tryptic hydrolysis) of the radioactive products obtained on exposure of mitochondria and mitochondrial extracts to radioactive orthophosphate. He proposed a model for adenosine triphosphate synthesis in a concerted reaction with adenosine diphosphate, orthophosphate and an activated derivative of cytochrome *c* formed through acylation of the histidyl residue on the hæm iron by the adjacent glutamyl side-chain.

Dr. A. M. Snoswell (New South Wales) described experiments in which reduction of nicotinamide-adenine dinucleotide by succinate in mitochondria from rabbit heart was coupled to electron transfer from succinate or from tetramethylphenylenediamine to oxygen through cytochrome *c* and cytochrome oxidase. The resistance of the coupled reductions to oligomycin was interpreted as evidence for activated intermediates other than adenosine triphosphate, which permit reduction of nicotinamide-adenine dinucleotide by compounds of higher oxidation-reduction potential. Dr. M. L. Birt (Melbourne) described related experiments with liver mitochondria prepared in a Krebs buffer in which reduction of the co-enzyme by succinate was inhibited by dinitrophenol but was not entirely inhibited by anaerobic conditions or by antimycin *A* and amytal. The relative importance of reduction through enzymes such as malate dehydrogenase and reduction of co-enzyme through reversal of the respiratory chain was discussed.

Prof. R. N. Robertson (Adelaide) reviewed recent investigations of the relationship of oxidative phosphorylation to the active transport of ions against an electrochemical gradient. Active transport need not be coupled to hydrolysis of adenosine triphosphate, but transport of ions or phosphorylation of adenosine diphosphate may be alternative consequences of the oxidative generation of compounds of the $A \sim B$ type or the oxidative separation of positive and negative charge, as envisaged by Mitchell. Dr. J. Charnock (Adelaide) described experiments on an adenosine triphosphatase from the microsomal fraction of kidney; this enzyme requires sodium and potassium ions for full activity and is inhibited by ouabain. Dr. Charnock discussed the evidence that a phosphoprotein intermediate is involved in the action of the enzyme and that the phosphoprotein might carry cations across membranes. Dr. B. Hetzel (Adelaide) discussed the uncoupling of oxidative phosphorylation by thyroxine and triiodothyronine and reviewed evidence that this process was involved in the physiological action of these compounds.

In his concluding remarks, Prof. R. K. Morton (Adelaide), who arranged the meeting, emphasized the need for caution in interpreting the results of investigations with phosphorylated compounds derived from mitochondria; these might differ from the true intermediates, just as the isolation of phosphorylated enzymes does not prove the involvement of these compounds in enzymatic phosphoryl transfer.

The cryptic nature of many publications on oxidative phosphorylation caused much good-humoured but frustrated comment, and most participants looked forward to the publication of experimental details which will permit more detailed examination of many recent claims in this remarkably active field of scientific investigation.

M. R. ATKINSON
[The late] R. K. MORTON

ORGANIC MATTER AND SOIL PRODUCTIVITY

IT has commonly been accepted that farmyard manure is desirable or even essential to maintain or improve soil fertility, because it exerts a beneficial effect on the physical condition of practically all mineral soils and steadily supplies plant nutrients as it decomposes. Market gardeners have relied on stable and byre manures from the nearest towns and farmers in arable areas have kept cattle over winter to provide manure for the potato and root crops in the rotation. Most growers in fact have been so convinced of the value of regular additions of organic waste material to the soil that, in face of declining supplies of farmyard manure, they have adopted various methods of green manuring or of composting or even of bringing in peat. In effect, a normal dressing of 10–15 tons of farmyard manure amounts to some 2 tons of organic matter per acre or 0·2 per cent in the top 9 in. of soil. This amount is barely measurable by sampling and analysis. It is substantially the same as the annual leaf litter in woodland; it is not much more than the amount in the stubble and roots of a cereal crop; it is much less than what is incorporated in the soil by ploughing in grass turf. Nevertheless, there remains the conviction that on many types of soil fresh organic matter confers a benefit that is not obtained from plant nutrients alone.

It is practically impossible to make a strict comparison of organic manures with inorganic fertilizers since the former contain nutrients that become available to the plant over a more or less prolonged period and, at the same time, modify the soil in a manner that affects all the factors like æration, water movement and biological activity that play a part in crop development. There is undoubtedly evidence that the crop responses to the total nutrients in farmyard manure are very much less than those obtained from the same amounts of nutrients applied as soluble fertilizers. There have also been recent assessments from field experiments which indicate that the merit of farmyard manure is to be attributed almost solely to its nutrient content. But the fact remains that on some soils it is not possible to produce maximum crops, with or without fertilizers, unless farmyard manure has been used. It is not surprising, therefore, that investigators have been searching for more precise information on the effects of additions of organic matter to the soil. Is it possible, for example, that organic matter may affect the availability of nutrients to the plant, or may produce derivatives that influence plant growth either directly, through absorption by the roots, or indirectly, by controlling the incidence of disease?

These matters are the subject of a well-documented review by D. C. Whitehead entitled "Some Aspects of the Influence of Organic Matter on Soil Fertility" in a recent issue of *Soils and Fertilizers* (26, No. 4, Commonwealth Bureau of Soils; 1963). He discusses the question of soil nitrogen released from organic residues or fixed by symbiotic or free-liming organisms; of the ability of organic acids to release insoluble forms of phosphorus and potassium, and certain trace elements, from the soil particles. He also directs attention to the absorption by the roots of organic molecules that could influence plant metabolism—this covers such substances as amino-acids, vitamins, phenolic compounds and auxins—and to the ability of organic matter to favour saprophytic organisms rather than parasitic; there are also various decomposition products that are toxic to fungi. There is much contradictory evidence and obviously a need for further work to establish the significance of these compounds. They are known to be produced, but the quantities concerned and the probable interactions are still largely speculative.

Closely related to this review is an article on "The Biological Nature of Soil Productivity", by G. V. Jacks (26, No. 3; 1963). This is designed to show how fertility is dependent on bio-physical rather than on physico-chemical changes in the soil. It is the action of plants that converts radiant energy into energy for animals and micro-organisms, which in turn produce a structure out of structureless material. The cementing together of individual soil particles to form aggregates is essentially a physico-chemical process, but the building of the aggregates into a stable granular structure is dependent on the activity of living organisms. The agencies are varied and include organic acids and polysaccharides, bacterial gums and fungal hyphæ and mycelia, all stages in the decomposition of organic residues. There is also the action of plant roots in binding soil particles and giving rise to a porous crumb, and of earthworms in not only producing casts of mineral-organic aggregates but also of making channels for æration and water movement. Indeed, much of the organic matter in the soil consists of excrement from soil fauna.

The soil medium becomes, therefore, a climax association of plant and fauna with a definite level of productivity. This productivity can be enhanced by man, through the physical and chemical modifications brought about by cultivation and manuring; but it can also be reduced by destroying the environment built by natural agencies. It is possible to grow healthy plants without soil, but that is a specialized business; so long as soil is used the grower must endeavour to preserve or improve its structure.

A. M. SMITH

RESOURCES OF PETROLEUM: HOW MUCH OIL?

EVER since petroleum became a world-wide commercial proposition and the industry thus firmly established, the phenomenal and rapid developments of the world's oilfields with concomitant expansion of production, especially in the United States since the turn of the century, have periodically posed these questions: How long will oil resources last, is production outstripping supply? Economists, perhaps even more vociferous than technologists, have from time to time uttered dire warnings that the day may come when oil will become scarce; that other sources of fuel and energy must be harnessed to make up any deficiences in supply. For example, there was a memorable occasion in 1923 when it was thought that the United States had passed peak production; thenceforward a downward trend was predicted, with some 15–20 years ahead before calamity overtook the industry. In 1925 I myself stated: "Petroleum production has hitherto been, still is, and for some time is likely to be entirely dominated by the output from the United States. With the average figure of 15 per cent as representative of the rest of the world's contribution to total production, we have probably not got a real assessment of the potentialities of other countries, since their economic activities must largely be subservient to the greater influence. In other words, it is quite conceivable that in the event of material decline in United States output, more could be made good by external oil production than appears at first glance. Factors tending to this end include increased geological exploration, increased production from shut-in reserves, and a higher technique in petroleum engineering". "The possibilities of the world's 'peak' of production of oil having been passed in 1923 have been shown to be open to considerable doubt" (*Mining Magazine*, November 1925).

Subsequent events have more than justified that opinion and the present position is adequate answer to pessimistic prophecies of the years between. It is a fact that one-third of the world's proved reserves of petroleum to-day are in oilfields that were literally unknown, probably still less imagined, before 1950. This fact, its significance and the theme "How Much Oil" are the substance of an article by Mr. M. J. Rathbone, chairman of the Standard Oil Co. (New Jersey), in a recent issue of the house-journal, *The Lamp* (45, No. 2; 1963). Therein he speaks with authority and makes some cogent comments on the present world oil situation. A nice distinction is rightly drawn between 'reserves' and 'resources', two words often loosely applied and economically misleading out of proper context. He comments, "If you read that the world's proved oil reserves are estimated at 300 billion barrels, that oil is being consumed at the rate of nearly 9 billion barrels a year, and that this rate of consumption will probably double by 1980—you may well wonder how soon we will reach the bottom of the barrel . . . that figure of 300 billion barrels of 'proved reserves' . . . is one of our most misunderstood statistics. It does not measure the world's true oil resources at all. It is no more than an estimate of the oil we can obtain from fields already discovered, using present recovery techniques. Despite rising world consumption rates, 'proved reserve' figures go up every year". The fact is that petroleum to-day is being discovered faster than it can be used. More oil is being obtained from old fields, new fields are being proved simultaneously. Submarine oilfields, often in extension of known continental developments, have to be reckoned with. One example is the shelf region off the Louisiana coast, opened to exploration only last year and, according to Mr. Rathbone, now proved to contain billions of barrels of oil. Another case he cites is that of Libya, where six years ago there were no known oil reserves, but to-day considered to be a major source of supply.

Thus, reserves are proved on a very large scale. Resources, that is, extensive land-areas of the world potentially oil-bearing but as yet untouched by the drill, remain to be explored quite apart from under-water researches. In view of the drastic readjustment of our ideas concerning geographical distribution of favourable oil-pool structures, occasioned by the discoveries of the past decade, the location of oil and gas-fields in regions where twenty or thirty years ago no hopes whatever were entertained, then we may agree with Mr. Rathbone's contention that ". . . we have solid grounds for reassurance that petroleum resources are abundant relative to foreseeable demand".

H. B. MILNER

MONOMER–DIMER FORMS OF BENCE JONES PROTEINS

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BENCE JONES proteins, the abnormal biosynthetic products excreted in the urine of myeloma patients, are defined as low-molecular-weight proteins, antigenically and chemically related to γ-globulin[1,2], which precipitate when heated to temperatures near 50° C, dissolve on boiling, and reprecipitate on cooling[3]. Isotopic investigations have shown that this protein probably represents an aberrant synthetic portion of γ-globulin[4]. Edelman and