been giving to others in the elucidation of the geomorphology of Peninsular India. The need for such type of work was being felt since a very long time.

The drainage pattern of Mysore is a little peculiar when compared with the general trend of drainage in Peninsular India. Professor Pichamuthu traces a relationship between the alignment of rock formations and the river systems of Mysore. The schists composed of the ferruginous quartzites and quartzites are found to be more resistant thus influencing the trend of the tributaries of the peninsular rivers as compared with the gneisses of the region. The universal law of differential weathering has been clearly indicated. The different type of topography exhibited by quartzites and gneisses of Mysore is similar to the one seen in the Nagari area.

The rivers of Mysore generally have a N.-W. and S.-E. trend in the west, N.-N.-W. and S.-S.-E. trend in the middle and northerly and southerly trend in the eastern position of the State. The only exceptions are the Tunga, Bhadra, Vedavati and Cauvery. Of these Vedavati has a number of gorges cutting across the resistant schists, but flows northwards when it meets the Closepet granite. Cauvery, since it flows in a gneissic country, has a general easterly trend.

The above type of arrangement is explained by Professor Pichamuthu as due to a dome with a central axial line of elevation running in an E.-W. direction across the State. The subsequent deviations in the trend of rivers are assigned to the subsequent elevation of the Western Ghats.

The remarkable east-west divide does not seem to have a structural basis. This may be either a superimposed feature or it may be due to dislocation in the northern and southern portions of the State. More evidences are required to indicate the uplift of the Western Ghats subsequent to the alignment of the drainage pattern. The rivers at the west, on the plateux and on the plains of the coast belong to different cycles of erosion and the pattern has to be studied from the source to the mouth. In this connection Cushing's[1] paper and the papers on the Palar[2] basin will give us some insight. Cushing considers most of the regions indicated in this paper as portions of an elevated peneplain.

Professor Pichamuthu is giving an impetus to Indian physiographers by the work that he has been doing and we look forward to an elaboration of many of the suggestions made in his paper. B. VARADARAJA IYENGAR.

1. "The East Coast of India" S. W. Cushing, *Bulletin of American Geographical Society*, 1913. 2. *Journal of the Madras Geographical Society*.

MINERAL NUTRITION OF PLANTS*

RECENT advances in our knowledge of plant nutrition have undoubtedly formed one of the important scientific foundations of modern crop production. Plant tissues are dominantly organic in nature once the water is driven off. Hence, the real problem of plant nutrition, from the point of view of the plant, is not, strictly speaking, a problem of inorganic nutrition but one of organic nutrition. What we should like to learn about the inorganic nutrients is how, directly or indirectly, they enter into the synthesis and utilization of organic compounds. Thus far, our knowledge of the functions of inorganic nutrients, except as they are present as components of the structure of indispensable organic compounds, has been very scanty. More recently, however, the application of the principles and techniques of biochemistry to plant nutrition has yielded a corpus of integrated knowledge on the mineral intake and metabolism of plants. A good deal of this knowledge has come from Dr. Hoagland's flourishing school of research at California, represented by numerous publications during the last quarter century. Workers in this field of research will, therefore, keenly welcome the publication of these lectures, seven in number, which, given originally at the Harvard University under the Prather Lectureship, present a general perspective of several important aspects of plant nutrition. The book is illustrated with many tables, text-figures and photographs of excellent quality and a selected bibiliography is appended to each lecture. Most of the illustrative material is drawn from the experiences of the Californian group of workers. It is but natural that, in lectures of the present type and objective, the author should have emphasized on the work with which he has had the most direct contact.

The first lecture introduces the reader to a brief survey of the soil-plant-air system with its innumerable interrelations and interreactions. The early theory of Liebig that the fertility of the soil does not rise and fall in exact proportion to the mineral elements withdrawn from or added to it has given place to the present-day dynamic interpretation of the soil as an ever-changing system, biologically controlled by the activities of the micro-organisms and of the higher plants growing in the soil. On this assumption, the concept of "supplying power" of the soil and the interrelation of the solid to the liquid phase of the soil become considerations of paramount significance in understanding the nutrient capacity of the soil.

The second lecture is devoted to a resumé of the development of knowledge of certain chemical elements needed by plants in minute amounts. The author has appropriately used the term "micro-nutrient" to cover these elements, hitherto called by students of plant nutrition variously as "rare", "minor", or "trace" elements. The functions of these elements, effective in minute amounts in plant-growth and metabolism, are, however, still in a large measure obscure, although there is little

* *Lectures on the Inorganic Nutrition of Plants*, by D. R. Hoagland (The Chronica Botanica Co., Waltham, Mass.; Macmillan & Co., Ltd., Calcutta), 1944, pp 226, Price $ 4·00.

doubt that they act in some not altogether well understood way as biochemical catalysts. Thus, zinc, deficiency of which results in a marked effect in retarding protein and, to a less extent, starch synthesis, may be a component of a catalytic system necessary for the phosphorylation of glucose (known to be a step in starch synthesis) or possibly of an amino acid. Likewise, boron requirement may arise on account of its role in the formation of pectic compounds: these contain galactose derivatives which require an inversion of H and OH on one of the C atoms if they are formed from glucose, this inversion being possibly brought about by boron. Several phases of organic metabolism need exploration before the exact mode of action of the different "micro-nutrient" elements is elucidated.

Another aspect of the problem of "micro-nutrient" deficiencies concerns their relation to animal nutrition. The requirements of the plant and of the animal are not necessarily coincidental quantitatively and not always qualitatively. Our knowledge of the factors that govern the quality of plant products from the point of view of human and animal nutrition is greatly limited but doubtless we should expect many unifying principles of metabolism common to living organisms of different categories. The "micro-nutrient" elements present an interesting aspect of these convergent investigations.

The mode of entry into the roots of the essential chemical elements and their upward movement and distribution in the plant are dealt with in the next two lectures. Radioactive isotopes or tagged ions have been of great value as a tool in these investigations inasmuch as they can indicate their presence in most cases without any operation on the plant, by application of a Geiger-Müller Counter and by radio autographs to the undisturbed tissue. It is now known that the intake of the nutrient ions is not, as many text-books have taught us, merely a diffusion process proceeding to attainment of equal concentrations or activities of a solute in internal and external phases, and that ion intake often takes place against gradient concentrations, this capacity being of course dependent on metabolic activities of the cell by which cellular energy is made available for ion transport.

A large portion of the nutrient salts absorbed is translocated to the upper part of the plant, there to serve the functions of growth and metabolism in the various above-ground organs. At one time, this upward movement of salt was, at least by implication, regarded by many botanists as a simple matter, transpiration being frequently assumed to play a determinative role therein. Recent evidence, much of it adduced by the author and his collaborators, would suggest that the absorption of salt and the absorption and transpiration of water are independent processes and that salt does not move in a plant merely in relation to the water absorbed. Essentially, salt absorption and movement are determined by the metabolic activities of the plant which are dependent upon the availability of energy-containing compounds or special organic units, and of substances catalysing or regulating metabolism, for all of which photosynthesis is ultimately necessary. Our knowledge of salt movement in the plant is still inadequate although the data reported permit a much closer approximation to an understanding of these phenomena than has been available in the past. One especially interesting aspect for study with regard to solute movement in plants will relate to the so-called "flow-back" of nutrients from the plant to the soil for which satisfactory experimental evidence is apparently lacking, although it is known that something like a circulatory movement of mobile inorganic nutrients can take place in the plant by which solutes are carried in the wood to foliar regions from which they may be re-exported through living cells even back to the roots.

The fifth lecture discusses some of the physiological aspects of the inorganic nutrition of plants as they are offered for examination under the controlled conditions of artificial culture technique (water culture, "hydroponics", sand culture, and gravel culture). These have certainly been of great service as tools for research in plant nutrition and, in recent years, have attracted an extraordinary amount of attention as a means not merely to study general scientific principles of plant nutrition but also to produce crops commercially. Many, among the uninformed, seem to gain the impression that a revolutionary development has taken place and that soon we could dispense with soil as medium for crop-growth on large scale. It should be distinctly borne in mind, however, that, save in unusual situations, artificial culture methods are at present applicable in a commercial way only to expensive green house crops. Even there, practical and economic factors should receive critical consideration before their adoption can be justified.

The chemical processes occurring in plant tissues as salt is moving into or through the cells, or soon after the salt has been accumulated are not well understood and the author discusses in his sixth lecture several aspects of the problem with special reference to the nitrogen and organic acid metabolism of higher plants. Progress in understanding the metabolism of plant-cells in relation to salt accumulation will depend largely on advancing knowledge of the biochemistry of respiration, together with a correlation of biochemical transformations with the maintenance of organized structures in the protoplasm.

The concluding chapter presents an illuminating discussion of the potassium nutrition of plants both in relation to soil problems and the functions of potassium in plant metabolism. These studies serve well to illustrate the ramifications of research in an attack on any general problem of plant nutrition and the need of many approaches to proceed towards a goal of increased understanding of soil-plant interrelations.

As the author has pointed out in his prefatory note, these lectures do not have the characteristics of a monograph or a text-book but it is not the least of the merits of Professor Hoagland's exposition that they are both authoritative and inspiring.

A. SREENIVASAN.