PHYSICS OF THE BOTTOM LAYERS OF THE ATMOSPHERE*

THE Physics of the Upper Atmosphere has been dealt with more than once by previous Presidents of this Section. On this occasion, I propose to make a rapid survey of some of the problems concerning the Bottom Layers of our Atmosphere and the Soil Layers immediately in contact with them. Weather is a three-dimensional problem, and to understand it fully one must explore the whole atmosphere. The troposphere, the seat of major weather phenomena, may be treated as a vast thermodynamic Heat Engine with water vapour as the working substance. Although every branch of classical and modern physics has the fullest scope for enquiry and research in the atmosphere around the earth, I confine myself here, as far as possible, to some of the happenings near the base of the atmosphere.

Radiation

When solar radiation passes through the atmosphere it is depleted by the processes of (1) absorption by certain components of the air, (2) molecular scattering by air molecules and (3) scattering by dust and other impurities. Solar radiation is absorbed by the oxygen, ozone, carbon dioxide and water vapour in the air but the most conspicuous is absorption in the near infra-red by water vapour and in the extreme ultraviolet by ozone. The last mentioned is of immense significance to life on the surface of the earth, as these radiations are very injurious except in minute doses.

The blue colour of the sky is due to the preferential scattering of shorter wave-lengths by the air molecules. Owing to paucity of actual radiation data in India (limited data are only available for Poona and Shajahanpur) computations have been undertaken for various latitudes over India on the basis of Bouguer's equation.

The total hemispherical radiation emitted by the earth's surface (0·669 gr. calories/cm.^{2}/mnt.) is comparable to the direct radiation (2 gr. calories/cm.^{2}/mnt.) from the sun at the upper limit of the atmosphere. In the disposal of the thermal radiation emitted by the earth's surface, water vapour in the troposphere, CO_2 which occurs throughout the atmosphere and ozone in the upper air play a significant part.

Thus the absorbing components like ozone, CO_2 and water vapour absorb the direct radiation from the sun and the thermal radiation from the earth's surface and also emit heat radiation in the wave-lengths that they absorb. It is important to know the exact distribution of the absorption coefficients with wave-length for the entire spectrum in order to evaluate the radiative equilibrium in different parts of the atmosphere. Our knowledge of absorption coefficients is incomplete and requires further thorough investigation of the absorption spectra of various gases at various temperatures and pressures.

In India, investigations on atmospheric radiation were commenced in 1930 by Ramanathan who was the first to give a complete picture of the thermal structure of the earth's atmosphere and to have conducted extensive measurements of ozone distribution in the upper atmosphere over India. Several workers have since continued radiation work mainly at Poona. Ramanathan's thermal picture brings out the interesting fact that the troposphere is highest and the air coolest just above the equator.

Phenomena Near the Ground

Coming to the base of the atmosphere which is comparatively easier to investigate, one has to remember that insolation is the most important factor governing the climate of the air and soil layers near the ground. Workers at Poona have taken experimental measurements of this factor under various conditions. The surface of the ground is an "active surface" as it absorbs solar radiation and thereby warms the air and soil layers near it, and its absorbing power depends on the colour of the soil. The insolational heating and radiational cooling of the ground are propagated upwards into the airlayers and downwards into the soil layers. The diurnal range of temperature is maximum at the ground and decreases in the soil very rapidly with depth, becoming negligible at 1 foot or more. In air layers, the range falls rapidly in the first few inches and more gradually aloft, becoming negligible several kilometers above the ground as against 1 foot in the soil. Theoretical as well as experimental work of Malurkar and Ramdas in 1930 have enabled a clear understanding of the convection processes near a hot surface. The temperature at the soil surface can be as high as 75 to 80° C., and the lapse rate in the first cm. or two, 200,000 times the adiabatic lapse rate. The processes involved in the nocturnal cooling of the ground and the airlayers near it, the temperature fluctuations and the turbulence in the air layers near the ground have been studied at the Central Agric. Met. Observatory at Poona. A complete picture of the growth and destruction of the thermal inversion layer near the ground has also been given for the first time as a result of work at Poona, and is based on temperature readings taken with an Assmann Psychrometer at short height intervals. These measurements have also shown that the time lag of the maximum temperature epoch as one moves away from the ground is much larger than should be the case if the conduction close to the ground was truly molecular. Considerable work has also been done at Poona on the transmission of heat by convection from insolated ground to the atmosphere and on the exchange of water vapour between the soil and the air layers. Soil samples containing only hygroscopic moisture, exposed in the open, lose water by evaporation from the morning up to the maximum temperature epoch, and thereafter the soil reabsorbs the water vapour from the atmosphere. There is a complementary phenomenon going on in the air layers near the ground. During the day there is an upward

* Extracts from the Presidential Address delivered by Dr. L. A. Ramdas at the Physics Section of the Indian Science Congress, at Patna, 1948.

flow of water vapour from the ground, vapour pressure decreasing with height; at night vapour pressure increases with height.

The thermal balance at the ground surface is controlled by radiation, convection, conduction and evaporation. Calculation on the basis of experimental measurements at Poona on 23rd April 1936 showed a gain of 1366 and loss of 1355 gr. calories per sq. cm., resulting in a carry-over of 11 calories to the next day.

Micro-Climates of Plant Communities: Investigations at Poona show that plant communities tend to develop their own characteristic local or micro-climates which deviate from the climate of a neighbouring open space to the extent that horizontal air movement and incidence of solar radiation are cut off by the stand of the crop. The state of the ground also plays its part. Inside the sugarcane crop the almost continuous canopy of foliage acts like an *active surface,* and during the day, the canopy gets warmer than the ground, and forms a 'forced inversion'. Micro-climates of plant communities and their variation with age and density of crops are of great interest to agriculture.

Problems of Hydrology: The Agric. Met. Section at Poona has also been investigating the movement of moisture through soil, evaporation from free water and soil surfaces, effects of salts on permeability of soils to water, etc. Problems relating to the evaporating power of air layers near the ground, the fate of rainfall on irrigation, which is controlled by various factors like drainage, percolation, etc., have been studied on the basis of experimental measurements. The results of these experiments are of obvious importance to indigenous agriculture.

B. N. SRINIVASIAH.

* The cost of printing this article has been met from a generous grant-in-aid from the Indian Council of Agricultural Research, New Delhi.

THE PLACE OF BIOCHEMISTRY IN INDIA*

EVERY student of Biochemistry knows what tremendous amount of literature has been produced during the last two decades on the subjects of vitamins, hormones and enzymes

The role of vitamins in the alleviation of disease, and the eradication of such plagues as beri-beri, scurvy, pellagra, which took an enormous toll of life in many parts of this earth, was important enough to justify the support which this study obtained in different laboratories of the world. The biological significance of these chemical substances went, however, much further. Many conditions of obscure ætiology, and in apparently normal individuals, a feeling of vague illness, proved to be due to a deficiency of one or the other vitamin, and yielded readily to vitamin therapy. Thus vitamin therapy became popular for the promotion of optimum health with considerable success.

Coming to the subject of hormones, this field has not lagged behind that of vitamins, in the prolificity of literature, the importance of its discoveries and their application to human problems. In fact the output of papers has been so prolific in this field that new journals were founded to publish researches in endocrinology. Taking the group of sex hormones alone, it is well known how the biochemistry of these developed rapidly after the isolation of Oestrone by Doisy and by Butenandt in 1929 from human pregnancy urine. In less than a decade the entire group of naturally occurring œstrogenic and androgenic compounds and progesterones were isolated, their chemical structure and the laboratory synthesis of some of them worked out. The physiological action of these compounds, their biosynthesis, their metabolism and their role in pregnancy, reproduction, lactation, growth, puberty, senility are subjects of profound human interest, and biochemistry has enriched our knowledge of these remarkably. Researches on hormones have also led to the discovery of new techniques both in chemistry and clinical medicine. In the latter field, the nature of sex determination, sex involution, pubertal growth have been delineated experimentally with the help of these hormones.

The possibility of cholesterol being the starting point of the biosynthesis of steroid hormones was indicated by Fieser and by Koch in their admirable monographs. Recent studies of Bloch with the help of deuterium-containing cholesterol have provided an experimental support for this view. The administration of this cholesterol led to the appearance of deuterium containing pregnandiol in pregnancy urine. The output was of the order expected. Discoveries of fundamental importance are likely to result from a study of the role of hormones in cell processes which are being actively pursued to-day. The action of androgens in the synthesis of proteins, and of adrenal cortex steroids in the metabolism of carbohydrates, proteins and salts are already well established.

Enzymology is another fruitful field which biochemistry has explored with admirable success. While the foundations of this study were laid almost in the middle of the last century by the work of Liebig and Pasteur on fermentation, it is only during the last two decades that we have been able to get a clearer glimpse of the myriads of chemical reactions taking place in the tiny living cell. These chemical reactions which are collectively referred to as intermediary metabolism and whose integrated systems are responsible for all the phenomena of life, are not spontaneous, but organised and well-controlled processes brought about by highly specialised catalysts, the enzymes. Since the number of chemical reactions in a tiny living

* Extract of the Presidential Address to the Section of Physiology, by Dr. Bashir Ahmad, at the 35th session of the Indian Science Congress, in January 1948, at Patna.