The World of an Evolutionist

Sir Gavin de Beer

Nearly 40 years ago I took out of their glass case in the Oxford University Museum the specimens of Mesozoic mammals from Stonesfield so that they might be studied by a young visiting scientist from the United States, George Gaylord Simpson. Since that day, in common with all biologists, I have followed with increasing wonder and admiration the ever-deepening debt in which he has placed his colleagues by his researches and his interpretation of their significance for the central problem in science, life, of which the most basic aspect is evolution. Since the work under review—**This View of Life** (Harcourt, Brace, and World, New York, 1964. 230 pp. $5.50), by George Gaylord Simpson—is in some respects autobiographical, it is pertinent to look back on that time.

The 1920's were a bewildering period for biologists. A year after the publication of T. H. Morgan's cast-iron proof that genes are carried in linear order in chromosomes, I remember arguing with W. Bateson who refused to accept it and sank himself into more and more impossible positions with his presence-and-absence hypothesis. Mendelian geneticists, who ascribed evolution to mutation but were utterly unable to account for adaptation, pointed scornful fingers at Darwinian selectionists because their own toy, mutation, provided the only evidence of heritable variation, in clear-cut steps, without selection playing any part in the process. Darwinian selectionists parried the attack by protesting that such mutations as were then known differed from the insensible gradations that Darwin had postulated and were either deleterious or even lethal. A third group called down a plague on both the other houses and marched behind a banner bearing Lamarck's name, refusing to admit any other cause for evolution than the inheritance of acquired characters by impressed effect of environmental factors, remanence of habitudinal innovations, use and disuse. Even P. Kammerer's suicide, after G. K. Noble had shown that his experimental demonstrations had been fraudulently faked by injecting newts' hands with Indian ink (and on the wrong side), had no effect on the Neo-Lamarckians, and the three-sided contest continued acrimoniously, aimlessly, and unprofitably, like a ship with neither compass nor chart but with three captains, until an unexpected thing happened.

Brought up in the Mendelian school, R. A. Fisher started to make experiments in genetics. To his astonishment he found that the phenotypic effect of any given gene was under the control of the other genes of what came to be called the gene-complex of an organism, whose action modified the said phenotypic effect in one way or another, and modified it *gradually* in a few generations. A gene that determines a dominant character does so as a result of a reshuffling of the gene-complex in such a way as to allow the gene in question to show its effect even when in the heterozygous state. This happens when this effect is beneficial to the organism. But reshuffling involves the production of many different gene-complexes, some of which produce viable organisms while others do not, and the gene in question has *become* dominant by gradual steps under selection. Conversely, a gene *becomes* recessive if its effect in the prevailing environment is deleterious, again as a result of selection. E. B. Ford then showed that, by selecting along different lines, one and the same gene can be made dominant in one strain and recessive in another. In other words, at the very heart of Mendelian genetics, Fisher found incontrovertible evidence for selection. Further, his mathematical analysis of selection showed that no gene has any chance of establishing itself in the wild type of a population if the slightest degree of selection is exerted against it, and that in nature the vast majority of mutations *are* acted upon adversely by selection under the conditions obtaining when they mutated, which is why so many of them are recessive.

This observation also shows that there is no "favorable breeze" of mutations with immediately beneficial effects, such as those on which upholders of programmed theories of evolution rest their case—"every theory of evolution which assumes, as do all theories alternative to natural selection, that evolutionary changes can be explained by some hypothetical agency capable of controlling the nature of the mutations that occur, is involving a cause which demonstrably would not work, even if it were known to exist." That put "paid" to the account of the Neo-Lamarckians and that of many other philosophers, and it meant that Darwinians and Mendelians had been fighting one another for groundless reasons; the two schools were then integrated, and the synthetic theory of evolution emerged, as if by magic, out of the seemingly hopeless muddle.

The last word on the credibility and course of evolution lies with the paleontologists, and this was where Simpson came in. Before him, paleontologists were prone to draw conclusions from inadequate evidence which they did not hesitate to write into grandiloquent theories. Because Cuvier found that a fauna appeared suddenly in a stratum and vanished completely in the next, he advocated special creation of that fauna at the start of the period of time represented by that stratum and a catastrophe at its end. After evolution was accepted, A. Hyatt was led to provide "proof" of the theory of recapitulation, and E. D. Cope of "orthogenesis." It is against this background of confusion, conclusions drawn from incomplete evidence, and muddled principles that the significance of Simpson's work emerges.

This is not the place to go into the details of his massive contributions to paleontology and taxonomy. It must suffice to say that as a result of minute attention to extensive material, he has shown that evolution is causally de-

The reviewer was until recently director of the British Museum (Natural History), and before that he was professor of embryology at University College, London. A past president of the zoology section of the British Association for the Advancement of Science, Sir Gavin served as president of the 15th International Congress of Zoology, London, 1958; his most recent book is *Charles Darwin* (Nelson, London; Doubleday, New York, 1964).

termined but not predetermined, and that its course has been opportunistic. To take one example, rigorous analysis of the history of the horse reveals that, instead of what had previously been thought to be a trend in a single constant direction, there have been several trends in as many different directions and that the horse of today has only become what he is as a result of a zigzag course followed by his ancestors, with respect to their toes, their teeth, and their sizes. This was not the fulfillment of any program but the result of opportune variations in directions, which at various times enabled the animals to cope with unpredictable changed conditions and so to escape the extinction that overtook all those forms that persisted too long in the directions of their old lines. Here was paleontology providing evidence for adaptation and selection. It became even stronger when the rate of evolution was found not to be correlated with the degree of variability shown by the evolving animals, nor with the length of time occupied by a generation. The result has been that, thanks to Simpson, paleontology provides the coping stone of the synthetic theory of evolution.

But Simpson is not only a paleontologist. Rare among his colleagues, he has made himself master of *all* the disciplines involved in the synthetic theory, and particularly of taxonomy, which makes him a great biologist. He is not only a biologist but a man of science with the widest horizon and experience. He recognizes that science is an exploration of the material universe which seeks natural, orderly relationships among observed phenomena and that it is self-testing. It is a mistake to think that prediction is the only way of testing hypotheses. Science and the unification of science, he believes, can be meaningfully sought not through principles that apply to all phenomena, but through phenomena to which all principles apply. This pregnant inversion reappears in the passage where he says that he does not think evolution supremely important because it is his speciality, but that, on the contrary, it is his speciality because he thinks it supremely important, not only for the extension of scientific knowledge, but to make so-called educated people aware of the nature of the world into which Darwin led them, out of the world in which Thomas Jefferson could deny that any species had become extinct and John Wesley could assert that there were no earthquakes before Adam and Eve were chased out of Eden because they had acquired a character, sin, which so many still believe to have been inherited.

To a British scientist it comes as something of a shock to realize the opposition to the teaching of evolution in the United States. In Britain this is not so among teachers or teaching authorities; there is of course the odd crank who raves against evolution because it is not "scriptural" (by which token he should also believe that the earth is flat with water underneath and the sun revolving around it), but otherwise there is no opposition, only apathy and ignorance. Two hundred and forty randomly selected television viewers were recently invited by the BBC to say what name they associated with evolution. Only one-third of that number had the idea that Darwin was an answer to the question.

But Simpson is not only a man of science; he understands and defines what it is. His chapter on the historical factor in science should be prescribed reading for all scientists, especially for those who claim that their science is "exact." The beautifully clear distinction drawn between "non-historical" and "historical" events in the universe, their relation to the "immanent" and "configurational" aspects of matter, the bearing of these relations on the great principles of uniformitarianism, predictability, emergence of new properties, extrapolation of trends, and the meaning of "explanation" brings simple order into a chaos of muddled thinking. Deans of arts faculties should not miss this inspired analysis either, for human history and sociology also come under the beam of its light. The sciences form a spectrum from physics, where the historical aspect of events is ignored and sometimes denied, to sociology, where the historic aspect is greatest and the nonhistorical is sometimes denied. "Unfortunately philosophers of science have tended to concentrate on one end of this spectrum, and that the simplest, so much as to give a distorted, in some instances quite false, idea of the philosophy of science as a whole." This is part of the unbalance that results from the "hegemony of physics" in the sciences. At the other end of the scale, there have been men, including Teilhard de Chardin, who have honestly deceived themselves into believing that they could and did achieve an integration of science with mysticism. In showing up the internal contradictions and inconsistencies amounting to double talk in such efforts, the acuteness and trenchancy of Simpson's analysis disposes once and for all of the pretensions of these works' authors that they have any claim to being science, without prejudice (so gentle is Simpson even in opposition) to their excellence as essays in mysticism.

A curious feature of the study of evolution has been the tardiness with which some of the most promising avenues of research (as recognized by hindsight) have been explored. Biologists are now aware of the paradox that Darwin owed his achievement largely to observation of nature in the field, but when the impact of his great breakthrough was realized, biologists rushed indoors to the dissecting dishes and microscopes and neglected nature in the field and in the breeding pen, where they have since fulfilled Darwin's prophecy that in about 50 years evidence for evolution by natural selection should be obtained, a prophecy that, toward the end of his life, Darwin made to his son Leonard. There is a pattern in this comedy which allows men to play for years with the very tools that will open the safe of knowledge without their realizing that they have the keys in their hands. Lyell and Blyth knew the ingredients out of which Darwin distilled the mechanism of evolution by natural selection, but they failed to see their significance because of their preference for theological orthodoxy. Darwin himself obtained genetical results from his breeding experiments analogous to those from which Mendel extracted the laws of particulate inheritance, which Darwin was unable to grasp because he was so deeply imbued with the correlated wholeness of the organism. Bateson had access to the facts which Fisher wove into the integration of genetics with selection, but Bateson passed them by while being driven into positions more and more untenable. As A. N. Whitehead remarked, "Everything of importance has already been said by someone who did not discover it." This is the pattern of the history of science.

There is another aspect of tardiness which is due to what Claude Bernard meant when he wrote "It is what we think we know that prevents us from learning." Until recently biologists thought they knew exactly how Darwin came by his theory of natural selection, but they misunderstood his *Autobiography* (not entirely their fault), and his *Notebooks* had to wait a hundred years after the publication of the *Origin of Species* before they were subjected to close scrutiny and the correct answer was found. Another basic consequence of Darwin's achievement had to wait the same time—the purposiveness of adaptation. As a fact, it is undeniable, and it was interpreted by Paley (and by other last-ditchers since then) to mean that teleological final causes, preordained programs, and providential (not to say divine) guidance were at work, an interpretation that led to a head-on collision between theologians and scientists as in the battles of Oxford and Dayton. Asa Gray praised Darwin for bringing teleology back into science because adaptation is purposive. But what Darwin really did was to show that organs which serve a purpose can and do arise, without any preceding agent of purposefulness at all but opportunistically, by the rigorously nonrandom directives of natural selection. This conclusion is inescapable now that it is known that the vast majority of species which have lived on earth have become extinct (was this providential guidance?) and that the vast majority of new heritable variations are acted upon adversely by selection (thereby wrecking any preordained program).

The term *teleology* was the trouble because of its metaphysical, not to say theological, connotation with which men of science were, of course, unable to compromise. Here it is fitting to recall the words of a forgotten mathematician from Cambridge (England), William Kingdon Clifford, who in 1875 pointed out the confusion that arises from the two meanings ascribed to the concept of purpose. In the first, the idea of the end precedes the use of the means as in theological teleology. In the second, an adaptation may serve a purpose even if it originated by accident, "by processes of natural selection." Clifford went on to say that "since the process of natural selection has been understood, *purpose* has ceased to suggest design to instructed people, except in cases where the agency of man is independently probable." This luminous analysis was, however, neglected, and the *Origin of Species* had to wait a hundred years for Colin Pittendrigh to clarify what Darwin meant by introducing the valuable term *teleonomic*, a term that does not antagonize scientists as teleology does.

It is difficult for a reviewer to criticize a book with which he is in fundamental agreement. This may mean that he is the wrong reviewer, but in order for this one to show that he does not swallow everything, he will end with two comments. Is Simpson right in drawing a distinction between the concept of differential mortality and survival, to which he restricts Darwin's view of selection, and reproductive selection, which means the consistent production of more offspring? It is true that in the later editions of the *Origin* Darwin made the mistake of adopting Spencer's unfortunate expression "survival of the fittest" when (rightly) dissatisfied with the adequacy of his own term "natural selection." He would have been better advised to turn to his *Notebook* of 1838 and use the words with which he committed to paper the flash of light that struck him on 28 September of that year: "One may say there is a force like a hundred thousand wedges trying to force every structure into the gaps in the oeconomy of nature, or rather forming gaps by thrusting out weaker ones." It is also true that Darwin frequently speaks of survival as the prize won by adequate adaptations, but this is always shorthand to mean survival in order to leave offspring, for he never lost sight of the fact that differential reproduction is the effective element in selection. As he wrote in the *Origin*, "I use the term struggle for existence in a large and metaphorical sense . . . including (which is more important) not only the life of the individual, but success in leaving progeny" (Peckham's *Variorum* edition, p. 146). I may also add that as David Lack has shown, it is deleterious for a species to produce too many offspring, because their ecological conditions may lead to the consequences that are now seen in many underdeveloped nations. I therefore prefer Darwin's guarded expression "success in leaving offspring."

Finally, I must question the impression which Simpson gives, that he deserted literature and poetry to devote himself to science. On the contrary he has enrolled these arts under the banner of science in a Simpson style that can be recognized in all his works because of its clarity and complete avoidance of ambiguity. He has a technique in writing which only accomplished artists can use with impunity (Charles Ferdinand Ramuz is one such). When the progress of his exposition or the thread of his argument requires the repetition in the same sentence of the same word or groups of words, Simpson repeats them, and the effect is incomparable.

Photochemistry

Advances in Photochemistry. vol. 1. W. Albert Noyes, Jr., George S. Hammond, and J. N. Pitts, Jr., Eds. Interscience (Wiley), New York, 1963. x + 443 pp. Illus. $16.50.

This volume is devoted to tracing the changes which befall a molecule that has absorbed radiation. Although photochemistry is more than 100 years old the field has advanced rapidly in recent times as a result of developments in related disciplines. A better understanding of spectroscopy and quantum mechanics has helped with the fundamental theory of photochemistry. The possibility of bringing about rapid changes with flash photolysis is noteworthy, while ascertaining what kinds of excited molecules and molecular fragments are present has been greatly helped by nuclear magnetic resonance and electron spin resonance.

The volume consists of 9 chapters written by 13 authors. The first chapter (Pitts, Wilkinson, and Hammond) is called the "Vocabulary of photochemistry," and it gives a quick rundown of nomenclature and of the concepts used. This will be especially useful to the nonspecialist.

A chapter by E. J. Bowen, "The photochemistry of aromatic hydrocarbon solutions," deals effectively with fluorescence, phosphorescence, energy degradation to the triplet or the ground states, dimer formation, photooxidation, and energy transfer. In another chapter D. H. Volman discusses the photochemical gas phase reactions in the hydrogen-oxygen systems.

Other chapters treat the photochemistry of cyclic ketones, the addition of atoms to olefins, organic mechanisms, mercury photosensitization, photochromism, and rearrangements of organic molecules. R. Srinivasan, R. J. Dveta-