THE POSSIBLE SIGNIFICANCE OF HEISENBERG'S PRINCIPLE OF INDETERMINACY TO THE CHEMISTRY OF LIVING MATTER

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HEISENBERG'S principle of indeterminacy might be described as the impossibility of 'peeking in' without disturbing Nature. When we come down to the smallest particles, in physics, the mere fact of observation disturbs the circumstances of the particle.

An analogy may help to visualize this difficulty. Let us suppose one wants to measure the distance between two cannon balls resting on a plane horizontal surface. There is sufficient gravitational pull to prevent the balls from moving when a yardstick is gently applied. In this case, measurement is possible. Now, suppose that the measurements have to be made in a space where there is no gravitational field. At a mere touch, the balls start moving, and in vacuum would keep on moving. Here measurement becomes impossible. The same situation will result when extremely small balls are used.

Another illustration, already used by others, may be drawn from an entirely different field. Suppose we want to determine the colour of a substance which bleaches the moment it is exposed to light. Here again we meet the same difficulty: the very application of our tool for measuring disturbs the subject of our experiment.

These difficulties, no doubt inherent to our spatio-temporal definitions, have been felt for some time in an analogous way, by the investigators of the chemistry of living matter. Indeed some of the substances which have fallen into the hands of biochemists are extraordinarily sensitive and very difficult to measure. The problem is even wider than that, since biochemistry is only one of the tools that is used to acquire an understanding of living matter.

Among the methods of approach to this subject, used at present, is physiology, which inherited its methods from medicine. It thrives upon the unusual stability of life and the capacity of the organism to compensate any loss, and its ability of re-establishing any disturbed equilibrium. It uses the knife, if not exclusively, at least with great sagacity.

Another method of approach is essentially composed of the first method with chemistry and physics, but only formally so. From the physical standpoint it is entirely unique. It consists of isolating and studying what has been already isolated by Nature. This statement may seem a bit paradoxical, but as in all important contributions, its simplicity is its virtue.

Blood, being isolated in veins and arteries is a unique field for such an approach. It may be obtained and studied by vigorous methods of physical chemistry with the certainty that it was a part of living matter. In a less vigorous way, this method has been extended to the study of individual muscles and nerves.

The last method is a familiar one. It is the method of destruction. I was almost ready to say that it is inherent in our spatio-temporal co-ordinates. Perhaps it may be. In any case it is inherent in our curiosity and is early manifested by the desire to take apart a watch or bicycle. It is childish in its simplicity and therefore extremely powerful. It has more adherents than any other method. From the standpoint of classical physics (I mean the late nineteenth century physics) it is extremely sound.

Its nature may be summarized in a few words: take apart all things which constitute living matter and after learning their nature put them together again. This method at first sight does not seem to have any limitations: *all* particles may be taken apart and *all* put together. The first part of this approach has contributed voluminous and interesting material, but the second half, the 'putting things together', has progressed but little. No doubt the difficulty lies partly in an insufficient knowledge of the various particles composing living matter, but we suspect that a considerable source of uncertainty arises from the far too rigorous methods used in their disintegration. There are too many 'missing links' about which we know little or nothing.

The power of estimating things depends on our sensitivity. We are fairly well endowed in that respect. An extremely small amount of light is sufficient to stimulate our optical centers. The presence of a few molecules is sufficient to stimulate the sense of smell. With proper training we could probably carry a considerable part of organic analysis, merely by smell. In this respect the achievements of the most famous wine-tasters is worth considering.

By suitable mechanical appliances we have enormously extended our powers of observation. There is no doubt we can see and measure the path of a single electron. In the past fifty years we have discovered many phenomena whose existence we never suspected.

The principle of indeterminacy applies to us, by the mere fact that we belong to the material system. This statement leaves a wide gap between what is known of biochemical substances and what may be deduced from atomic physics. However, it is of use in trying to visualize what can be done by the method of 'taking things apart and putting them together again'. It is apparent, in this case, that all things cannot be taken apart without modifying them, for we are dealing with particles to which Heisenberg's principle wholly applies.

Let us investigate the reverse process:—synthesis. For this biochemists are no doubt responsible.

SIGNIFICANCE OF HEISENBERG'S PRINCIPLE

In early youth many of us practised the delicate art of building high towers from blocks. As far as my personal experience is concerned these attempts ended in the following way. A desire to build a higher and higher tower resulted in the last block crumpling the whole structure. Conversely the removal of a single block from the top of a high tower often brought about the same disastrous result.

The final stages of the synthesis of living matter may bring about a situation very like the one just described. Will not the last atom we attempt to add, modify the whole structure in an uncontrollable way? Or, in more general terms, will not our attempt to affect or modify, produce a change in the system which cannot be measured? The fact that we have built does not necessarily mean that we know how we have done it.

Heisenberg's principle and certain physical uncertainties which now confront modern physics may be of direct significance to the student of living matter. A lack of determinism in any description of the phenomenon of life may be in reality inherent to our way of looking at the physical world.