LECTURE

The temperature of Europe

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> « The brain may devise laws for the blood, but a hot temper leaps over a cold decree ». (Shakespeare, *The Merchant of Venice,* Act I, Scene 2)

« Heat is a central topic, the point where all roads meet. . . It is the hub of science, just as Greece was the hub of the world to the Ancients . . . ». This parody of famous words by Dastre the physiologist gets us right to the heart of our subject.

The scholar endeavours to separate the different aspects of a science so that he can better analyse them. But he must also reverse the process in order to fully appreciate the progress that has been achieved and to better coordinate and be more prepared for future progress. There should always be interchange between analysis and synthesis.

The present-day extreme specialisation that has followed in the wake of technology and technocracy has been beneficial in more ways than one. But the cosiness of exclusive specialisation dulls our natural adaptability.

The specialist must also be, or be complemented by what the contemporary North American humanist, Buckminster Fuller, calls a « comprehensivist » : a person who, whether naturally or by conscious effort, is always sufficiently detached to be able to view his science as a whole.

This approach is particularly suitable for Thermology. For this science of heat exists only a specific part of other studies and not as a separate subject in its own right. Yet heat is everywhere, and every science has its thermology branch: thermo-electricity, thermo-pathology, thermo-ecology.

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It is paradoxical that all these branches are joined only nominally to the common trunk of thermology, which is nourished by the interrelated parameters of heat, temperature, and entropy and the four dimensions of space and time.

The recent development of thermology techniques, in particular those which produce images, and numerous acute problems which depend wholly or partially on thermology for their solution, such as cancer prognosis, biomass assessment or economy of energy, these all are reason enough to group together everything concerned with heat. Not only in the foundations of thermology, in inert matter, in human beings and in ecosystems, but also from the point of view of the exploitation of thermal phenomena for utilitarian purposes, especially in the fields of health, energy and food.

I invite you today, to reflect upon these ideas of cooperation, and I shall also attempt to justify some recent and probable future moves, made in particular by the European Thermographic Association and by the Louis Pasteur University in Strasbourg. I ask you in advance to excuse any excessive enthusiasm, and remind you that figuratively speaking, heat is the synonym of ardour, passion and zeal, and that, as Saint-Exupery wrote: « . . . *happiness and progress are only to be found in the warmth of our actions ».*

Heat everywhere . . ,

Compared with all other scientific terms, the word « heat » is very rich in meaning, especially in the figurative sense. The heat of the day, and of youth, of blood and of fever, the heated atmosphere of debates and auctions, the heat of battles or of victory, and also the heat of passion. It can be qualified by the most varied adjectives: heat can be mild and soothing, pleasant, and indiscreet, dry or humid, consuming and stifling.. . As La Bruyere said: . . . *de chaleur vient chaleu-*

reux, . . a wealth for our language. Man experienced sensations of heat and cold right from his beginnings, long before the era of fire, whereas it was only much later that he discovered, then defined the laws of electricity, magnetism and radiation . . .

It is not only in language that heat is everywhere. Even before birth we are enveloped in amniotic heat, and as Charles Marie Gros so neatly puts it: *Man, the eternal foetus, will always dream of his return to paradisiac heat.* We are surrounded by heat to such an extent, that we find it as natural as the air we pollute and the water we waste. In all systems, natural or artificial, biological or ecological, stable or evolving, heat and temperature play a most important role. Our daily life gives proof of it at every turn, and our wellbeing depends on the temperature of our bodies and of our environment.

It was taught physical thermology in an old Institute of Mineralogy, which I still remember fondly. There I studied the growth of crystals, from molten organic compounds and then from metals with low melting point, and through calorimetry and thermometry I acquired a feeling for the influence of temperature on the state and physical properties of bodies, and the absorption or release of latent heat during changes of state. As we know from everyday experience, heat penetrates everywhere, even more insidiously than air or water. Thermal radiation, conduction, and convection are vital phenomena, but difficult to master and control. The physicist knows how difficult it is to maintain an isothermal system, to measure an increase in heat, to register a temperature, particularly a surface temperature. Perhaps these problems could be solved more easily, if thermokinetics were taught in a more through and pragmatic way, and if the mathematical concepts of Stefan, Boltzmann, Fourrier, and Newton were considered more as a means than an end. The chemist is confronted with similar difficulties owing to the laws of Van't Hoff and Arrhenius, according to which the speed of chemical reactions, especially combustion, increases exponentially with the temperature. On the other hand, the two main principles of thermodynamics describe satisfactorily most physicochemical systems. The first one, formulated by Carnot, emphasises the confermation of energy for all systems. The second, formulated by Boltzmann, concentrates on irreversible processes and non-insulated systems. He points out that such a system evolves spontaneously towards a state of equilibrium, where molecular disorder is maximum. This disorder is measured by a quantity called entropy, which continues to increase during the evolution of the system owing to internal production and possibly to additional entropy from outside.

Likewise, temperature and heat flow are fundamental parameters in biology and physiology. At cell level, the enzyme systems, by which synthesis and metabolism are brought about, both in animals and plants, are only active between narrow temperature and pH limits. But although these two factors play parallel rôles, the thermal conditions of biochemical reactions are sometimes considered secondary, or even disregarded, often from university practical classes onwards. At organism level, heat production is the reflection of tissue activity, and it is significant that in man, thermogenesis is highest for grey matter and cardiac muscles. Blood, which distributes metabolic calories throughout different parts of the body, plays the rô1e of heat convector, just as important as its rô1e as conveyer of oxygen and water. The old concept of caloric in the sense of fluid which conveys heat retains its value in my eyes, and makes Claude Bernard's « milieu intérieur » one of the most brilliant expressions of Einstein's concepts of the non-dissociability and equivalence of matter and energy. Human beings are wonderful thermal machines, and the gap between the computer and the human brain is just as wide as that between the most advanced internal combustion engine and the thermoregulating mechanisms of homoeotherms. In the latter, thermoregulation has the job of maintaining homoestasis, indispensable to life and necessary for comfort; it is chemical in the heat generating organs, physiological in the vasomotor adjustment of circulation, physical at skin level, where heat changes take place due to contact with the atmosphere. Some habits, such as dress in Man, migration in birds, hibernation in some animals and the dormant period in insects, are no less regulating thermo-ethological reaction, sometimes only defensive or adaptable, but often vital.

As Odum stated, *« Temperature is the basic factor in ecology ». Night* to day and season *to* season changes in the environment are determined by rhythmic variations, inherent in the combined action of the sun's radiation and the movements of our planet. Land and water are characterised by a thermal stratification on which the distribution and growth of flora and fauna depend. In lakes and seas, for example, the water near the top, which is influenced by thermal fluctuations in the air, is warmer in summer and colder in winter than the water near the bottom, which is below the thermocline. Thus, in winter, some marketable fish migrate below the thermocline, because of their stenothermia, that is to say, their poor resistance to changes in temperature. On land, these phenomena are similar near the surface, but further down our knowledge is still speculative in spite of deep drilling and volcanic research. After descending 20,000 leagues under the sea and flying from the earth to the moon, Man whill have to undertake the journey to the centre of the earth. The temperature of the air is the most important climatic factor, and our almost daily complaints about bad weather and wrong meteorological forecasts, only go to show how complex thermoatmospheric phenomena are. The variety in vegetation, in living species, in ways of life, in economic activities from one part of the globe to another, is the direct result of geographical and seasonal variability in the thermosphere, as is shown by the study of natural and artificial microclimates. The effect of temperature on the phenotype and on fertility has been demonstrated in many organisms.

Boltzmann's principle of order describes the evolution of irreversible systems, involving short-range molecular interactions. But it doesn't apply to either the astronomic structures characterised by long-range forces of gravity, or to biological structures. The latter are, in fact, highly organised, both from the architectural point of view, in its macromolecular protein combinations, and from the functional point of view in the chains of metabolic reactions; also, they correspond to open systems, exchanging not only energy but also matter with the exterior. General thermodynamics, developed recently by Prigogine and Glansdorff open the way for conciliation between thermology in physics and in biology, starting from the concept of dissipative structure. Such structures are brought about as the results of a system's wide fluctuation from a thermodynamic equilibrium, and they are kept far from this equilibrium due to exchanges in energy and/or matter with the exterior. There are examples of spatial dissipative structures: in hydrodynamics, Bernard's instability corresponds to the formation of hexagonal macroscopic convection cells in a liquid heated to a high temperature; in chemistry, Zhabotinsky's reaction, in which the oxydation of malonic acid by potassium bromate in the presence of cerium ions, leads to the formation of a build-up of alternate layers composed of tri-and tetravalent cerium ions. The application of the concept of dissipative structure in the working of biological systems is just in its infancy. However, encouraging results have been achieved for the glycolysis cycle and cerebral waves, which can be described as temporal dissipative structures. More recently, Eigen's research has shown that the interactions between proteins and polynucleotides enable the system to reach a remarkably stable final condition, characterised by a genetic code. The concept of dissipative structure should also be applied to the ecosystems, which are open ones, characterised by exchanges in energy and matter with the exterior.

In this way, heat has clearly added a new dimension to various scientific disciplines. But in addition to all laboratory experiments, there is something more precious: human warmth. This source, from which comes friendship, is perhaps the most noble form of emotion, whereas the physical heat is generally the least noble form of energy. For example, the family circle or our close frieds, many a time, warm our hearts. It is something almost natural, born of kinship, of neighbourliness, of shared experiences and moments enjoyed together. What is in fact warmer than the smile or gestures of a small child, or reminiscing over hard times, or recalling warm memories, by the fireside? Does it not, however, restrict the range of our emotions and progress, to limit ourselves, consciously or not, to the ties of family or friendship which life provides us with? Shouldn't we reach beyond these friendships in order to further enrich our heart and mind, with all that might distinguish us from others?

In truth, such bonds are difficult to form outside our own frontiers. The reason lies no doubt in the linguistic, idealogical and socio-economic barriers, but more so in some defects in the school or parents' teaching of contemporary history. We are crammed with preconceived ideas, from all English girls having freckles, to all Germans being unfeeling, and we are convinced that the path leading to understanding with other nations is strewn with insurmountable obstacles. Luckily, young people take little notice of such cliches, and are able to cast them aside more quickly than ever before. The older generation should first recognise this quality of theirs. I well remember, that when I was in my teens, my first artistic and amorous experiences were, by chance, English and German. In the context of a rather individualistic and chauvinist education, these pleasures were a surprise. Since then, I make every effort to watch, listen and understand, regardless of time, place or nationality,. . . For each human being and each nation has its good points, not to say outstanding qualities. And these are easy to discover, by those who are not hampered by Aesop's beggar's bag, asking everyone what he is able to give. We just have to show good will and good humour, following the example of Major Thompson, who found France very Gallic but nice.. .!

Some will complain that this constant search for friendship is vain, naive, and even ridiculous. Regardless of that, let us grant them that it is a Folly, joining with Erasmus in the praise of this quality which is the source of all our real pleasures . . . *« Indeed, when one thinks that all men are condemned by nature to suffer some basic* neck and breast uncovered 10 to 12 minutes in a room at an ambient temperature of 18°C. Then pictures of the neck are taken with an Aga Thermovision Unit 680. It can be helpful to observe the rewarming after having cooled the neck with alcohol. But we do not use this procedure for every patient. Pictures are in black, grey, and white. The temperature scale usually chosen is 1 to 10°C; the temperatures are measured with an accuracy of 0,5°C. The nodule is slighty encircled on the skin with a dermographic pencil. On the thermogram a mark is taken either with a fine guide which indicates the nodule's center or with a metallic ring which is not in contact with the skin. If necessary, and in order to be more precise, a Polaroid photo of the neck is taken in the scanning position.

ANALYSIS OF THE CASES

The microscopic examination revealed 59 cancers out of 364 studied cases. In reality, for 7 of them, the malignancy did not seem certain to one of our histologists, who considered them as only potentially cancerous; we discarded these 7 cases. Consequently, the analysis concerns 52 malignant diseases. They are classified by the histopathologists as indicated in the Table I.

Tab. I.

	Number of *cases*
Papillary carcinoma	18
Follicular carcinoma	9
Mixed papillary and follicular carcinoma	9
Polymorph carcinoma	3
Sclerosing occult cancer	3
Trabecular carcinoma	2
Medullary carcinoma	3
Intrathyroid metastasis (hypernephroma) (bronchial epithelioma)	2
Anaplastic neoplasm	2

Table II summarizes clinical data according to age, sex and physical examination.

For 14 patients, the nodule appeared 3 to 6 weeks before examination. For the other cases the nodule discovered accidentally. 5 patients with a solitary nodule had regional lymph nodes; 11 out of 12 multinodular goitres were old and 4 had recently grown.

Tab. II.

		Number of *cases*
Age (years)	under 30	16
	30 to 50	17
	over 50	19
Sex	male	44
	female	8
Palpation.	isolated nodule	34
	2 or 3 separate nodules	6
	multinodular goiter	12

For the 12th case, the goitre developed after two operations, the first for toxic adenoma, the second for Graves disease.

Table III gives the results of the isotopic scanning.

Tab. III.

Palpation	*Radioisotopic scan*	Number of cases
Solitary nodule	Hypoactive area	27
	Heterogeneous area	4
	Normal	1
2 or 3 nodules	All hypoactive	7
	One hypoactive	1
Multinodular goiter	Overall hypoactive	3
	Heterogeneous	9

In two cases with only one nodule at the physical examination radioactive scanning showed two hypoactive areas. So we can count at least 20 cases of multiple nodules. Nevertheless histopathological controls revealed only one cancerous focus, out of 10.

Apart from multinodular masses, pathological associations were:

friendly one. And WC *realise that we are of the same world . . . ».* The fact that discussions are now taken for granted, is a big step forward, encouraging optimism. For European reality can only begin with a clash of mentalities and an exchange of ideas. Gradually the ordinary people and the young are forming friendships, thanks to *a* great increase in school, artistic, tourist and economic exchanges.

Scholars are certainly strongly convinced of this evolution, which they experience almost daily in their literature, instruments and travel. It may well be that scientific Europe can be more easily brought about than all the others, because scientific method teaches modesty, and because the research worker or lecturer realises that scientific progress can be the work of anyone, irrespective of Nationality. C.E.R.N., in Geneva, is the outstanding example of this: *its* success in corpuscular physics is the work of several countries, pooling their great financial and intelectual resources. Thd work of the European Science Foundation, recently installed in Strasbourg, should crystallize and reflect the notion of a European scientific community.

Many learned societies whose European purpose is written into their statute, get no further than their good intentions: Because establishing contacts and creating international research teams, demand more than just rules and skills. Scientific association only survive and prosper if their leaders can give them a soul and human warmth. These qualities are a guarantee of success, immunisation against the dangers that come from sheer size, breakaway groups and bureaucracy. The European Thermographic Association has been growing for more than five years, emboying this state of mind. All those who work for it have to struggle each day with their professional and personal worries. Much good would European Thermography do them, were it not also an opportunity to meet their friends. I wish, therefore, to pay hommage to my thermologist colleagues, who have accepted a rôle in furthering their discipline, in particular, to those present today. For they are men of good will.

But incidentally, in speaking of men, or of Man, to disegnate Humanity, or our work groups, we are involuntarily perpetuating the myth of machismo, the deification of the male. Is this not untoward, at a time when 1975, Women's Year, has just drawn to a close! Is it not even ungracious towards mothers, wives, girl friend and daughters, who are the catalysts if not the leaven of all our joys and actions? Well, for our female colleagues who have already helped to give birth to and nourish thermology, I would like to quote a few lines from Holderlin, entreating Vulcan: *« . . . spirit of the familiar fire,. to come and wrap woman's tender heart in the clouds, to come and protect these flowers of infinite peace and kindness in the gold* of *dreams. . . ».*

Heat is of service to Man in all his activities. It occupies a considerable place in daily domestic problems, from cooking and freezing to heating and air-conditioning. In industry, it is the invisible tool, causing multiple transformations, be it in refining oil, distilling alcohol, smelting, manufacturing steel and glass, moulding plastics, or preparing medicaments. Produced or exploited in internal combustion or jet engines, in gas or steam turbines, in nuclear fission reactors and breeders, heat is a factor in the propulsion of vehicles and supply of electricity. By the way, those who rise up in arms against the installation of nuclear power stations, are paradoxically less hostile to the atomic arms race, and they would probably be the last to give up their home comforts. All discussion on this serious problem demands great integrity of judgement and deep concern for Humanity, and it should exclude apocalyptical visions and political aberrations. With all these spectacular implications, we tend to forget that the heat of the sun makes the corn grow, ripens the grapes, and also makes us happy and exuberant without knowing why. The measurement of temperature and heat-flow enables the soldier to detect *a* camouflage and reach his target, the doctor to detect an illness and give a prognosis, the ecologist to catalogue the earth's resources and evaluate pollution, the farmer to get the best yield and create new species. It is very significant that the fourteen planning groups under France's « 7th Plan », are all more or less concerned with calorific energy and thermology techniques, particularly in health and welfare, energy and industry, agriculture and food.

Rises in temperature, whether rectal or cutaneous, reveal clearly a great number of illnesses. Fever and the association rubor-calor-dolor are the major pathological signs. Ever since Wunderlich's famous clinical experiments last century, the thermometer has been an essential instrument in medicine, assisting hand and eye, just as the stethoscope and sphygmomanometer. Cutaneous thermography, either infra-red or to a lesser degree by liquid crystals, is at present useful in the diagnosis of numerous mammary, vascular and particularly rheumatic diseases; above all it supplies conclusive information for the prognosis and therapy in breast and skin cancer, due to the connection between heat and the development of cancerous tissue. Thermotherapy exploits the beneficial effects of heat on skin, pain, and blood circulation, and all kinds of methods are used, some centuries old. Localised heating of tissue can be carried out with short waves or fango mud baths, or total heating of the body with baths or saunas. In the treatment of cancer, attempts have been made to potentialise the effect of ionising radiation, by creating a selective hyperthermia in the tumour, or to set in motion a kind of selective self-destruction of the malignant tissue by inducing a general hyperthermia by immersion near the lethal temperature.

Even in our modern world, where aesthetics and fashion play such an important part, clothes and dwelling places have kept their primitive function, which is to comfort the body in its struggle against the cold; for it is relatively poorly equipped for this. Our well-being is closely bound up with the heat around us, both in our professional occupations and in our leisure hours. Whether it be in officers or workshops, the work output, manual or intellectual can be improved by finding the most suitable temperature, taking into account the preference of the employees, but also avoiding too high temperatures in which microbes can breed. In short, amongst all the various reasons for summer migration to sunny shores, or simply for Sunday morning lie-ins, the search for warm surroundings is one of the most important.

In the energy field, especially in electricity, heat occurs at production and then exploitation level, in accordance with Carnot's principle. The natural forms of calorific energy, solar and geothermic, recently become a reality, are not at all competitive, because of their uncertain and localised character; however, they should play a more important role, especially in the conception and heating of living premises. Thermonuclear fusion has already been achieved on a small scale, in laboratory work, with the help of plasma temperatures of several million degrees, attained in virtual recipients created by strong magnetic fields: it should be mastered in one or two decades and will free man from the restrictions imposed upon him by the increased urgency of finding sources of energy. The degree of harmfulness in thermal pollution is harldy worth mentioning, except for the matter of the hot water discharged by he power stations, but it lies actually at a point common to all kinds of pollution, that of water which it potentializes or precipitates, and that of the atmosphere of which it is a by-product. The recommended economies in all fields of energy amount to a limitation in the production of heat from combustion, either directly, in the reduction of heat in buildings and improved insulation, or indirectly, by restricting the consumption of fuel, petrol or electricity.

In the industrial field, thermography is becoming increasingly important, for it provides original and economical solutions to complex problems, such as checking manufacture and running order, and detecting faults or breakdowns. From amongst the already numerous uses, let me quote as examples: in aeronautics, it measures the temperature of special alloys during manufacture, in order to avoid exceeding the critical temperature, detrimental to the mechanical properties; in the metal industry, it is used in the regular checks of the fire-proof linings of furnaces and converters, in order to prevent accidents and plan repairs; in electronics, it verifies the components of integrated circuits with the help of infra-red microscopes. In all those cases, the main advantage of the infrared techniques, is that they supply a global thermal vision, in real time, without touching the object, which is therefore not disturbed at all, and can be moving.

Food is also a matter for thermology: in the organism, food suffers metabolic loss, which generates heat, and energy requirements continue to be commonly described as « calories ». The problem of nutrition on a world wide scale, is bound up with that of demography, and is the object of cooperation by specialised international organisations, particularly F.A.O. and W.H.O. Preoccupation with calories may be one of the charms of the fair sex, and over-eating and some forms of dieting the luxury of rich countries, but millions of human beings in developing countries suffer each day from a calory and protein deficiency. For the purpose of improving food supplies, remote sensing techniques have recently been used to help the combined efforts of the agricultural experts, hydrologists, meteorologists and geographers. Remote sensing, a key element among the techniques covered by UNESCO's «Man and Biosphere » programme, analyses the radiation of the earth's surface in the infra-red spectrum and in the domain of micro-waves, by means of scanners aboard aeroplanes or satellites. The advantage of such methods lies in the fact that each element, and by extension each plant type, leaves traces of its own characteristics: temperature, composition, structure, in its emitted transmitted or reflected electro-magnetic radiation. This idea of « signature » can be applied to complex units, such as fields of cereals or shoals of fish, which can thus be counted rapidly and on a large scale. The same techniques permit early detection of attacks by parasites, faults in irrigation and the seat of fires.

Agriculture is fundamentally dependent on two thermoclimatic features, sunshine and rainfall, and the aptitude of the ground to accept one or the other. And there too, remote sensing satellites will help us from now on to consider the problem on the scale of the biosphere, from the point of view of describing the land, supervising farming, and forecasting the weather. Finally, numerous types of cultivation and breeding are carried out in premises specially planned and climatised with a view to maximum returns; the most widespread example is that of giant greenhouses, where the sun's rays supply not only the energy for biosynthesis, but indirectly the heat favourable to the germination and maturation of plants.

Indignation or exasperation may make us « not under the collar », . . . « Someone who is annoyed or exasperated can be said to be all het up » . . . We may live to regret something we said « in the heat of the moment » . . . Someone who is very angry is said to be « in a flaming temper ». . . There are really so many pejorative or abusive uses of the words conected with heat, some which we resort to when we get upset at work or in the hustle and bustle of town life! . . . But once at home with wife, children, or friends, at the fireside, in bed, or out in the sunshine.. . how pleasant is this heat; it is once more gentle, soft and soothing. An now and again, the warm and iridiscent colours of roses and young girls, and the warm and ardent reds of impressionist paintings delight our senses. For if heat is life, quickening our blood and improving our environment, it is also the fire of passion, the flame of tenderness, the light of friendship, and, in short, the reason for all our activity, today and probably for always . . .

Ladies and Gentlemen, it is a great pleasure but also a happy coincidence, to find ourselves gathered here in Bath, where the natural thermal springs have been an attraction and source of prosperity since Roman times. We shall not forget the warm welcome and the mysterious charm of this so typically Engilsh city which seems to have been immortalised in one of William Shakespeare's wonderful sonnets:

The little love-god, lying once asleep
Laid by his side his heart-inflaming brand,
Whilst many nymphs that vow'd chaste life to keep
Came tripping by: but in her maiden hand
The fairest votary took up that fire..
This brand she quenched in a cool well by,
Which from love's fire took heat perpetual
Growing a bath and healthful remedy
For men diseas'd; but I my mistress thrall,
Came there for cure, and this by that I prove,
Love's fire heats water, water cools not love.