X-ray crystallography in India

Having been associated with S. Ramaseshan as a research scholar in the Physics Department, Indian Institute of Science, during the period 1958–62, it was with considerable pleasure that I read his absorbing article 'Dorothy Hodgkin and the Indian Connection' (*Curr. Sci.*, 1997, 72, 457–463). This is one of the introductory articles of the *Collected Works of Dorothy Crowfoot Hodgkin* published by the Indian Academy of Sciences, wherein he describes the influence Dorothy had on the growth of X-ray crystallography in India. After discussing at length the contributions of Indian scientists at Oxford, and in India after their return, Ramaseshan talks briefly about other crystallography groups in India. In this connection I would like to mention my own little contribution to inorganic crystallography.

Around 1964, the Inorganic and Physical Chemistry Department, IISc., in a far-sighted move, decided to recruit a faculty member in X-ray crystallography to train students of chemistry in chemical crystallography and initiate research in this field. I realized even at that time that the future growth of crystallography would take place in departments of chemistry, where new molecules are synthesized, and that is where I wanted to be. That is how I happened to join the Department as a lecturer in the summer of 1965. I feel that I can claim with justifiable pride that I was the first to initiate teaching and research in the field of X-ray crystallography in a chemistry department in India, all the work until then being done in physics departments. As described vividly by Ramaseshan, 'Venkatesan's complete conversion to organic chemistry took place through his association with Jack Dunitz in Zurich and Dorothy in Oxford.' He joined the Organic Chemistry Department, IISc., in 1971 to establish 'one of the better laboratories in organic and drug chemistry'.

To conclude, I believe that both Venkatesan and I can look back with satisfaction on our diverse contributions to structural organic and inorganic chemistry and on pooling our efforts to promote crystallography among chemists in India.

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Agriculture in floating fields on Loktak Lake, Manipur

In Manipur, agriculture is not confined only to land, but also extends to the floating fields on the lake (Figure 1). It appears that the people around the Loktak lake, particularly in the Thanga village, because of limited land space for cultivation, had earned experience, through trial and error, of the use of water environment in the cultivation of plants. For this they first collect the floated mass of water grass at a particular place in the Loktak lake and spread it approximately to an area of about 0.62 acre or more. The thickness of such a mass of floated grass varies from 1 m to 2 m. They burn the long grass that rose above the water. Then the sprouted young sots are again cut with a knife to allow decay with the ash to form a rich organic soil-like field.

Figure 1. Floating fields.

Now the field is ready for the transplantation of young paddy plants that have been grown in the land nursery field. Such floating fields can be used effectively for three years continuously after which the field becomes thin and loses fertility. After three years, some people upturn the floating field and the roots of the water-grass are allowed to decay to enhance the fertility of the field or a new field is prepared. Now double cropping of paddy is also done, and April is the season for the plantation of the first crop. The yield per acre is said to be almost equal to that of the land agricultural field.

There are both advantages and disadvantages of cultivation in such floating fields. As the field is being floated, there will be no problem of destroying the crop by water, rather cultivation can be done one after another throughout the year. However rodents, particularly the rats, destroy the crop very easily and birds too eat up the crops in the fields that are far away from the permanent village at the foot-hills. Of course, people construct floating huts by their floating fields to watch the crop and to protect it from rodents and birds. Yet they face problems for the protection of the crop. Transportation of the crop from the floating fields to their village is done with dug-out canoes.

It seems to be the first instance where a floating mass of grass on the lake has been used for rice cultivation. If the laborious technology in current use is changed with new improved methods that may be developed by the agricultural scientist, we may use the many presently uncultivable inundated places and may help in bringing about a better economy. Since the major part of the earth's surface is covered by water, the extension of using the water surface for agricultural work will be of global interest.

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Modelling biological systems*

At the end of his life, the master sleuth Sherlock Holmes said, 'Of late I have been tempted to look into the problems furnished by Nature, rather than those more superficial ones for which our artificial state of society is responsible' (Final Problem). He realized that no riddle can be more challenging than a natural one. Because he was well aware of the complementary roles of facts, hypotheses and theory in solving riddles, he said 'It is of the highest importance in the art of detection to be able to recognize out of a number of facts, which are incidental and which vital', and that 'It is a capital mistake to theorize before one has data'. He also knew that it is possible for people to 'come into those conjectures where the most logical minds may be at fault; each may form its own hypothesis upon the present evidence, and yours is as likely to be correct as mine'. A complete solution involves not only the collection and understanding of data, but also the use of logical and mathematical reasoning to draw inferences in a self-consistent fashion. And isn't that what a scientist aims to do?

Why modelling?

Though formalization or modelling has been a common approach to problem-solving in all branches of knowledge, its use in biology has not been all pervasive. Modelling biological systems are both complex and challenging. This is mainly because they contain extensive coupling, high degree of redundancy and widespread nonlinear interactions moulded by millions of years of evolution. This has led modern biology to become largely an experimental science, continuously striving to explain mechanisms in detail. The explosion of physio-chemical information at the molecular level of biological processes/systems necessitates an effort to organize all data into models which would represent the processes/mechanisms/structures being studied in generalized abstract forms (schemes). Mathematics is used to model the schemes and the predictions of the models are checked with existing and new experimental data. New experimental data may support, enhance (by adding more features), alter, or even falsify the model. There are celebrated examples of pooling of facts into a general framework of understanding (theory) in the concept of operon; or, have detailed description of the processes in the form of compact equations (laws) in Mendel's Laws of genetics. It is probably now all too common to be able to appreciate the role of enzyme kinetics theory in explaining the phenomenon of allostery, feedback regulation, molecular interactions such as DNA melting or promoter search. In all the cases the 'models' help in categorizing a large pool of experimental facts into a coherent and logical understanding which then provide direction to further experimentation. Modelling offers a powerful analytical research tool to a biologist. And that is why wise men have said 'Theory without facts is fantasy, and facts without theory is chaos'.

The complexity of biological systems makes interdisciplinary involvement essential. Increasing use of mathematics or theoretical studies is inevitable as biology becomes more quantitative. There is another compelling reason to study biological systems from the theoretical point of view. Living systems are perfect examples of complex systems, and the interest in understanding complexity at a purely abstract level allows the theorist to gain insight from the new and exciting natural complex processes, thus enhancing the conceptual knowledge base. This level of enquiry may not seem biologically relevant at present, but it, in turn, can be of much relevance in future experimentation or technology. But for this to happen most fruitfully, the theoretician needs to understand the phenomenon being modelled in great detail, and the biologist needs to look for the underlying generalizations in their sphere of enquiry and appreciate the validity of the assumptions in theoretical methods. Both have to be aware of the conceptual developments in other fields.

Indian scenario

The present scenario in theoretical studies in biology in our country is far from adequate. Apart from the widely known and significant contribution in

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