"Æther and Matter," or, an extremely simple exposition of some of the simpler of Larmor's ideas on pages 322–325 of Franklin and MacNutt's "General Physics." Others besides Bertrand Russell have recognized the Doctrinal Function.

W. S. Franklin
Barry MacNutt

SCIENTIFIC BOOKS

The Origin and Evolution of Life, on the Theory of the Action, Reaction and Interaction of Energy. By Henry Fairfield Osborn. New York, Charles Scribner's Sons. 1918. Pp. xxxi + 322. Price $3.00.

Professor Osborn's Hale Lectures, reprinted in an enlarged form in this attractive volume, raise anew the question: are the factors of organic evolution *centripetal,* consisting in the direct "moulding" action of environmental agencies upon the organism? or are they *centrifugal,* the expression of the innate formative and other physiological activities of the germ itself, operating under conditions largely independent of the immediate environment? He perceives, however, that the question can not rightly be put as one of alternatives, but that factors of both kinds necessarily enter. Organism and environment are in continual interaction; what affects the one inevitably affects the other; there is always an interchange of material and energies, constituting a more or less stable equilibrium in a well adapted organism. Organic evolution has had a complex and diversified outcome because the conditions are complex; adaptation, both of structure and activity, has developed as a distinctive feature of living beings because it is an essential condition of the vital equilibrium, *i. e.,* of survival. The factors of evolution are thus various and are classified by the author under four chief heads: (1) action of the inorganic environment, (2) of the organism itself, (3) of the germinal substance of the organism ("heredity chromatin"), and (4) of the living environment, *i. e.,* influence exerted by other living organisms, *e. g.,* competitors. Each of these "four complexes of energy" is to be conceived as itself evolving, partly independently, partly in relation with the others; and the evolution of living organisms has taken place under this fourfold or "tetrakinetic" influence. While the environment, inorganic and organic, *controls* the evolutionary process —permitting the survival only of those organisms which are adapted—the process itself is largely conditioned from *within, i. e.,* by the internal or constitutional peculiarities of the germinal substance, which throughout the book is identified with the chromatin of the germ-cells. Evolution is creative, *i. e.,* novelty perpetually arises, although at varying rates and in varying degree in the different lines of evolutionary descent; but the precise causes and conditions of its appearance remain to be determined; to explain the origin of new varieties a more complete knowledge of the physiology of the germinal substance is required. Paleontological research indicates that variations in the germ can be referred only partly, if at all, to the direct action of the environment upon the entire organism; thus rapid evolution may take place during periods in which there is little geological evidence of extensive natural change, and conversely many forms of life remain stable through the changes and chances of whole geological epochs (p. 137). Paleontology finds one evolutionary line, *e. g.,* reptiles, exhibiting active diversification at a certain period of its history, while at a later periods it relapses into conservatism at the very time when another line, the mammals, develops extraordinary creative activity (p. 231). Evolution, as observed in the paleontological succession of animal forms, often appears to progress in definite directions toward adaptive ends (pp. 146–240),—a fact which would seem to indicate a guidance by natural selection; but selection, while an important condition, can not be regarded as in itself an active agent. Repeated instances occur of characters, at first apparently non-adaptive, continuing to evolve until they become important assets in the struggle for existence. The author inclines to regard the essential agency in evolution as an apparently spontaneous germinal variability. directed along certain definite lines; this "internal

evolutionary impulse "he conceives as mainly determined by the innate properties of the germinal substance, *i. e.*, by "chromatin potentiality" (p. 231). This potentiality determines the rate of appearance and the character of new variations independently of natural selection; for example, paleontology shows that the slowly breeding race of elephants, on which selection might be expected to act slowly, have evolved much more rapidly than the frequently breeding rodents (p. 271). Everything depends upon the "invisible predispositions and tendencies in the ancestral heredity chromatin" (p. 242). There is, however, no evidence in paleontology of an internal extraphysical directive principle or entelechy; on the other hand, environmental conditions appear to exert a direct modifying influence, not attributable to selection, upon the evolving organism, but the nature of this influence remains obscure (pp. 243-244). That the germinal material possesses a power of "adaptive response" to the environment is indicated (*e. g.*,) by the evolution of teeth (p. 257).

In general, therefore, the author refers the evolution of the various metazoön stocks primarily to germinal variations, *i. e.*, more specifically, to variations of an orthogenetic or definitely directed kind in the "heredity chromatin." The evolution of visible bodily form and function is to be regarded as essentially the external sign and symbol of the invisible evolution of the heredity chromatin (p. 151). This "chromatin evolution" has its distinctive peculiarities; it is not "experimental" or hap-hazard but tends to be continuous in one direction toward adaptive ends (p. 146); evolutionary progress is thus not dependent either upon mutations or upon fortuitous variations which are held to a definite course only through the agency of natural selection. In a certain sense the author supports the Weismannian conception that the evolutionary factors act primarily upon the "germ-plasm," rather than upon the "soma"; he recognizes, however, that somatic modifications may secondarily influence the germ; and he appears to favor a kind of qualified Lamarckianism (p. 244); he suggests that possibly bodily changes may influence the germ through the intermediary of hormones (pp. 278 *seq.*). He insists, however, that the factors determining germinal evolution are still for the most part unknown (*cf.* pp. 23, 151).

The problem of the causes of germinal variation is essentially a physiological one. Everywhere in the book the author emphasizes the difference between the somatic and the germinal material, and it seems to the reviewer that this distinction is too sharply drawn. Certainly it can not be maintained in the case of the lowest organisms, *e. g.*, the bacteria or the ultramicroscopic forms of life, in which nevertheless heredity and variation are as truly manifested as in the highest. Such forms multiply or proliferate in a manner which is specific or true to type, but which may be influenced in definite directions by changes (*e. g.*, chemical) in the surroundings; and the same is undoubtedly true of all growing or developing regions in multicellular organisms, including the special germinal material (egg-cell and embryo) at the different stages of its development. Any form of organic growth implies the property of incorporating and assimilating, *i. e.*, transforming specifically, food and other materials taken from the surroundings; this property constitutes in fact the essential or distinctive feature of vital activity; it is common to all forms of living matter and heredity is one of its expressions. Hence the germ-cell can not be regarded as fundamentally different in its physiological constitution and properties from other cells or tissues of the organism. It is true that in higher animals the fertilized egg-cell has special powers of development not normally exhibited by other regions after isolation; but in many lower forms almost any detached portion of sufficient size may act as a germ, *i. e.*, may proliferate under favorable conditions and give rise to a complete organism. The appearance of a sharp distinction between soma and germ in higher organisms is itself a product of evolution; it represents a differentiation which does not exist in the lowest forms of life. Weismann's distinction is based upon the fact that

the germ in multicellular organisms is less readily influenced by environmental influences than the soma; profound somatic modifications may leave the germ-plasm apparently unaffected. There is, however, nothing surprising in this when it is considered that the undeveloped germ forms in most cases only a small and inaccessible part of the total organism; it is usually not subjected to external influences until it separates from the parent and begins its own independent development. But after this has happened environmental conditions may affect the egg and developing embryo just as they affect the adult, and the normal course of development may then be experimentally modified; *e. g.*, cyclopia may be produced in fish embryos, etc. No one can say at what time the protoplasm of the developing germ, whether in the one-celled or many-celled stage, ceases to be germ-plasm and becomes somatoplasm. Just as the rigid distinction between germ and soma can not be maintained, so it is doubtful if the "hereditary material" can be identified with any special single structures or cell-constituents, such as the chromatin. A universal peculiarity of the cellular type of organization appears to be that the nucleus, which always contains chromatin among other constituents, is indispensable to the continued normal physiological activities of the cell, including those specific synthetic processes of which growth and heredity are the most evident expressions. But to regard protoplasm (somatoplasm) as the *expression* and chromatin as the *seat* of heredity (p. 93) does not seem justifiable on physiological grounds. In the specific constructive processes which determine the course of development the physiological activity of the *entire* cell is concerned. To say this, however, is not to deny that there may be a functional differentiation, corresponding to the chemical and structural differentiation, among the various cell-constituents; and that a special significance in relation to the specific syntheses involved in development may attach to the nucleoproteins of the cell-nuclei, *i. e.*, to the chromatin. It is more consistent with modern physiology to conceive of chromatin as an especially active or constant participant in cell-metabolism, with some such special rôle as this, rather than as primarily a reservoir of hereditary determinants.

The consideration of organic evolution leads inevitably to a consideration of the physico-chemical nature of living matter and to speculations regarding its possible mode of origin from non-living matter. In Part I. the author discusses briefly some of the supposed steps in this evolution. He points out that the process must have been prolonged and complex. A prerequisite for the appearance of life was the production of the vital energy-yielding compounds, probably by photosynthesis, as well as of other compounds of colloidal character forming the structural substratum required for the metabolic reactions of protoplasm. To produce a regulated self-maintaining system of this kind, capable of indefinite growth, probably required ages of evolution. The rôle of electrolytes in living matter, and the necessity for special chemical compounds (catalysers, hormones) to control and coordinate the chemical processes of the primitive protoplasm, are among the matters especially discussed in this section. Interesting geological evidence is presented indicating the existence of an abundant unicellular flora and fauna (*e. g.*, calcareous bacteria) at extremely remote periods. This part of the book is highly suggestive, but less complete and authoritative than Part II.

Many striking observations and generalizations are scattered throughout the whole book and a masterly survey is given of the paleontological succession of animal forms. The illustrations are especially interesting, particularly the reproductions of Knight's landscapes, at once imaginative and scientifically exact, showing the prehistoric monsters in their native surroundings.

Ralph S. Lillie

Clark University

SPECIAL ARTICLES

NOTE ON A SIMPLE DEVICE FOR ILLUSTRATING MOLECULAR MOTION

In experimenting with mercury heated in an evacuated glass vessel, I observed that fine