Physics and Chemistry Nobel Prizes

AMERICANS have made a clean sweep of this year's Nobel Prizes in chemistry and physics which were announced last week. The physics prize is awarded for the formulation of the BCS theory, aptly named after its originators, to John Bardeen of the University of Illinois, Leon N. Cooper of Brown University, Rhode Island and J. Robert Schrieffer of the University of Pennsylvania. BCS theory gives a macroscopic description of the properties of superconductors. One half of the chemistry prize is awarded to Christian B. Anfinsen of the National Institutes of Health at Bethesda, Maryland and the other half is divided between Stanford Moore and William H. Stein of the Rockefeller University, New York, for their work which led to the determination of the composition and the action of the enzyme ribonuclease.

Professor John Bardeen

Professor John Bardeen becomes the first person to win two Nobel Prizes in the same category. He is not, however, the first person to win two Nobel Prizes, that honour falling to Marie Curie who was awarded the physics prize in 1903 jointly with her husband, Pierre Curie, and H. Becquerel, and the chemistry prize, eight years later, was awarded to her alone. Linus Pauling has, of course, also won two. John Bardeen was awarded his first prize in 1956 jointly with W. Shockley and W. H. Brattain for their discovery of the transistor effect.

The award of the physics prize to Bardeen, Cooper and Schrieffer marks the end of one of the most exciting hunts in science in this century. Superconductors, the first of which was discovered in 1911, are metals which lose their resistance to direct current at very low temperatures, mostly below 15 K. The understanding of this property presented a problem for physicists that many leading theoretical physicists have attempted to solve. In 1956, Cooper, then a research associate at the University of Illinois, pointed out that two electrons in a metal with energies near the Fermi energy which weakly attracted each other would form a resonant state, now called a Cooper pair. One Cooper pair, however, does not make a superconductor. It was a year later that Bardeen, Cooper and Schrieffer (then a research student) working together at the University of Illinois, showed how Cooper's idea could be applied to many electrons and how a new cooperative state of all the conduction electrons, the superconductive state, would be formed.

The publication of this theory has given rise to a long period of fruitful research, which confirmed and extended the original work. For instance, B. D. Josephson used the theory to predict a variety of microscopic quantum phenomena and these, in turn, have led to new sensitive devices for measuring electric currents, voltages and magnetic fields and to the new international standard for the volt. As yet, there have been no everyday applications of superconductors but there remain the possibilities of their use in underground electric transmission lines.

The award to Anfinsen, Moore and Stein will meet with the approval of all protein chemists, for nobody has done more in these past twenty years to determine the shape of the field as we know it today. The names of Moore and Stein are inseparably linked (to the point where many students of biochemistry must have wondered whether they had any independent existences) in a series of discoveries. They were responsible in the first place for developing the technique of amino-acid analysis, which cleared the way to the determination of protein sequences. They recognized at an early stage the potentialities of ion-exchange chromatography as a means of fractionating so complex a mixture of species as the amino-acids in a protein hydrolysate, and many of the associated techniques that are now taken for granted were evolved by the painstaking chemistry of Moore and Stein. The culmination of their work at this stage was the automatic amino-acid analyser, which is now to be found in every biochemistry laboratory. Moore and Stein, with some of their younger associates at the Rockefeller Institute, developed methods of labelling and identifying residues at catalytic sites, and succeeded in defining the constituent side chains in that of ribonuclease. In what was at the time a great technical *tour de force*, they determined the total sequence of this chain of 124 residues.

Anfinsen's name is also to a considerable extent associated with pancreatic ribonuclease, for it was with this enzyme that he first demonstrated the principle that the three-dimensional structure of a protein is uniquely determined by its sequence. He showed that in proteins that contain disulphide bonds, the refolding process occurs by a continual shuffling of the many possible pairings until the pairing that corresponds to the native conformation is attained. He also found that molecules containing incorrect pairings could be isolated, and that they would in time, under mild oxidizing conditions, rearrange to give the native disulphide arrangement and conformation. Anfinsen and his colleagues next looked for and found a protein in animal tissues that catalyses disulphide exchange, and so greatly hastens the rate of appearance of the active conformation of enzymes. Anfinsen's interest in folding and its relation to the newly synthesized chain led him also to study the synthesis of ovalbumin in oviduct tissue, and the resulting publications gave important information on the rates of the processes that were involved, and stand as among the most elegantly conceived and executed essays in the field of protein synthesis. Another of Anfinsen's objectives was to synthesize the enzyme *ab initio*, and this has been to a considerable extent achieved, for it was found that the molecule could be non-covalently assembled (like the ribonuclease S-protein-S-peptide system of Richards) from fragments. This discovery made possible a series of elegant experiments on the factors that determine the folding, by changing or omitting individual side chains, and by looking at recombinations of overlapping sequences. A by-product of this and other work in Anfinsen's laboratory has been a series of important contributions to the technique of affinity chromatography, an approach that has now achieved a position of central importance in hormone research and other areas.