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# SCIENCE AND HISTORY: A SHORT CONTRIBUTION TO PHILOSOPHY[1]

By E. C. ANDREWS

GOVERNMENT GEOLOGIST OF NEW SOUTH WALES

IF the ordinary member of the Australian and New Zealand Association for the Advancement of Science were questioned concerning the main objects of the association, he or she would naturally reply that the title is self-explanatory, implying, on the one hand, coordination and correlation of scientific work by cooperation, and, on the other hand, the promotion of harmonious social relations both between scientific workers themselves and between them and the general public. The question thus naturally arises as to the scope of the association's activities and the best means of securing the desired cooperation. A glance at the names of the sections reveals a range of subjects for discussion varying from mathematics, physics, chemistry, geology and biology, to economics, medical science, social science, education, psychology and philosophy. Whether we consider philosophy in its general meaning as inclusive of psychology, epistemology, ontology, logic, esthetics and ethics, or in its narrower sense as synonymous with metaphysics, it is evident that the subjects considered are so diverse as to imply the possession either of decided versatility or of a broad grasp of scientific method on the part of one who would attempt the correlation of these subjects. Coherence of parts (sections), at least, is necessary, however, and in view of the present centrifugal movement towards specialization with its resultant divergency of interests and tendency to misunderstanding between the workers in the peripheral excrescences

[1] Abstract of the address of the president of the Australian and New Zealand Association for the Advancement of Science, Brisbane, 1930.

thus formed, it appears advisable to direct one's attention centripetally, as it were, and investigate the possibility of the existence of a principle common to, or underlying, all.

One of the main difficulties encountered in seeking to promote cooperation among the students of scientific method in the various branches of knowledge (disciplines), especially in connection with the study of possible underlying principles, is the tendency in the individual groups to undervalue the work done in branches far removed. The physicist and chemist in their syntheses do not appear to value sufficiently the vast gulf separating complex material mixtures from vital sense, or coenesthesis, and intellection in organisms. The idealist, on the other hand, does not appear to note that "bodies have not been successfully separated except into bodies, as real matter," and so on; the materialist does not appear to take sufficiently into account the fact that "bodies evolving account neither for themselves, their nature and their fundamental order of resemblance and difference, nor for the nature and origin of consciousness, nor even as yet for their becoming good for conscious beings." Moreover, the psychologist, the physiologist, the physicist, the biologist, claim too great a scope individually in the exploration of various activities, which, although consentaneous in action, nevertheless may only be described as psychoneural parallelisms. The true philosopher was he who was styled συνοπτικός by Plato, that is, he who takes a "synoptic" or comprehensive view of the universe as a whole.

Gilbert, the philosopher-geologist of America, advocated the extensive use of the "intellectual excursion" among workers, the peeping over the shoulders of one's colleagues, as it were, in all departments alike, to learn the lessons of tolerance, sympathy and the probable interrelatedness of all at base. Darwin's utilization in the "Origin" of the results of Mathews' work on "Naval Timber" is an example of the value of the "intellectual excursion." Especially valuable is this method in teaching the subjective nature of our knowledge, and the dependence on empiricism for the most definite advance in all branches, and in revealing the strangle-hold which traditions and beliefs acquired in infancy, childhood and youth have upon workers in all departments alike.

In order to obtain a clearer idea as to the advance which the universe, or at least the organic world, may be expected to make in the distant future, an ideal Observer is assumed, who visits the earth on several occasions—(1) in early Pre-Cambrian time, (2) during the whole of historical time and (3) say about one hundred or one thousand millions of years hence. He is possessed of human emotions and general sympathies; his vitality is perennial, yet his strength and endurance are only those of human beings; he journeys to the earth in a special self-contained chariot, but because of his physical limitations he can not approach the stellar bodies within very many millions of miles; he has no "early" training, as understood by human beings, but springs full-fledged intellectually, thereby being without either the help or the incubus of early traditions, beliefs and revelations, and without desires resulting from the "stable animal heritages" which had been grafted onto the evolving organisms one by one from the Pre-Cambrian. On the other hand, he has access to the whole of human knowledge, in mundane and sacred literature alike, wherewith to form a judgment by his sympathetic but disciplined mind.

His visit during the Pre-Cambrian leads him to consider the universe as a great inorganic cosmos, being a similar but more complete presentation of the beautiful and simple picture set out by Jeans in "The Universe around Us." The real meaning of such a cosmos, however, he is unable to divine, inasmuch as there is vouchsafed to him no sign of mentality such as his own, except in the suggestion presented of a grand industry, firmly established and running well apparently on its own.

His second visit extends throughout the historical period. At the outset he is impressed with the different aspect the earth has assumed. Where before were only the signs of inorganic activities, he now sees the organic world as it is to-day; nevertheless he is still ignorant of the results of geology, biology, psychology and history.

At the commencement he is inclined to agree with the ancient philosophers, namely, that there are four or five elements—air, water, earth, fire, ether—and that there are three forms of substance or fact, namely, matter, intelligence and an underlying and pervasive activity giving rise both to material and so-called immaterial manifestations.

As he dwells with men and follows the history of races through their successive stages of barbarism, fetichism, inquiry, reason and intellectual decrepitude, he notes that there is a general advance intellectually and ethically, in undulatory fashion, the scepter passing from one race to another as reason in each in turn abdicates its throne, to pass into a trough of hedonism and skepticism.

Geology and biology now come to his aid and reveal to him a similar progress in the organic world from insignificant beginnings in Pre-Cambrian time to the highest organic structures and mentality, nevertheless in undulatory fashion, with the scepter passing from one animal and plant race or group to another better fitted to carry aloft the torch of progress. In all, however, the advance appears to be of the nature of an imposed gift.

Several other points impress him, namely, the tendency in man to specialization in scientific study; the tendency in each department of scientific research to reveal an underlying unity of activity, or a close interrelatedness of the objects of special study, nevertheless indicating, in each case, a still deeper underlying unity as yet undiscovered specifically and perceived only "as in a glass darkly"; the peculiar separate rather than disparate powers of the objective and subjective (subliminal) mental activities in organisms; also the violent and determined opposition manifested generally to progress by organisms, the general opposition exhibited consciously to progress by man himself (considered as a whole) being well expressed in the epigrammatic line of Plautus, "Homo homini lupus." With all, however, he observes that this persistent opposition has never been able to block progress, although it has retarded it for short periods. History indicates also to the Observer that true advance comes only through cooperation, and that the latter stage can come only when man throws off "the clog of individuality and remembers that he has grand race connections."

The explanation of man's individualistic attitude is simple. The inorganic cosmos arrived first among the universal manifestations of an earlier activity. Thus, atomic, molecular, crystal and stellar worlds were developed before organic life. Gravitation, light, heat, electricity, magnetism, inertia, sound, and so on, are universal. The play of these inorganic activities was inexorable, and the earlier organic adjustments were directed in accordance with them. The organism had to meet the storm, the flood, the drought. Benevolence, sympathy and justice were unknown to them as such. The early organisms were to be rendered stable in this inorganic setting. On these stable organic heritages the subjective and objective mental activities developed with excessive slowness throughout geological time. Each stage in this parallel mental series developed in opposition, as it were, to the rigors of their physical environment. There were opportunities for consentaneousness of activity with these lower stable heritages, however, on the part of the higher qualities which became engrafted, or harnessed in parallel, one by one, and such harmony of adjustment or correspondence was accomplished sooner or later, but all unconsciously, on the part of the organism. An analogy may be seen in the difficulty experienced, so to speak, by an electron attaching itself to a rounded-out stable system, such as a noble (inert) gas, like helium or argon.

The comprehension of the universe is to come by inductive study, or, to revive a somewhat obsolete term, by perduction, implying an inductive-deductive process. Science advances in proportion to the capacity to develop organizing ideas whereby observations and experiments are "colligated into intelligible system." In scientific inquiry we endeavor to ascertain the plan upon which our material has been built. Facts are collected and experiments are conducted. After the plan is assumed to have been ascertained, the deductive method is employed to discover additional detail. It is generally recognized that an initial "flash of genius" is needed—the faculty of suggesting new and valuable hypotheses. No one at present knows why the flash of genius comes; it is possible, however, to indicate how to secure it. The mind must rigorously examine and check its data; an attitude of open-mindedness and freedom from "conservatism" must be observed, with a confident belief that the proper inference will come later after a period, as it were, of fallowness in "consciousness." In this inductive-deductive process, the objective mentality is the great inductive agent, the subjective apparently the deductive, the former giving scope for the abundant exercise of "free-will," the subjective opposing the way, so to speak, by its tremendous wealth of traditions, inherited beliefs and instincts, yet under proper discipline revealing a truly marvelous power of advance by the syllogistic method, once the correct premises have been presented to it with sufficient force.

All inductive study indicates an increasing appreciation of an underlying unity of phenomena, and "noümena," the disparateness of to-day being merely the separate, but related, of to-morrow. Physicists have broken down the partitions formerly supposed to separate mechanics, molecular physics, light, sound, heat, electricity. But a more subtle unity appears to underlie the proton, the electron and the energy. The biologist, the physiologist and the psychologist perceive the gradual development of complex syntheses from a primitive simplicity; the paleontologist tells us of the wonders of the factor of time in the development of each of the above syntheses, and his studies strongly indicate an underlying unity to the psychoneural (not psychophysical) parallelism exhibited in all organisms. Ethics, esthetics, art and calisthenics add their convergent testimony of correspondence and parallelism to biology, physiology and psychology. The physicist and the chemist perceive that as these higher correspondences or consentaneous activities are stripped off, one by one, the matter remains, that is, the material of the instrument upon which the tune of progress was played. Philosophy, in its broader acceptation, makes the "intellectual excursion" in order to bridge the gulf or gulfs separating the methodological parallelisms in organic activities. Philosophy considers that these activities studied by science all belong to the universe; they all appear to be universal in their application under the proper conditions; in each department of research, moreover, an underlying unity is discovered; each succeeding generation of mankind discovers additional evidence of the interdependence and interrelatedness of all; it is, therefore, perhaps permissible to infer that all are the manifestations of a still deeper underlying unity, more far-reaching even than Einstein's law concerning the convertibility of matter into energy; moreover, since no energy can rise above its source, the universe, as the origin of all these activities, even of the "highest qualities" such as intellection and altruism, may be inferred to comprehend, sympathize with and to appreciate to the full their origin, their gradual synthesis and their peculiar resultant attributes. In this connection it appears probable that inductive study will reveal noümena as the totality of phenomena. Nevertheless, the study of nature, as generally understood, will, by itself, be insufficient. The inner meaning of the "cosmos" can not be expected to come from any inference or hypothesis which excludes from its premises "the intelligence in which nature, as it were, gathers herself up."

The Observer perceives that universal progress has been unbroken and unfailing, and that man, or some similar organism, will penetrate to the inner meaning of "things." Merriam considers a related point in an interesting article in a recent number of *Scribner's* (1927) entitled "Are the Days of Creation Ended?" The conditions for man to occupy the dominant position appear to be that he shall think and act impersonally; that he shall employ the inductive method in the broader sense as mentioned above; that he preserve his "stable heritages" intact, and that he appreciate time in generous terms as an essential factor in universal progress. The knowledge that was Newton's and Darwin's is to be but a basement stone, as it were, to the mighty temple of knowledge whose peak is to pierce the clouds. The greatest intellect, or the mind of the seer, is but a base upon which greater and grander examples are to rise and rest in countless thousands.

# SOME SCIENTIFIC INSTRUMENT MAKERS OF THE EIGHTEENTH CENTURY[1]

By ROBERT S. WHIPPLE

ALTHOUGH numerous references are found in early British manuscripts to instruments of an elementary kind, chiefly for the determination of time or position, there is little evidence that before the sixteenth century scientific instrument making as a craft had obtained a position of any importance in Great Britain. The demand for instruments to assist navigation became more insistent as new lands were discovered and the length of the voyages increased.

Gradually the professional scientific instrument maker came into existence, two of the more distinguished being Humphrey Cole, the maker of the astrolabe used by Sir Francis Drake, and Elias Allen, the maker of Oughtred's double horizontal dial. In a book by Oughtred, dated 1632, describing the double horizontal dial, it is stated that it is printed for Elias Allen, "Maker of these and all other Mathematical Instruments, and are to be sold at his Shop over against St. Clements Church without Temple-barr."

With the discovery of the telescope in 1608 and its development by Galileo in the following years a great impetus was given to the instrument-making industry. Although Gregory and Newton propounded the reflecting telescopes known by their names in 1663 and 1666, they were unable to find makers capable of developing their ideas. Newton made his own instruments, but it was not until about 1730 that John Short, of Edinburgh, succeeded in making a Gregorian telescope.

The latter half of the seventeenth century was a great period of scientific development. Experimental science, under its leaders Boyle, Hooke, Newton and others, created a demand for scientific instruments which could only be satisfied by skilled craftsmen. The work of Hooke and Leeuwenhoek did much to develop the microscope and to draw attention to the possibilities of the instrument. Fortunately an instrument made about 1670, and somewhat similar in its details to that described and illustrated in Hooke's "Micrographia" (1655), has been preserved, and by Mr. Court's courtesy is exhibited here this evening. The evidence is, I think, convincing that this instrument was made by Christopher Cocks, the well-known telescope maker, who lived in Long Acre, and of whose telescopes there are at least three in existence. It is known that in March, 1672, Cocks was ordered to make a four- or five-foot Newtonian reflecting telescope, but the instrument was not successful. About 1680 he was admitted a freeman of the Spectacle Makers' Company.

[1] Address given at the weekly evening meeting of the Royal Institution of Great Britain, Friday, May 23, 1930. Lord Rayleigh, Sc.D., F.R.S., manager and vice-president, in the chair.