port the observatory, which has since been done. The observatory now receives by law the income of a tax levy of one twentieth of a mill.

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December 2, 1921

SCIENTIFIC BOOKS

THE ORDER OF NATURE

The Principles of Natural Knowledge, by A. N. Whitehead, Cambridge University Press, 1919.

L'Unité de la Science, by Leclerc du Sablon. Félix Alcan, Paris, 1919.

The Order of Nature, by Lawrence J. Henderson. Harvard University Press, 1917.

The System of Animate Nature, by J. A. Thomson. Two volumes. Williams and Norgate, London, 1920.

In the first dialogue between Hylas and Philonous Berkeley has the latter to say: "I am not for imposing any sense on your words: you are at liberty to explain them as you please. Only, I beseech you, make me understand something by them." The author of "The Principles of Natural Knowledge" has obviously had before him not only this demand, which he sets forth by giving the foregoing quotation on his title-page, but also the further one that every intelligent reader shall understand the same things by his words. Neither of these ideals is easily realized in philosophical writings; and this is most emphatically true of those which are addressed to readers not interested in the technical aspects of philosophy. Why does this difficulty exist? "We have to remember that while nature is complex with timeless subtlety, human thought issues from the simple-mindedness of beings whose active life is less than half a century."

The author seeks to realize clarity by the so-called "method of logical atomism" which "has gradually crept into philosophy through the critical scrutiny of mathematics" and in his discussion to substitute "piecemeal, detailed and verifiable results for large untested generalities recommended only by a certain appeal to the imagination," to use Bertrand Russell's characterization of the philosophy of logical atomism. Whitehead analyzes thought into elements which the unsophisticated mind could never recognize as parts of its original thought content; and sometimes even for the expert, one must believe, there is real difficulty in putting together the parts so as to recover the whole. But the reader is not in doubt as to what the author says or what he means. Whitehead says:

"The fundamental assumption to be elaborated in the course of this enquiry, is that the ultimate facts of nature, in terms of which all physical and biological explanation must be expressed, are events connected by their spatio-temporal relations, and that these relations are in the main reducible to the property of events that they contain (or extend over) other events which are parts of them." Time is not a succession of instants. but a complex of interlocking events, each helping to tie the others to the past and the future. "The conception of the instant of time as an ultimate entity is the source of all our difficulties of explanation. . . . Our perception of time is as a duration."

The work as a whole contains a somewhat technical and rather disjointed analysis of four matters, namely: the traditions of science; the data of science; the method of extensive abstraction; the theory of objects. The book will have its greatest appeal to the reader of considerable mathematical maturity, even though it does not at all depend on mathematical detail; for the point of view is evidently taken in the light of the recent philosophy of mathematics.

In "L'Unité de la Science" by M. Leclerc du Sablon we have an equal clarity, but it differs from that of Whitehead's work in being strongly marked by French characteristics.

In his preface Whitehead says: "In matters philosophic the obligations of an author to others usually arise from schools of debate rather than from schools of agreement. Also such schools are the more important in pro-

portion as assertion and retort do not have to wait for the infrequent opportunities of formal publication, hampered by the formidable permanence of the printed word. At the present moment England is fortunate in this respect. London, Oxford and Cambridge are within easy reach of each other, and provide a common school of debate which rivals schools of the ancient and medieval worlds." The authors of the first and last books under review have evidently profited much by such frequent interchange of opinion and this matching of judgment to opposed judgment. Doubtless some parts of the other two books would have been modified if their authors had more freely discussed certain controversial points with persons of a different opinion. This applies particularly to the philosophic aspects of the books, but does not affect their more positive contributions.

The philosophical part of "L'Unité de la Science" is not strong. It is sometimes naïve. In particular, the psychological theory underlying the first chapter is far from being satisfactory. But numerous scientific theories and experiments are analyzed in a way to be profitable. For M. Leclerc du Sablon unity of science is a unity of method. The scientific method, par excellence, is the experimental method. Working himself in the field of biology, where deduction is less frequently used than in several other disciplines, he has failed to grasp its whole importance. The experimental character of science is emphasized to the detriment of its rational character. The author insists (wrongly we think) that all reasoning, even that of induction, can be reduced to the form of syllogism. A first demand for science is its objectivity. The principle of causality (both direct and inverse) lies at the root of all science. Phenomena are irreversible. Beginning with arithmetic and geometry, the author analyzes, from the point of view of unity, each of the several fundamental sciences of nature. He devotes one chapter to the moral sciences. He sums up his principal findings in a useful conclusion of ten pages. The book is interesting and valuable; but it does not reach the height of being an inspiring contribution to the philosophy of science.

The purpose of Henderson's "Order of Nature" is more restricted. This essay professes to demonstrate the "existence of a new order among the properties of matter" and to "examine the teleological character of this order." Modern science is said to have failed to make a systematic study of adaptability, which (it is maintained) is at bottom "a physical and chemical problem uncomplicated by the riddle of life," even though it is true that "the organism and the environment each fits and is fitted by the other." The author asks, "What are the physical and chemical origins of diversity among inorganic and organic things, and how shall the adaptability of matter and energy be described?" To this question he reaches an answer with such remarkable ease as almost to cast doubt upon its validity; nevertheless it must be admitted that he has marshaled much evidence for his conclusion.

"What is known with certainty about the history of the earth enables us to see that a few elements, and especially the four organic ones, are the chief factors. Among these nitrogen plays a somewhat subordinate rôle, especially in the mineral kingdom, while hydrogen, carbon, and oxygen, notably as constituents of water and carbon dioxide, are almost everywhere of equal importance." After discussing rather fully the characteristics of the latter three elements the author says, "We are therefore led to the hypothesis that the properties of the three elements are somehow a preparation for the evolutionary process. In truth this is the only explanation of the connection which is at present imaginable. . . . The connection between the properties of the three elements and the evolutionary process is teleological and non-mechanical."

Each of the four authors under review is evidently convinced of the truth of what one of them (Henderson) states explicitly, namely, that "men of science can no longer

shirk the responsibility of philosophical thought." The philosophy of these four, with the possible exception of Whitehead, is general and non-technical in character and is addressed primarily to those who have a trend in the direction of science. For the "general reader" the investigation of Whitehead is rather too technical and special; the work of Leclerc du Sablon is elementary and somewhat rarefied, being dispersed over too wide a range of subjects to help much in forming a scientific philosophy to live by; the work of Henderson is moved by a too narrow view, and he exhibits what Thomson in another connection speaks of as the false simplicity of materialism; but in "The System of Animate Nature" we have a magnificent contribution to the foundations of a philosophy of biology of such sort as to find a secure place in the lives of people of intelligence whether devoted to scientific pursuits or following other interests.

At the front of the two volumes of his Gifford lectures on "The System of Animate Nature" Thomson sets the following classic quotation from Francis Bacon: "This I dare affirm in knowledge of Nature, that a little natural philosophy, and the first entrance into it, doth dispose the opinion to atheism, but on the other side, much natural philosophy and wading deep into it, will bring about men's minds to religion." Thomson insists that "the scientific picture has satisfied very few thinkers of distinction, the chief reason being that the contributions which each science makes are always partial views, reached by processes of abstraction, by focusing attention on certain aspects of things." We need a more comprehensive view which allows a place for the feeling for nature and enables us to relate it to the whole of our activity.

Consequently, "the aim of this study of Animate Nature is to state the general results of biological inquiry which must be taken account of if we are to think of organic Nature as a whole and in relation to the rest of our experience. Both among careful thinkers and careless passers-by views of organic Nature are held in regard, for instance, to the organism as mechanism, the determinism of heredity, the struggle for existence. which seem to the author to be lacking in accuracy or in adequacy, which therefore tend to involve unnecessary difficulties in systematisation and perhaps gratuitous confusion in conduct. . . . While trying to keep wishes from fathering thoughts, we have been led in our study to see that the general results of Biology, when stated with accuracy, are not out of line with transcendental conclusions reached along other paths. . . . It looks as if Nature were much more conformable than is often supposed to religious interpretation, but we have not seen it to be our duty to justify the ways of God to man. We have tried to keep as close as possible to the facts of the case, leaving philosophical and religious inferences for those who are better qualified to draw them."

There is no attempt to reach transcendental results by the methods of science; but there is a persistent purpose in the lectures to show that there is nothing in science to interfere with a certain class of transcendental conclusions reached by other means. And the author does not hesitate to close his twentieth and last lecture, a remarkable one on "Vis Medicatrix Naturae" (The Healing Power of Nature), with the question: "Shall we not seek to worship Him whom Nature increasingly reveals, from whom all comes and by whom all lives?"

The first of the two volumes is devoted to the realm of organisms as it is, and the second to the evolution of the realm of organisms. The author is thoroughly convinced that the mechanistic interpretation of life is insufficient. He quotes with approval: "On the whole, there is no evidence of real progress towards a mechanistic explanation of life." He says: "The apsychic view is outrageous." "There has not yet been given any physico-chemical description of any total vital operation."

Biology seems justified in holding to the view that the evolutionary process gives rise to frequent outcrops of genuine novelties,

things not already necessarily implied in the past. "The outstanding fact about organic evolution is the increasing dominance of Mind." "Unless we have quite misunderstood evolution it implies an emergence of novelties. It is like original thinking." In it there is something like the joyous play of the organism at self expression. "It may be well for us, on our own behalf and for our children to ask whether we are making what we might of the well-springs of joy in the world; and whether we have begun to know what we ought to know regarding the Biology or the Psycho-biology of Joy."

Perhaps the most remarkable single matter in these lectures is the suggestion of a sort of cell-intelligence, particularly in the germ-cells. "Just as an intact organism from the Amoeba to the Elephant tries experiments, so the germ-cell, which is no ordinary cell, but an implicit organism, a condensed individuality, may make experiments in self-expression, which we call variations or mutations. Such, at least, is our present view of a great mystery." "The position we are suggesting is that the larger mutations, the big novelties, are expressions of the whole organism in its germ-cell phase of being, comparable to experiments in practical life, solutions of problems in intellectual life, or creations in artistic life." "The germ-cell is the blind artist whose many inventions are expressed, embodied, and exercised in the developed organism, the seeing artist who, beholding the work of the germ-cell, either pronounces it . . . to be good or . . . curses it effectively by sinking with it into extinction."

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SPECIAL ARTICLES

MORE LINKED GENES IN RABBITS

In Science for August 13, 1920, I presented evidence indicating the existence of linkage between the genes for English spotting and dilute pigmentation in rabbits. The evidence consisted of a group of 83 young produced in matings of a male heterozygous for both characters, mated with doubly recessive females. Such matings are expected to produce equal numbers of individuals of four color classes, if no linkage exists. Consistently, in his successive litters of offspring, this male sired more young in the non-cross-over classes than in the cross-over classes, which result indicated linkage of strength 23 on a scale of 100, the cross-over percentage being 38.5.

A second heterozygous male has since been tested, in similar matings with doubly recessive females, for the occurrence of linkage between the same pair of characters as seemed to be linked in the gametes of the first male, but shows *no linkage* with as much consistency as the first male showed linkage. The totals for the first male were 32 cross-over; 51 non-cross-over gametes; for the second male they are 75 : 76, as near equality as possible. The question now arises, Were the results given by the first male statistically significant? The cross-over percentage calculated as 38.5 has a probable error of 3.6 per cent. Hence the departure from 50 per cent. cross-overs (which would indicate *no* linkage) slightly exceeds three times the probable error, a result which would ordinarily be considered significant. Unfortunately no further experimental tests of this animal can now be made as he is no longer living. There can be no doubt about the negative result given by the second male. We are now confronted by this dilemma. Either the result given by the first male was *not* significant, or we may have in the same strain of rabbits two individuals, in one of which two characters show linkage, while in the other they do *not* show linkage. This latter alternative seems improbable, yet it can not be regarded as impossible on the chromosome hypothesis. Gates and Rees [1] in discussing the pollen development of *Lactuca sativa* state that the number of chromosome pairs in the species is nine but that

> Occasionally in diakinesis only eight chromosome bivalents were present, and frequently there were only seven or eight bodies present on the heterotypic spindle. This was found to be due to a tem-

[1] *Annals of Botany*, 35, 1921, p. 394.