of the struggle for life, which allowed only those individuals most suited by favourable variation to the environment to survive and rear their offspring. The advantage thus given to beings with useful variations may develop into permanent modifications in the course of ages, and, when the parent types have disappeared, their common posterity may exhibit the marked differences characteristic of the separate and distinct species now existent. From the point of view of scientific thought, the significance of Darwin’s theory lies in the new and vast extension it gives to the field in which causes intelligible to the human mind can be sought as explanations of phenomena. Thus evolution is co-ordinated in the history of thought with the Newtonian theory of gravitation, and with the uniformitarian theory of geology.

Both before and after the appearance of Darwin’s work, biologists devoted their attention to the study of how the useful variations arise. Three views have been held. (1) Jean Baptiste, chevalier de Lamarck (1744-1829), regarded variation as due to the accumulated and inherited effect of use. Thus the giraffe acquires his long neck by the successive efforts of countless generations to browse on leaves just beyond their reach. (2) Darwin, while accepting changes in accordance with Lamarck’s ideas as exceptional aids to variation, revolutionized biology by showing the primary importance of the struggle for life, when extended over long periods of time, in selecting useful variations which arise acci­dentally or in other ways. (3) Darwin also recognized the possible occasional effect of discontinuous variations or “sports,” when a plant or an animal diverges from its parents in a marked manner. But of late years the study by Hugo de Vries, William Bateson and others, of discontinuous variations which arise spontaneously has pointed to the conclusion that in nature such sudden leaps are the normal cause of development. If a “ sport ” has advantages over the parental type, it tends to survive, while, if it is not as fitted for its life struggle, it is destroyed by natural selection and never establishes itself. Such a theory avoids the difficulty of pure “ Darwinism, ” that organs useful, when fully developed, to an animal or plant are of no advantage in incipient stages. Statistical methods, too, suggest that a definite limit may exist to the amount of a given variation which proceeds by small steps, each insignificant

in itself.

Closely connected with such problems is the question of inheritance. Lamarck’s theory required the inheritance of characteristics acquired during the life of a parent. But difficulties, such as that of seeing how such a change could affect the simple germ cells, has led some more recent biologists to pass to the other extreme, and to deny the possibility of any acquired characteristic being transmitted

to offspring.

A new light has been thrown on the problem of inheritance by the recent re-discovery of the work of G. J. Mendel, abbot of Brunn (1822-1884). Certain characters in both plants and animals have been found to be separable, and some of these characters exist in pairs, so that the presence of one involves the absence of the other. To take a simple example. Blue Andalusian fowls do not breed “ true. ” On the average, half the offspring of two blue parents are blue, while the remaining half are divided equally between black and white birds. Both black and white when mated with a consort of the same colour breed “ true ” and yield only offspring similar to the parents. A white bird mated with a black, however, produces invariably all blue chicks. White mated with blue gives half blue and half white, while black mated with blue gives half blue and half black. Such phenomena are explained if we suppose that of the germ cells of the blue birds half bear the black character and half the white. If, in reproduction, a “ black ” cell meets a “ black ” the resulting chick is black; if “ white ” meets “ white ’’ the chick is white; while if “ white ” meets “ black ” the chick possesses a mixture of the two char­acters which in this case yield blue colour. But the reproductive cells of this intermediate form are not intermediate in character;

they possess the pure parental characters in equal numbers. Knowing these facts, it is evident that we can reproduce any of the results at will, and from the mixed blue type produce a pure true breed of either black or white birds. Experiments of this kind must lead to a power of breeding new varieties of plants and animals hitherto undreamed of, and already have changed altogether our views of the problems of heredity. Instead of a vague mixture of all our ancestors, we possess definite characteristics of some of them only, though, like the blue Andalusian fowl, we may transmit to our children ancestral characters we do not ourselves exhibit. The family or race is more important in heredity than the individual parent. Thus the aristocratic theory of politics receives support from the experience of biology.

Simultaneously with the growth **of** geology, and the birth of the Darwinian hypothesis, a new development took place in physical science—the development of the conception of energy as a quantity invariable in amount through­out a series of physical changes. The genesis of the idea in its modern form may be traced in the work of Newton and C. Huygens (1629-1695), who applied it to the problems of pure dynamics. But, in∣ the middle of the 19th century, by the work of James Prescott Joule (1818-1889), Lord Kelvin (1824-1907), H. L. F. von Helmholtz (1821-1894), J. Willard Gibbs (1839-1903), R. J. E. Clausius (1822-1888) and others, it was extended to physical processes. The amount of heat produced by friction was found to bear a constant proportion to the work expended, and this experimental result led to the conception of an invariable quantity of something, to which the name of energy was given, manifesting itself in various forms such as heat or mechanical work. Energy thus took its place beside mass as a real quantity, conserved through- out a series of physical changes. Of late years, as we shall see below, evidence has appeared to show that mass is not absolutely constant, but may depend on the velocity when the velocity approaches that of light. Since the only essential quality of matter is its mass, this result seems to strike at the root of the metaphysical conception of matter as a real, invariable quantity. It remains to be seen whether the conception of energy as an invariable quantity will hold its place or give way to some similar modification as science develops. But, in the present state of knowledge, we may accept the principle of the con­servation of energy as one of the most firmly established of physical laws.

The amount of energy in an isolated system remains invariable, but, if changes are going on in the system, the energy tends continually to become less and less available for the performance of useful work. All heat engines require a difference of temperature—a boiler and refrigerator, or their equivalents. We cannot continue to transform heat into mechanical work if all available objects are at a uniform temperature. But, if temperature differences exist, they tend to equalize themselves by irreversible processes of thermal conduction, and it becomes increasingly difficult to get useful work out of the supplies of heat. In an isolated system, then, equilibrium will be reached when this process of “ dissipation of energy ” is complete, and, from this single principle, the whole theory of the equilibrium of physical and chemical systems was worked out by Willard Gibbs. Such a method avoids altogether the use of atomic and molecular conceptions. In fact, some supporters of the theory of “ ener­getics ” expressly disclaim the conceptions of natural atoms and molecules as unnecessary and misleading, and prefer to found all science on the idea of energy. Matter, they argue, is known to us only as a vehicle for energy, and may itself be but a manifestation of that energy.

But the other great line of advance in recent physics, although it may lead us in the end to somewhat similar conclusions, has been traced by a method which used atomic and molecular conceptions in an extreme form. The passage of electricity through liquids had been explained by Michael Faraday (1791-1867) and others as a transference of a succession of electric charges carried by