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Nobel Prize in Chemistry 1977

Ilya Prigogine

The Nobel Prize in Chemistry 1977 was awarded to Ilya Prigogine *"for his contributions to non-equilibrium thermodynamics, particularly the theory of dissipative structures"*.

Information about winners:

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RESEARCH INFORMATION:

ORDER FROM DISORDER LED TO NOBEL PRIZE IN CHEMISTRY

Thermodynamics is a central branch of modern science, and its general laws govern the physical and chemical processes which occur in our world. An important early application of thermodynamics dealt with steam engines (heat engines) in which heat is converted to mechanical energy. Classical thermodynamics was developed in the nineteenth and in the beginning of the twentieth century by a number of prominent scientists, theoreticians as well as experimentalists, many of which have their names immortalized as designations for units or laws. Some examples are Watt, Carnot, Clausius, Joule, von Helmholtz, Lord Kelvin, Nernst, Boltzmann and Gibbs.

The so-called First, Second and Third Laws of Thermodynamics were discovered during this period. They set general limits for the conversion of one form of energy, for example heat or chemical energy, to another one, for example mechanical work. One phase in the development of thermodynamics ended with the formulation of statistical thermodynamics by Boltzmann and Gibbs. Statistical thermodynamics is based on the fact that what we experience as heat is actually an outward manifestation of molecular and atomic motion.

Classical thermodynamics has played a dominant role in the development of modern science and technology. In suffers, however, from certain limitations, as it cannot be used for the study of irreversible processes but only for reversible processes and transitions between different states of equilibrium.

Many of the most important and interesting processes in Nature are irreversible. A good example is provided by living organisms which consume chemical energy in the form of nutrients, perform work and excrete waste as well as give off heat to the surroundings without themselves undergoing changes; they represent what is called a stationary or steady state. The boiling of an egg provides another example, and still another one is, a thermocouple with a cold and a hot junction connected to an electrical measuring instrument.

The first investigator who developed a method for the exact treatment of such problems, for example of the thermocouple, was Onsager who received the 1968 Nobel Prize for this contribution. His approach was, however based on assumptions which in principle make it applicable only to systems close to equilibrium.

The great contribution of Prigogine to thermodynamic theory in his successful extension of it to systems which are far from thermodynamic equilibrium. This is extremely interesting as large differences compared to conditions close to equilibrium had to be expected. Prigogine has demonstrated that a new form of ordered structures can exist under such conditions, and he has given them the name ''dissipative structures" to stress that they only exist in conjunction with their environment.

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The most well-known dissipative structure is perhaps the so-called Benárd instability. This is formed when a layer of liquid is heated from below. At a given temperature heat conduction starts to occur predominantly through convection, and it can be observed that regularly spaced, hexagonal convection cells are formed in the layer of liquid. This structure is wholly dependent on the supply of heat and disappears when this ceases.

Quite generally it is possible in principle to distinguish between two types of structures: equilibrium structures, which can exist as isolated systems (for example crystals), and dissipative structures, which can only exist in symbiosis with their surroundings. Dissipative structures display two types of behaviour: close to equilibrium their order tends to be destroyed but far from equilibrium order can be maintained and new structures be formed.

The probability for order to arise from disorder is infinitesimal according to the laws of chance. The formation of ordered, dissipative systems demonstrates, however, that it is possible to create order from disorder. The description of these structures have led to many fundamental discoveries and applications in diverse fields of human endeavour, not only in chemistry. In the last few years applications in biology have been dominating but the theory of dissipative structures has also been used to describe phenomena in social-systems.

<u>For more details please visit:</u>

http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1977/press.html