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The Presidential Address—
Some Chemical Aspects of Life.

SIR FREDERICK HOPKINS' thoughtful address relates to the chemical processes that determine the mechanism of life.

'Though speculations concerning the origin of life have given intellectual pleasure to many; all that we know about it is that we know nothing[1]. We do, however, know a few fundamental facts concerning that process. One such is the arrest of the steady increase of entropy displayed by all the rest of the Universe. That the living organism checks the degradation of energy in Nature is primarily a biological concept. Related to it and of equal importance is the concept of organisation.

'It is almost impossible to avoid thinking and talking of life in this, abstract way, but we perceive it, of course, only as manifested in organised material systems, and it is them we must seek the mechanisms which arrest the fall of energy. Evolution has established division of labour here. From far back the wonderfully efficient functioning of structures containing chlorophyll has, as everyone knows, provided the trap which arrests and transforms radiant energy fated otherwise to degrade —and so provides power for nearly the whole living world. It is impossible to believe, however, that such a complex mechanism was associated with life's earliest stages. Existing organisms illustrate what was perhaps an earlier method. The so-called autotrophic bacteria obtain energy for growth by the catalysed oxidation of materials belonging wholly to the inorganic world; such as sulphur, iron or ammonia, and even free hydrogen. These organisms dispense with solar energy, but they have lost in the evolutionary race because their method lacks economy. Other existing organisms, certain purple bacteria, seem to have taken a step towards greater economy, without reaching that of the green cell. They dispense with free oxygen and yet obtain energy from the inorganic world. They control a process in which carbon dioxide is reduced and hydrogen sulphide simultaneously oxidised. The molecules of the former are activated by solar energy which their pigmentary equipment enables these organisms to arrest.

Are we to believe that life still exists in association with systems that are much more simply organised than any bacterial cell? The very minute filter-passing viruses which, owing to their causal relations with disease, are now the subject of intense study, awaken deep curiosity with respect to this question. We cannot yet claim to know whether or not they are living organisms. In some sense they grow and multiply, but, so far as we yet know with certainty, only when inhabitants of living cells. If they have the less living, this would suggest that they have no independent power of obtaining energy and so cannot represent the earliest forms in which life appeared. At present, however, judgement on their biological significance must be suspended. The fullest understanding of all the methods by which energy may be acquired for life's processes is much to be desired.'

The past one hundred years have witnessed considerable amount of controversy between the extreme physico-chemical and the vitalistic concept of life. We are yet far from knowing the ultimate truth but it would form a useful basis for discussion if we recognise that 'at a different and recognisable level of its dynamic organisation, an organism can be logically described in physico-chemical terms alone.

Researches conducted during the present century have brought about marked changes in our outlook in various directions. To take an instance one may cite the respiration of the muscle and the attendant transformations. To-day we know that the previous 'conception of continuous building up and break-down of the muscle substance, as a whole, has but a small element of truth. The colloidal miscle structure is, so to speak, an apparatus relatively stable even as a whole when metabolism is normal, and in essential parts very stable'. The related chemical processes and energy transformations have also been studied with remarkable thoroughness. They show, among other things, that the conditions are, to a large extent, similar to those occurring in the yeast cell, thus providing a striking illustration of the unity of life.

The living cell would be a static system were it not for the fact that it is equipped with a variety of enzymes which assist in bringing about the required transformations. Each enzyme is specific in its action. The combined activities of the different enzymes present in a cell determine its ultimate physiological behaviour and thus distinguish it from other forms of life.

When the multitude of chemical events in a living cell are well co-ordinated, then the latter displays its sensitiveness to molecules of the special nature which enter from without. A striking instance of this is provided by the response of the heart to the impulse of the vagus nerve. When the heart receives vagus impulses, the substance, acetyl choline is liberated within that organ. It is acetyl choline that ultimately produces the characteristic effect as may be demonstrated by direct injection of graded doses of that chemical.

Similar and, perhaps, even more profound are the effects of the chemicals which are formed in specialised organs of the animal body and which maintain harmonious growth and control the rate of metabolism. Some of these chemicals such as adrenalin, thyroxin, secretin and insulin are already well known. More recently, considerable light has been thrown on the nature and mode of action of oestrin, the harmone which, in a most remarkable manner, co-ordinates the phenomena of sex.

In the group of substances which control and coordinate events in the animal body by virtue of specific molecular structure we must also include the vitamins. As distinct from the harmones which are formed in the animal body, the vitamins have to be supplied in the diet. The distinction between the two is not, however, so great as it may appear because some animals can synthesise the requisite vitamins, in which case the latter become harmones.

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