main types, mineralo-corticoid and gluco-corticoid, and that cortisone and adrenocorticotrophic hormone are in the latter category. The idea of a balance between these types may explain some apparent anomalies, such as the fact that arthritic symptoms do not necessarily appear at a low level of activity of the adrenals.

Finally, mention must be made of some very interesting work by Rittenberg and Bloch on the biogenesis of cholesterol. The sterol is synthesized by surviving rat-liver slices *in vitro* from labelled acetate and afterwards degraded in various ways. The results indicate that all the carbon atoms can be derived from acetate. It will soon be possible to attribute to each of the carbon atoms its origin from a methyl or carboxyl of acetic acid.

In spite of, or better, because of, all these brilliant achievements, it cannot be supposed that more than a small part of the wonder of the sterols and their derivatives has thus far been brought to light.

Reverting to the tropic hormones of the anterior pituitary, it should be noted that these are by no means the only examples. There seems to be a fairly general and adaptable mechanism whereby the appearance of a protein stimulates the formation or release of various steroid hormones at different sites in the body. There must be some common factor in these processes, and it may not be so far from our reach as we imagine. There is a widespread belief that steroid hormones are intimately connected in some way with malignancy, and for this reason alone research in this field must be vigorously pursued. All the topics we have touched reach out into the unknown and all are of profound significance for the progress of biological science and hence for the health and happiness of mankind. There is a good case for the international organisation of a supreme effort, which could conveniently be directed in the first instance towards following up the cortisone-adrenocorticotrophic hormone clues.

Those who control the United Nations Educational, Scientific and Cultural Organisation have wisely decided to initiate certain international laboratories, but it is doubtful whether any of the subjects so far advanced, important as they undoubtedly are, should be preferred to a concerted investigation of the chemistry, biochemistry and endocrinology of the sterinoids. This is not the place or the time to consider the details, which can be adjusted to suit the different circumstances of the participants, but it is already clear that centralization in terms of bricks and mortar would prove difficult. An organisation, with ample funds to be used for the promotion of research in existing centres, and capable of effecting full liaison between them, is the first objective.

MICROBIAL DIGESTION IN THE ALIMENTARY TRACT

ON September 6, a symposium on microbial digestion in the alimentary tract was held jointly between Section I (Physiology) and Section M (Agriculture) of the British Association at the recent meeting at Newcastle upon Tyne. Dr. D. P. Cuthbertson (Rowett Research Institute) introduced the subject by referring to the comparative anatomy and physiology of the alimentary tracts of various classes of mammals, with particular reference to sites of

microbial activity. So far, all mammals examined have a microbial population in the large intestine, and so this form of digestion is general and normal. In carnivorous animals, fermentation on any large scale does not take place in the large intestine; but in most other mammals the caecum and colon have the size, and provide the environment, necessary for bacterial growth on food residues. Only substances produced outside the living microbial cell or made soluble by the break-up of the dead cell in the large intestine are potentially available to the host. The presumptive evidence is that some of these are absorbed directly from the alimentary tract or after coprophagy.

The ruminant stomach is in four compartments of which the first two, the rumen and reticulum, together form a large fermentation vat where coarse fodder materials which resist the enzymes secreted by the glands of the alimentary tract are digested, and new compounds, such as microbial protein and starch, are formed which later become available to the animal by the normal digestive processes. Other compounds such as the short-chain fatty acids and ammonia are formed and absorbed through the stratified squamous epithelium of the wall of the rumen. Dr. Cuthbertson briefly referred to the recent work of Marston in Australia and Becker and his co-workers in the United States, which has shown that cobalt pine in sheep is not susceptible to vitamin B₁₂ (which contains cobalt) by vein or by mouth, at least in the amount administered which is presumed more than sufficient.

Dr. A. T. Phillipson (Rowett Research Institute) pointed out that short-chain fatty acids are present in most parts of the alimentary tract in which fermentation occurs. The concentrations found in the rumen and in the large intestine of other species are of the same order, and the mixture of acids consists principally of acetic, propionic and butyric. In order that fermentation can proceed, the acid products must be removed or neutralized. In the sheep the saliva contains bicarbonate, and in twenty-four hours sufficient is secreted to neutralize from one-half to two-thirds of the acids present in the rumen of animals taken from pasture. As fermentation is continuous, it is clear that saliva alone is not sufficient to maintain a pH between 6 and 7. The amount of acid passing to the abomasum is less than 1 gm. per hr. The principal means whereby the pH is maintained close to neutrality is by the passage of ions from the rumen to the blood. This is shown by the fact that acid or alkaline solutions, when introduced into the empty rumen from which the entrance and exit are closed, rapidly move towards a pH of approximately 7.4. Fatty acids, in both free and ionized states, are absorbed from the rumen into the blood stream.

The conditions in the rumen are anaerobic, and this limits the nature of the organisms which are active. The food eaten is mixed with the residues of previous meals so that the rate at which any one meal leaves the rumen is extended over a considerable period, and traces of residues of one meal have been found in the rumen seven days later. The rate of passage of food through the whole alimentary tract of the ruminant is slower than it is through the horse or pig. As digestible cellulose is present in the faeces of sheep fed on hay or straw, time appears to be one of the factors limiting the degree of fermentation that can occur when partially lignified plant foods are given.

Certain aspects of food structure and microbial interrelations were dealt with by Mr. F. Baker and Mr. H. Nasr (Rowett Research Institute). They showed how comparisons can be made, chiefly by direct microscopy, of the relative importance of microbial agents and gut secretions in the digestion and assimilation of various food materials, special attention being given to starch. The nutritional consequences have been studied in a variety of animals and have been found to depend on the anatomical structure of the alimentary tract, the structural organisation of the food material and the growth and activities of specific micro-organisms. Detailed study of microbial digestion of starch in the caecum of the pig has been carried out. The organism chiefly responsible for the breakdown has been isolated and typed as *Cl. butyricum*. This organism is capable of producing an alpha amylase in cell-free filtrates. The kinetics of the enzyme and its action on twenty-three starches have been studied. *Cl. butyricum* is capable of synthesizing a polysaccharide and some members of the vitamin B complex. They include riboflavin, nicotinic acid, pantothenic acid, pyridoxine and folic acid. Whether and to what extent the vitamins synthesized by microbial agents are available to the animal is being studied. The solution of the problem has a direct practical bearing on the relative nutritional value of cooked and uncooked potatoes in diets fed to pigs.

Dr. I. McDonald (Institute of Animal Physiology of the Agricultural Research Council) spoke on some aspects of the role of microbes in the digestion of proteins by ruminants, and pointed out that the special usefulness of the ruminants to mankind is largely to be found in their capacity to act as converters of plant proteins to specific animal proteins. Curiously enough, although a great deal of effort has been devoted to the estimation of the apparent digestibility of the proteins of feedstuffs by ruminants, comparatively little attention has been paid to the physiological processes underlying the digestion, absorption and utilization of nitrogenous substances.

The activities of ruminal microbes may lead either to a net gain or loss of nitrogen to the host animal. Digestion of cellulose is the primary function of the rumen, and hence the supply of nitrogen for the growth of cellulose-splitting organisms becomes an essential requirement for ruminal function. The microbes are able to utilize nitrogenous substances, other than amino-acids, for their growth, and the subsequent digestion of the microbes yields protein to the host animal. Ammonia occupies a key position in ruminal metabolism; it is probably the chief source of nitrogen, apart from amino-acids, for bacterial growth; it is formed by hydrolysis of urea (from saliva or feedstuffs) and by deamination of protein, and may accumulate to high levels in the rumen fluid. Ammonia is absorbed from the rumen and converted into urea by the liver, thus establishing a nitrogen cycle via the saliva, rumen and liver; excess of absorbed ammonia would be excreted as urea in the urine. When the microbes use protein as the source of nitrogen for growth, a new assemblage of amino-acids is presented to the host animal for digestion; this change may either enhance or reduce the biological value of the feed proteins. The microbes synthesize not only protein but also a variety of other nitrogenous substances, especially nucleic acids, which probably represent waste products for the host.

In their discussion on vitamin synthesis in relation to requirements, Drs. K. M. Henry, S. K. Kon and

J. W. G. Porter (National Institute for Research in Dairying) pointed out that microbial synthesis of vitamins of the B-complex and of vitamin K takes place in the intestine of most animals. In ruminants, synthesis occurs mainly in the rumen, which precedes the main digestive and absorptive tracts; thus conditions for the release and absorption of vitamins are specially favourable. Such synthesis supplies all or most of these vitamins needed by ruminants. In non-ruminants, synthesis proceeds mainly in the large intestine. Conditions for absorption are less favourable, since vitamins within microbial cells excreted intact are not available to the host, and vitamins present outside the cells are poorly absorbed. Nevertheless, non-ruminants derive some benefit from this microbial synthesis.

Dr. J. Tosic (Unit of Chemical Microbiology of the Medical Research Council) wound up by referring to the data he had collected while at the Rowett Research Institute for certain of the constituents of rumen contents during a digestion cycle in sheep. These indicate some of the environmental conditions under which rumen micro-organisms attain their great density and chemical activity; these in turn are associated with the transformation and digestion of the ingested food in the rumen. In discussing the anabolic cycle of rumen micro-organisms, mention was made of their ability to assimilate cobalt and other 'trace elements' from their external environment, and the available figures were briefly discussed in relation to some possible mechanisms of cobalt and other 'trace element' deficiencies in the ruminant.

In the discussion which followed, Dr. E. C. Owen (Hannah Dairy Research Institute) pointed out that this symbiotic phenomenon is of very general occurrence in the animal kingdom, and instanced the bacteria in the intestines of wood-eating insects such as the termites and wood wasps. He also mentioned Florkin's recent reference to the cellulose-splitting activities of bacteria in the digestive tract of snails and slugs.

Miss M. I. Chalmers (Rowett Research Institute) indicated the extent of loss of nitrogen which may occur in the urine when a protein such as casein is introduced into the rumen of the pregnant sheep held on a plane of nutrition such as would have been expected to induce a definite retention of dietary protein.

D. P. CUTHBERTSON

OBITUARIES

Dr. J. N. Keynes

DR. JOHN NEVILLE KEYNES, who died at his home in Cambridge on November 15, at the age of ninety-seven, was born at Salisbury on August 31, 1852, to John Keynes and his wife, Anna Maynard Neville. After studying at University College, London, he went up to Cambridge as a member of Pembroke College. He took the Moral Sciences Tripos, which at that time included political economy, and was Senior Moralists in 1875. In the following year he became Fellow of Pembroke. In 1882 he married Florence Ada, daughter of the Rev. John Brown. His wife, who survives him, has played a prominent part in the municipal life of Cambridge and has been mayor of the town. They had two sons and one daughter. The eldest son, who became Baron Keynes of Tilton, was perhaps the ablest and most many-sided Englishman of our time; and his death, in what should have been