

Book Reviews

A Biologist's World View

Chance and Necessity. An Essay on the Natural Philosophy of Modern Biology. JACQUES MONOD. Translated from the French edition (Paris, 1970) by Austryn Wainhouse. Knopf, New York, 1971. xiv, 204 pp., illus. \$6.95.

Few are the scientists who take time and effort to articulate for themselves, and to tell others, how their science fits in the wider framework of our culture and society. This is a pity, because such exercises would clarify their own thinking and explain to the layman what science is really about. Monod has done exactly that. The *Weltanschauung* of a person of his stature and brilliance merits respectful consideration, even by those who feel constrained to disagree with him. Since I cannot concur with some of his ideas, I must make clear from the outset that, in my judgment, his book ought to be read and pondered by everyone who is concerned about where science may lead mankind. Monod has accomplished more than a delineation of his own world view. He has stated with admirable clarity, and eloquence often verging on pathos, the mechanistic materialist philosophy explicitly or implicitly shared by most of the present "establishment" in the biological sciences. But while many see this philosophy through a glass darkly, Monod makes it crystal clear.

Of the nine chapters of the book, the first two ("Of strange objects" and "Vitalisms and animisms") and the last two ("The frontiers" and "The kingdom and the darkness") are in the main discursive and philosophical. The five chapters in between review the basic biological and chemical facts and principles on which Monod's philosophy rests. Despite the conciseness and elegance of presentation, these five chapters will be hard going for adepts of C. P. Snow's literary-intellectual subculture and for many social scientists, though one hopes not for natural scientists. The efforts of those who would study them will certainly be repaid.

An analysis of this book best starts with its final conclusions. Monod rightly regards man as a "creature who, belonging simultaneously to the animal kingdom and the kingdom of ideas, is simultaneously torn and enriched by this agonizing duality, alike expressed in art and poetry and in human love." This "goads us to search out the meaning of existence," and "has created all the myths, all the religions, all the philosophies, and science itself." Alas, the search for meaning ends in frustration: "nineteenth-century scientism saw [a path] leading infallibly upward to an empyrean noon hour for mankind, whereas what we see opening before us today is an abyss of darkness." Monod's diagnosis of the causes of this tragic predicament is: "For their moral bases the 'liberal' societies of the West still teach—or pay lip-service to—a disgusting farrago of Judeo-Christian religiosity, scientistic progressivism, belief in the 'natural' rights of man, and utilitarian pragmatism." The root of the "farrago" is what Monod calls the animist tradition. This is explained in the first two chapters of the book.

Organisms are "strange objects," strange because they possess adaptedness to live and to reproduce in certain environments and are "objects endowed with a purpose or project." This property Monod calls "teleonomy"; I prefer F. J. Ayala's term "internal teleology," which stems from the historically evolved biological organization and contrasts with "external teleology" imposed on human artifacts by their builders or makers. Vitalist, animist, and Darwinist explanations of internal teleology have been proposed. Vitalism posits the existence in living organisms of a special vital force or energy, for which a variety of names have been invented by various authors. Monod rejects the metaphysical vitalism of Bergson, as well as the curious recrudescence of "scientistic vitalism" started by some modern physicists and mathematicians

rather than biologists. He ignores the panpsychism of philosophers like A. N. Whitehead and C. Hartshorn and of biologists B. Rensch and L. C. Birch, who ascribe some rudimentary forms of life, sensation, and even volition to entities such as molecules, atoms, and subatomic particles. This is a kind of vitalism made to stand on its head.

Animism posits "a *universal* teleonomic principle, responsible for the course of affairs throughout the cosmos as well as in the biosphere, where it is said to express itself simply in a more precise and intense manner." Monod includes a great deal, I believe too much, under the rubric of animism. He makes it stretch all the way from primitive man to Leibnitz, Hegel, Teilhard de Chardin, Spencer, Marx, Engels, and present-day dialectical materialists. He sees an "ancient animist covenant between man and nature," which endured a hundred thousand years until modern science, particularly molecular biology, swept it away. Space prohibits detailed analysis of Monod's ingenious argumentation. However, I see nothing in modern science to forbid, and much to recommend, the view that evolution (though not its particular products) stems from the laws built into the very fabric of the universe. Cosmic evolution has given rise to life on at least one minor planet, biological evolution has transcended itself in producing man, and human evolution may, in a future perhaps not too remote, be directed by man himself. I am in accord with Monod that there is no need to assume, as vitalists and some "animists" did, that evolution is directed by an external teleological force or principle. Man alone may achieve the ability to direct evolution according to plans which man himself will devise. Whether or not evolution is an enterprise serving someone's purpose is neither proven nor refuted by scientific evidence. Teilhard de Chardin was one of those who thought that there was such a purpose. He did not attempt to deduce its existence from what he knew of biological evolution; his aim was the same as Monod's: a coherent *Weltanschauung*. That of Teilhard included, however, religious faith.

Monod recognizes that "no other science has quite the same significance for man [as biology]; none has already so heavily contributed to the shaping of modern thought, profoundly and definitively affected as it has been in every domain—philosophical, religious, po-

litical—by the advent of the theory of evolution.” Yet he sees “pure chance, absolutely free but blind, at the very root of the stupendous edifice of evolution.” In the concluding paragraph of the last chapter he states: “man knows at last that he is alone in the universe’s unfeeling immensity, out of which he emerged only by chance.” “Chance” is a slippery word that must be used with care when applied to evolution. There are two kinds of “chanciness,” or randomness, in the process of mutation. First, alterations in the hereditary materials arise by accidental substitution, addition, or deletion of nucleotides in the DNA of the genes, or of the gene complexes in the chromosomes. Second, mutations occur regardless of whether they are useful or harmful to the organisms that inherit them. It does not follow that any gene can be transformed into any other gene by a single mutation; though a gene can be changed in many ways, the repertoire of possible mutations in a gene is limited by its composition, which is in turn a product of its evolutionary history. Thus a gene coding for hemoglobin cannot mutate into one coding for myoglobin, although these genes are remote descendants of the same ancestral gene.

The process of mutation is the source of the raw materials for evolution. A supply of raw materials for a building is, however, not a building, and it does not by itself guarantee that a building will be built. Evolution occurs when mutational materials are compounded by natural selection into adaptively coherent genotypes. This is the source of the internal teleology which Monod rightly regards as a distinctive property of living beings. He acknowledges the fundamental importance of natural selection in evolution, but underestimates its antichance function. Selection is far more than a sieve which retains useful mutants and disposes of harmful ones (the “sieve analogy” is not mentioned by Monod, but that view is implicit in his discussion). Mutation and Mendelian recombination, the latter being a corollary of sexual reproduction, bring forth an immense variety of different genotypes, the numbers of which are in higher organisms almost as great as the numbers of individuals conceived. Mutation and recombination link with selection to form a cybernetic system that maintains or enhances the internal teleology, that is, the harmony between a living species and its environments. Disruption of this system results

in eclipse or extinction of the species.

Neither mankind nor any other biological species evolved by pure chance. Yet it does not follow that they were predetermined to arise. Monod rightly stresses that in evolution “destiny is written concurrently with the event, not prior to it. Our own was not written before the emergence of the human species, alone in all the biosphere to utilize a logical system of symbolic communication.” Yet Monod stops short of concluding that we are the products neither of chance alone nor of pure necessity. In biological evolution, and also on the human level, chance and necessity are not the two horns of a dilemma; natural selection blends them in a unique creative system. No more than remote analogues of this system are found in the nonliving world, but analogues are common on the biological and the human levels. Did Beethoven create the *Eroica* by chance or out of necessity? The majestic march of biological evolution resembles human creativity more than it does the hazards of roulette, and this in the face of the fact that natural selection is a “blind” agent which cannot foresee the future needs of a species on which it operates.

The anchor of Monod’s world view is “that nature is objective, that the systematic confronting of logic and experience is the sole source of true knowledge.” It is this idea that “wrote an end to the ancient animist covenant between man and nature, leaving nothing in place of that precious bond but an anxious quest in a frozen universe of solitude.” It also “prohibits any confusion of value judgments with judgments arrived at through knowledge.” Yet the principle of objectivity is in itself “the ethic of knowledge,” and Monod sees in this ethic the foundation of man’s future development. A most inspiring and noble view, but in this short book the author is unable to come down to specifics. How can the ethic of objective knowledge be applied to the everlasting problems of good and evil, or to the particular problems which mankind faces at present? Monod does mention that it can provide “the moral inspiration for a really *scientific* socialist humanism” but does not explain what this socialism will be like. In conclusion, let me say that, despite some fairly major disagreements, no recent book by a biologist have I found more fascinating and thought-provoking.

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Construction and Invention

Science and Civilisation in China. Vol. 4, Physics and Physical Technology. Part 3, Civil Engineering and Nautics. JOSEPH NEEDHAM, with the collaboration of Wang Ling and Lu Gwei-Djen. Cambridge University Press, New York, 1971. lviii, 932 pp., illus., + foldout maps. \$55.

No appropriate words can be found to describe the enormous energy and wide-ranging erudition which mark the works of Joseph Needham. A biochemist in his own right, Needham took an interest in Chinese culture and learned Chinese under his own steam. His appointment as the leader of the British scientific mission to China during the Second World War marked the beginning of his seven-volume project on science and civilization in China, of which three more volumes, in five tomes, are still to come. Meanwhile, as by-products of this project, Needham has published a number of important smaller works, most recently *The Grand Titration: Science and Society in East and West* (1969) and *Clerks and Craftsmen in China and the West* (1970).

The present volume, dealing with civil engineering and nautics under the general heading of Physics and Physical Technology, constitutes the third and final part of volume 4. Sheer bulk demands the separation into parts for “comfortable meditative evening reading.” The volume, like its predecessors, is well produced and extremely generous with Chinese characters and illustrations. The illustrations alone, of which there are over 300, are a veritable record of the achievements of traditional Chinese technology, and when they are juxtaposed with examples from Europe (for example, bridges, ships, cartography) and the rest of the world (for example, types of sails), their comparative value cannot be denied. In many cases, lengthy and instructive comments accompany the illustrations.

In the vein of his previous works, Needham again emphasizes the importance of understanding Chinese science within the Chinese frame of reference. Chinese drawing, for example, has often been criticized as being unable to represent distance. Needham tells us that this is by no means the case. The criticism arises only because the Chinese, in the absence of Euclidean geometry and the post-Renaissance science of optics, had to resort to different conventions such as the “parallel perspective” to represent distance (see illustration). Once this is understood, Chinese “work-