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.

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* 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.

cell are to be counted in hundreds, it supposes the presence of hundreds of enzymes. This, in fact, is true, and literally hundreds of enzymes have been isolated from the small yeast cell.

One of the most remarkable achievements of biochemistry in the field of enzymes is the reconstruction of the entire process of the fermentation of glucose to alcohol and glucose to lactic acid *in vitro*. Some twenty enzymes are involved which have been isolated and prepared in a pure state. A complete picture has been produced of the chemical details of how the various enzyme systems are linked and how the different chemical reactions are synchronised. This indeed is a remarkable achievement, but it is a drop in the ocean. Vast fields of virgin territory remain unexplored in enzyme chemistry.

Some other landmarks in the field of enzymes are the elucidation of the chemical nature of cozymase by Euler and his school (1937); of cocarboxylase by Lohman and Schuster (1937); of the yellow enzyme of Warburg by Warburg himself and by Kuhn (1935) and Karrer (1935); of the enzyme of tyrosine decarboxylase by Gunsalus (1944); all of which are examples of vitamins functioning as prosthetic groups. These explain the organism's continuous requirement of vitamins. Similarly the indispensability of certain trace elements in nutrition point to their being parts of some important enzyme systems. The development of the knowledge of enzyme chemistry also provides a basis for the understanding of the chemotherapeutic action of drugs. Observations on the relation of sulphonamides and *p*-aminobenzoic acid are important landmarks in this direction. These support the view that sulphonamides only compete with *p*-amino-benzoic acid in the formation of an essential enzyme complex. The action is not unlike that of an anti-vitamin. For the first time these studies open up an important avenue for a rational programme of chemotherapeutic research after many decades of much wasteful effort in organic synthesis.

Fundamental knowledge of plant biochemistry is essential to the plant pathologist, the plant geneticist, the horticulturist, and the economic botanist. This knowledge has grown into an important branch, though not as far developed as animal or bacterial biochemistry. The course of biochemical reactions in the plant are somewhat more complex than in the animal. Starting from carbon dioxide, water and a few inorganic elements, the plant cells synthesise an extraordinary range of complex organic compounds providing complete systems of synthesis and break down within themselves. Plant tissues, unfortunately, do not offer the same facilities for study, as the blood, the glands, the liver, or the organs of digestion and excretion in the animal; but new techniques for investigating the complex biochemical systems of plants are being devised which open up avenues of enormous possibilities. For example an enzyme system has been isolated from plants by the help of which starch can be synthesized *in vitro*. Even the enzymic synthesis of sucrose has been accomplished *in vitro*. Though the starting materials in this case were glucose-monophosphate, fructose and an enzyme system obtained from a bacterial organism, a line of attack has been opened which offers possibilities of development.

There are many other important fields in which biochemistry is making contributions of fundamental importance. Mention may be made of genetics, viruses, chemotherapy and immunology. An insight is being gained into the nature of genes and viruses, and how they direct biochemical reactions. The mechanism of the genetic control of the oxidation of homogenetic acid, presumably through a specific enzyme; of the synthesis of plant pigments such as carotinoids, anthocyanins and flavones; and several other oxidations and syntheses in the plant and in the animal are being gradually elucidated. Recent observations on the chemical and genetic mechanism of the reproductive system of *Chlamydomonas*, and of the amino-acid synthesis in *Neurospora* are of great significance. Encouraging investigation have been made on the chemical nature of viruses, and change of their chemical structure by certain chemical reactions. A clearer understanding of the biochemical mechanism of the therapeutic action of drugs is being reached. Chemical nature of the protein antigens and specific polysaccharides, of toxin and antitoxin reactions is being revealed and foundations of the science of immunochemistry laid.

I have picked up and presented to you a few glittering fragments from the large mass of scientific literature in biochemistry and indicated the role which they play in the progress and welfare of man. Biochemistry to-day is no longer the handmaid of medicine, or the ugly duckling of physiology. It is a full-grown science in its own right. Though still young, it has grown in stature bigger than some of the traditional branches. It has already done tremendous service to man, but its unexplored potentialities are even greater.

K. S. R.

Note.—The cost of printing this contribution has been defrayed by a generous grant from the Rockefeller Foundation for the publication of results of scientific work made to us through the kindness of the National Institute of Sciences, India.—*Ed.*