statistically valid.

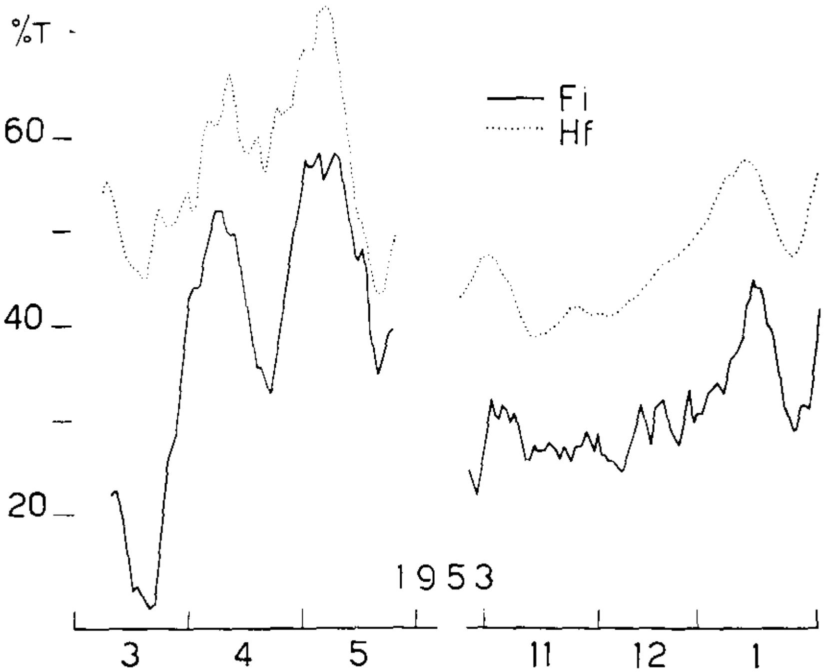

FIG. 7. Test D in Florence and the intensity of cosmic radiation on the Hafelekar (Innsbruck) during two periods of three months each. *On the abscissa:* the time. *On the ordinate:* test D and the intensity of the cosmic radiation (on arbitrary scale).

Annual Variation. Test F in the years of rare sun activity reveals an annual sinusoidal variation which differs greatly from that of test D. The minimum occurs in summer, the maximum in winter. This variation has been studied by Becker. In the years of great activity the behaviour of test F results not too differently from those of test D.

Short-term Variation. Test F reveals short-term variations which may be connected with different phenomena. Becker has demonstrated the existence of a very brilliant effect of *solar eruptions* and Burkard has revealed the existence of an effect of magnetic storms.

TEST P

Test P has been studied both by Becker and by Mayer. I can only list very briefly the information with which they have privately furnished me. These authors have not as yet published their results, which are quite recent. I will merely say that *test P must also be connected with solar activity*. The results of correlation are significant and positive for the Florence test. Test P has yielded significant and negative results in other localities. As I have said before, only in Florence do we utilise a completely sealed copper chamber. The other stations use nothing but a simple copper plate with which they cover half of the beakers in which the hydrolysis of oxychloride of bismuth is taking place. As we have said, the problem of test P is related to the problem of the screens.

Since laboratory tests have demonstrated that electromagnetic fields of relatively low frequency influence the flocculation and the sedimentation of the oxychloride of bismuth, it would also be necessary to relate the result of test P to the *atmospherics* or, in general, to terrestrial, solar and cosmic *radioelectric emission*. It would consequently be necessary to further relate it to the state of the ionosphere, that is to say, to solar phenomena. Everything is bound up in an incessantly-fluctuating whole.

THE COMPUTATION OF THE RESULTS

We have counted always the results, as we have said before. Upon the suggestion of Prof. Van der Elst, Mrs. Capel Boute has examined the possibility of increasing the results obtained by normal method without doing other chemical operations.

It is enough, in effect, for this to be able to note the succession order of the sedimentations in each series of different experiments.

Van der Elst had ascertained mathematically that one can also obtain for N pair of simultaneous precipitations N^2 results, but of those results only 2N-1 were independent.

One of the two successive operations standardised for the IGY research consist of 5 pairs of simultaneous precipitations for each test, and they were capable of giving 2.5-1   9 results instead of 5. Totally: 18 results instead of 10.

To realise this appreciable gain in the statistical field from daily results, without making new precipitations, Mrs. Capel Boute added a system which aided in establishing the order in which the sedimentations came. The data obtained from Van der Elst's method were called *complete results,* the normal data were called *diagonal results.*

The observation and calculation of the complete results in Brussels was made from December 1, 1957, until September 30, 1958. From a comparison of the diagonal with the complete data it was apparent that they give practically the same results. Our first method of counting was also good. We could therefore continue to use the normal method.

CHEMICAL TESTS AND TEMPERATURE

The routine experiments have given us a way of determining over a long period of time if the great fluctuation of the chemical tests depends upon the variations of the temperature of the environment. The great fluctuations of the chemical tests are *independent* of the temperature variations (Fig. 8).

In spite of the extreme complexity of the research, in spite of difficulties with regard to material and personnel, the chemical tests have yielded results that are very precise and very clear.

This is the first time that a very commonplace chemical operation, conducted according to a new method, relative and statistical, has provided the means of discovering whether important phenomena are taking place in surrounding space and, above all, on the Sun.

And, finally, *it is the first time that it has been possible to ascertain, by chemical means, whether something is disturbing our colloidal systems in evolution and, consequently, our biological systems.*

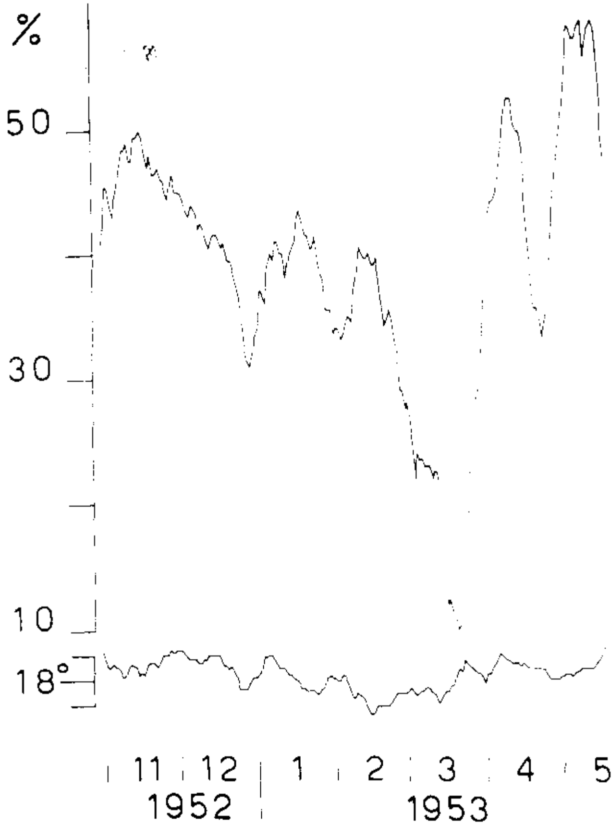

FIG. 8. Test D and the temperature of water during seven months. *Above:* test D. *Below:* the temperature of water. Daily averages smoothed by ten. The temperature of water fluctuates between two degrees (17 and 19°C). There is no correspondence between temperature and test D.

In figures 9, 10, 11 and 12 are shown the monthly averages of test F and D over ten years and three series of daily averages of test P.

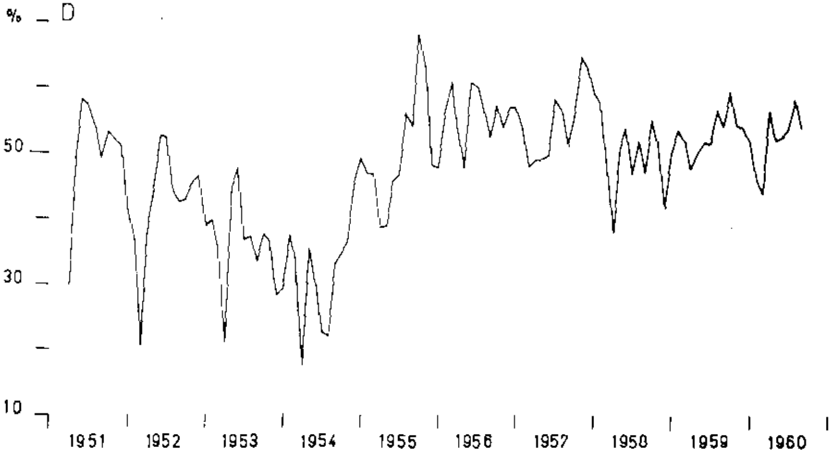

FIG. 9. Test D over ten years. Monthly averages. *On the abscissa:* the time. *On the ordinate:* test D. Note the secular variation.

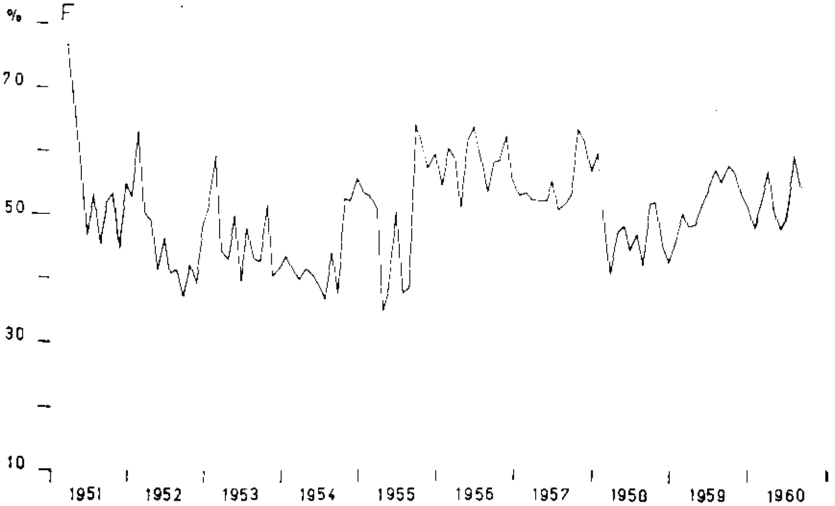

FIG. 10. Test F over ten years. Monthly averages. *On the abscissa:* the time. *On the ordinate:* test F.

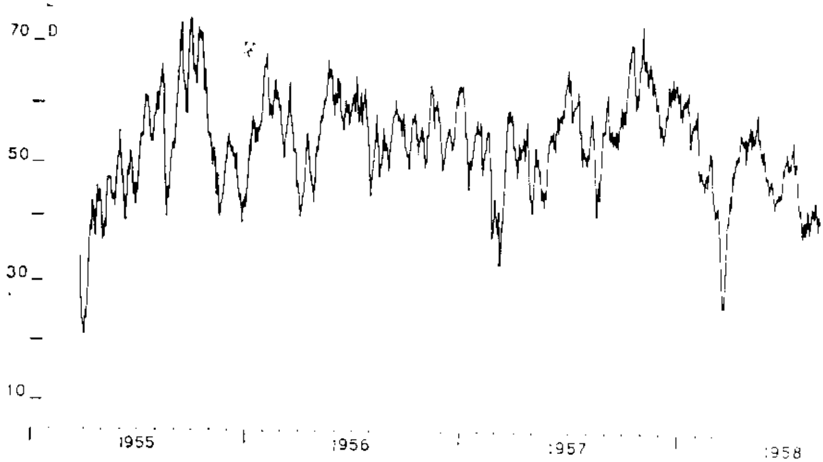

FIG. 11. Test D during the large resurgence of solar activity. Daily averages smoothed by ten. *On the abscissa:* the time. *On the ordinate:* test D.

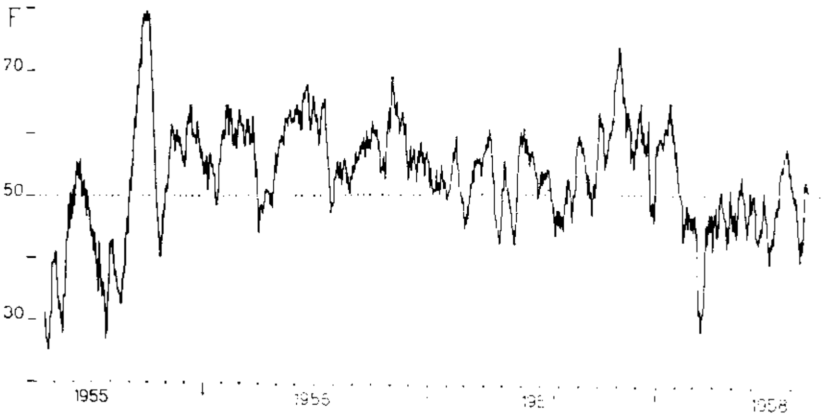

FIG. 12. Test F during the large resurgence of solar activity. Daily averages smoothed by ten. *On the abscissa:* the time. *On the ordinate:* test F.

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POLYMERIZATION AS A CHEMICAL TEST

The Polymerization of the Acrylonitryle as a Chemical Test

New and more precise experiments on acrylonitryle were carried out in 1960, according to the test P techniques.

A single solution of acrylonitryle in water, to which was added the proper quantity of potassium persulphate as an activator, was divided in equal measure into 20 flasks. Ten flasks were placed in a blackened cardboard box and the remaining ten were placed in a copper container which was likewise blackened and which was identical in shape and dimensions to the first. The two containers were then put into a double-walled cardboard box which was later wrapped in a layer of wool for better insulation. It was verified that the apparatus assured the same thermic history in the two containers (between 0.1° C). After 24 hours the boxes were opened and the polymer which had formed in the flasks was filtered, dried and weighed. The surface tension of the clear liquid was measured.

The surface tension of an aqueous acrylonitryle solution lessens as the quantity of monomer acrylonitryle present in the solution increases. Polymer acrylonitryle has no effect on surface tension. For this reason, the measurement of surface tension tells us how much monomer acrylonitryle has remained in the solution and thus *how* much acrylonitryle has been polymerized.

Since the polymer is hydrated, the quantity of water remaining on the polymer varies depending on the length of the polymer molecules: many short chains hold more water than fewer long chains, the amount of polymer acrylonitryle being the same, because a greater number of heads is involved. The *gross weight* of the polymer may thus vary depending upon the manner in which it is polymerized, even though it contains the same quantity of acrylonitryle.

The weight of polymer and the quantity of acrylonitryle polymerized do not necessarily correspond. For this reason we have taken both figures into account, the weight of the polymer and the quantity of acrylonitryle polymerized.

The thermostatic cardboard box was placed in a room situated on the first floor of our Institute, just below the roof, which is of wood and terra cotta and contains no noteworthy metal components, and therefore not able to screen appreciably the atmospherics. This was verified with an appropriate instrument.

Everything was arranged so that after 36 hours the quantity of polymer formed should not amount to more than half of the monomer introduced, and so that it should, indeed, be considerably less.

At first, we considered only the weight of the polymer formed. The study of the fluctuations in the quantity of acrylonitryle polymerized (measured by surface tension) was postponed until a later date.

For the sake of simplicity we noted *the total weight* of the polymer acrylonitryle obtained from the 10 flasks in the cardboard box and the 10 flasks in the copper container; we then counted *how many times in the space of one month the quantity of polymer had been greater in the copper container* and related the result to 100. In this way, the operation came to correspond to a true and proper test P.

In the room under the roof, the temperature varied considerably from one day to another and with the arrival of the first summer heat it was often necessary to reduce the quantity of persulphate added to the solution so that the polymerization would not take place too rapidly, reaching a total polymerization of monomer. This did not invalidate the differential method.

The percentage of times that a greater weight of polymer was obtained in the copper container in the course of a month *varied over the months.* The patterns of the monthly percentages relative to the polymerization under the roof were also parallel to that of inorganic test P(oxychloride of bismuth).

This means that the very actions that had modified the polymerization process had also modified the precipitation of oxychloride of bismuth.

One sees that these actions had to be a certain duration, because the process of polymerization as desired by us is very slow. In spite of this, the total result was practically the same as that of the inorganic test P.

Since the duration of polymerization may be controlled at will, we are able, by employing acrylonitryle, to obtain tests which integrate the effects of external forces in the best possible way.

Polymerization and the Low-frequency Electromagnetic Field

In Chapter III we referred briefly to the subject of polymerization of acrylonitryle in an aqueous solution, treating the problem as one does a problem of natural science. We tried to show how the phenomena which take place in the space which surrounds us act upon the polymerization of acrylonitryle.

It is not hard to admit to a perceivable influence due to spacial phenomena; the free radicals play a very important role in the polymerization of many substances. We know that free radicals of water prime the polymerization of acrylonitryle. These radicals are generated not only by appropriate chemical reactions (e.g., hydrogen peroxide + ferrous sulphate) and by other physical-chemical processes, but also by ionizing radiations.

It is enough to know then that the ionizing radiations originating in surrounding space can reach the Earth, in order to concede that the *polymerization of acrylonitryle will always be subject to spontaneously established conditions* which are beyond our control, and which *fluctuate incessantly.*

However, natural phenomena *other than ionizing radiations* can influence the process of polymerization. One can demonstrate the existence of this influence in a rather general way by conducting tests outside of and within a thin copper screen.

Piccardi and Cini have studied at length the influence exercised by a low-frequency electromagnetic field (10 kHz) on the precipitation of oxychloride of bismuth and they wanted to study the influence of the same low-frequencies on the polymerization of acrylonitryle.

The new experiments were routine and for this reason they were standardized.

Solution A: Monomer acrylonitryle (Badische-Anilin und Soda Fabrik) dissolved in distilled water, in the proportion of 60 ml per litre of solution.

Solution B: 40 gr of persulphate of ammonia dissolved in 1 litre of distilled water.

Solution C: 3.5 gr of bisulphite of sodium dissolved in 1 litre of distilled water.

To each litre of Solution A we added 10 ml of Solution B and 20 ml of Solution C (Solution ABC). Solution ABC thus prepared remained perfectly limpid a sufficiently long time, at least a half hour at 20° C; it could be divided and placed in several containers and the containers taken and put away without difficulty, before the polymerization began to take place.

Blank Tests

Solution ABC was poured into three sets of 10 flasks, numbered 1, 2 and 3. The flasks, of Pyrex glass, had a capacity of 100 ml. Into each flask we poured only 50 ml of solution so that the flasks were half filled and the solution offered the greatest possible surface towards the top. After filling, the flasks were closed with rubber stoppers.

The three sets of flasks were placed in one wooden box, which was long and narrow, in three parallel rows. The box was sealed by a wooden cover and it was left by itself in a closed room. After 12-14 hours the flasks were removed and their contents filtered. The filtering was carried out with a pump, using three identical funnels, numbered 1, 2 and 3, each receiving the contents of the corresponding set. Thus we collected the total quantity of polymer formed in each set. The polymer was dried at 110° C, until a constancy of weight was reached, then it was weighed. The quantity of monomer remaining in the liquid was checked by measurements of surface tension (4).

The weights of polymer obtained varied frequently from one day to another, but, *for one single experiment, the weights given by each set were equal or nearly equal.* The differences never surpassed 2%.

The method of operation therefore seemed to be very satisfactory.

Tests with the Electromagnetic Field

The flasks of the three sets were filled with Solution ABC as in the case of the blank tests. Then were distributed in the following fashion:

Set 1 — The flasks were placed in a cylindrical copper container, set on the ground, which could be completely sealed by a copper cover. On the inside of this container, a second, smaller, cylinder of copper was fixed coaxially, electrically isolated from the first. The flasks were placed between the two cylinders. Then the cover was put in place and an electromagnetic field was applied between the two cylinders.

The field was produced by a generator with a power of 10 W. the AF Mod. 1C: 101, of the Firm Damiani & Ciappi, Florence. This was the same generator used for studying the precipitation of oxychloride of bismuth. It was regulated on a 30 km wave length, that is to say on a frequency of 10 kHz, as in the case of the oxychloride of bismuth. The copper screen constituted a shield against the exterior fields.

Set 2 – The flasks were set in a container quite identical to that of Set 1. The position of the flasks was the same. Only, the electromagnetic field was not applied. The copper screen constituted a shield against the external field.

Set 3 – The flasks were set in a blackened cardboard container, identical in size and shape to the two previously described. The position of the flasks was again the same; no electromagnetic field, no copper enclosing the flasks. The cardboard screen did not constitute a shield against the external fields.

The tests were begun at 7 p.m. and were interrupted at 9 o'clock the following morning, for the polymerization was not to be allowed to surpass, generally, 50% of the monomer. The three containers were permanently kept in a room with the temperature carefully regulated at 21 + 0.1° C. The generator, completely screened, was also in the same room. A field indicator tuned on the 30 km wave length did not show any appreciable emission in the room while the generator was running.

We measured the temperature inside the containers and inside the flasks and found that if polymerization did not take place, the temperature inside the flasks was identical to that of the room.

If polymerization took place, the temperature in the flasks rose some tenth of a degree because of the heat given off by the polymerization.

The bisulphite sodium solution was also daily controlled by iodometry, so as to assure the constancy of its reductive power.

Experiments were made from December 1, 1959 to January 7, 1960.

Three tests out of 37 did not give any polymer, in spite of the constancy of the experimental conditions. These tests *are not be rejected* but must be considered as quite successful tests which gave a nil weight of polymer.

The 34 remaining tests gave the following results:

1) The total weights of polymer given in the three sets, in one single experiment, *differed among themselves much more than was the case in the blank tests: up to 50%!*

2) Comparing the weights of Set 1 (field and shield) with the corresponding weights of Set 2 (no field, shield), it was found that Set 1 gave a greater weight of polymer 19 times over 34. That is about 56%.

3) Comparing the weights of Set 1 (field and shield) with the corresponding weights of Set 3 (no field, no shield), it was found that Set 1 gave a greater weight of polymer 20 times over 34. That is about 59%.

4) Comparing the weights of Set 2 (no field, shield) with the corresponding weights of Set 3 (no field, no shield), it was found that Set 2 gave a greater weight of polymer 19 times over 33. That is about 57%.

We therefore observed *an effect of the electromagnetic field*, small but appreciable, and *an effect of shield*, also small but appreciable. It is evident that, being given the chemical identity of the polymerizable material and the identity of the temperature and of the other traditional variables, *the factors responsible for disturbing the polymerization were only those introduced by ourselves (electromagnetic field and shield) or those of a spacial origin*. But in this connection it is necessary to take note of an even more important fact, it seems to us:

5) The total weight of polymer collected in a set of 10 flasks varies greatly from one day to another: from 0 to 19 gr, for 30 gr of monomer introduced into the 10 flasks; that is to say, from 0 to 63% of the monomer. All of this in spite of the perfect uniformity of solutions A, B and C, which were prepared and measured anew each day.

The variation is felt *at the same time by the three sets*, which simultaneously give either very small weights, medium weights, large weights or very large weights.

Correlation with Chemical Test P

Evidently there are *natural phenomena which operate with much more force than our fields and screens*. We have therefore correlated the weights of polymer furnished by Set 3 (no field, no shield) with the results of *Test P* (5) which were registered at Florence.

The correlation is significant—or better—very good. The Rawer's correlation number, is indeed 0.28. It therefore becomes necessary to think that the observed variations are truly due to the influence of spacial phenomena.

* * *

The polymerization of acrylonitryle in an aqueous medium, which is certainly dependent on the structure of water and on variations in this structure, seems then to be influenced by:

1) a low-frequency electromagnetic field;

2) a metal shield;

3) natural phenomena, for the moment unidentified, which operate much more powerfully than an electromagnetic field of 10 kHz, and the effect is therefore not completely eliminated by a thin copper shield.

The same "forces" which act upon the polymerization of acrylonitryle are felt by a quite different chemical process: the hydrolysis of trichloride of bismuth with formation of insoluble oxychloride in a colloidal state. But under these conditions, polymerization is a rather long process, hydrolysis of trichloride of bismuth is extremely rapid.

These two processes, so different, have nothing in common save the medium in which they take place: *water.*

This is most instructive for us.

A Remark

In my exposition in this particular chapter perhaps I have gone too far into minute details prolonging the discussion, but, given the complexity and singularity of the material, there was no other recourse.

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APPENDIX

(Instructions for IGY research)

Preparation of the Bismuth Chloride Solution

Chemicals

1) Concentrated hydrochloric acid (commercial pure).
2) Bismuth carbonate (commercial).
3) Water (drinkable).

Preparation

Dilute 1:8 the acid with drinkable water, for ex. add 7 liters water to 1 liter acid. We obtain 8 liters hydrochloric acid 1.5 N. (approximately).

Dissolve 35 grms bismuth carbonate per liter acid 1.5 N. The solution is ready for use. It is necessary to ascertain if the dissolution is complete. With a greater amount of solution (50-60 liters) the dissolution process is complete after 24 hours about. It is preferable to prepare a larger amount of solution and keep it in a glass or plastic demijohn.

Recovering

Bismuth is dear. It is convenient to recover it. Assemble the contents of the beakers after the experiment, decant the clear liquid and keep the white precipitate of BiOCl.

Remark

It is not necessary that the composition of the solution be absolutely exact. It is instead *necessary* to take the solution from the same bottle for each experiment.

P-Test

Number 10 beakers from 1 to 10 with blue colour and 10 with red colour.

Pour in each numbered beaker 5 ml solution.

Take 20 beakers without number and pour 25 ml water in each.

Place the blue numbered beakers in open air and the red numbered beakers under a large plate of copper—or better in a room completely covered with copper plates.

Place 10 beakers without number (containing 25 ml water) near the blue numbered beakers and 10 near the red numbered beakers.

Pour the water simultaneously in a blue numbered beaker and in a red numbered beaker with same number.

When the sedimentation begins, take the beakers and pair the beakers with the same number, one blue and the other red.

Read how many times the precipitate is lower in the red numbered beakers and calculate the percentage of these. This percentage is the numerical answer of the chemical test P.

F-Test and D-Test

For F and D test the operation is similar, but we must fill the blue and the red numbered beakers alternatively with normal and activated water—that is, the *odd* numbered with normal and the *even* numbered with activated water.

Form the pair with an odd numbered and an even numbered beaker of the same colour.

Better than glass beakers are polystyrol tubes for pharmaceutical use. The diameter of the beakers is approximately 30 mm (internal).

For activation use a glass bulb with mercury and neon (already described in this chapter) or magnetic field.

Mechanization of Chemical Tests

For the research during the IGY a syncronous mixer (Model 20 A) was built which permits the effecting of 20 precipitations simultaneously under standard conditions.

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Chapter IV

SOLAR PHENOMENA AND CHEMICAL TESTS
A SOLAR HYPOTHESIS

SOLAR ACTIVITY AND CHEMICAL TESTS

IN ORDER TO SHOW whether there exist a real dependence between solar activity (measured roughly using Wolf's R number) and the results of tests F and D, Becker carried out a general study on the subject.

First of all he considered the average of the three *magnitudes* R, F and D over periods of 27 days so that each group of 27 days represented the solar rotations according to Bartels. The first rotation considered was the 1612, which goes from March 13 to April 8, 1951, the last was the 1666, which goes from March 10 to April 5, 1955.

Directly comparing the rotation averages of D and R, a strict relationship is already discernible between the two magnitudes. The relationship becomes even better if an R average belonging to a given rotation is compared with the D average of the successive rotation. This fact must definitely be borne in mind in climatological studies!

In order to compare the oscillations of a short period, with a duration of from some weeks to some months, Becker calculated the current averages of five solar rotations. Five rotations are equivalent to 135 days. The 135-day duration still makes it possible to study an eventual annual variation (the relationship between R and D becomes that seen in Fig. 13). The constellations of points are so tightly arranged around the regression line that the calculation of the rotation coefficient becomes truly superfluous. The regression lines are:

test D $\%T = 0.34.\ R + 29$

test F $\%T = 0.23.\ R + 40$

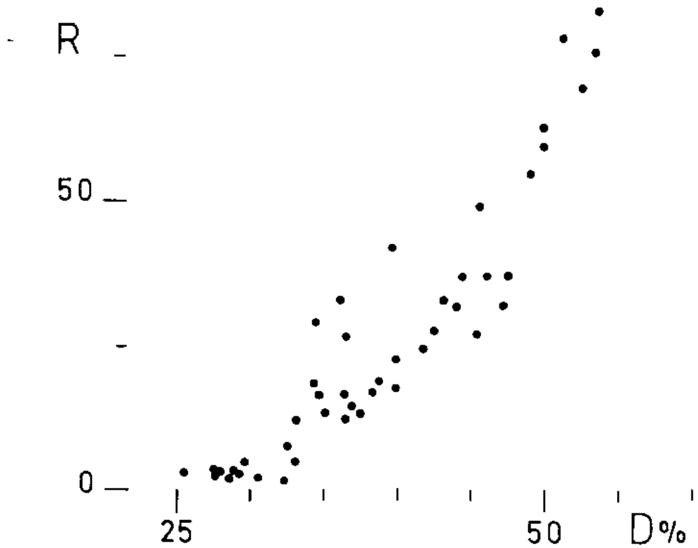

FIG. 13. Correlation between test D and solar activity, according to Becker. *On the abscissa:* test D. *On the ordinate:* Wolf's number R. Averages of rotation smoothed by fives.

To be certain that the discovered relationships were not due to a mere correlation between two magnitudes which were both by chance in the process of diminishing, Becker calculated the current averages of 13 rotations of R, of F and of D, and compared them. Figure 14 gives an idea of the results of this comparison. The three magnitudes reveal a minimum in correspondence with the 1653 rotations—that is, in correspondence with the minimum of solar activity during the period April-May, 1954.

The three curves begin tightly united, they diminish, touch the minimum and rise together once again with such perfect agreement that it is not possible to consider this an accidental or ordinary correlation. Becker, at that time, did not believe that the marked annual minimum of test D, recurring regularly at the end of winter or at the beginning of spring, had to be considered as a separate phenomenon, independent of solar activity. According to him, it could have been a minimum which depended on a chance minimum of solar activity; but then, the persistence of the

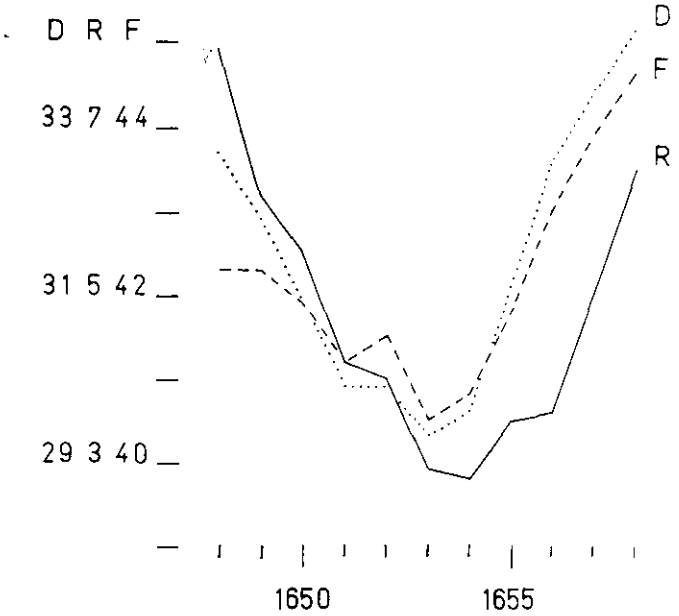

FIG. 14. Test D *(dotted line)*, test F *(heavy line)* and R, Wolf's number *(continual line)*, in function of time. *On the abscissa:* the time in solar rotations according to Bartels. *On the ordinate:* tests F and D and Wolf's number R. Rotation averages smoothed to 13.

annual minimum of test D, without R presenting any corresponding minimum, led him to review the problem some years later. In fact, after due calculation, Becker found that while *the spring minimum of test D is statistically real, the presumed spring minimum of the solar spots is statistically unreal.* From a statistical point of view, the test D minimum exists, the R minimum does not exist. The test D minimum therefore has nothing to do with solar activity.

CROMOSPHERIC ERUPTIONS AND CHEMICAL TESTS

Having verified the existence of a relationship between Wolf's number and the results of tests F and D, Becker wanted to find out whether one of the phenomena which depend on solar activity was capable of influencing the chemical tests by itself. He examined the more conspicuous second and third class cromospheric eruptions reported in the Quarterly Bulletin on Solar Activity. The eruptions chosen were those observed contemporaneously by various observatories, with the same intensity, or those recorded at stations possessing a known and reproduceable scale of intensity. For the period 1951 to 1953, 37 eruptions remained after the choice was made.

The days in which the chosen solar eruptions took place were used as point days (zero days, Stichtage) for the superimposition of the results of test F and D, according to the *n-method.*

Figure 15 illustrates the average values of the results of tests F and D, on the superimposed days—that is, on the four days preceding that of the eruption (−4, −3, −2, −1), on the day of eruption (0), on the four days following the eruption (+1, +2, +3,

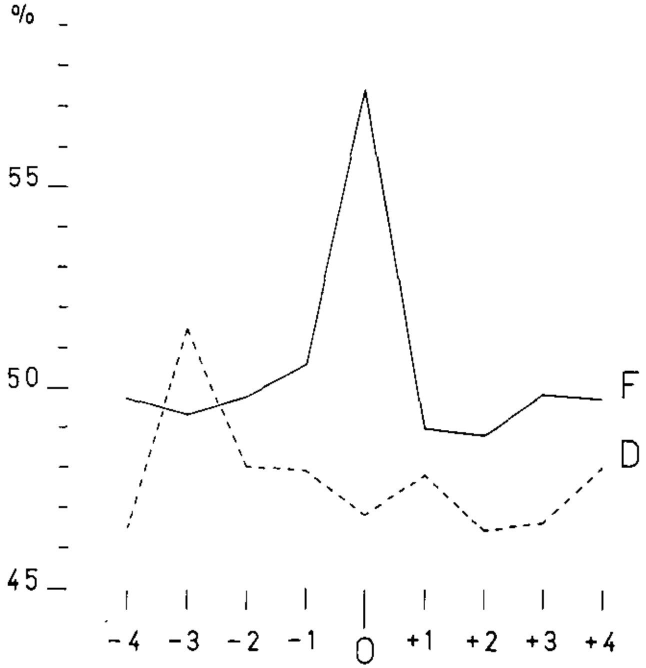

FIG. 15. Effect of solar eruptions on test F *(continual line)* and test D *(dotted line),* according to Becker. Method of superposed epochs. *On the abscissa:* the day of eruption (O), four days before and four days after. *On the ordinate:* the averages of tests F and D. Note how the eruption influence test F and not test D

+4). The effect of the eruption appears sharply in test F, nil in test D. The effect of the eruption consists of a sharp rise of value in test F, directly observable in 80% of the single cases.

Table XIV illustrates the average values of the superimposed data, year by year.

TABLE XIV

Year	*Days*								
	—4	*—3*	*—2*	*—1*	*0*	*+1*	*+2*	*+3*	*+4*
1951	53.6	57.5	60.2	60.2	63.7	60.1	55.7	55.8	55.0
1952	45.1	43.6	39.8	40.6	54.8	39.1	41.2	46.5	47.2
1953	44.0	40.0	42.0	46.0	57.0	40.0	48.8	44.0	45.0

The effect is highly evident even for the individual years.

In order to check the validity of the discovered relationship, Becker treated the considered data with a special method, calculating the average of the values of F on the four days preceding and the four days following the day of the eruption. The dispersion, comparing proved to be ±2.74. Then, on the basis of this dispersion, comparing the displacement of the F values on the days of the eruption with the remaining eight days, he found that the shift average is +9.5. The effect of the eruption is therefore 3.5 times greater than the dispersion (found on the basis of the particular method adopted) and is thus statistically certain.

Becker then examined the differences between the average values of the single superimposed days, submitting them to the *t-test* proof. He was thus able to show in a completely different manner that the relationship arrived at was perfectly dependable. Even subjecting the relationship to a highly exacting criterion, that of requiring that the remainder probability (*Restwahrscheinlichkeit*) not surpass the value of 0.3%, the relationship remained fully confirmed.

Then Becker studied the annual behaviour of the two tests, F and D, and found that while test F revealed a sinusoidal behaviour with a minimum in the summer, test D revealed a non-sinusoidal behaviour. We have already referred and will again refer to the importance of this fact and its consequences.

Burkard, studying the results of tests F and D as compared with various geophysical phenomena, found that the chemical tests indicated some connection or other with the variation in pressure in the 96 mb stratum or with the density of first five km of the troposphere or with geomagnetic disturbances. But the scarcity of observational material did not permit him to certify the discovered relationships with the finality that he would have wished.

However, note must be made in this connection that magnetic storms and phenomena of the high atmosphere largely depend on solar phenomena; as a result, the chemical tests, which are certainly related to solar phenomena, also had to be related more or less closely with the geophysical phenomena studied by Burkard.

The problem of the relationships between solar and geophysical phenomena and chemical tests was later critically analysed by Berg. The results of his critical examination, embracing all of the results published by the various authors up to that time, were published in *Vol. XXX of Probleme der Kosmischen Physik.:* "Solar terrestrische Beziehungen in Meteorologie und Biologie." Berg's final judgment was as following:

"The T% is not only a function similar to R. The relationship binding the T% to solar activity is much more developed and complex.

"Here, for the first time, we have the connection between a terrestrial experiment and a solar phenomena. This connection remains valid, even adopting the severe conventional statistical criterion of a remainder probability not over 0.3%. As a result of this, even the relationships disclosed by other authors which have already been recognized as being less certain or as being of a merely indicative nature, take on a certain significance."

CHEMICAL TEST D AND SOLAR ACTIVITY REPORT OVER TEN YEARS

A more profound study of the relationship between R and D was not too easy because of a conspicuous disturbance inflicted upon test D by a factor that was *non-solar* or, more precisely, that was not solar activity, and thus independent of Wolf's number. The factor in question is to be linked with the motion of the

Earth, since the disturbance is periodical and this period is one year. (3)

In 1956, Becker formulated a mathematical procedure capable of freeing the relationship between R and D from the relationship between D and the non-solar factor. The procedure was as follows:

1) To subdivide the daily values of R and D into groups of 27, according to the solar rotations of Bartels, and to calculate the *rotation averages*, both of R and of D.

2) To calculate the average of the first 13 rotation averages and to allot it to the seventh of the 13 rotations considered, both of R and of D.

3) Step by step, to shift the averages to 13; that is, to "smooth" the rotation averages, both of R and D, to 13.

Thirteen rotations cover 351 days; that is nearly a year. Each average smoothed to 13 thus approximately represents an *annual average*. Since the annual average takes in and reduces the annual variation of D almost to zero, one obtains, by comparing the smoothed averages of R and of D, a *relationship that is exempt, or nearly so, from the influx of the non-solar factor.*

On the basis of this procedure, the behaviour of D as related with R was studied in 70 consecutive rotations, from 1618 to 1681, inclusive, with a minimum of solar activity from April to May, 1954 (4).

Today, after nine years of uninterrupted experimentation, *after having encountered a minimum and a maximum of solar activity*, I am in a position to set out the general characteristics of the relationship between R and D, determined on the basis of the excellent method proposed by Becker.

In the graph of Figure 16 referred to, *3 quantities are represented:* R, on the abscissa; D, on the ordinate; *the time*, on the plane of the graph, is represented by the number of the order of the rotations.

The relationship between R and D is strikingly evidenced.

Starting from rotation 1618, D, in the course of time, fell little by little as R fell, until reaching the minimum value in correspond-

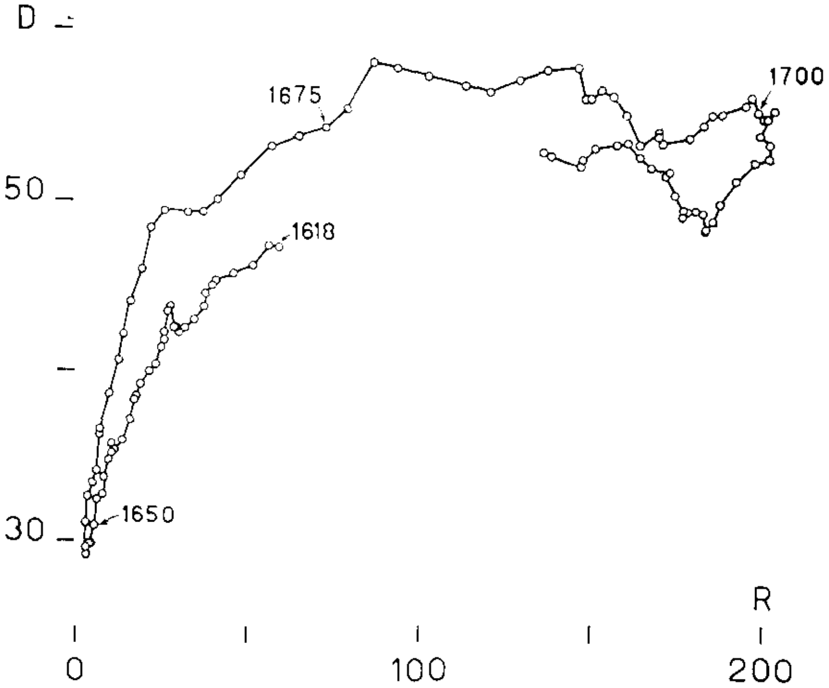

FIG. 16. Relation between test D and Wolf's number R, according to Becker. *On the abscissa:* Wolf's number R. *On the ordinate:* test D. Rotation averages smoothed to 13. The numbers on the graph indicate the rotation numbers according to Bartels.

ence with the minimum value of R (rotation 1653). The old solar cycle had reached its conclusion.

Following this, D, in the course of time, rose by degrees as R rose, and the new solar cycle was evolving.

But D did not follow R to the point of maximum value. While R, surpassing the value of 100, continued to—even surpassing (by a slight degree)—the value of 200, D remained practically constant, as if at that moment it had reached a *state of saturation.* The oscillations or irregularities that are noted in its behaviour are very likely due to a carryover from the annual variation independent of R, not completely eliminated by the smoothing to 13.

During the diminishing stage of the solar activity, D followed a path slightly different from that followed in the rising stage of the very same solar activity, remaining at inferior values and clearly showing a tendency to adhere to the course followed during the diminishing stage of the preceding solar cycle. Test D therefore presents *hysteris* compared with R.

Saturation and *hysteris* are highly important facts for anyone wishing to study phenomena revealed by chemical tests and the chemical tests themselves.

FLUCTUATIONS OF THE CHEMICAL TESTS AND NATURAL PHENOMENA

The Results of the Periodical Analysis

Understanding the relationship between the results of our chemical tests and those of other natural fluctuating phenomena was a matter of greatest importance to us. There existed a particular means, highly suitable for the carrying out of this type of investigation: the periodical analysis according to Vercelli and Labrouste. It was proposed by Dr. Mosetti of the Trieste Geophysical Observatory who later concerned himself with its application.

Vercelli and Labrouste's periodical analysis is a very different thing from the periodic analysis according to Fourier. In resolving a function of time in periodicities, periodical analysis reveals any series of periodicity, while periodic analysis reveals only harmonic series. Applied to phenomena of a harmonic nature (tides, for example), periodical analysis gives the same results as periodic analysis. Since the results of our tests were not of a harmonic nature, it was infinitely preferable to make use of the Vercelli's periodical analysis, which allows much greater scope to the investigation.

The periodical analysis conducted by Mosetti on the results of the chemical tests revealed that the very same results, considered as functions of time, could be resolved into many sinusoidal periodicities, whose lengths when placed in ascending order formed a geometrical progression whose rate is $\sqrt{2}$.

On that occasion, Mosetti made the observation that the data regarding very many fluctuating natural phenomena, both physical and biological, when treated with Vercelli and Labrouste's periodical analysis or similar methods, gave rise at first glance to periods of the same length. This held true examining the periodicity of the order of days and the periodicity of the order of months or years. The periods thus established almost always appeared to be arrangeable according to a geometric progression with an average rate of $\sqrt{2}$.

Taking a year as the basic period and calculating multiples and submultiples according to $\sqrt{2}$, a theoretical succession of values may be constructed which faithfully approximates the succession of periods found in the case of natural phenomena.

This observation is of the greatest importance even though it must be considered as being very rough. The most disparate phenomena follow the $\sqrt{2}$ law:

raininess (rainfall)
solar spots
solar activity
magnetic activity
sun hours
solar radiation
cancer mortality
frequency of pulmonary diseases
tree growth
sea levels
atmospheric pressure
barometric waves
chemical test F
chemical test D
chemical test P
varves

The fact the chemical tests obey a very general law obliges us to think that the precipitations of oxychloride of bismuth have been influenced by the same events which have influenced other phenomena in the past and which are continuing to influence them now. Even this had to happen if the chemical tests were truly capable of taking into account spacial actions as, indeed, they were.

What is extraordinarily interesting, because of the general deductions which it makes possible, is the study of *varves.*

Varves, as is well-known, are finely stratified sediments, often alternating sands and clays, that form in placid waters: lakes, ponds, marshes, etc., in glacial zones. Both recent varves, in the process of formation, and fossilized varves have been studied. According to Zeuner, the same periodic oscillations have been discerned on the basis of periodical analysis, in fossilized varves as have been discerned in the case of other natural phenomena.

If we take a year as the basic period, one of the multiples, according to $\sqrt{2}$, is 11.4 years—that is, the average period of solar spots. The following corresponding periods have been observed in fossilized varves:

Precambrian	11.3	years
Superior Devonian	11.4	"
Inferior Carboniferous	11.4	"
Eocene	12	"
Oligocene	11.5	"

Periodicities existed even hundreds of millions of years ago, and thus were the same as today with respect to one of the more important cycles, that of sun spots.

As pointed out earlier, the chemical tests obey the $\sqrt{2}$ law. Our experiments have not yet covered an entire solar cycle, but the greater part of one has been covered: nine and one-half years out of eleven. What we have seen is already sufficiently clear There is no doubt that chemical test D will close its cycle together with the sun spots.

While I am on the subject, I would like to point out that in the field of climatology, the periodical analysis according to Vercelli and Labrouste will be a highly valued means of investigation because in revealing, as it does, true rhythms (not choosing just the harmonic rhythms), it can show which phenomena are in true mutual relationship, even if the raw data do not reveal similar behaviours. Test F and test D, during the diminishing phase of the old solar cycle, revealed what was apparently a highly varying behaviour, but under periodical analysis they revealed the same periods.

Thus periodical analysis would be an analytical method to introduce in order to establish once and for all which are the periods comprising the periodicity of the natural phenomena of climatological interest.

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A SOLAR HYPOTHESIS

Experimental Data

Among the regularly-conducted studies which have been under way since March 1, 1951, there was one which, we believe, merited development from an astronomical and geophysical point of view: the study that was carried out by means of test D.

The results of test D may be correlated with *solar activity R.* For practical reasons, we have adopted the spot number R (Wolf's number), published in Zurich by Prof. Waldemeyer, as the measure of solar activity.

The correspondence between D and R is shown in Figure 17. On the abscissa: the time (in years); on the ordinate: the annual average of D and of R. The parallelism of the two curves is perfect: the test D minimum falls in coincidence with the R minimum.

But test D, in addition to the secular variation, also reveals a pronounced annual variation marked by a very low minimum in correspondence with the month of March.

There is no doubt today about the actual existence of this minimum, from a statistical point of view. *This minimum is not accidental.*

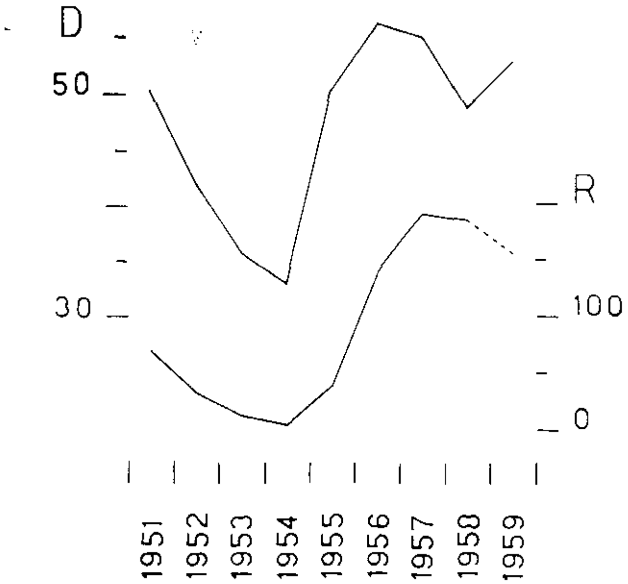

FIG. 17. Test D *(above)* and Wolf's number R *(below)*. Annual averages. *On the abscissa:* the time in years. *On the ordinate:* test D (scale at the left) and R (scale at the right). Note the parallelism of the two curves.

On the other hand, R reveals no annual variation; this fact is demonstrated in Figure 18. On the abscissa: the 12 months of the years; on the ordinate: the monthly averages of D, and the monthly averages of R over 9½ years.

The behaviour of R is completely different from that of test D. *The annual minimum of D is therefore not to be connected with solar activity.*

To what can we attribute this minimum which is so low and which recurs every year, roughly at the same time, with astonishing constancy? This minimum has appeared for 10 consecutive years, very marked when solar activity was reduced, less marked and more or less distorted when solar activity was strong and violent, as during the beginning of the last solar cycle. The annual minimum of D has also been recorded at Vienna in 1953 and 1954 during the minimum of solar activity, by Piccardi and Doat.

The annual variation of D is not sinusoidal but is, instead, cycloidal. The strange nature of this variation has led us to search

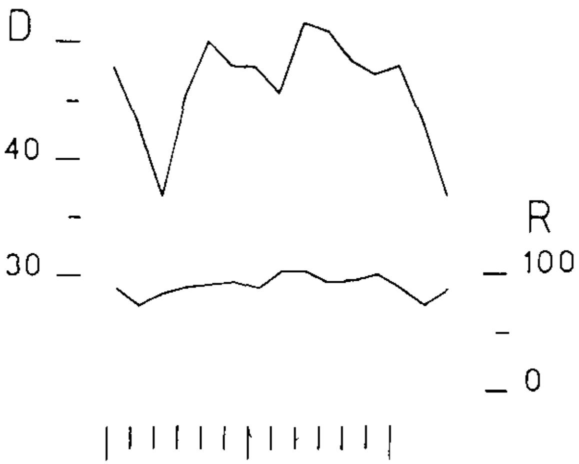

FIG. 18. Test D *(above)* and Wolf's number R *(below)* in the course of a year. *On the abscissa:* the twelve months of the year. *On the ordinate:* test D *(left scale)* and Wolf's number R *(right scale).* Monthly averages on nine yers. Note the marked minimum of Test D in March and the little minimum in August. Note also how Wolf's number does not present minima in correspondence with March and August. The minima od test D have nothing to do with solar activity.

for, in the space which surrounds us, a phenomenon which might manifest a similar behaviour, occurring all by itself with an annual rhythm. The result of the search has been the *solar hypothesis* which is the subject of this chapter.

The Solar Hypothesis

We know that the sun moves, together with all the bodies which are bound to it, towards the constellation Hercules. Standard apex: $\propto = 270^\circ$, $\zeta = 30^\circ$ (in equatorial coordinates). Its motion is uniform and rectilinear; its speed (constant for us): 19-20 Km/sec.

We know too that the Earth turns about the sun at an approximate average speed of 30 km/sec.

From the combination of these two motions, one rectilinear and uniform, the other circular and uniform roughly speaking, a *helicoidal trajectory* results. *This is the helicoidal motion of the Earth in the Galaxy, referred* to the neighboring stars (Fig. 19).

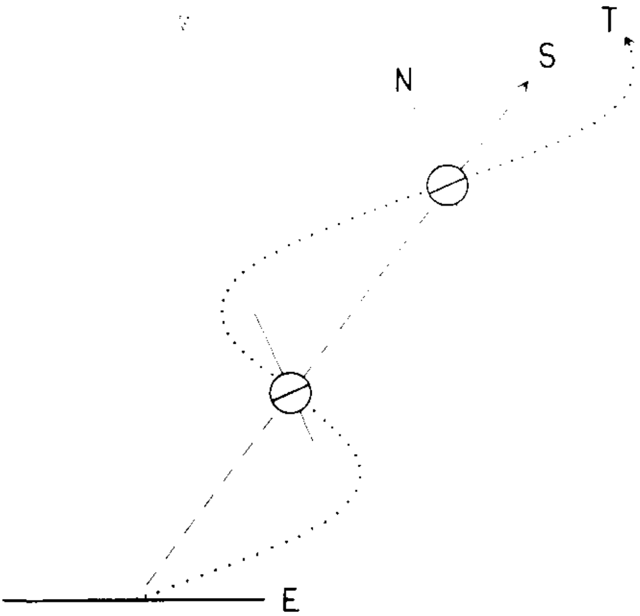

FIG. 19. Helicoidal motion of the Earth in the Galaxy.
E = plan of the ecliptic (profile);
S = solar apex;
N = direction of north pole;
T = helicoidal path of the Earth.

From this fact an elementary calculation or a simple graph shows that:

1) during the month of March the Earth moves in its equatorial plane;

2) during the month of September the Earth moves, if not along its axis, then in a direction not too far removed from that of the North Pole;

3) the speed of the Earth's helicoidal displacement varies during the year and passes from a maximum in March (45 Km/sec.) to a minimum in September (24 Km/sec).

4) the Earth is displaced with the Northern hemisphere leading, except during a small part of the month of March.

If space were empty, empty of fields of matter and inactive, a consideration of this type would be of no importance. But today we know instead that both matter and fields exist in space. For this reason, *the displacement of a body such as the Earth in one direction or another is not inconsequential. Its general physical conditions must vary in the course of a year.*

I have tried to give an interpretation of the annual variation of test D. But the variation of test D need not be considered. The

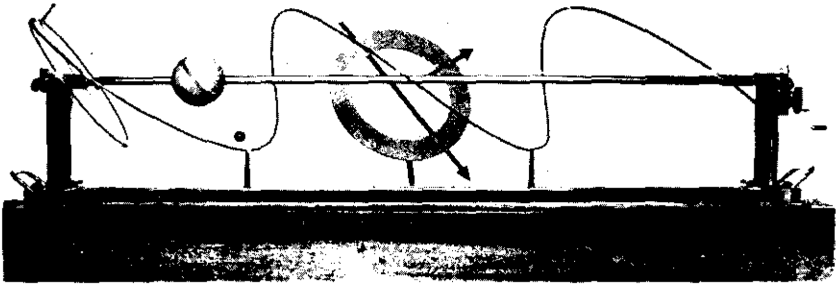

FIG. 20. Animated model of the helicoidal motion of the Earth in the Galaxy, presented at the Brussels World-Fair (side view).

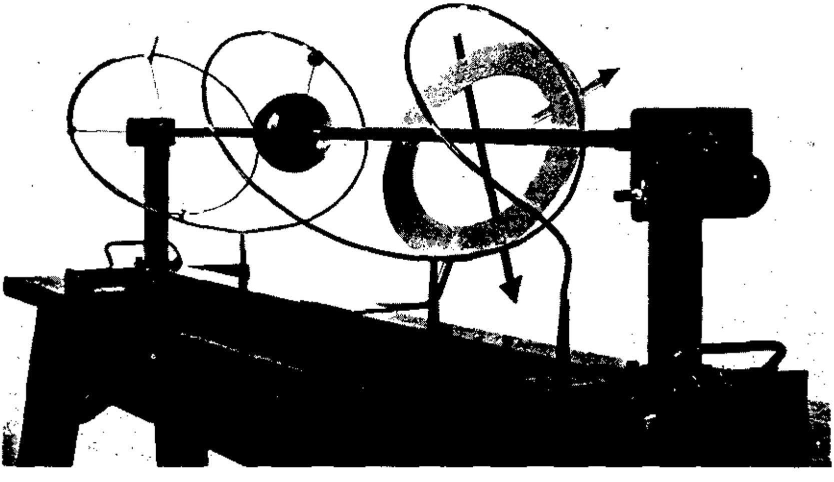

FIG. 21. Animated model of the helicoidal motion of the Earth in the Galaxy, presented at the Brussels World-Fair (close to).

hypothesis—that the helicoidal motion of the Earth in the Galaxy brings with it a regularly recurrent modification of the Earth's general physical conditions, with a *non-sinusoidal rhythm* going from March to March of the next year—*can exist as an idea on its own,* independent of the experimental facts which pointed to it. This is the *solar hypothesis.*

Considering the motion of the Earth in the Galaxy, it was necessary to determine in what manner the Earth was displaced towards the galactic centre.

The standard galactic coordinates of the centre are: $l = 325^\circ$, $b = 0^\circ$, the apex of the sun: $l = 23^\circ$, $b = 22^\circ$. From this fact it is easily deduced that during the month of March the Earth is directed approximately towards the galactic centre. The angle formed by its speed and the direction of the centre is at a minimum. To continue, during March, and only during March, the Earth is directed approximately, at maximum speed, towards the galactic centre—that is, along the lines of force of a radial field and perpendicular to the lines of force of a dipolar galactic field. This double condition will not be encountered again throughout the year. The conditions during March are thus quite exceptional.

The precise characteristics of the helicoidal orbit of the Earth have been recently calculated by Dr. Quilghini of the Rational Mechanics Institute of the University of Florence. A working model of the motion of the Earth in the Galaxy was displayed in 1958 at the Brussels Planetarium during the World Fair (Figs. 20, 21).

The Effect of Latitude and the Dissymmetry of the Northern and Southern Hemispheres

The fact that the Earth is displaced with the North Pole in a more or less leading position throughout the year, save for a very short period which corresponds with the month of March, should lead to a *dissymmetry* between the two hemispheres of the Earth and to an *effect of latitude.* The calculated maximum of dissymmetry occurs in correspondence with the month of September.

I have already considered a persistent difference between the data from Florence, Vienna and Brussels, *recorded during the period in which falls the annual minimum of test D:* January, February, March, April, for the years 1953, 1954 and 1955. Those years of minimum solar activity (Table XV).

TABLE XV

Year	*Test D* *Florence*	 *Vienna*	 *Brussels*
1953	31.8	46.3	51.8
1954	29.9	40.2	54.7
1955	38.4	45.0	53.4
Averages	33.3	45.0	53.3

But the stations in Florence, Vienna and Brussels cover a zone too limited to derive a general picture from our observations.

The International Geophysical Year (IGY) and the International Geophysical Cooperation (IGC) afforded us the opportunity of gathering data from widely separated localities as well as from the southern hemisphere: Uccle-Brussels, Tuebingen, Jungfraujoch, Vienna, Trieste, Genova, Florence, Castellana Grotte (Bari), Libreville, Leopoldville, Fort Dauphin, Kerguelen Islands. To these were added then Sapporo and Kumamoto (Japan), New Amsterdam Island and Tromsoe, but not in the picture of the works of the IGY.

The places in which *standardised observations* were made continuously and regularly during the AGI were: Brussels, Florence, Libreville, Leopoldville, Fort Dauphin and Kerguelen Islands. In some stations the observations were begun in 1957, in others in 1958. In some stations the observations finished at the end of 1959, in others thus are still going on. We can confront now the result obtained in the various stations only in the years 1958 and 1959 for reasons of homogeneity.

The dissymmetry between the two hemispheres becomes therefore most evident. In the Table XVI we report the annual averages of test F gathered in the places indicated in the years 1958 and 1959 and the general averages of two years. We report also the general averages of the data gathered in the two hemispheres.

The dissymmetry of the two hemispheres according to the solar hypothesis should be at a minimum during March and at a maximum during September. No tests were carried out at Leopold-

TABLE XVI

September 1958 and September 1959 (Total Averages)

	F		*F*
Brussels	51.0		
Florence	50.3	northern hemisphere	49.7
Libreville	47.8		
Leopoldville	46.8		
Fort Dauphin	30.5	southern hemisphere	32.8
Kerguelen	21.2		

ville or at Kerguelen during March 1958; for September, however, we have the complete series of values of two years. Test F, which is on this occasion the most dependable for a general comparison, reveals very satisfactory patterns: Table XVII.

TABLE XVII

Total Averages Over Two Years: 1958 and 1959

	F		*F*
Brussels	51.2		
Florence	49.9	northern hemisphere	50.1
Libreville	49.3		
Leopoldville	45.6		
Fort Dauphin	28.7	southern hemisphere	33.2
Kerguelen	25.4		

As one sees, the values of test F tend to diminish strongly with the increase of the latitude of the southern hemisphere and to remain constant or increase slightly with the increase of the latitude in the northern hemisphere.

There is no doubt therefore that test F accounts for dissymmetry predicted by the solar hypothesis; Test D hints at it less evidently and test P does not show it at all. It is possible to explain the diversity with the behaviour characteristics of the three tests towards natural phenomena.

Test F receives directly *all* the external actions capable of modifying the chemical reaction precipitation of bismuth oxychloride; test D *only* those which pass through the copper screen; test P, probably, only the electromagnetic fields. One remembers that test F is sensitive to the solar eruptions and consequent phenomena, and test D is not.

It is not necessary, for the moment however, to enter this field.

We know today that the general conditions of the southern hemisphere are very different from those of the northern hemisphere, not only from the geographic point of view, but also from the meteorological one. The problem was clearly stated by Van Mieghem in a general report on the meteorology of the Antarctic. On the other hand Lecce and Del Trono found a marked dissymmetry between the northern and southern hemispheres in the barometric field at 500 mb.

The Pattern of Test D in the Two Hemispheres

The solar hypothesis brings up another problem: if the annual minimum of test D depends upon the motion of the Earth in the Galaxy, this minimum should be observed not only in the northern hemisphere, but also, and *at the same time,* in the southern hemisphere. The *entire* Earth should feel the effects of the change in conditions resulting from its helicoidal motion.

Unfortunately, during the Spring of 1958 the chemical test research was interrupted for two months at Leopoldville and had not yet been initiated at Kerguelen.

The research was prolonged in these two places up through all of July 1960, that way it was possible to have the data of two complete years.

We can make a resume of the results regarding test D in this manner:

Let us distinguish above all the data gathered at northern and southern mean latitudes from those gathered nearest the equator, remembering that Libreville lies less than 1° N and Leopoldville about 4° S from the equator.

a) Test D at Northern and Southern Mean Latitude

If we calculate the monthly averages of *all* the data gathered in Uccle-Brussels and in Florence in 1957, 1958, 1959 and 1960, and all the useful data gathered at Fort Dauphin and Kerguelen and order them by month we obtain two functions of the time of D which have parallel behaviour.

Both present the large minimum and the little minimum *at the same time*. The effect of the helicoidal motion of the Earth seems therefore evident because they are independent of the seasonal effect.

In the North test D maintains itself on higher values and in the South on lesser values. The amplitude of the two functions are almost equal, perhaps the amplitude in the South is wider. The dissymmetry of the Earth depending upon the helicoidal motion seems therefore evident in the case of test D (Fig. 22).

The little August minimum divides the time function of D in two parts. In the North the first part (spring-summer) curve, the second part (autumnal-winter) comes to a sharp point. In the

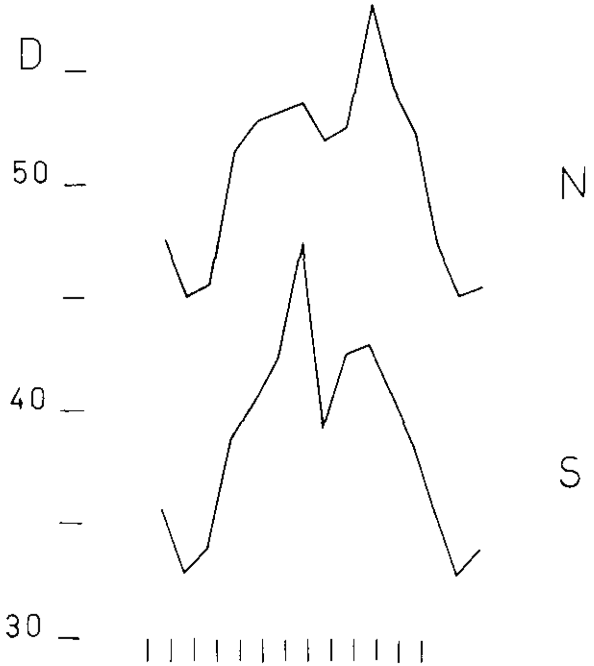

Fig. 22. Annual variation od test D in the northern and in the southern hemispheres (mean latitudes). *On the abscissa:* the twelve months of the year. *On the ordinate:* test D. Monthly averages of two years. Winter-spring minima and August minima appear together in both hemispheres. They do not depend upon a seasonal effect: thermic summer at the north and thermic winter at the south and vice versa.

South the inverse happens: the first part comes to a sharp point and the second curves. This is a *typical seasonal effect,* to place in relation to the height of the Sun on the horizon.

We could not hope for more or better. Test D shows one more time the effects of helicoidal motion of the Earth: large annual minimum, small annual minimum and dissymmetry between northern and southern hemispheres. Further, it shows us an ordinary seasonal effect.

b) Test D at the Equator

If we calculate the monthly averages of all the data gathered at Libreville and Leopoldville in the same period of time and order them by month, we obtain a time function of D which is about the inverse of those found for the northern and southern latitude averages.

Reversing the function, we find that it resembles very much the other two and is about coincident with the northern function.

The equatorial zone behaves therefore in a particular way. It is too soon to proceed to serious hypothesis. It would be necessary at this point to know what happens in the polar regions. Experiments are in course at Tromsoe at the Auroral Observatory, and there are also experiments going on in the Earth of King Baldwin in Antarctic. While at Tromsoe, thanks to the Norwegian physicists, the experiments are being carried on regularly and will have their results directly. In the Antarctic the immense general difficulties met by the Belgian expedition, have impeded the regularity of the experiments.

I shall not prolong this argument because the problem is still far from being resolved.

In the southern and in the equatorial zone the data was gathered by the Meteorological Service in the Belgian Congo and Ruanda Urundi directed by Prof. Van der Elst; by the French Overseas Meteorological Services of Gabon, Madagascar, Comore and Réunion Islands and by the French Expedition of the TAAF (Terres Australes et Antarctiques Françaises) to the Kerguelen Islands. Great was the interest in these enterprises shown by M. Viaut, Président de l'OMM (Organisation Météorologique Mondiale), by Prof. Roulleau, head of the Météorologie Nationale Francaise, and by Prof. Bost, Chef du Bureau Scientifique des Terres Australes et Antarctiques Françaises. Without the careful diligence of these people the study of the effects of latitude of the Earth's dissymmetry, etc., would not have been possible because we would not have known what happens in the southern hemisphere.

Figure 23 shows the synchronous mixer for IGY research.

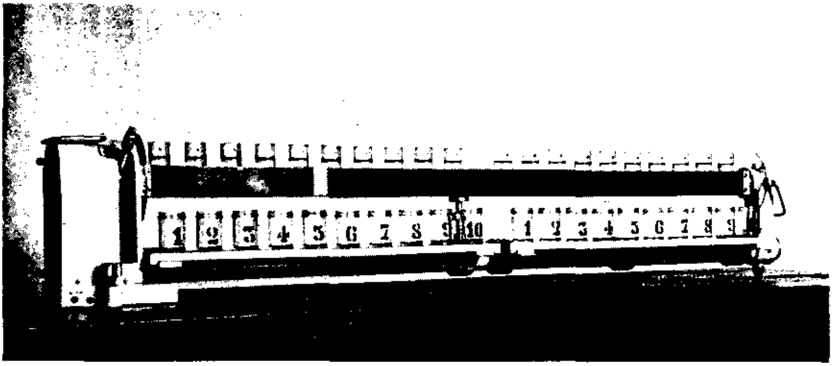

FIG. 23. The synchronous mixer model 20 A in distribution for systematic research in the Geophysical Year and the Geophysical Cooperation.

Test D and its Cosmogonical Sense

The annual variation of test D is of such importance that it is difficult to interpret it as a result of the interaction of weak fields, which are the terrestrial field and the exterior field in which the Earth moves. Until the present it was held that the fields which exist in space are weak, but this belief is not firm. *A much more profound and general cause must come into play.* Prof. Giao has considered the solar hypothesis from a point of view of relativistic cosmology and is able to explain the annual variation of test D in a quite general manner by means of relativity.

Giao, studying the problem of the existence and properties of Time (evolution, succession, sense), shows that besides the four-dimensional space-time solution (the physical Universe) the relativistic field equations also have a three-dimensional spacial solution. This solution is a three-dimensional Universe which performs a successive *exploration* of the four-dimensional physical Universe thus introducing an evolution, in other words a *real Time,* in the physical Universe. Giao analysed the important interactions of the three-dimensional and the four-dimensional Universe and shows that it is possible to explain the annual variation of the D test from relativistic point of view on the basis of the Earth's annual helicoidal motion as a manifestation of the energy flow representing the action of the three-dimensional Universe on the physical Universe.

Today the solar hypothesis, as I have shown, embodies extensive experimental results obtained during the IGY and IGC.

It is owing to this hypothesis that it was possible to foresee these facts, to seek them out and to study them.

It can thus be considered at least a *highly useful working hypothesis.*

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Chapter V

BIOLOGICAL TESTS

IF, WHILE *maintaining constant the modalities of the differential experiment,* we substitute the inorganic reaction in an aqueous and colloidal system taken as a test (the hydrolisis of chloride of bismuth) with a biological reaction, we have a *biological test.*

The technique of tests F and D lends itself particularly to our purposes except in special cases because of the necessity of *activating* a part of the material to be tested. The test P technique however, which does not require any interference with the material in question, is highly suitable.

In order to determine whether a biological test P possesses the characteristics necessary to a test, some exploratory experiments were carried out at the Camerata Hospital in Florence by Piccardi and Danti. It is perhaps worthwhile to describe briefly how these experiments were carried out, since they later served as the model for other experiments of the same nature.

On 23 consecutive days, two cc of blood were taken from five healthy persons on an empty stomach. Each sample of blood was subdivided into two series of drops on two paraffined capsules. One of the capsules was covered with a thin copper screen (0.1 mm) horizontally placed above it at a distance of 3 cm. The other capsule was left in the open air near the first. The temperature in which the experiments took place was always constant at 23 C.

Every 30 seconds the drops were touched with a glass rod which had been sharpened to point and a note was made of the time at which a thin thread of fibrin clung to the point of the rod. The coagulation time was counted from the moment at which blood appeared in the cannula to the moment at which the thread of fibrin appeared.

115 experiments were carried out during the month of August 1955. The coagulation time was always greater in the case of the blood placed under the screen at that time. The differences in coagulation time (time under the screen, time away from the screen) fluctuated from a minimum of one minute to a maximum of eight minutes, with a mean value of four minutes. The average coagulation time was 8 minutes for the blood away from the screen, and 12 minutes for the blood under the screen.

Particular note was taken of the fluctuation in the differences of coagulation time because it is precisely this fluctuation of results which guarantees that our system behave effectively in the same manner, as is necessary in a P test (chemical or biological). The differences in coagulation times were correlated with the results of the chemical test P carried on almost simultaneously at the Physical Chemistry Institute of the University. The Institute and the Camerata Hospital are roughly 1.5 km apart. A significant correlation was found to exist between biological test P and chemical test P. It was thus evident that the same spacial phenomena that influenced biological test P influenced chemical test P as well.

After four years, in 1959, experiments on blood coagulation were resumed at the Physiological Institute of the University of Hokkaido at Sapporo (Japan) by Itoh, Tsuijoka and Saito. These authors studied both the blood coagulation of rabbits according to the biological test P technique, and the precipitation of oxychloride of bismuth according to the chemical test P technique. For the two tests they obtained results which fluctuated in the course of time but which could be mutually correlated, precisely as was found in Florence four years earlier. In an article in *The International Journal of Bioclimatology and Biometeorology*, these authors explained the procedure as follows:

"We measured the clotting time of rabbit blood both inside and outside a copper box simultaneously, according to the method of Sahli and Fonio. The ratio of the time *outside/inside* was compared with T% which was determined at the same time. One hundred experiments were carried out during a period from November 1958 to June 1959. Though individual values fluctuated considerably, the mean value of each group showed a consistent tendency: a low ratio of the clotting time when the T% was low, and vice versa. That is, when the rate of colloidal precipitation of bismuth is slower in the copper box than outside of it, the clotting time of blood is also slower in the box. Statistical analysis indicated that the results are highly significant. Thus, the biological P-Test is proven to be correlated with the inorganic P-Test."

As we see, in spite of the different technique (the use of a completely closed copper box instead of a simple horizontal screen placed above the blood samples) and the different method of calculation (ratio of the quotient of clotting times, instead of the difference in clotting), the general results are the same.

This type of study is steadily being developed. For some years, experiments have been under way on the speed of erythrosedimentation, on the flocculation of *Saccharomyces Ellipsoideus* and on its fermenting capabilities, with a view to determining the action of the screen and to study more closely the mechanism of the observed phenomena as related to the results yielded by the chemical tests. Giordano measured erythrosedimentation rates in the open air and in a copper box, using blood samples obtained from several farm animals. All plasmas in spite of their difference showed a significant effect of the copper shield.

The same author, in the spring of 1959, observed several correlations between the behaviour of the fermentation rate of the same stock of *Saccharomyces Ellipsoideus* and Piccardi's Test D.

Giordano and Trenta examined the behaviour of the coagulation of human blood by the relief of its electric resistance, in the open air and under a copper screen. 22 subjects were examined and coagulation was always delayed under the copper screen, during that period of time.

Giordano, Mazza and Maga measured the erythrosedimentation rate according to the differential technique in the open air, in three localities about 70 km apart. The sign of the outside/inside difference was the same.

Mazza studied erythrocyte sedimentation and erythrocyte sedimentation rates by replacing human plasma with liquids of known and constant composition (sodium chloride 0.9%; Macrodex, Subsotan). He observed that a copper screen had a delaying effect during the period in which the tests were being conducted.

Blood clotting is a process which seems subject to the influence of the weather. The blood coagulation rate of rabbits was studied by Caroli and Pichotka. The correspondence with the atmospheric dynamical processes and the clotting seems significant. But Schultz, on the basis of more 120,000 observations on the white blood carried in the years from 1954 to 1959 inclusive, established a sure correlation between the rate of the functional leucopenies, the relative lymphocytoses and the Wolf's number. The correspondence with the solar activity is certain and therefore the correspondence with the inorganic chemical tests is certain also.

We must not forget that Bortels observed an effect of a metallic screen on various micro-biological tests, as was said before.

Vering has demonstrated the action of spacial factors, following the evolution of a single living biological specimen away from and under a copper screen (bacteria cultures that clouded a clear liquid culture or cleared a cloudy liquid culture) by means of photometric methods and automatic recording. The effect of the screen became evident. The variability of the results, accurately analyzed in their relation to operative and experimental conditions, has lead the author to affirm the necessity of reviewing our experimental ideas and the principle of analysis in certain biological, medical and sociological fields.

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Chapter VI

ON THE MECHANISM OF SPACIAL ACTIONS

BEFORE CONCLUDING this exposition it would be at least necessary to state generally the problem of the mechanism of spacial actions. I say state and not resolve because at the present moment it does not seem possible to resolve the problem.

It is evident that the mechanism according to which the spacial phenomena act at a distance (not those which act upon contact) consists of two parts: 1) a *mechanism of short path* or of entrance of spacial actions into the living organism; and 2) a *mechanism of long path* or of diffusion of spacial actions, eventually accompanied by the transformation of the action itself.

The mechanism of short path regards physiology more than climatology, just as the mechanism of actions upon contact, studiable in the laboratory regards physiology more. It is not my task to speak of these mechanisms.

I should like however to note the importance in this field of the ionization of air, an importance which justifies the many studies which are being carried out in it.

Regarding the mechanism of long path, it would seem opportune to take note of that which Berg has already synthesized in his last work, that one with which he concluded prematurely his life. I shall recapitulate it, conserving the original train of thought.

De Rudder had discovered various relationships between solar phenomena and biological phenomena, between biological phenomena and meteorological phenomena, and between meteorological phenomena and solar phenomena. Admitted that the existence of this closed cycle be real, it would be extremely difficult to separate the effects of the solar actions from the effects of the meteorological actions, given that the meteorological phenomena are in relationship with the solar phenomena upon which they would depend. It would be then most difficult to know which of the two types of phenomena is that which gives preponderant effects, which is thus the more *biotropic*.

But today, as was noted, a correspondence between solar and meteorological phenomena *is not significant* in the light of modern statistics, and, however certain it be, that the sun has a great hand in atmospheric phenomena, of which it is the primary cause, the variations of solar energy transmitted to the Earth do not account for the multiplicity of phenomena which one notes in our atmosphere. The lack of correspondence between the fluctuations of energy radiated by the sun and the complex meteorological phenomena, obliges one to consider separately solar and meteorological actions.

Solar actions reach us as electromagnetic radiations of various frequencies and as corpuscular radiations. The problem remains as to their reaching us as variations of the general field. One could respond affirmatively, thinking, for example, that the cloud of particles launched towards the Earth from a solar eruption, carries with it the magnetic field (I was not speaking of fields generated upon the Earth from eruptions as secondary effects, but those solar ones or ones provoked by the sun).

Solar radiations can act upon organisms either directly or indirectly through secondary phenomena generated by the radiations themselves. From the secondary phenomena one must, of course, exclude the meteorological, for the reasons already cited.

Duell set forth the hypothesis that bursts of ultra-violet solar radiations generate high tensions in the stratum D of the ionosphere, in the ozonosphere, and in the troposphere. These high tensions, leveling themselves, would give origin to electromagnetic waves of great length. The electromagnetic waves would become directly absorbed by living organisms, disturbing the neuro-vegetative system. But this regards the mechanism of the shortest path.

Again, according to Duell, corpuscular radiations would not have such an important and certain action as the electromagnetic ones do (and I add: *there,* where we live on the outer surface of the Earth). On the other hand, according to Duell, secondary phenomena caused by these corpuscular radiations (electrons, gamma rays, traces of chemical substances, etc.) can have a biological action.

To the electromagnetic radiations of great wave length generated in the terrestrial atmosphere by solar radiations are added the electromagnetic radiations of short wave length generated from the sun itself.

Waves from 1 cm to 20 m radiate constantly from the solar corona. Spots, eruptions and disturbed zones of the corona during periods of disturbance, generate these same waves with an intensity thousands and thousands of times greater.

There existed therefore a certain interest to find out if these waves possessed a biotropic action. But the biotropic actions of these waves did not remain very clear or at least evident. Kiepenheuer, Harte and Brauer experimented with the action of waves of 1.50 m upon buds of *Vicia Faba* and observed a certain effect: an increased frequency of cellular division. The experiments were carried on by Harte and Brauer.

Afterwards Elvert, Reinert and Mitlacher searched in vain for an effect of metric waves on biological specimens: germination of seeds from *Digitalis lutea* or of spores from *Aspergillum niger.*

It is difficult to reach a conclusion from these results: the biological tests, the experimental conditions, and likewise the period of time during which they were conducted differ. This last circumstance is of the utmost importance. And still, at that time, no one knew of the effect of the metallic screen.

It should be noted that this first step was taken by an eminent astrophysicist who collaborated directly with biologists. The first and the last links of the biotropic chain were joined by them.

The effects of the short waves do not seem for the moment a field that interests many. At any rate the interesting one is that of the long waves.

According to Berg, the chemical tests brought a clarifying element to today's situation. They demonstrated more than exhaustively that inorganic colloidal systems in aqueous media are influenced above and before all by solar phenomena. There is no doubt of certainty of the relationships discovered because that certainty is founded upon most rigorous statistical analysis.

I add that it is true for inorganic and organic colloids, and seems true identically for biological colloids. One has therefore a reason for insisting that also in medical climatology the phenomena that react with greater certainty are the solar phenomena. The mechanism of long path *in* this case is that of propagation and transformation of solar radiations.

On the other hand, the effect of the metallic screen on chemical tests, that is upon colloidal systems in evolution, confirms that solar action is above all of radiant nature. If the thinnest sheet of metal is enough to change considerably the mode of precipitation of an inorganic compound, one must admit that the spectrum of incidental radiations can be modified at least in part by modifying the sheet of metal itself. The metallic screenage reflects or absorbs some of the components of the incidental radiation.

The fact that a simple roof of metallic lustre or also of metallic net placed above the system to be tested, changes the precipitation of colloids of the system itself, shows us that the action exerted *is not an action of contact* (as in the case of chemical substances or of electrical charges contained in the air) but is actually the action of a radiation or of a field. We must note this does not concern visible or ultra-violet radiations or those of the shortest wave-length.

Since the short waves, that is the electromagnetic high frequencies, do not give free play to biological researches, it is well to direct our attention to the field of low and ultra-low frequencies.

On the other hand, modern radio technique permits us today to follow the variations in the intensity of the ultra-violet and roetngen solar radiations that fall on the upper atmosphere, on the basis of the very low frequency radiations intensity.

Studies of the VLF in relation to the polar auroras are going on in the Antarctic.

One notes that sudden increases of intensity in the atmospherics are attributed today to astrophysical causes. These sudden disturbances correspond to flares. Methodical recordings were made at the Wilfred Hall Observatory at Preston on the part of Prof. Barocas, director of the same.

At Munich, Schumann, considering that the Earth and the ionosphere that circles it constitute a kind of concave spherical resonator, calculated its resonance frequency and found a frequency of about 10 Hz. Koenig, on the basis of Schumann's calculations, conducted research in the field of new techniques for the radioelectric measurements with the intention to receive the natural ultra-low frequency signals coming from the space around. Koenig was able to gather signals between 1 and 25 Hz. and to record them regularly, ascertaining among other things a most notable diurnal effect.

The studies of the Munich school brought about a great interest among the biologists. The ultra-low frequencies seem in fact to produce remarkable biological effects (Koenig, Reiter, etc.). It is perfectly logical:

If, in the case of the very light molecules (for example: those of ammonia), the high frequencies are able to generate effects, already well noted, in the case of the very large molecules, or very large micelles or very large and deformable structures, the high frequencies have probably little or no effect. Instead the low and ultra-low frequencies can have it.

The biological systems are therefore vulnerable to the low frequencies because they are all constituted of colloids in aqueous media which are in turn made up of very large molecules or micelles suspended in molecularly structured aqueous solutions.

The preceding considerations have conducted us into a completely new field, that one of very low frequencies. It will be in this that we shall find perhaps one of the roads which will conduct us to the solution of some of the problems of medical climatology. But the field is new and unknown as yet and we find ourselves to be quite at sea, deprived of the benefit of direct and old experience.

I must conclude for now, affirming that as premature as is the talking about the mechanism of spacial actions for me as a chemist, at any rate it was necessary to point out the situation in this field.

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Chapter VII

CONCLUSION

IT IS NOW TIME to summarize the more salient facts brought to light up to this point and to derive from them some precepts: first of all let us turn back to a subject which was barely touched upon in the introduction.

Living organisms of necessity take part in the events of the environment in which they exist. Very often they participate by means of specialized organs in accordance with their degree of evolution and complexity. But it is not so important for us to know whether the beings in question possess these organs or not, or, if they possess them, whether in greater or lesser number.

The function of these organs is merely for "knowledge," "information" or the "exploration" of their environment and to serve as aides in locomotion, nutrition, defense and so on. All of this is of no use to us so we will concern ourselves with the possibilities offered to living beings of being directly aware of particular environmental phenomena.

The events which take place in space act upon living organisms either b*y contact* or at a *distance.*

The air or water in which living organisms find themselves, and therefore all that is contained in these fluids (dissolved or suspended chemical substances, electric charges, etc.), act by direct contact. Air ions, aerosoles, gaseous emanations, free radicals, peroxy compounds, etc., are highly important factors in vital phenomena and this fact justifies the great attention devoted to them today by scholars.

But the study of action by contact, which is accessible to direct experimental investigation, is, as I see it, related more to physiology than to medical climatology. Climatology will be able to add its contribution to the subject, transferring it to its particular field, after physiology has clarified the mechanism by which action by contact is exercised.

On the other hand, certain phenomena which take place in geophysical space and all of the phenomena which take place in solar space and astrophysical space act at a distance. No matter what the nature of far-off spacial phenomena, their action is exercised by means of radiations of an electromagnetic or corpuscular nature, or by means of variations in the general field, electrical, magnetic, electromagnetic or gravitational. All of this may today be listed as being distant actions.

It is to be noted that these actions, in our case, are able to affect only those places in which living beings under study are found, or else one part of the Earth or, finally, the entire Earth.

With the exception of visible light, which is discernible with the eyes and of infra-red rays (thermal rays), which are discernible on the surface of living organisms, no other radiations are noticed. Organisms undergo them unawares and then discount their eventual effects. The same may be said of variation in the general field.

It has already been stated in the introduction that the modern tendency is to ignore common meteorological factors which are discernible by living organisms (heat, cold, humidity, wind, rain, etc.) as determining factors in medical climatology. Modern climatology tends instead to consider certain biotropic factors, undiscernible by living organisms, accompanying the emission of certain electromagnetic waves, certain variations in the atmospheric electric field, etc.

The interest of modern climatological studies is therefore directed toward factors which are yet unfathomable and which may be studied only with the greatest difficulty in laboratory, and therefore studied with great difficulty in the field of physiology.

At this point I must remind the reader of the fact that, practically speaking, almost nothing is known about electromagnetic fields of low and very low frequency, either from a strictly physical standpoint or from the standpoint of biological application. Long-wave spectroscopic studies are still at an initial stage.

The naturalistic study of low frequency and ultra-low frequency electromagnetic fields is beginning to interest scientists, but a very great deal remains to be done.

I would like to point out that in putting our chemical tests in operation we have not advanced any hypothesis regarding the phenomena which should have been able to influence their results. It was left so that the chemical tests themselves might indicate which were the phenomena which seemed to determine their fluctuation in order to demonstrate later, on the basis of statistical analysis, if the relationships between the test results and the phenomena under consideration were valid.

Up to the present time we have not been able to discern any behaviour in the tests that could be linked to the behaviour of normal meteorological or climatic phenomena in the traditional sense of the word. More precisely, one should say that nothing climatic has been manifested before our eyes with the same evidence as was the case with solar activity and the annual variation of test D, which later gave rise to the solar hypothesis.

This is not to say, of course, that a more profound and more accurate investigation might not unearth a new element, but this element, which has not been evident up to the present, could be of no more than secondary importance compared with solar elements.

This spontaneous graduation of the importance of spacial phenomena as they concern our research will have certain things to teach us; in fact, it will be impossible to study, in restricted and specialized fields, less apparent phenomena if before these the major sun phenomena and the helicoidal motion are not first studied profoundly. Those who have established relationships in restricted fields without taking into account the *great rulers of space* have placed their work in jeopardy.

To be unconcerned with solar activity and the helicoidal motion of the Earth in medical climatology is like being unconcerned with temperature in physical chemistry. Temperature has a strong influence on the course of chemical reactions and it *must* be considered if we want to study any chemical problem. In the same way, we cannot study a biological or medical problem in medical climatology without taking into consideration *the state of the sun* and *the season* in which the studies are being carried out.

In considering the state of the sun, one must take into account the phase of the current solar cycle, whether it be one of *rising or diminishing activity* because of so-called *hysteresis*, as indicated by the chemical tests, just as it is necessary to take into account the saturation of the effects of the activity, which, too, are clearly revealed by the chemical tests.

Bioclimatological studies should be organized in various ways, depending on the nature of the spacial phenomena under consideration. Solar effects and effects of the helicoidal motion of the Earth should be studied throughout the entire surface of the Earth. This is work which should be carried out with the assistance and collaboration of astrophysicists and geophysicists. The organization of experiments must, in fact, respond to general needs. Special and local effects should be studied in a more restricted locality, always, however, of necessity bearing in mind general effects.

It is for this reason that I stated in the introduction that medical climatology is a general science.

If we are interested in solar effects, it would be well to conduct our research during *a period of maximum solar activity* (as was done during the recent Geophysical Year); if, however, we are interested in the effects of the helicoidal motion of the Earth, and thus the seasonal change from a relativistic-astrophysical standpoint, the dissymmetry between the northern and southern hemispheres of the Earth, or the effects of latitude, it would be best to conduct our experiments during *a period of minimum solar* activity. Solar outbursts do not aid research in this field; rather, they confuse it, superimposing the unasked-for effects of capricious and inconstant solar activity upon the highly regular effects that should be studied.

Beyond this naturalistic part which constitutes the underlying basis of medical climatology, and which may be studied by astrophysical, geophysical and physio-chemical means (chemical tests), the more *chemical-physical-biological part* is still to be studied, the part which concerns the mechanism by which external biotropic events set upon water and upon non-biological and biological colloids.

Upon this latter point, studies are not very far advanced. The reasons for this lack of development are two.

One of the reasons is the following: It is only lately, as I showed earlier in the chapter on water, that a satisfactory theory has been formed regarding the structure of water and solutions. The new theory is still being developed and has not got to the bottom of all the problems posed by water and solutions. The fine properties of water and of solutions have not as yet been well-defined from an experimental point of view in the physio-chemical field.

The other reason is this: the influence of radiations upon water, upon solutions and, generally, upon chemical phenomena in aqueous media, has not as yet been thoroughly studied, either from a theoretical point of view or from an experimental point of view. This lack depends in turn upon the fact that *the scale of natural radiations has not as yet been entirely studied.* If the short wave-length scales are sufficiently understood, the long and very long wave-length scales are completely ignored, as I pointed out earlier.

If it is necessary to lay the chemical basis of medical climatology with exactitude, we should answer the following question in a completely general sense:

What is acting from space upon living organisms, and in what way does it act?

The question is simple, but it bears with it a world of things astrophysical, geophysical, physical, physio-chemical, chemical and biological. If, for the sake of simplicity, we disregard actions by contact, those that may be studied in laboratory, the question, taking into account our general knowledge in the astrophysical and geophysical field, can be restated thus:

Upon what do the radiations which strike the Earth and the general variations in the field act?

In order to answer this question, let us review some of the more salient facts which were set out earlier and place them in mutual relationship.

1) We are certain that in the space which surrounds us phenomena occur which influence living beings from afar (and not by contact wtih material things) by means of radiations or variations in the general field.

2) We are certain that inorganic and organic (non biological!) colloidal systems, in the process of evolution are sensitive to spacial phenomena and make it possible to follow some of these, at least the more imposing of them, with statistical sureness. This has made it possible to successfully make use of particular chemical tests for the study of geophysical and astrophysical phenomena. The connection between spacial phenomena and physical-chemical (non biological!) phenomena is by now firmly established.

3) Modern theory, the best and most refined, attributes to water and thus to solutions and thus again aqueous colloidal systems, a structure which offers infinite possibilities of geometric and energetic variation. It is from this, at least in principle, that the fine properties of water, colloids and solutions are derived; those fine properties that hydrologists and biologists know so well but which physical-chemists and chemists do not recognize or—perhaps more precisely—are not capable of identifying in their work.

4) It is reasonable and logical to recognize the geometric and energetic element, sensitive to external radiations and to general variations in the field, in the structure of water, aqueous solutions and colloidal systems in an aqueous medium. A few words on this subject would not be amiss.

First of all it is necessary to distinguish the action of a corpuscular radiation from the action of an electromagnetic radiation and from that of a variation in the field. Particles strike at random and their action is sporadic and limited to the zone which is struck.

The action of particles never involves the whole mass of a body nor, therefore, of an organism. Electromagnetic radiations and field variations, however, strike the entire mass of a body, and thus of an organism, and provoke the oscillation, excitation or, at any rate, the resonance, so to speak, of all the structural elements capable of responding to their stimulus, wherever they are found. Their action is total.

In other words, those elements which, depending on their dimensions, their geometric form and their internal energetic relationships, are able to resound to radiations of appropriate frequency, are the structural elements. There can be no resonance without precise spacial energetic distribution. Therefore, there can be no resonance without structure.

Definitely, all living matter reacts to far-off spacial actions, both electromagnetic and field.

Returning to the colloidal systems used as chemical tests, it is best remembered that these were *not living* colloids but were *inorganic* colloids (oxychloride of bismuth) or *organic* colloids (acrylonitryle). There can then be no doubt regarding the physical validity of the discovered relationships, not even from a theoretical standpoint.

That which reacted to spacial actions was, in our case, *dead matter* and was thus exempt from vital processes and from hereditary, constitutional, pathological factors and so on. The unknown factor, "life," played no part in our operations.

The reaction of dead matter is both pure physical reaction and a physical action and is thus perfectly dependable, controllable, experimentally reproducible and comprehensible, at least in principle.

On the other hand, living matter reacts to spacial actions like dead matter. This shows us that the sensitive part of living matter is its *non-living substratum:* water and the colloids dispersed throughout. I am not sure whether the expression is exact, but "non-living substratum" renders the idea clearly.

This is not a supposition but a logical deduction. If inorganic colloids in aqueous media and in evolution, that is, not yet having attained a state of thermodynamic equilibrium, react in a marked manner to major spacial phenomena, how could biological colloids, which are also colloids in aqueous media and not in a state of thermodynamic equilibrium, refuse to react? If a living colloid were to attain a state of thermodynamic equilibrium it would no longer be living since it would be incapable of any transformation or any evolution and could not be host to vital phenomena.

Experiments corroborate the deduction I have just mentioned, because they have clearly shown that the same fluctuations revealed by inorganic colloids are *simultaneously* revealed also by biological colloids. The data which have been gathered speak clearly: there can be no doubts of any consistency.

It could be objected that living matter, unlike non-living matter, would do its utmost to maintain its conditions of life or to re-establish them, whenever these should be altered. It could be, therefore, that the reaction of living organisms to spacial actions would be less conspicuous than that of inorganic colloids. The effects of spacial actions will be compensated in some manner and so rendered less apparent. But conserving or renewing vital conditions is also a reaction to external actions and is consuming and troublesome: it is the suffering of *all the matter* comprising an organism because, as I have said earlier, the actions strike all of the living matter by means of the non-living substratum. It could also be, in certain cases, that the organism does not reveal visible alterations, but how much would not revealing any reaction have cost it?

And now, a final consideration:

The fact that living matter reacts to spacial actions like non-living matter, because what reacts is its non-living substratum, is something of major importance, as I see it.

It is to be borne in mind for general reasons, because we are thus assured that whatever living being, an animal or plant, unicellular being or superior organism there be, is destined to be subject to the general influence of spacial events. All living beings are bound more intimately to the external world than one would think.

It is also to be borne in mind from a methodological standpoint, since it provides us with the hope of being able to study the phenomena of medical climatology *on inorganic models*, as pointed out earlier. Chemistry offers an infinity of inorganic models of highly varying types which we might be able to utilize in the most disparate circumstances for the study of various natural phenomena.

And, finally, it must be taken into account from an ecological-climatic point of view because everything that is made up of water or which contains water, solutions, colloidal solutions, suspensions, is subject to the same spacial actions as are living organisms, and is modified as a result. Thus the water of rivers, lakes, seas, marshes and ponds, their inorganic, organic and biological colloids, clay, sediment, mud, in short all that is found in a dispersed state and which has not yet attained a state of thermodynamic equilibrium.

Even this is not a supposition, but a deduction based on experimental facts. Mosetti has observed, on the basis of Vercelli's periodical analysis, that a very great part of major natural phenomena, considered as functions of time, are subject to a general law. Their fluctuations may be broken down into a series of periods whose lengths arranged in order of size, form a geometrical progression whose rate is $\sqrt{2}$. Solar spots, raininess, certain sicknesses, sediments in lakes and marshes, varve, magnetism, etc., act in the same manner. This means that all of these phenomena, so dissimilar, are either all mutually connected or else they all depend upon the same major spacial occurrence which effects them all, both with eventual de-phasing and with varying intensity, the same rhythmic characteristics.

If the ideas postulated herein are acceptable, spacial action, from a climatic standpoint, should be two-fold: 1) directly striking the living organism; and 2) modifying its environment.

Spacial action reacts upon the inner world and, at the same time, upon the outer world. So that the modified organism finds itself in a modified environment. The inner world *(Inwelt)* and the outer world *(Umwelt)* react jointly to the major spacial phenomena.

The foregoing is no more than an attempt to give a chemical basis or, more precisely, a physical-chemical basis to medical climatology. It does not seem possible to say more at this moment in view of the present state of climatic studies and physical-chemical studies of the fine properties of water, aqueous solutions and colloidal solutions. The latter studies are still in the process of development and great hopes are attached to their future.

Anyone with sufficient patience to have followed this exposition will have noticed that I have set out certain facts of a varied nature in order to form from them a logically connected and interdependent whole, notwithstanding the great disparity in these facts. I used the word "facts," meaning by this established and certified facts. I had no desire to advance a hypothesis which was not based on experiment.

I realize that this has not been a complete exposition; I am equally aware that I have stripped my presentation of all arguments that were not absolutely essential to the aims of this report. I am also aware that I am far from solving the problem set before me, but I hope to have at least been able to indicate a direction capable of guiding whoever should wish to concern himself further with this intriguing study.

By

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