BIO-
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Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649225521

Bio-philosophy by Joel N. Eno

Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

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Trieste

BIO-PHILOSOPHY: OR, THE MEANING OF COMPARATIVE PHYSIOLOGY AND BIOLOGICAL EVOLUTION.

The general force or energy which shapes matter is the mutual gravitative attraction of the particles toward each other; if they are free to move, tending to draw them toward a common centre, with the spherical form as a result.

There is also special shaping-force as, for example, the force of crystallization; each of the point-systems of the crystal possessing in the nucleus a "centre of gravity;" and the whole crystal as many centres of gravity as it has point-systems. "A crystal consists of a finite number of interpenetrating regular point-systems which all possess like and like-directed coincidence-movements," —each point-system formed of similar atoms, and being built up from a number of interpenetrating space-lattices, each consisting of three sets of parallel planes which enclose parallelopipeda; the number of point-systems is six, forming only thirty-two classes of crystals. Such is the inexorable fixity of physico-chemical types, in crystallization. But we turn from inorganic petrified forms to the organic.

When we study vital force,—the essential force which shapes living beings, and transforms non-living matter into living matter, we find, instead of immediate hardening in molds into fixed and unchangeable shapes,—its distinctive characteristic is adaptive variation from type, a natural adaptation to the conditions in which the plant or animal lives, and to all which constitutes its environment; the variation being termed a response. Protoplasm is the dominant factor in living development; both the lowest plant and the lowest animal starting from a single cell of protoplasm, consisting of protein (a chemical composition of one or more forms of a complex compound of carbon, hydrogen, oxygen, and nitrogen ($C_{40}\ H_{31}\ O_{12}\ N_5$), and water, for which protoplasm has a powerful attraction; for water is a primal necessity of protoplasm, its life depending upon it. As there is only one essential subject of physiology,—namely, the behavior of protoplasm, we begin it here. The first of the differentiations of the original cell is the protective covering or cell-wall; the cell producing on its external surface smaller, closer-set and denser protoplasts (or protoplasmic units) than those within. Naked cells live in water, and so are saturated by it; but cells with walls have a vacuole or cavity occupying the greater part of the interior, and the hydrostatic pressure keeps the cell full or turgid with water, through which also a plant receives in solution the substances from which it manufactures food; certain cells of the interior being differentiated for the absorption of water, as from the soil. There is no fundamental difference between the living protoplasm of plants and that of animals, there being such forms as Volvox and Myxomycetes which cannot with certainty be determined whether they belong with plants or animals. Plants in general not being able to travel to seek food, have a mechanism by which they can manufacture food from the inorganic, gaseous, and liquid matter which they absorb as raw material; not merely the absorption of the solution in water, and the squeezing out by internal pressure of waste and insoluble material, processes which suggest digestion and excretion, but a mechanism by which the absorbed materials are converted into substances that can nourish protoplasm, both vegetable and animal; namely, the chlorophyll apparatus, formed of corpuscles impregnated with a green coloring matter imbedded in the protoplasm. The algae (such as seaweed) being immersed in water and having only a gelatinous cell-wall absorb food-material all over; and they with the higher plants, having chlorophyll, are capable of manufacturing carbo-hydrates by the use of the carbon-dioxide absorbed from the air, in the presence of light; the fungi, being devoid of chlorophyll, are dependent on carbo-hydrates ready-made by other plants, or, exceptionally, derived from animal sources. In the higher plants, the cells of the foliage-leaves and the bark of young twigs are the manufacturers; these plants have a power not clearly understood, of converting nitrogen drawn from the soil, especially in the form of nitrates, into proteids, and of forming sugar and starch which is stored plant-food, and proteids as albumoses and globulins from the crude carbo-hydrate material. Under the increased influence of the sun in the spring, watery sap travels up through the spaces of a tree's sap-wood to supply the twigs and buds rapidly drained by evaporation, but chiefly probably by pressure caused by the turgid condition and the rapid absorption of water by the roots; when the food-material thus carried up arrives, the leaves unfold and take the more active part in making carbo-hydrates; growth is a necessity incidental to the enormous multiplication of protoplasts under the above favoring conditions. The petals, sepals, pistils and stamens of the flower, as well as the tendrils and scales are modifications or differentiations of the leaf; the shoot from which it springs must, for the performances of its functions have light; hence we find it in the sprout from the seed strongly seeking light: the root springing from the seed with like avidity seeks water, which it must find in the opposite direction; the very sunlight which draws up the sprout draws by evaporation from the immediate surface of the soil the water; and the more surface exposed to the sunlight in the foliage, the more the roots must spread and sink to seek water and food-material in water-solution below. The quantity of growth of the trunk or stem depends mainly on the quantity of available food-material in the soil where it grows, which goes to thickness in the open, while among close-set trees the stem must grow higher proportionately in order to obtain sufficient lighted space for the performance of its foliage-functions; plants must also respire oxygen, absorbing it in the dark and exhaling it in the sunlight, exactly the reverse of the day-absorption and night-exhalation of carbon-dioxide. Finally, the seed consists of a germ surrounded by proteid substance ready for use as the food of the starting sprout. The force in the great tree makes conquest of gravitation, growing upward and carrying up with it tons of matter, in direct opposition to gravitation, and the shape of its trunk is cylindrical, not spherical nor with crystalline angles; yet it has a principle of symmetry, and its leaves have a balanced arrangement, and a typical form for each genus, with minor variation for each species, even a modification of the latter to adapt it to the peculiar position of a leaf on the tree. A marked example of plant-adaptation is the Drosera or sundew, which grows on soil so poor that only mosses can live with it, but moist; hence, its small roots find scarcely anything to absorb except water, and the plant must depend on the atmosphere for sustenance, and has differentiated its leaves into traps for seizing objects which fall upon them, closing on those which are moist as they come in contact with its acutely sensitive glands, or in case of the Venus' Flytrap, the filaments on the upper surface of each of the two lobes of the leaf.

Not only is vital force able to press other forces into its service, but even material form may be a secondary and evanescent matter. An extreme example of self-variation through vital force is the amoeba, the simplest prototype of animal life, and in the simplest form, to appearance a viscid drop, varying in different species from one one-hundredth to one-eighth inch in diameter. Without an arm or tentacle for catching the food substances around it, it improvises such by protruding portions of its substance: the food met with and grasped, it is without a stomach-receptacle, and improvises one by wrapping its substance completely around objects of suitable size till the nutriment is absorbed, determining its shape by its own endeavor, a prophecy of at least muscular volition: a remarkable potentiality of self-adaptation for self-needs; and evincing the power or capability of even the simplest rudiment or slight beginning of mind to make use of even the rudest instruments, as well as its large degree of independence of fixed form or permanent organs. Its extreme plasticity, though it be useful to the execution of a single and simple desire, is replaced in the higher animals by a higher kind of self-adaptation, qualitative, not quantitative; accompanying mental plasticity or versatility; instead of a change of form, a change of the use of permanent organs; a change due to the mind, intellectual more than muscular volition; thus the hands of Edison are very like the hands of other men; the difference is in the inventiveness of his mind.

The upward progress or development from rank to rank of living beings, from the single cell, reveals a principle of specialization, or branching off from a common basis or beginning, by an unusual development of a particular function or functions. The susceptible state or condition of protoplasm in plants when it responds to a change in external influences or in the adjacent protoplasm, is called irritability; and the change which initiates the response is called the stimulus; for example, light or heat effects. The nature of the stimulus does not in any way determine the character of the response, but this is conditioned by the mechanism which the stimulus sets in action. The stimulus is only a releasing cause, and were not the energy provided by the living protoplasm, no reaction would occur; the reaction being due to the fact that the matter is living matter. When the stimulus acts upon protoplasm, this substance is decomposed, and in its destruction energy is liberated, by means of which the response is made. Every living cell of a plant is in reality, in the broad sense defined above, an irritable structure. Though in some plants the response to stimulus is movement, it is a mistake to consider motor organs as specially irritable organs; tendrils, the motile leaves of Venus' flytrap, and the tentacles of Drosera, though looked upon as sensitive organs par excellence, are, many of them inferior in sensitiveness to structures whose reaction is less evident. Though in plants there is no structure corresponding to nerves of animals the place of response may be distant from the place of stimulus, whose propagation may take time, varying from the sensitive plant in which the final response follows in a fraction of a second after the stimulus; usually longer, even minutes or hours, in other plants. It seems a long look from plant irritability and its motile reaction, to the sensory and the motor system of human nerves, but evolution seems to feel its way, as by experiment, to the fittest instruments, at the same time providing for the self-preservation and continuance of the species, by renewal and reproduction. The plant has its indispensable work of manufacturing earthy into vegetable substance, which in its turn is assimilable by various classes of animal life, as earthy substance is not: but evolution is involved chiefly through the variation and reproduction of the kind, rather than the conservation of the individual; and the lowest animal has much in common here with the vegetable, and taken as a starting-point, hastens along the discussion by the shortest line. The amoeba-sphere has in itself, as it were, a world of possibilities not only of self-variation into improvised organs, but also of improvised reduplication, when it has grown to a certain size or stage; its nucleus or life-center becomes double, and the two nuclei pushing apart, gradually attenuate the connecting plasm to a thread, becoming at last, twins, and separate. This self-production of two selves gives a sort of side-wise immortality or life-continuity through numberless repetition of the process; but as we might ask,—what avails eternity of duration to the unconscious rock? so what avails such immortality to the almost vegetable nature of the amoeba? Vegetable life and the lowest animal life represents the extreme of diffusedness of the power of life and of sensation; an organization which seems to emphasize tenacity of mere existence at the expense of mental sensibility, as by a principle of compensation; for example, some trees continue their semi-life through centuries. On the other hand, as we proceed in the upward direction to the higher and the highest animals, we note increasing concentratedness of the animal powers, by specialization, with increasing danger of cutting off the life by a blow at the seat of concentration. The principle of compensation has been caught sight of in the saying, "that which is really valuable, costs." This term does not refer to the proportion between stimulus and response of the animal to it; for a small stimulus from without causes a response disproportionately large, as a small blow will set off a powerful explosion, if the material struck be nitro-glycerine.

Every plant and every animal begins life as a single cell, derived from a previous plant or animal, and goes through an amoeba-like process of division; but reproduction as compared with growth, is a diversion of growth from the increase of the individual to the increase or perpetuation of the species; and, starting from the common protoplasmic base of both animal and plant, in the evolution upward, each affords many parallelisms of process with the other, as well as transitional or compromise forms and stages which bridge the gaps. As to the relation of the germ-cell to the parent, Lamarck held that acquired characters are transmissible to offspring: Weissmann, that the germ-plasm of the original cell is unique, not like general protoplasm, and contains the "id" or determinant of the character of the new individual; and not acquired characters, but the germ-ids themselves are transmitted from generation to generation;

Hertwig holds that germ-plasm is similar to protoplasm; Mendel, that the character of the offspring, including sex, is determined by the dominant factor in the germ, an odd number of chromosomes producing a male; an even number a female. Sex, in its general sense, means a differentuation into giving - and receiving-organs of reproduction, the former representing the male and the latter the female.

Plants may be grouped under two modes of reproduction, namely: vegetative propagation, and true reproduction; animals, in like manner. In the first, the protozoa reproduce by almost mechanical breakage or division; budding, which is an orderly or systematic rupture, is continuous in sponges and in some plants; discontinuous, in the tiger lily, zoophyte and hydra. Yet true or sexual reproduction is nearly as primitive and fundamental a mode, arising in a differentiation in one direction anabolic, or accumulative of substance, as is needed for the production of offspring, with a passive "sexual diathesis" prefiguring the female; in the other direction katabolic or substance-expending, with an appetent or seeking, active diathesis; with the result that in the lower animals, the active or male form is smaller than the female. We cross from vegetative to true reproduction through the thallophytes (bacteria, fungi, algae) among plants, and the coelenterates among animals; in the former, there is no differentiation into leaf, stem, or root; a reproductive cell (gonidium) gives rise to an organism resembling the parent plant; the protoplasm, at the end of its growth or vegetative life, either becomes quiescent and encysted in cell-walls, or is set free as a motile ciliated cell. In the primitive mould, myxomycetes, flagellates (active) and encysted (passive) both recur to the amoeboid as a compromise stage. The three stages have their representatives in permanent species; the low alga, Protococcus, divides into equal units or spores; compare amoeba. In a higher alga, Ulothrix, both large and small reproductive cells are developed; and in Ectocarpus are developed both the large sluggish (female) cells and the small, active (male) cells, a distinct beginning of the distinction between male and female. In another alga, Cutleria, the differentiation may be traced since two kinds of units result, which must unite if development is to take place, the anabolic being fertilized by the small katabolic cells. In Protococcus, the whole body, being only a single cell has reproductive power diffused throughout it; while Volvox has advanced the next step toward separate sex, the whole colony being unisexual, either male or female. In one of the brown algae (seaweeds) asexual and sexual reproduction occur at different periods in the same plant. Among protozoa occur the first distinctions among animals between "body" and reproduction cells,—"a stated antecedent of sex"; for certain units of loose colonies set adrift meet and fuse with others to form a double cell,—virtually a fertilized ovum (egg) from which, by continuous division, a fresh colony is developed. Thus in these transition-forms, there are reproductive cells, but no sexual organs; compare sponges. A different kind of transitional form appears in the alternate generation in mosses; the germ producing first a filament, then a bud from which develops the true moss; in ferns the prothallus appears transiently as a liverwort, in which are reproductive organs and an embryo whence develops the true fern: the antheridia and archegonia of such higher flowerless plants, though they produce only germ-cells called spores, are considered to represent respectively the male and female reproductive organs (stamens and carpels) of flowering plants, which produce both the large (female) and the small (male) germ-cells. Hermaphroditism, or the combination of both sexes in one individual, obtains in most plants and flowers, and in sluggish, fixed, or isolated animals and parasites; since unisexual individuals, under such conditions would remain unfertilized, and so die out; yet if we consider each stamen and carpel as a modification from a separate leaf, each by itself would be unisexual. as distinguished from the prothallus of a fern, which bears on the same expansion, both male and female organs. Compare with the flower the animal, hydra, which has near the base of its tube a rudimentary ovary; farther up the tube, a protuberance containing small cells (spermatozoa) from the simplest, most rudimentary male organ or testis. Hermaphroditism is a primitive state among the many-celled organisms, alternately male and female. and ranks lower than unisexualism, which arises through specialization of function. It is rare among birds and mammals, and exceptional among amphibians; though frogs and toads, like fishes, sometimes have an ovary and a testis side by side or one in front of the other. One of the phenomena of alternate generation is parthenogenesis or virgin conception; the organism arising from sexual generation, producing offspring unlike itself, without sexual union with a male. Such organisms in time acquire sexual organs, and from their impregnated germs the original parent form is produced. The only clear instance among animals so highly organized as the insects is in aphides or plant-lice, a large proportion of which remain in the larva state (none being males) and bring forth living young resembling themselves, and these young repeat the process, if well-fed, up to 10 or 11 successive broods of females, during the abundant food of summer; but with the scanty food of autumn,