

SECTION I. THE SCIENCE OF ORGANIC LIFE

PROBLEM 3

THE NOTION OF ORGANIC LIFE

1. *The Biology of the Organism*

To the ordinary person life means *movement*, particularly that sort of movement in which the agent behind it is hidden from view. Such a criterion is naive, of course, yet there is something to be said in favor of it. We know that the lightning which plunges through the clouds is not living, because we are better informed than our primitive ancestors about the nature of such things. But what one of us has not touched some tiny insect or animal, to see if it stirs and is really alive? The scientist has more definite views on the subject. For him, life is a *mode of organization*; and more specifically, since we are speaking here of organic life, it is that particular kind of organization which is found in protoplasm, manifesting itself through the possession of certain vital properties. These are, in a summary way, nutrition, growth and development, reproduction, and tropistic or adaptive movements. For an object to be recognized as living in the biological sense it must display in greater or less degree all these features, none of which is *solely* a peculiarity of living bodies, and all of which are organized. Organization in fact is the keynote to the biologist's concept of life. For him it refers to the particular arrangement of structures and functions that characterizes protoplasm; and though he does not exclude such a condition from other physical bodies, yet he reserves the term especially for living bodies and in this manner admits of its peculiarity. His idea of organiza-

tion relates to two specific features in all living matter: first, the special disposition of parts that are structurally different; secondly, the coordination of organic functions in a way that is calculated to achieve unity and simplicity. In order to get a better notion of what organic life means let us select a typical cell and see just how it is built and how it works. Since it is the unit of biological life we can learn from it practically all the fundamental concepts that lie behind the wonderful organism which we call the *human body*.

2. The Structure of the Cell

Protoplasm is a jelly-like or viscous material resembling the white of an egg. It represents the substance of the cell and is generally, though not always, surrounded by a definite wall. We may think of it as composed in the main of two constituents, namely, *cytoplasm* and a *nucleus*.

The first thing to be noted among the cytoplasmic contents of the cell is a network or *reticulum* which has the appearance of a sponge and is therefore sometimes referred to as *spongio-plasm*. Enclosed within it we find small open spaces known as *vacuoles*. These may be persistent or temporary. If they enclose nutritive particles they are called food vacuoles; if they have the power of suddenly contracting and thus ejecting their contents they are referred to as excretory vacuoles. Also scattered throughout the reticulum are a number of important bodies known as *plastids*. They are differentiated portions of protoplasm and are presumed to act like dynamos in radiating physiological energy for the life work of the cell. *Chondriosomes* are small threads, rods, or granules, quite constant in the various kinds of protoplasm. Close to the nucleus there is a tiny system of rods known as the *Golgi bodies*. Most cytologists are agreed that the function of both chondriosomes and Golgi

bodies is trophic, that is, concerned with the growth and elaboration of cell products. Another extremely important structure lying close to the nucleus is the *centrosphere* or attraction center and the minute dot of cytoplasm lying in the middle of it is called the *centrosome*. Both are parts of the reproductive apparatus, and where they are lacking, as in the

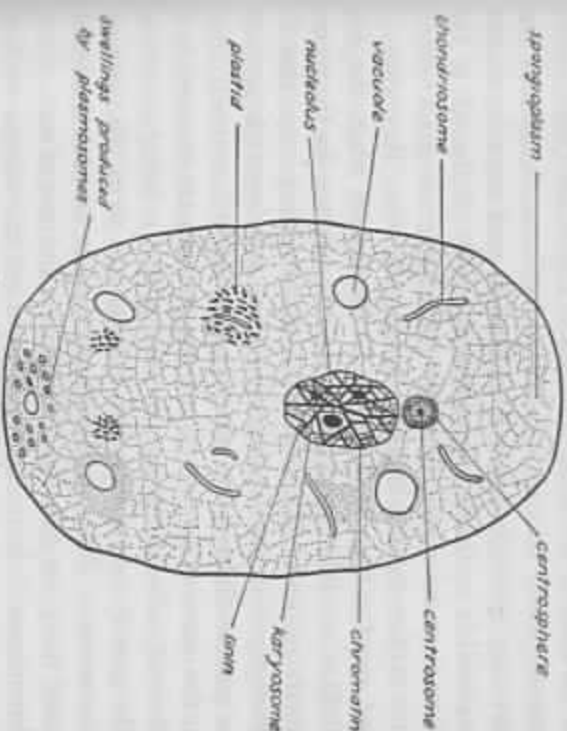


FIG. 1.—A typical cell.

neurons of the adult nervous system, cell division does not take place. The term *plasmasome* is reserved for certain substances that are invisible to the eye of the scientist, yet are presumed to exist because of the swellings that their by-products cause in the cell body. Finally we have to enumerate the *paraplasmic substances* which, while discernible in cytoplasm, are really foreign to it. Such substances include granules of calcium, pigment, fat globules,

indigestible matter, and body waste that has not yet been eliminated.

On the inside of the cell there is a seemingly smaller cell called the *nucleus*. It too has a wall and a network. After a cell has been chemically treated it is found that a portion of this network stains and a portion does not. The former is known as *chromatin*, the latter as *linin*. The entire protoplasmic content of the nucleus is called *nucleoplasm*. A cell may not have any definitely outlined nucleus. In such cases the nuclear material is scattered throughout the body of the cell in the form of granules. On the inside of the nucleus a smaller structure is often found which is called the *nucleolus*. Its purpose is not exactly known, but since it disappears when the cell divides it is thought to hold metabolic reserves for the reproductive process. When the cell is in the resting stage, that is, when reproduction is not taking place, the chromatin appears as granules dispersed in strands about the linin network. But in the course of reproduction these granules are arranged in a filament called a *spireme*, something like a string of beads. The particles composing the filament are given the name of *chromosomes*. They are definite in number for each species of living thing; for example, forty-eight in the case of man. Each chromosome is in reality a packet of sub-microscopic entities known as *genes*. These latter structures are probably the most important elements of all protoplasm, because of the part they play in the transmission of hereditary characters. At certain places in the nucleus where the various strands of chromatin material cross each other, little net-knots or *karyosomes* sometimes form. They are not to be confused with nucleoli. In conclusion we note the presence of small perforations in the nuclear wall which establish a direct connection between the nucleus and the cytoplasm, so that it can be said that the living substance of the cell is one physical continuum. (1)

3. *The Chemical Composition of the Cell*

It is impossible to distinguish between a living and a non-living substance solely on a basis of chemical constituents, for an analysis of protoplasm reveals such familiar elements as carbon, oxygen, hydrogen, sulphur, nitrogen, phosphorus, *et cetera*, the total weight of which is accounted for both before and after life has ceased. However, there is a recognizable difference in the way that these elements are combined. In fact the complexity of such syntheses is so involved that we are unable to devise a formula which adequately expresses the chemical structure of protoplasm. The molecules of which it is composed are enormously large and intricate, as compared with the molecules of substances that have never been alive. To resolve a cell chemically entails its destruction. The results obtained by such analyses can therefore be accepted only with qualification since the passage from life to death causes innumerable structural changes in the form of decompositions and recombinations. As a result the compounds found in dead matter offer us at best only an incomplete idea of what the composition of living protoplasm is like. From what we can gather by this indirect method it is concluded that living bodies resemble colloids. They maintain their integrity to a marked degree and are only selectively permeable by outside substances. Again, whatever their actual structure, there is no doubt that the extraordinary properties of surfaces characteristic of colloids play a large rôle in protoplasmic phenomena. The components of living bodies are both inorganic and organic. Among the *inorganic* substances water is most abundant, representing nearly 80% of the total contents. Salts are also present in the form of chlorides, carbonates, and phosphates of sodium, potassium, ammonium, calcium, magnesium, and iron. Oxygen and carbon dioxide are found in solution. The organic

compounds of the cell are represented by three kinds of chemical structures: the carbohydrates and fatty substances, which serve as building material and supply energy by undergoing oxidation; and the proteins, the most complex of organic substances and therefore very probably furnishing the basis of the intricate system of structure and chemical interaction which is a special feature of protoplasm. In studying the cell from the point of view of chemistry we are dealing with an essentially unstable compound which can be maintained only by re-combinations that involve a continuous expenditure of energy. This it receives in potential form with the foodstuffs that it assimilates, and releases in actual form as mechanical energy, heat, magnetic phenomena, and so forth. The instability of the living organism is further shown by the ease with which slight changes in the constitution of its physical or chemical environment destroy it and convert it into a non-reversible and unorganized mixture of substances. (2)

4. *The Functions of the Cell*

The cell is not only the anatomical unit of protoplasm but the source of vital activity also. It can appropriate energy from its surroundings and by the exercise of an inherent capacity is able to utilize this energy in a manner that is decidedly peculiar to living substances. It metabolizes, grows and develops, reproduces, and adapts itself to the ever-varying factors of its environment.

i. METABOLISM

The cell is able to incorporate matter and energy from its environment and to make them serviceable for its various life reactions. The entire procedure is known as metabolism. There are two cycles to the process. The first is *anabolic* wherein energy-containing substances are taken in, worked

over, and finally built up into the tissue of the cell itself. The second is *katabolic*, in which part of the protoplasmic material of the cell is wasted through the breaking down of complex organic molecules into simpler compounds less rich in energy. The liberation of potential forces is made possible by oxidation or the application of oxygen to living protoplasm, in much the same way that the stored-up energies of a lump of coal are released by burning it. The whole metabolic process is made possible by the extremely labile composition of the cell.

ii. GROWTH AND DEVELOPMENT

Growth means increase in size and is the direct outcome of constructive metabolism. It derives its vital character from the fact that, like the anabolic function, it is essentially *intra-susceptive*. This means that the new particles of formative material which are deposited in the living substance of the cell actually become protoplasm and are not, therefore, mere mechanical accretions to it. When the organism is young the anabolic phase of metabolism is greater than the katabolic, and an increase in mass follows. In the mature organism there is more or less of an equilibrium established between the two phases, and mass remains at a relative standstill. During the senescent stages of life katabolism slowly gains upon anabolism with the result that there is a gradual wasting away of physical mass and a lowering of the rate of chemical activity. Natural death, in its physiological aspect, simply means the slowing down of metabolic processes beyond the point where wastes can be eliminated and the necessary exchange of energy made with the physical world.

Development is closely related to growth. It involves not only quantitative change but also those processes that are concerned with the attainment of a definite organic structure. Thus man begins his biological life as a single cell in which no

traces of systematic differentiation can be found other than the ordinary complexities that are seen in any unicellular organism, like an *amoeba* or a *paramecium*. But by the time he is born he is equipped with an array of organs that is unbelievably involved. For metabolism he has the digestive, circulatory, respiratory, and excretory systems; for protection, support, and motion, the musculo-skeletal system; for sensation and correlation, the nervous system; for the continuance of life, the reproductive system. All of these arrangements have been fairly well perfected during the period of gestation, and illustrate the phenomenon of development. We might state the whole matter in a brief way by saying that development is growth plus specialization.

iii. REPRODUCTION

Reproduction includes the whole sequence of events by which new individuals arise and life is perpetuated. The organism, as a distinct entity, is mortal, and if the species is to be provided for, new individuals must be produced from materials supplied by the parent organism. It is often and correctly said that the major functions of protoplasm center around the contrasted activities of nutrition and reproduction. This does not imply that such functions are sharply circumscribed, but merely indicates the direction of different vital energies toward two particular ends, namely, the preservation of the individual and the continuance of the species. In man it is impossible to consider either metabolism or reproduction apart from his sensory and motor mechanisms, or even from thought and volition; for on the higher levels of life these activities, and especially reproduction, have definite psychological implications.

The modes of reproduction are either agamic or gamic. The agamic type includes *amitosis* or direct division of a cell by a

simple cleavage of its nucleus and cytoplasm; *mitosis* or indirect cell division, so described because there must be some previous preparation of chromatin material and centrosphere before the cell separates into two; *budding* or the multiplication of cells in certain portions of the organism, thus giving rise to specialized areas or buds, from which new individuals may be evolved; *sporulation* or the formation of tiny nucleated masses of protoplasm called spores. Each spore, either by itself or through union with another spore, is capable of growing into a new individual, but only in the former case is the method asexual. One common feature about all the agamic modes of reproduction is the absence of any special germ plasma or sex mechanism. The case is quite different with *gamic* modes of reproduction which always presuppose the development of special units called *gametes* or *germ cells*. Such, for example, are the human sperm and ovum, or the pollen and ovule in flowering plants. Although virgin-birth (parthenogenesis or ephobogenesis) is a recognized phenomenon of nature, gametes as a rule unite in pairs to form the unicellular organism known as a *zygote*, which in turn divides by mitosis and grows and develops until the parent stock is effectively reproduced and provision thus made for the continuance of the species.

iv. ADAPTIVE MOVEMENTS

Adaptation refers to the structural and functional fitness which protoplasm manifests in making its adjustment to environment. Whether or not it possesses a nervous system, there is an innate tendency in every organism to react in a definite manner to external stimuli. Such tendencies are known as *tropisms* and their presence is proof of the natural selective ability of all living matter to equip itself more perfectly for existence under the conditions of its environment. (3) Protoplasm conforms to its surroundings in various ways. It is

irritable. Even slight stimuli excite it. The intensity of response is often entirely disproportionate to the amount of stimulation applied. By changes in form or motion it is able to respond effectively to whatever the external or internal situation demands. Again, protoplasm has a remarkable power of *preserving its own integrity*. Like every other material body it is subject to wear and tear. It must constantly spend its vital energies to live, and must always be ready to cope with accidental injury. Such damages are made good by natural means.

This remarkable phenomenon we call *repair*. Wounds are found to heal up after a certain time and wasted cells will generally be replaced by new ones. But even more astounding, from the biological point of view, is the function of *regeneration* where parts that have been entirely lost are replaced, where an organ is reconstructed from a fragment of tissue, or where a whole living body is completed from what was originally only a part of it, the sole condition being that each portion which develops into a total organism must contain a bit of nuclear material. Regeneration has been observed in both the plant and animal world, but its powers are somewhat limited in the higher forms of life. This is due in part to specialization of structure, and in part to the division of physiological labor, especially that of metabolism. As a final feature of adaptation we should note the *unstable chemical structure* of protoplasm, which makes possible the decomposition of chemical components in the living substance with its corresponding liberation of energy, and prepares the way for new anabolic activities as fresh materials are incorporated or as recombinations are formed from oxidation products. The reversible nature of some of these chemical functions is interesting. Thus the plant, during the process of metabolism, takes in carbon dioxide while the animal turns the process in the opposite direction.

It is obvious, from all that we have said in discussing vital

functions, that the term *protoplasm* represents a generic concept. In actual fact it is always this or that particular kind of protoplasm, according to the type of organism that we are considering. It may be one-celled, like *Paramecium caudatum*, or multicellular, like most of the animals with which we are familiar. It may exercise *only* the functions of organic life, as in the case of the plant, or it may combine biological phenomena with a number of other and higher functions, such as are found in man. The properties which we have described as peculiar to protoplasm are what we may call the *constants* of organic life. It will be observed that these constants have been ascribed to the cell without specification of the exact manner in which physiological labor is divided. As a matter of fact, it is quite impossible at our present stage of knowledge, to give a satisfactory account of this interesting problem. Although each part of the cell may be particularly concerned with one or more special functions, it is the organism as a whole that profits by such divisions of labor; or to put it in another way, it is the entire protoplasmic system, exhibiting the phenomena of metabolism, growth, reproduction, and adaptation, which has become differentiated into cytoplasm and nucleus, as such functions have become more highly developed and localized. (4)

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SECTION 2. THE PHILOSOPHY OF ORGANIC LIFE

PROBLEM 4

THE THEORY OF MATTER AND FORM

1. *The Meaning of Hylomorphism*

For Thomas Aquinas, the explanation of the inner structure or nature of physical bodies is based upon the hylomorphic theory of Aristotle. Whether such bodies are living or non-living makes no difference as far as the terms of the theory are concerned, for it is designed by its broad metaphysical outlines to include both. Aristotle taught that every corporeal substance from the lowest mineral unit up to the highest psychophysical organism which is man is composed of two principles that lie at the very roots of its being: the one *hylic* or material, the other *morphic* or formal. The relations that obtain between these two factors are those of natural complementation, since each principle is an incomplete substance; each is necessary to the other; and only when both are intimately knit together is the perfection of existence or the perfection of life actually achieved. Let us see how this hylomorphic concept of matter and form originated.

2. *The Notion of Accidental and Substantial Change*

Things are constantly altering their aspects around us. Such changes of course are purely accidental, for even though they bring about differences in the thing involved, they do not affect its essential nature. We might think of them in general as surface-changes. Most of them are amenable to the observation of our senses. Aquinas, following Aristotle, distinguishes

three kinds of accidental change. The first is *local motion*, easily perceived when bodies change their position in space. The second is *change in quality*, like the kaleidoscopic variation of hues or colors in nature. The third is growth and shrinkage in the material mass of objects, or *quantitative change*. All these different sorts of mutation have one factor in common in as much as they fail to touch the real inner nature of the thing involved.

Substantial change, on the other hand, is quite different. Here we are dealing with another kind of event, one which penetrates to the inner core of the thing and makes it over into something entirely new. In this case it may be said that the thing simply is no longer what it was but something else. The *nature* is changed. Thus if an orange which we are holding in our hands were suddenly turned into a living breathing organism, we would regard the change as drastic. Yet this very thing, in point of fact, actually happens to it every time it is eaten and converted into protoplasm. Here is a good example of substantial change which it will pay us to examine more closely.

3. *The Hylomorphic Implications of Substantial Change*

When the orange is transformed into living tissue there is obviously something which remains throughout the change, for we can note the effects of the assimilative process. This permanent substrate, in the language of Aristotle, is called *primary matter*. On the other hand, there is something lost in conversion, since the orange as such disappears, and what is left of it, namely, its material substrate, immediately acquires something new. What the orange loses, according to Aristotle, is its *substantial form*, and what its material substrate acquires is the substantial form of protoplasm. It is possible then, by a simple inference, to indicate the fundamental parts out of

which the substance of the orange is constructed. They are primary matter, or the principle of indetermination which makes possible the change-over from orange to protoplasm; and substantial form or the determining principle which accounts for the fact that an orange is the particular kind of fruit that it is and not something else. Each of these two basic constituents, it should be observed, is *real*, even though their reality is arrived at by a deductive process. The very fact that the orange is able to nourish the body should be reasonable enough proof for the reality of primary matter, that is, of a permanent substrate which makes the conversion of substance possible. On the other hand, it is equally true that this same material substrate loses something real in the disappearance of the orange, just as it gains something by metabolic conversion. Further, when in the course of the change the substantial form of the orange disappears, its substrate immediately takes on the new form which is that of protoplasm. Thus there is no moment when the material substrate lacks a form or when primary matter is without a principle of determination. In fact the two are regarded as inseparable for the reason that each in itself is an incomplete substance, representing therefore only part of the nature of the thing under consideration; and existence with only a partial nature is, metaphysically speaking, an inconceivable kind of existence. Either we have an orange, precisely that, and nothing else; or we have something that is different from an orange. There is no such thing, really, as *almost* an orange.

4. *The Terms of the Hylomorphic Theory*

From observations on substantial change of the sort that we have just described, it is easy to understand how the outlines of a vast hylomorphic theory, designed to explain the inner structure of all physical bodies, should have occurred to Aris-

tole. To go over the main points of the theory again: every individual object in the universe is a compound of matter and form. By matter we mean *primary matter* or the material substrate that underlies everything. By form we mean *substantial form* or the principle that makes a thing what it actually is. Each of these two ultimate factors is not only substantial but real. Each is opponent by nature. Because of this opponency they are separable in thought though never separated in fact. There is no such thing as matter without form. Matter in itself has no character. It is absolutely featureless, indefinite, without quality. What gives it definiteness, specific quality, character, makes it this or that particular object, is form. Consequently there are no differences within matter. It is the same wherever found: in chemicals, plants, animals, man. All these several things are different solely because their material substrate possesses different forms. But primary matter is conjoined to only one form at a time.

It may be gathered from what we have said that the Aristotelian concept of matter is not the same as our modern notion of physical substance. When we say today that one kind of matter differs from another, we mean what Aristotle calls *second matter*, that is, the thing that we perceive through the senses, the component of primary matter and substantial form. And so we say that carbon differs from hydrogen, oxygen from iron, a plant from an animal, and all these things from man. Such differences are qualitative, and quality for Aristotle is an emergence from substantial form. Thus in his view the differences of the things that we have just enumerated are differences, not of primary matter, but of substantial form; and just as primary matter is differentiated from second matter, so substantial form is distinguished from *accidental form*. Thus in Aristotle's theory, substantial form is an essential constituent of a body; whereas accidental form is something which con-

ceivably may or may not be present without affecting the inner nature of the body—for example, its color, shape, or weight. Primary matter may become anything according to the kind of form that is impressed upon it. It is, so to speak, the possibility of everything, though actually it is nothing. It only becomes something by the acquisition of form.

This leads us to the most important of all the Aristotelian antitheses, namely, that between *potency* and *act*. For primary matter in its ultimate analysis is the same as potency, while substantial form is the same as act. To repeat what we have already said, matter is potentially everything, though it is not actually anything. The thing that gives it specific existence and really makes it a particular entity, is its form. Thus the act of a thing is simply its form. Such in outline are the essential features of the hylomorphic theory which Thomas Aquinas prized so highly that he took it over without reservation and applied it universally throughout all his writings. Its importance for the philosophy of the organism and for the problems of metaphysical psychology will become more obvious when we see how effectively Aquinas used it to solve some of the critical issues that we shall have occasion to discuss.

5. *The Value of the Hylomorphic Theory*

From the time of Aristotle down to our own the theory of matter and form has made persistent claims for recognition in philosophic circles. We shall examine some of the reasons why it has always gained such wide consideration. To begin with, it is based on facts of experience. It recognizes the phenomena of substantial change. Further, it explains why all physical objects have something in common at the same time that they possess their own special properties. It should be noted again, however, that neither primary matter nor substantial form are perceptible to the senses. They represent contrasts that exceed

the limits of our sense abilities. We must rely on intellectual criteria in judging the merits of the hylomorphic theory. It is not a scientific but a metaphysical explanation of the inner structure of things, an interpretation of the data of observation. It is based upon principles that lie at the very roots of physical nature by its proclamation of the philosophic ultimates of *act* or what a thing is, and *potency* or what a thing may become. Both biology and psychology stand in need of a great deal of unification, and certainly it can do no harm to test out again such a splendid synthetic theory by applying it to the new actual knowledge that is accumulating in scientific laboratories. Though large in outline, there are no limits set upon the hylomorphic concept by the smallness of the specimen under consideration. It applies equally well to the inorganic unit, to the biological unit, to the psychophysical unit. Irrespective of the size of such units, of their living or non-living character, it simply affirms their essential composition of primary matter and substantial form. (1)

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PROBLEM 5

THE NATURE OF ORGANIC LIFE

1. *The Metaphysical Concept of Life*

Ask the philosopher what he means by organic life and you will likely be puzzled by his answer until you realize that what he says is applicable not merely to organic life but to any conceivable kind of living existence. Let us take Thomas Aquinas as an example of this ultimate attitude. At the outset it should be noted that his whole point of view is a development from personal observations on the basic facts of life. All vital activities, such as metabolism, growth, and adaptation, are forms of *movement*; and movement for Aquinas means any kind of change or alteration. Next, all vital activities proceed from the organism itself. This is obvious enough when we reflect that the organism possesses inherent abilities to nourish and reproduce itself. Such features are signs of the *spontaneity* of life. Finally, all vital activities have the effect of perfecting the same organism from which they emanate. At least this is their primary effect because it is only when living matter has secured and utilized the things that are necessary to its own life that it can transmit energy to other bodies. It is chiefly by virtue of this third quality which he calls *immanence* that Aquinas differentiates between vital and non-vital forms of movement. Life, then, means any kind of spontaneous and immanent movement. (1)

Because protoplasm is an organized system, it is commonly referred to in terms of a machine. The eye, or ear, or even the whole body of man, is often described as a mechanism of varying delicacy. There is no quarrel with this nomenclature, pro-

vided we understand what is meant by such descriptions. Every machine is an organized system. Its parts are so inter-related that the whole, as a cause, is adapted to the attainment of certain ends, as an effect. (2) This concept might be equally well applied to a universe or an *amaba*, but with a difference of course. The universe is a purely mechanical system, operating according to the laws of external design. An *amaba*, on the other hand, represents a special organization of matter which is controlled in its functions by the laws of internal design. The same thing is true of the human body which is much more complex than the *amaba*. "The organization of our body," says Carrel, "is not similar to that of the machine. A machine is composed of many parts, originally separate. Once these parts are put together, its manifoldness becomes unity. Like the human individual, it is assembled for a specific purpose. Like him, it is both simple and complex. But it is primarily complex and secondarily simple. On the contrary, man is primarily simple and secondarily complex. He originates from a single cell. This cell divides into two others, which divide in their turn, and such division continues indefinitely. In the course of this process of structural elaboration, the embryo retains the functional simplicity of the egg. The cells seem to remember their original unity, even when they become the elements of an innumerable multitude. They know spontaneously the functions attributed to them in the organized whole." (3) Driesch sums up the whole case very succinctly when he says, referring to the living egg: "It is a 'material system' in the language of physics. . . . But it is *not* a *mechanical system*." (4) The difference is enormous and touches the metaphysical basis of the distinction between matter-in-life and matter-outside-of-life.

Whatever philosophic attitude we evolve in attempting to explain the nature of the organism, there are certain generally

recognized facts that every theorist must take into account. Each of these facts constitutes what we may call a primary datum of organic life. They are: the *unity* of the organism; the *inner design* of its processes and their *vital character*; the *co-ordination of its living energies with the closed mechanical system of the universe*. Interpretations of life are usually grouped under two general headings, accordingly as they attach a mechanistic or a vitalistic meaning to the activities of the organism.

2. *The Mechanistic Theories of Life*

Howsoever they may differ in form and exposition, mechanistic theories have certain features in common. All of them agree, either explicitly or implicitly, that vital phenomena are *merely* so many forms of material energy—physical, chemical, magnetic, and so forth. Further, all agree that the postulate of a vital principle or special biotic force to account for the organization of life is an unwarranted because unnecessary assumption. But there are differences of a quite positive character that make it possible for us to study the systems separately. We may distinguish three important types of mechanism.

A. *Absolute mechanism* pictures the whole world of physical reality, both living and non-living, as the result of the mutual interaction of the forces of matter. Organic life, therefore, is an effect of the inherent capacity of matter to live. Le Dantec, Darwin, Huxley, Haeckel, and the majority of the evolutionary biologists who were prominent at the close of the 19th century, are associated with this extreme attitude. Among the modern exponents of a thorough-going materialistic monism, J. B. S. Haldane is conspicuous. (5)

B. *Restricted mechanism* holds to the idea that life is a unique kind of activity, requiring for its description terms that transcend the naïve concepts of an absolute machine-theory. It is

the point of view represented by C. Lloyd Morgan and the advocates of emergent evolution. Morgan distinguishes in the events of nature between what he calls *resultants*, which are fully known when their components are known, and *emergents*, which are unpredictable even when their elements are recognized. The latter are discoverable in non-living matter but are particularly characteristic of life which is an emergence from special complex collocations of chemicals. Mind itself finally came into existence when these new modes of unpredictable relation reached a sufficiently intricate level. (6) The theory of emergent evolution has gained a wide following and marks a new point of departure for several other theories of a kindred nature. Bergson's *élan vital*, Alexander's *space-time matrix*, Smuts's *whole-making principle*, Whitehead's vision of the universe as a *lotum organism* of which the living organism is an exemplar, are all expressions of the emergent idea. (7) In each of these theories it will be found, upon close examination, that the lines of demarcation between matter-in-life and matter-outside-of-life are practically wiped out. There is no essential difference between emergence in the physical realm, and emergence in the biological and mental realms. And even though the theorists deny the adequacy of physical and chemical laws to explain vital phenomena, yet they oppose any form of vitalism which refuses to postulate the emergence of life from matter.

C. *Vitalistic mechanism* argues that matter may have derived its power to produce vital effects from an external source, specifically a Creator. This power could have been transmitted from one organism to another. If such is the case, then living matter does not require any special principle or biotic force to account for its peculiar properties since it already possesses an inherent ability to live. U. A. Hauber has recently defended views of this sort. (8)

3. *An Evolution of the Mechanistic Theories of Life*

A. One of the main difficulties in the way to an acceptance of any mechanistic theory is what we have already referred to as the *internal design* of all biological functions. Even if we were to agree with the view that organic life may be expressed in terms of the general laws of matter, there is still a distinction between living and non-living matter which is not explained. It is not because of the special nature of its physical energies, nor because of its extraordinary chemical complexities, that protoplasm is differentiated from inorganic matter, *but because it utilizes all its forces toward the realization of an intrinsic end*, which is the preservation of the total organism. Even the simplest analysis of cell life reveals that no single function is independent of the whole system. It is the immanent manner in which these functions are related back to their point of origin, or the reflexive orientation of its energies, that constitutes the real *differentia specifica* between matter-in-life and matter-outside-of-life. To say that matter-in-life has an inherent capacity of self-adaptation means, in effect, that it has metabolic powers, that it grows and develops and reproduces after its kind, and further that all these particular ends are secured for the sake of a more fundamental purpose which concerns the organism *as a whole*. In matter-outside-of-life, on the other hand, there are no evidences of such intrinsic finality.

B. Another weakness of mechanism, especially that form of it which we have associated with the theory of evolution, is its inability to fit in with the metaphysical notion of causality. Every effect must have an adequate explanation, and no effect can be disproportionate to the principle from which it is derived. It cannot, for example, exceed its cause. Now let us suppose the essential correctness of Mercier's views in saying that "the chemical transformations that occur in living bodies

are of the very same nature as those which take place in the laboratory; and the physical and mechanical properties manifested by living bodies are the same as those displayed by inorganic bodies." (9) There is still the phenomenon of immanence or intrinsic design which is not accounted for by the terms of physical or chemical transformation. To say that life is a species of emergence from inorganic matter or that special collocations of non-living substances made imperative the appearance of life, implies that a higher kind of structural and functional organization can emerge from a lower. Since a vital principle is denied, the only thing left to explain such emergence is the inherent power of matter. But the forces of matter constantly tend in an outward direction, since their natural disposition is always to place their effects outside the subject from which they proceed. Vital functions, on the contrary, have a uniformly constant inward direction. Thomas Aquinas expresses the difference very briefly when he says: "The former type of activity is a perfection not of the agent which moves but of the recipient which is moved; the latter type, on the other hand, perfects the agent itself." (10) The theory of emergence fails to recognize this difference. By attributing to matter the ability of readapting itself from extrinsic to intrinsic design of operation, it violates the law of causality because it supposes an effect which transcends the known powers of matter; or because it predicts, without logical grounds, the emergence of a more perfect existence such as is life, from a less perfect existence such as is matter. If there were some reason for this prediction, the case would be different. But emergent evolution makes no provision, in the terms of its theory, for any life-giving agency, either outside or inside the organism, to account for the fact that it is actually living. At the same time that it invokes the laws of nature to explain the emergence of life through inherent capacities in matter, it

entirely disregards other natural laws that govern the constancy of relation between cause and effect.

C. As a possible explanation of organic life, there is no quarrel with the theistic theory of mechanism. To deny its possibility would be tantamount to setting limits to the effectiveness of the First Cause in producing results that are perfectly within the range of its powers. But looking at the problem from another angle, is it a scientific attitude to refer the explanation of organic life to an Agency outside the living body when a more immediate cause for it may be discovered within the organism itself? For if the mechanical interpretation is out of question, there appears to be no alternative for the theistic mechanist except to assume the active interpolation of the Absolute for every exercise of purely biological function. Before we commit ourselves to such a view, the claims of vitalism should be carefully examined.

Some scientists, e. g. J. Needham, E. B. Wilson, *et alii*, propose mechanism simply as a methodological fiction, proceeding in their studies as if the theory were true. (11) There may be advantages to such an attitude, particularly where one is interested in the details of vital processes. But there are dangers too. If the investigator limits himself severely to physical and chemical tests alone, he is likely to recognize only similar activities in protoplasm, losing sight of its coordinated functions as a whole. Even more serious is the danger of his mistaking the original fiction for established philosophic doctrine. On the other hand, those who express unequivocal distaste for such a fiction are not necessarily defendants of a vitalistic theory. J. B. S. Haldane rejects the idea that the orchestrated behavior of a living body can be described in purely mechanical terms. Yet he regards vitalism also as a useless hypothesis because of its introduction of influences from without—supernatural forces—in explaining the phe-

nomena of life. The incorrectness of Haldane's views on vitalism will appear after we have given some idea of its various forms. (12)

4. *The Vitalistic Theories of Life*

Vitalistic theories of life have always enjoyed a wide following. Though varying considerably in their descriptions of the underlying causes of life all vitalistic interpretations are agreed, first, that a purely mechanical account of vital phenomena is *inadequate*; secondly, that some operational principle or biotic force *other than the physico-chemical forms of energy* manifested by the organism must be assumed if we are to understand the peculiar coordination both of structure and function in living matter. There is an additional element that is not included within the limits of a strictly mechanical system. In their efforts to deal with this plus factor the vitalists have adopted numerous explanations.

A. There is an important series of accounts that may be grouped together under the title of *theories of vital energy*. All of them, either openly or by implication, involve the concept of a special living energy or biotic force in their terms. All of them too have directly challenged the mechanistic view of life. One of the foremost exponents of such a view is Eugenio Rignano. Living matter, according to Rignano, is able to store up quantities of a peculiar kind of energy which it receives from its environment. Vital energy is thus differentiated into several qualitatively distinct forms according to the needs of the organism. In the embryonic stages of life the germ cells constitute a dynamic center from which definite amounts of biotic force radiate out to other cells in succession, directing the course of development which proceeds by a new formation of parts or organs, an *epigenesis* of the original relatively simple mass of protoplasm in the egg. But whether we are dealing

with a single cell or with multicellulars, it is the constant exchange of energies that makes up the life of an organism. The same essentially functional concept of organic life is represented in von Monakow's *horné*, a vital force in protoplasm endowed with the power of envisaging the future at the same time that it summarizes the past; in McDougall's *hormic activity* which is essentially an explanation of life in terms of energy manifestation with a definite goal behind it; in Jung's *libido*, which designates the sum total of all vital impulses; in B. Moore's *biotic energy*, in Osborn's *chemical bion*; and in Bergson's *élan vital* which, though mechanical in character, yet borrows from observations made on living organisms its central idea of placing an impulse to live in all matter. (13)

B. There is another series of explanations which we may treat together under the title of *entelechean theories of life*. The most important of these, from the experimental point of view, is Hans Driesch's account. Driesch observed that with certain forms of life, for example the *sea urchin* and *amphioxus*, it is possible to cut the young embryo into many fragments and eventually get a complete organism from each fragment. Thus cells that were originally designed to become parts of a single mature animal actually became several animals. This phenomenon he construed as proof for the existence of some flexible power in the organism which is able to direct its vital processes along different paths and to adapt physical and chemical energy to its own specific needs. In the theory which he evolves from his embryological studies, Driesch employs the term *entelechy* to indicate the formative agent of the organism, while he reserves the term *psychoid* for the special factor that directs vital activity. Since there are several lines of direction there are presumably several psychoids in the organism. In any event at least one formative and one directive principle are explicit in the terms of his theory. (14)

C. By far the oldest of the vitalistic interpretations is the system of Aristotle who is the creator of the term *entelechy*. We have already described the hylomorphic concept of matter and form (problem 4). Entelechy is part of that concept since it is identified with Aristotle's notion of substantial form, which means that it is the specifying factor, the source of unity, the whole-making principle in every unit of matter, both living and non-living. In the case of the organism, therefore, we have two components that enter into its make-up: one primary matter or a material substrate; the other substantial form or entelechy. Because the organism is living matter we call its entelechy a vital principle in order to indicate the source from which its life originates. While it is correct then to say that every vital principle is an entelechy, it is quite a misapprehension of Aristotle's teaching to say that every entelechy is a vital principle. The principle of life is first and foremost *enteliche* in character. It is a partial constituent of the organism, distinct from matter in the same sense that substantial form is distinct from the material substrate which it inhabits. But it is also a *principle of operation*. This it achieves through its possession of certain powers which, in the case of the simple organism, are metabolic, augmentative, and reproductive in function.

The Aristotelian theory of organic life was adopted in its entirety by Thomas Aquinas who recognized in it a valid application of the Stagyrte's doctrine of hylomorphism. (15)

5. An Evaluation of the Vitalistic Theories of Life

A. There are certain difficulties attached to all theories that involve vital energy or biotic force in their terms. First, the use of such terms makes it incumbent upon the theorist to explain how vital energy or biotic force in the organism is squared with the law of conservation. Again, if living reactions are

properly regarded as effects, not causes, of life, then it may be argued that the various forms of energy manifested by the organism are not self-directive, but depend for their reception and release upon some principle which itself is not energy, but which controls the amount and disposition of such physical, chemical, and magnetic forces as are necessary to the life of the organism. Again, the epigenetic character of growth and development, as the organism advances from simplicity to complexity of structure, establishes without a doubt the presence of peculiar forces in living bodies not discoverable in a purely mechanical system. But there is still the need to explain why such energies are unified and directed to one specific goal which is the actual formation of the organism. Finally, there must be some reason for the fact that the material forces of the universe are converted into vital energies. To say that an organism is living because it functions in a vital manner is merely a restatement of the problem at issue which is to give the ultimate reason for the vital character of such phenomena.

B. Driesch's theory is founded on experimentation that is definitely conclusive, we think, against the claims of mechanism. But it is unfortunately vitiated by an inaccurate use of Aristotle's concept of entelechy. Some of his statements are entirely reconcilable with the Stagyrite's teaching, as when he says: "Matter and something else are at work, and this 'something else' acts in a teleological, a *whole-making* way." (16) To repeat, however, what we have already said, the Aristotelian idea of entelechy refers to something that is primarily entitative and secondarily operational. Again, the postulate of more than one vital agency in the organism, such as entelechy and psychoid, is certainly opposed to the very evidence upon which Driesch establishes his theory. If there is one phenomenon which more than any other has impressed itself upon observers it is the fact, of biological unity in the organism:

which means that all vital activities are subservient to one main purpose, namely, the perfection of the total organism. Another fact, perhaps not so obvious, yet a logical deduction from the manner in which structures and functions are coordinated, is the substantial character of such unity. But a plurality of vital agencies can hardly be reconciled with the notion of coordinated behavior, just as anything short of a substantial union between the principle of life and its material substrate is at variance with the phenomenon of physico-vital unity which the organism manifests.

C. The most satisfactory interpretation that has yet been made of organic life is the hylomorphic theory of Aristotle. Starting with the fact of biological organization, it accounts for the vital quality of organic functions, and for their wholeness and unity, by the supposition of a principle of life, an entelechy or specifying factor, which is distinct from its material substrate at the same time that it is substantially conjoined to this material substrate. The facts upon which the postulated existence of a principle of life is founded are as follows:

(a) Despite its differentiation of material parts an organism possesses unity of function. It moves, responds to stimuli, breathes and feeds itself, carries on complicated chemical reactions, increases in size, and multiplies. The term of all these varied activities is, first, the organism, not something extrinsic to it; secondly, the whole organism, not any particular part of it. Identity of purpose like this cannot be the outcome of aggregating material units, such as molecules, atoms, protons, electrons, and so forth; rather it gives unmistakable evidence of a special kind of unity, biological in character, effected in the presence of an amazing complexity of elements and forces. Constancy of organization like this must have some reason behind it, since it cannot be self-explanatory.

(b) When it is said that growth is a vital process, we do not mean to imply that all the physical and chemical processes involved in metabolism are vital activities. It is obvious that all the changes in food material up to the actual building of such material particles into the protoplasmic system represent transitive forms of energy. But all these are merely so many preparatory stages necessary to the functions of assimilation. It is the *intus-susception* of food, in excess of the amounts that

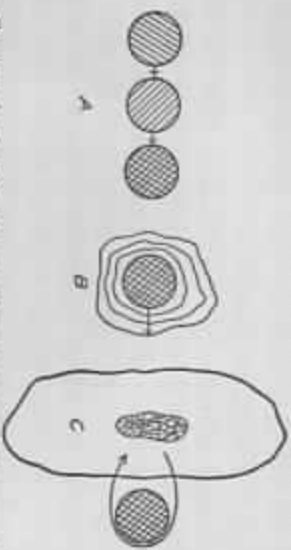


FIG. 2.—Contrast in the direction of different types of energy. A, chemical changes involved in the formation of salt; B, mechanical accretion, in which a salt-crystal is built up from material already existing in solution; C, absorption of salt by cell.

are needed to carry on vital activity, that constitutes the growth of the organism. A simple comparison with the growth processes of a crystal will help to make the matter clearer. When a crystal grows it is by mere mechanical accumulation of one layer of material upon another, starting with a nucleus and gradually extending outward. Intus-susception, on the other hand, means absorption of food or conversion of it into a totally different substance. Again, the crystal in its formation liberates energy, whereas the living body in its accumulating energy as it grows. Finally, it is impossible to conceive of the crystal as having anything but accidental unity of structure, while the organism is one substantial whole. Whether viewed with the naked eye, or scrutinized under the

microscope, the elements of which the organism is composed never appear disconnected, nor do they suggest that they have been brought together by chance. What we have said of growth in particular is true of every living process. After a careful survey of all the important researches in the field of physiology, McDougall concludes "that no single organic function has been found to be wholly explicable on physical and chemical principles; that in every case there is manifested some power of selection, of regulation, of restitution, or of synthesis, which continues completely to elude all attempts at mechanical explanation. Even so simple a process as the secretion of fluid through a very thin membrane shows itself to be other than, and more than, a process of filtration or osmosis." (17)

(c) One of the most remarkable features about the organism is its ability to restore damaged parts. If any portion of the protoplasmic system is wounded the whole organism exhibits an altered mode of reaction. The normal course of metabolism is more limited in area as vital energies are concentrated in an effort to heal the injured part. Other phenomena of regeneration, based directly on experimental evidence, reveal the flexible nature of organic life as contrasted with the rigidity of the machine and the immutable character of physical and chemical modes of action. From his studies of regeneration Driesch concludes to the existence of an *harmonious equipotential system* in the organism. Thus in the early embryonic stages of an *amphioxus* or a *sea urchin*, each cell can play every rôle of morphogenesis. The rôle it actually plays is merely a function of its position. But what, it is asked, transforms such equal potentialities into realities? It cannot be anything from without, for external agencies, light, gravity, *et cetera*, have no effect on ontogenesis. Nor can it be due to chemical processes within the organism, since, as Driesch points out, only equi-

librium or a new geometrical arrangement arises from chemical disintegration. (18) Some non-mechanical factor must be present in the organism which is responsible ultimately both for the harmonious character of the protoplasmic system and for the direction that its potentialities actually take.

The law of conservation presents a difficulty that all vitalists must face. This law is a generalization from experience. It expresses the idea that the total energy of any material system, though capable of transformation, can be neither increased nor decreased by any action between the parts of the material system. But if the vital principle is the source of special forms of energy, how does such energy square with the law? Clues to a possible solution of the problem have already been indicated in our treatment of Aristotle's theory. They may be briefly recapitulated. First let us observe that the quantum of work done by the organism precisely equates the amount of material energy derived from its environment. The same idea may be expressed by saying that all energy incorporated into the body in the form of food, water, air, and so forth, is eventually returned to the world of inert matter. The function of the vital principle is simply to regulate the qualitative transformations of these energies without increasing or diminishing their quantitative values. It is able to initiate and check movements when, for example, it impels the organism to seek its food and distributes energy according to the metabolic, reproductive, and adaptive needs of the living body. Its purpose is to direct, not to create, the physico-chemical forces of matter. But however we explain the action of the vital principle upon the energies of the organism we must remember that, according to both Aristotle and Thomas Aquinas, the entelechy of the living body is not a foreign agent. On the contrary, it is as natural to the body as the material structures which are so obviously part of the organism's make-up.

6. *The Nature of the Vital Principle*

Aristotle defines the principle of life as "*the first act of a natural organized potentially alive body*." (19) Three important factors, each essential to a correct understanding of his vitalistic theory, are contained in the terms of this definition.

A. The first act of a physical body is its *substantial form*. But the principle of life is the substantial form of the organism may be inferred from two angles: first, because it is the source of all those vital functions that specifically characterize the organism; and secondly, because on its extinction the whole nature of the organism is destroyed and its protoplasmic contents resolved back into a lifeless kind of matter. As Thomas Aquinas observes: "Matter as such is not a principle of life . . . otherwise all matter would be living." And he concludes that an organism is alive because it possesses a substantial form which is alive. (20)

B. The body or material substrate to which the vital principle is conjoined is both *natural* and *organized*. Although actually composed of a variety of elements, this body represents no mere artificial aggregate of material particles. On the contrary, it is unified, and presents the aspect of a consistent whole. Similarly, in spite of its diversity of functions, there is only one goal for all its operation. In a special sense, therefore, the organism is a whole or a unity, as Joad remarks, "the distinction between a whole and an aggregate being that, whereas an aggregate is merely the sum of its parts, a whole is more than the sum of its parts. It is something over and above them, brought into being by their coming together, but not, therefore, to be resolved into them. . . . You cannot, in short, take a living creature to pieces and put him together again as you can do in the case of a machine, nor can you rearrange his parts so as to make a different creature; and you

cannot do these things for the simple reason that by taking him to pieces you would not merely disperse an aggregate but would destroy a whole." (21) Substantial unity of this sort is accounted for only on the supposition that a single internal principle of life exists within the organism.

C. In Aristotle's definition the body is referred to as *potentially alive*, because, until it is informed by a vital principle it is merely capable of life. This leads to the real essential distinction between living and non-living bodies. Taking as our criterion the Aristotelian formula *agere sequitur esse*, we may draw up a comparison between the entelechy of an organism and that of any species of inorganic matter. In chemical changes involving non-living substances, as O'Toole points out "entelechy is the variant and matter is the constant, but in metabolic change, matter is the variant and entelechy is the constant." (22) Further, the energizing of an organism presents a striking contrast to that of non-living matter. The former is decidedly peculiar, and finds no absolute counterpart in any purely material system of interaction. The most intricate machine, the most ingenious arrangement of elements, like a watch or an electric robot, is, to quote from Joad again, "simply the assembly of its parts, the arithmetical sum total of all the cranks and nuts and screws which it may be found to contain. You can take a machine to pieces, examine each of its component parts separately, and put them together again A living body is not susceptible of this treatment." (23) It is impossible to imagine how such a machine, if disorganized could assemble itself, much less how any of its scattered parts could reproduce the whole machine. Yet this is what an organism does when it repairs or regenerates itself.

Again, the living body represents a vast assembly of physical units of matter. Each of these units has an entelechy of its own before it enters the organism; each will repossess its own

appropriate substantial form after the life of the body is gone. But all of them, from the moment of their conversion into protoplasm, have but one entelechy which is the single living principle of all the activities of the organism. Finally, the most important of all the comparisons to be drawn between the functions of matter-in-life and those of matter-outside-of-life is based upon a study of their respective designs. In the case of the former, it is intrinsic since the direction of its energizing is inward, toward self-regulation and self-perfection. In the case of the latter, the design is outward. Here indeed we find the ultimate basis for the distinction of vital from purely mechanical operations. As O'Toole says: "The radical difference between living and non-living units does not consist in the possession or non-possession of an entelechy, nor yet in the peculiar nature of the forces displayed in the execution of vital functions, but solely in the orientation of these forces towards an inner finality." (24)

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- articles 1 and 2. *Quaestiones Disputatae, De Veritate*, question 1, article 8.
- (2) Abbott, F. E. *Scientific Theism*. Boston: Little, Brown, 1884, p. 189 ff.
- (3) Carr, A. *Man the Unknown*. London: Hamilton, 1935, p. 100.
- (4) Driesch, H. *The Breakdown of Materialism. The Great Design*, edited by F. Mason. N. Y.: Macmillan, 1934, p. 288.
- (5) M. Le Danterec says: "Between life and death the difference is of the same order as that which exists between a phenol and a sulphate, or between an electrified body and a neutral body. In other words, all phenomena which we study objectively in living beings can be analyzed by the methods of physics and chemistry." (*The Nature and Origin of Life*. London: Hodder and Stoughton, 1907, p. 5.)

Referring to what he calls "the fundamental proposition of Evolution" which he himself accepted in common with Darwin (*The Origin of Species*) and Haeckel (*The History of Creation*), Huxley says: "That proposition is, that the whole world, living and not living, is the result of the mutual interaction, according to definite laws, of the forces possessed by the molecules of which the primitive nebula of the universe was composed." (T. H. Huxley, *Darwiniana*. N. Y.: Appleton, 1896, p. 110.)

Toward the end of the book (pp. 317-18), and after a survey of the phenomena of organic nature, Huxley reaches the conclusion "that not only as to living matter itself, but as to the forces that matter exerts, there is a close relationship between the organic and the inorganic world—the difference between them arising from the diverse combination and disposition of identical forces, and not from any primary diversity, so far as we can see."

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evolution motif, v. McDougall, W. *Modern Materialism and Emergent Evolution*. N. Y.: Van Nostrand, 1929, appendix, note 12.

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- (9) Mercier, D. *A Manual of Modern Scholastic Philosophy*. Trans. by T. L. and S. A. Parker. London: Kegan Paul; St. Louis: Herder, 2nd edition, revised, 1919, volume I, p. 169.
- (10) Aquinas, T. *Summa Theologiae*, part I, question 18, article 3, reply to objection 1: "Duplex est actio: una quae transit in exteriorem materiam, ut calcitrare et secare; alia quae manet in agente, ut intelligere, sentire et velle: quarum haec est differentia, quia prima actio non est perfectio agentis quod movet, sed ipsius moti; secunda autem actio est perfectio agentis."
- (11) Needham, J. *The Septicidal Biologist*. N. Y.: Norton, 1930. Pp. 270. The necessity of a methodological fiction is strengthened in the minds of many investigators because of the presumption that a mechanistic attitude is the only one which is in accord with the spirit of modern scientific inquiry. To such investigators, vitalism involves a practical abandonment of the problem of life. Cf. E. B. Wilson, *The Cell in Heredity and Environment*. N. Y.: Macmillan, 3rd edition with corrections, 1934, pp. 1116-17.
- (12) J. B. S. Haldane is opposed to dualism of any sort,—matter and vital principle, matter and mind, matter and spirit, and so forth. If matter displays mind-like or whole-making properties of the kind that are associated with an organism, the system is called *material* by Haldane; all other types of functioning in matter are referred to as simply *mechanical*. For him all ultimate realities are qualitatively included within the limits of matter (cf. J. B. S. Haldane, *The Causes of Evolution*. Based on a series of lectures delivered in January, 1931. London: Harper, chapter vi).
- NORRÉ, J. B. S. Haldane is not to be confused with J. S. Haldane, the eminent authority on the physiology of respiration (v. *infra*, rel. 17).
- (13) Rignano, E. *Man Is Not a Machine*. London: Kegan Paul, 1926, Pp. 77.
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primarily interested in the teleology of human events, but would apply the concept to all living organisms,—provided of course it is established in the case of man's activity.

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(16) Driesch, H. "The Breakdown of Materialism. *The Great Debate*, edited by F. Mason, N. Y.: Macmillan, 1934, p. 288.

(17) McDougall, W. *Body and Mind*. N. Y.: Macmillan, 1911, p. 231. After careful study of so simple and familiar a mechanism as the feather of a bird, its growth and development, A. R. Wallace says: "To myself, not all that has been written about the properties of protoplasm or the innate forces of the cell, neither the physiological units of Herbert Spencer, the pangensis hypothesis of Darwin, nor the continuity of the germ-plasm of Weismann, throw the least glimmer of light on this problem. . . ."

"Modern physiologists have given us a vast body of information on the structure of the cell, on the extreme complexity of the processes which take place in the fertilized ovum, and on the exact nature of the successive changes up to the stage of maturity. But of the forces at work, and of the power which guides these forces in building up the whole organ, we find no enlightenment." (*The World of Life*, N. Y.: Moffat, Yard, 1911, pp. 318-19.)

J. S. Haldane, after years of research on the phenomena of respiration says: "At present it is usual to treat the physiology of respiration as being nothing more than a description and analysis of all the physical and chemical processes by which oxygen is supplied to the living body and carbon dioxide removed from it. But when we survey such a description, it is quite evident that some thing essential is missing in it. Not only is oxygen supplied and carbon dioxide removed, but these processes are coordinated at every stage among themselves and with other physiological activities, in a manner which is characteristic for each organism. . . . A mere physical and chemical description furnishes no account of this co-ordination, maintenance, and development." (*Respiration*,

New Haven: Yale University Press, preface to the 2nd edition, 1935, pp. v-vi.)

(18) Driesch, H. *Op. cit.*, pp. 85-109.

For an interesting criticism of Driesch's interpretation of embryological phenomena, see Wilson, E. B. *The Cell in Development and Heredity*. N. Y.: Macmillan, 3rd edition with corrections, 1935, pp. 114-16.

(19) Silverster Maurus, *Aristotelis Opera Omnia*. Edited by F. Ehrle. Paris: Lethielleux, 1886, volume iv, De Anima, book ii, chapter 1.

(20) Aquinas, T. *Summa Theologica*, part i, question 75, article 1: "Manifestum est enim quod esse principium vite, vel vivens, non convenit corpori ex hoc quod est corpus: alioquin omne corpus esset vivens, aut principium vite. . . . Anima igitur, que est primum principium vite, non est corpus, sed corporis actus."

(21) Joeld, C. E. M. *Guide to Modern Thought*. N. Y.: Stokes, 1933, pp. 114-15.

(22) O'Toole, G. B. *The Case against Evolution*. N. Y.: Macmillan, 1925, p. 175.

(23) Joeld, C. E. M. *Op. cit.*, pp. 113-14.

(24) O'Toole, G. B. *Op. cit.*, p. 176.

In his *Quæstiones Disputate*, de Anima (one question, article 13), Aquinas says: "Oportet autem quod quantum ad modum agendi omnis actio animæ transcendat operationem vel actionem naturæ inanimatæ; quia cum actio animæ sit actio vite, vivum autem est quod seipsum movet ad operandum; oportet quod omnis operatio animæ sit secundum aliquod intrinsecum agens. Sed quantum ad id quod agit, non omnis actio transcendit actionem naturæ inanimatæ; oportet enim quod fit, esse naturale, et quæ ad ipsum requiruntur, sic in corporibus inanimatis, sicut in corporibus animatis; sed in corporibus inanimatis fit ab agente extrinseco, in corporibus vero animatis ab agente intrinseco."