radiologists, and by myself. The same specialists withdrew their own diagnosis and changed a cancer tumor to a harmless inflammation after orgone treatment reached decisive therapeutic success and the tumor was in a rapid disintegration. But a microscopic examination of the remainder of the tumor at the University of Jerusalem resulted in the unequivocal diagnosis of a cancerous melanoma."

It is now more than thirty years since Reich began his treatment of cancer. The amount of work done by others in extending it and building on his findings is still pitifully small, but at least a beginning has been made, with the work of Hoppe, Chiurco and Bizzi in Italy, that is already having international repercussions.

"There are today some thirty or forty men and women who constitute a sort of inner cabinet of cancerology," wrote Bernard Glemser in his survey of cancer research and progress. "They are scientists of great accomplishment and total dedication; they have immense prestige and, deservedly, considerable power; and they are involved directly or indirectly with virtually every aspect of cancer research all over the world."

That Professor Chiurco, who is one of this leading group, should be sufficiently convinced of the correctness of Reich's bioenergetic concepts to support and encourage the wider application and development of orgone therapy, may shake the confidence a little of those who, on hearsay evidence, by rumor and roundabout report, and without reference to any of the original source materials or experiments, wrote off Reich's cancer work as worthless.

15

The Electrodynamic Theory of Life

Harold Saxton Burr and F. S. C. Northrop

Interest in life energy has in turn revived interest in the "electrodynamic theory of life." Here is the classic statement, which is only now, after almost forty years, becoming recognized by many scientists as one of the most important scientific and philosophical statements of the century.

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There are several factors which suggest that living things must be viewed from the electrodynamic point of view. Certain of these factors appear in the nonbiological sciences and in general philosophical considerations; others arise in biology itself, and particularly in connection with recent evidence concerning the factors controlling the development of the nervous system.

I.
General Scientific and Philosophical Considerations

If one views the history of science as a whole, including its Greek as well as its modern manifestations, a certain contrast appears. Greek science was dominated largely by mathematics and astronomy, whereas since the seventeenth century physics and chemistry have been the leading disciplines. This difference in emphasis among the special sciences bespeaks a more fundamental difference in scientific outlook. Mathematics and astronomy as they appeared in

Greek times in the geometry of Euclid and in the mathematical astronomy of Eudoxus were systematic deductive sciences dealing with the entire spatial and astronomical universe as a whole. It is an obvious peculiarity of geometry as a pure science that it is concerned wholly with structure and not at all with matter. It is a more unexpected peculiarity of astronomy that it, more than any other of the natural sciences, tends to conceive of nature as a purely formal system. This was the case in Greek times and with Kepler, and is, or was, the case in our own time with Eddington and Jeans. It was not the case, however, with Galilei and Newton. They conceived of the astronomical universe as a physical system analogous to the system of earth and ball and inclined plane with which Galilei verified his profound and revolutionary reflections.

This brings us to the sharp contrast between traditional modern science and Greek science. The latter, dominated as it was by such scientists as Eudoxus, Euclid, Apollonius, and Archimedes, tended to regard mathematics as more fundamental than physics and to think of nature as a purely formal structure; the former, following Galilei and Newton, made physics primary, and hence regarded nature as an aggregate of many physical objects in motion, mathematics becoming a very necessary means, but nevertheless merely a means, of precisely formulating this physical conception. Stated in more general philosophical terms, Greek science, including biology with Aristotle, tended to conceive of nature in terms of formal causes; modern science, in terms of material causes. The two views have not been compatible in traditional scientific or philosophical theory. To maintain that nature is a system of forms, unconditioned by matter, is to maintain that nature and its systems possess a changeless structure; hence, the doctrine of the fixity of biological types in Greek biology. To maintain that nature is a collection of physical objects in motion is to regard structure as a relation between these objects, and subject to change with their motion; hence, the essentially modern character of Darwin's doctrine of the modification of biological types. In short, Greek inorganic and organic science put the emphasis on structure and the eternal constancy of forms, whereas modern science has placed the emphasis of physical and chemical and biological entities and the variability and evolution of forms.

This difference between Greek and modern science expresses itself in one contrast which is implicit in what [illegible] already indicated. The ancient emphasis on structure and on systematic science, such as appeared in the geometry of Euclid and the astronomy of Eudoxus, led to the conception of nature as a single system. This means that no local system can be completely understood by itself and that thoroughgoing specialization is not sound science; nothing is truly understood until nature as a whole is understood and the local part is perceived in its exact status in and connection with that whole. This was one of the major reasons why Greek science was so inherently and inescapably philosophical. The modern conception, arising with Galilei's founding of "the science of local motion," and with Newton's principle of isolation and the attendant emphasis on masses rather than structure, led naturally to the conception of nature as an aggregate of many physical objects; hence, the current notion that scientific knowledge is possible for a person only in a very narrow field, and the attendant corollary that any attempt, such as the philosopher sometimes proposes, to talk about the whole, is idle footless speculation.

This opposition expresses itself in one other distinction: Greek science, except for the atomists, who were repudiated in mathematics, for reasons which we shall show immediately, placed the emphasis on continuity; modern science, on discontinuity. The reason for the Greek point of view is to be found in the discovery of the incommensurable by the Pythagoreans. They and the atomists, like the moderns, began with a discontinuous theory. The attempt was made to build up lines and surfaces and solids out of discontinuous elements or "pebbles." In short, they tried to define the continuous in terms of the discontinuous, and to reduce geometry to arithmetic. This worked beautifully until they came upon the length of the hypotenuse of a right-angled triangle, the other two sides of which are equal. Setting the sides equal to unity the length of the hypotenuse is $\sqrt{2}$. Stated in more concrete terms, this means that any "pebble" or unit of length which goes into the length of either side a definite number of times leaving nothing over will always leave something over when the hypotenuse is measured. This convinced the Greeks that the continuous will not reduce to the discontinuous and that geometry is more fundamental than arithmetic. Modern science, on the other hand, discovered nature to be atomic, reduced geometry to arithmetic by generalizing its theory of number, and regarded discontinuity, and the many, as more fundamental than continuity, and the one.

This modern emphasis on entities, fluid forms, atomicity, and discontinuity has dominated biological thought. Galilei had no more than developed his physical and mechanical theory of the inorganic universe before Harvey proceeded to apply physical and mechanical conceptions to living creatures in the discovery of the circulation of the blood. Lavoisier revealed the chemical character of respiration and metabolism in living things at the same time that he placed chemistry upon secure foundations with the discovery of the principle of the conservation of mass. Gradually with Liebig and Wöhler, and the vast army of physiological chemists, the chemical nature of living creatures has become more and more evident. It is to be noted that this is a distinctly modern emphasis. Chemistry rests upon a discontinuous atomic conception of nature, and atomism in its traditional interpretation involves an emphasis upon entities rather than upon structure and on the constituent elements rather than upon the whole. This attitude of mind has gone all through biology even where no appeal has been made to the chemical nature of the processes or factors considered. Practically a century ago Schleiden and Schwann discovered the cellular nature of plants and animals. Here was the supposedly ultimate biological atom. More recently the emphasis has shifted from the cell to the gene, but even so the emphasis is still on entities.

It is to be noted that this entire development involves the carrying over into biology of a philosophical standpoint which was discovered and clearly formulated first in physics and chemistry. There can be no doubt of its success or validity. There is nothing to date to indicate that the biologist should hesitate to follow the lead which the more mature and exact science of physics gives him.

If this be granted, then it is clear that a slight change of emphasis must come into biological theory. For the entire modern standpoint with its emphasis on entities rather than organization, upon discontinuity rather than continuity, upon local systems rather than upon their status in the total field of nature as a whole, has been found in physics to need rather radical and thoroughgoing supplementation. The word "supplementation" is to be emphasized, for the modern standpoint has not been rejected; it is being merely amended. The amendment is so thoroughgoing, however, as to amount

to the placing of the Greek upon an equal footing with the modern standpoint. Moreover, the concepts modified are so primary in the levels of importance and so general and universal in their application that every branch of human activity and even the very meaning and significance of any fact we observe or experiment we perform are affected.

The elemental and essential fact as it appears in physics can be stated very briefly; atomic physics has had to be supplemented with field physics. The point to be noted is that the particle both conditions and is conditioned by its field. Stated in more general terms this means that continuity as well as discontinuity is ultimate, that nature is both one and many. In short, any local system in part constitutes and is in part constituted in its behavior by nature as a whole and the physical field in which it is embedded. This rediscovery of the continuous field, or the one, as a causal factor conditioning the behavior of the constituent particles, or the many, is a return to the Greek standpoint. But the particles also determine the character of the field. This is the modern viewpoint. The reciprocal causal relation between field and particle amounts to a union of both viewpoints. This is the fact which anyone with an eye to first principles can see standing out amid all the complexities and confusions of current discoveries in physics.

But this mere designation of the fact is not enough. We do not possess science until our findings are formulated in terms of clear consistent principles. At this point, current scientific and philosophical thought is confronted with a serious difficulty. According to all traditional scientific and philosophical conceptions the Greek and modern views of science contradict each other. It was precisely because of this contradiction that we had to reject Plato's and Aristotle's physics, biology, and philosophy in order to accept Galilei's, Newton's, and Darwin's. The difficulty can be put very simply. The modern conception of nature as a discontinuous collection of moving particles makes all order in nature a temporary effect, renders nature as a whole a mere aggregate, and provides no meaning for continuity as a primary factor or for the field as a causal factor. The Greek conception, as formulated, either in mathematics and astronomy by Plato and Eudoxus, or in biology by Aristotle, does justice to the continuity and unity and organization, and to the field character of natural phenomena, at the cost of interpreting nature as a single substance or system and rendering change, atomicity, and the temporal origin of species meaningless. It is clear, therefore, that before the doctrine of reciprocal causal interaction between particle and field can possess meaningful, consistent theoretical formulation a new theory of the first principles of science must be developed. Moreover, this new theory must combine the Greek and modern conceptions of science which have previously been supposed to be incompatible.

It is essential that the reader sense the necessity of this theoretical formulation before going further. Otherwise the electrodynamic theory of life proposed in this paper will appear as but a new name for traditional conceptions, and its essential novelty and significance will be missed. This point may be made by referring to an experimental anatomist. He replied, "Yes, the field theory of life is reasonable, but what is the field except as it is determined by its physicochemical constituents?" In this query he gave expression to the fundamental presupposition of traditional modern science that the field, or nature as a whole, is a mere aggregate of the atomic parts and in [illegible] He was quite right also in suggesting that the field theory of life would be but a new name for old commonplaces were this all that it means. The point is, however, that the theory which we are proposing means more than this. The microscopic physicochemical constituents do determine the character of the field. No one cognizant of modern physics and physiological chemistry can deny this. But this relation between field and particle is not, as traditional modern scientific theory has assumed, an asymmetrical or one-way relation. The field both determines and is determined by the particle. But to find meaning for the field as, in this partial sense, an ultimate causal factor is the real difficulty. In the traditional modern scientific conception of nature as a collection of particles in motion and physicochemical interaction, there is no meaning to the field as anything more than (a mere aggregate and effect of their compounding;) in Newton's physics, given the masses with their inertial and accelerative forces, the gravitational field and the orbits are completely determined. To make sense out of the notion that the field determines the behavior of any local process or constituent within it, it is necessary to modify modern science at its very foundations by revising our theory of first principles to provide meaning for the unity of nature

as a causal factor. Without this revision in our most elemental and fundamental conception of nature as conceived by science,(all field theories)whether in physiology or physics are mere verbiage.

It is easy enough to find meaning for the unity of nature and for the field as a causal factor providing we return to that Greek conception of science which makes continuity ultimate, regards nature as one substance, and interprets all plurality as a mere abstraction from the unity. But this is to go to the other extreme and find meaning for the causal efficacy of the field at the cost of denying all determination of the field by the particle. Clearly, modern science will not permit us to do this. It is impossible now to deny the validity of physicochemical categories. There is the particle as well as the field. It is clear, therefore, that meaning for the field and the unity of nature as a causal factor must be gained without rejecting the primacy of the atomic physicochemical categories of modern science. The only completely physical theory of the first principles of science proposed to date which accomplishes this is the macroscopic atomic theory developed by one of the authors of this paper (Northrop). It retains the kinetic atomic theory of traditional modern science, thereby providing theoretical foundations for the physicochemical categories which modern investigations have established, and providing meaning for the determination of the field by the particle. To this traditional kinetic atomic theory it adds one macroscopic atom which surrounds, and, *solely because of its relatively small fixed finite size,* compresses and congests the microscopic particles, of the whole of nature, of traditional theory, which it contains. Thus a unity of nature as a whole is impressed upon the compounding and aggregating of the microscopic particles to make complex nature one as well as many, a unity as well as an aggregate, a field which in part determines the behavior of each particle and process, as well as a complex continuum, in part constituted by the motion and interaction of the particles. Whether the macroscopic atomic theory will gain confirmation directly by further empirical investigations need not concern us here. Its mere existence as a possible theory is sufficient for our present purposes, since this demonstrates that it is possible to combine the Greek scientific conceptions of nature as a single system with the modern scientific conception of nature as an aggregate of many particles, without contradiction, and thereby gives meaningful formulation to the thesis that the particle in its behavior both determines and is determined by the field in which it is embedded.

Having demonstrated that the doctrine of the reciprocal interaction between field and particle can be given consistent meaningful theoretical formulation, it remains to designate the evidence in both physics and biology which supports it, and the modification in our attitude toward all systems in nature, which its acceptance must entail.

The first conclusive evidence in physics of the necessity of supplementing atomic physics with field physics appeared in the relativity theory. A short survey of certain developments in the history of science will make this clear. Science has always distinguished between two types of structure or relatedness in nature. The one type, most evident in space, is relatively constant through time; the other, evident in the obvious changing relations between things, is subject to change with time. Actually both types of structure of relatedness apply to the physical content of the universe, but Newtonian physics did not view the situation in this light. Instead, it separated the relatively constant spatial structure of physical nature from the physical content and turned the separated structure into an independent entity called absolute space. This space was really a field, but since it permitted matter to move through it without opposition, there was little or no meaning to the statement that the field conditioned the behavior of the particle. A similar separation and reification of the field character of physical nature occurred in the sciences of optics and electricity with the introduction of the ether. The theory of relativity has demonstrated, however, that this entire procedure is mistaken. In doing away with the independent ether, and in merging matter and space and time, Einstein has shown that the approximately constant macroscopic structure of space is the approximately constant macroscopic structure of matter itself. The field is not independent of matter but a very condition for an causal determiner of the behavior of matter. Thus Einstein replaces Newton's three laws of motion with the single law that a body moves in a path which is a geodesic of the space-time of the observer's frame of reference. But the general theory of relativity also prescribes that the distribution of matter determines the character of the metrical field, and thereby the lay of the geodesic. Thus the particle both conditions and is conditioned by the metrical field.

These considerations from the verified general theory of

relativity are sufficient to indicate that the attempt to conceive of nature entirely in terms of the pluralistic discontinuous microscopic atomic physicochemical categories of traditional scientific thought is inadequate. This does not mean that these traditional categories are invalid; they are in fact necessary, as the general theory of relativity indicates when it makes the metrical properties of space dependent upon them and their distribution, but they are nevertheless insufficient. The field also conditions the behavior of the particle.

The second evidence in physics for the theory of the reciprocal determination of particle and field appears in wave mechanics. At this point the relevance of all this for biology can be made more direct and explicit. Biologists have discovered that whatever else living creatures may be, they are in a very real and significant sense physicochemical systems. But chemists and physicists have now conclusively demonstrated that the electrodynamic theory of nature is more fundamental than the chemical theory. The reduction of the chemical atom to electrons and protons and the development of quantum theory and wave mechanics implies this. Moreover, the recent surprising tendency in wave mechanics is to put the emphasis on the field even to the point at times of attempting to derive the particle from it. This, as Darrow and G. P. Thomson have pointed out, is an error; moreover, quantum physics reveals even new evidences of discontinuity. Nevertheless, the fact still remains that the field as a distinctly causal factor is indispensable.

These established and accepted findings of contemporary physics are sufficient to indicate that the same influence from the mature science of physics, which previously drove biology with Harvey to the mechanical theory of living creatures, and with Lavoisier to the chemical theory of their nature, must now drive us to an electrodynamic theory of life. Contemporary developments in physics rest upon the discovery of the primacy of electrodynamic theory over chemical or traditional physical theory.

Moreover, and this is the crucial point, this shift involves much more than a mere shift in terms. Contemporary physics has gone very much further than the mere statement of chemical elements in terms of electrons and protons. The latter advance, while of great importance, still involves the traditional emphasis solely on entities and their motion. The current shift is much more fundamental than this, for the field as well as the particle is now revealed as a causal factor. Once this point is really grasped our whole attitude toward our scientific knowledge must change. Structure again becomes significant. It is no longer permissible to assume, as traditional modern science has done, that if the constituent chemical components are determined, the field and the structure will take care of itself.

The significance of this for biology can be made evident by a brief consideration of its most fundamental and perplexing problem—the problem of organization. It is a commonplace that living creatures, notwithstanding the modification in types in evolution, maintain a certain constancy of structure through continuous changes of material. Aristotle with his doctrine of formal as well as material causes provided a theoretical basis for this fact, but failed to account for the mutability of species. Modern science with its rediscovery of the kinetic atomic theory and its attendant doctrine of the variability of structure with motion provided meaning for Darwin's discovery, and the physicochemical nature of life, but at the cost, as Claude Bernard indicated, and as Driesch and J. S. Haldane have emphasized more recently, of failing to do adequate justice to the relative constancy of biological organization. The traditional modern doctrine that the chemical elements completely condition the structure and organization of the organism failed to explain why a certain structural constancy persisted through the chemical flux.

This obvious inadequacy led to the introduction of nonphysical factors such as *Driesch's* "entelechy," *Spemann's* "organizer," *Rignano's* "biological energy," *Child's* "physiological gradient," *Weiss's* "biological field," and *Köhler's* "Gestalten," all of which have certain validity as descriptive terms. It now appears, however, that the difficulty may have its basis not in the failure of any possible physical theory, but in the inadequacy of traditional physical theory. For the chemical view with its emphasis on entities has been demonstrated to reduce to the electrodynamic view in which the more constant structural guiding contribution of the field is found to supplement the contingent changing relatedness introduced by the motion of the particles.

If this new electrodynamic theory is correct, it follows that biological science must supplement its present emphasis on chemical analysis and on entities with a more serious study, by the experimental determination of potential distribution, of field factors and structure and organization in itself. It appears also that biology itself suggests the necessity of the particle-field theory.

II.
Biological and Neurological Considerations

The necessity is apparent when an attempt is made to unravel the underlying processes inherent in ontogeny. In spite of the mass of accumulated data concerning the development of the organism in general and of the nervous system in particular, no thoroughly satisfactory explanation has been given of the regulation and control of growth. Description of successive steps of development in a wide variety of forms reveals little of the relationships which exist between the steps or the factors which regulate the passage from one to the other. The very wealth of the accumulated facts tends to obscure the underlying regulation and to defy analysis. It was this difficulty which led Driesch to the repostulation of a "vital force," or entelechy. This brilliant hypothesis has never received its just due. The whole theory is a very adequate description of an extraordinarily constant control and regulation of growth. Its weakness lays in its assumption of an extrabiological agent incapable of scientific description. The field theories of Spemann, Weiss, and Gurwitsch are also valuable attempts at explanation, but like the entelechies of Driesch, scientific analysis is well-nigh impossible.

All embryologists have been impressed at one time or another with one aspect of the problem noted above. Growing systems posses an extraordinary capacity for self-regulation. Some powerful agent seems to be inherent in the system through which the progress of development from stage to stage is coordinated and regulated according to a definite plan. Each and every biological system seems to possess a dynamic "wholeness," the maintenance of whose integrity is a necessity of continued organic existence. Virtually all the theoretical analyses stress this quality, but no adequate definition of this dynamic agent or adequate explanation of its working has been offered.

Not only is the regulation in ontogeny an enigma, but we are still almost completely ignorant of the dynamic relationships in living systems. A considerable body of information is available concerning the physical and chemical structure of protoplasm, but we know little of the way in which the elements are organized into a dynamic whole. The cytoplasm of a living cell is not a formless agglomeration of chemical substances but is an integrated and coordinated system. It is impossible to conceive of cytoplasm as a haphazard arrangement of molecules. A definite pattern of relationships must exist. We possess a modicum of knowledge of these relationships at any one moment, but we have no adequate theory of the mechanism which maintains that pattern throughout the rapidly changing flux in living systems. Study of the situation in the nucleus is somewhat more advanced because of the greater definiteness of the formed elements. We possess fairly clear statements of the physical and to some extent of the chemical components of the nucleus. The dynamic activities of the formed elements, the chromosomes, have been partially unraveled by geneticists. As in cytoplasm, however, we lack any adequate hypothesis of the mechanisms involved in chromosomal aggregations or in the splitting and distribution of the component elements. The results of the processes have been widely studied and have provided an important body of information, but we still lack understanding as to how the results are accomplished. Here then, as in embryology, we find "pattern or organization" the fundamental problem.

The difficulties suggested above are no less apparent in the analysis of the development of the nervous system. The successive steps have been described by innumerable workers, but we lack any rational explanation of the appearance of local regions of growth and differentiation and of the final establishment of nuclear masses and fiber-tract pathways. Although Spemann has shown the importance of the dorsal lip of the blastopore as a concomitant of the formation of the nervous system, there is little understanding of the factors involved in this relationship. Moreover, neither fact nor theory has yet made clear the nature of the factors which give this power to the dorsal lip of the blastopore.

Careful consideration of the many facts, of which the above is but a suggestive résumé, compels us to look for a hypothesis which will cover not only the dynamics of development but also the pattern of organization of unitary biological systems. The search for such a hypothesis has intrigued many investigators. As has been shown earlier in this paper, its formulation has been hindered by reliance upon earlier physical theory. With the advent in physics of the field theory of the relationships between particulate matter, the resolution of the biological theory becomes clearer. It is believed that the theory about to be proposed satisfies this condition and, if it can be demonstrated, gives the solution to many problems of biology.

The theory is the result of many years of experimental investigation of the mechanisms involved in the development of the nervous system. In these studies it has been shown that an extremely important factor in the organization of the nervous system is the rise and fall of differential growth rates within the wall of the neural tube. Moreover, experimental work confirms the belief that the direction of growth and the end station of differentiating nerve fibers is related to these primary centers of rapid proliferation. Inasmuch as they seem to be potent factors in imparting the fiber pattern to the nervous system, it becomes necessary to inquire into the agents which could act to determine the locus of these areas and to regulate the division rates in them. If this could be settled, then it would be possible to formulate a hypothesis as to the origin of pattern in the nervous system. Conceivably this might provide a clue to the origin of pattern in developing organisms and in other living systems.

An increasing body of evidence indicates that bioelectric phenomena underlie growth as well as many other biological processes. Numerous electrometric studies compel us to believe in the presence of polar and potential differences in living systems. If this is true, it follows by definition that electrodynamic fields are also present. Their existence in the physical world is generally accepted. Moreover, the formed relations of particulate matter is to a considerable degree a function of such fields. Thus the individual characteristics of atomic matter are a result of the interdependence of fields and particles. Pattern in physics, then, is determined by the interplay of electrodynamic fields and the particular matter therein contained.

It is reasonable to extend this hypothesis into the realm of biology: potential gradients and polar differences exist in living systems. If this is so, then electrodynamic fields are also present. The following theory may therefore be formulated. The pattern or organization of any biological system is established by a complex electrodynamic field, which is in part determined by its atomic physicochemical components and which in part determines the behavior and orientation of those components. This field is electrical in the physical sense and by its properties it relates the entities of the biological system in a characteristic pattern and is itself in part a result of the existence of those entities. It determines and is determined by the components. More than establishing pattern, it must maintain pattern in the midst of a physicochemical flux. Therefore, it must regulate and control living things, it must be the mechanism the outcome of whose activity is "wholeness," organization, and continuity. The electrodynamic field then is comparable to the entelechy of Driesch, the embryonic field of Spemann, the biological field of Weiss.

The implication of the above theory for embryology yields a number of interesting points, only one of which can be considered here. An intriguing problem in chordate development is the establishment of a longitudinal axis. This is a very real structural alignment, although at early stages in development the cells which are related to it may be totipotent. Experimental rearrangement of the cellular units does not change the axis although they themselves may have their ultimate fate altered. Caudal cells may become cephalic cells, right cells may become left with little serious interference with the normal processes of growth. Yet in some way the constituent cells of the growing system have their fate determined and their behavior and orientation controlled.

At least two factors in this regulation are familiar. Embryology and genetics have given adequate evidence of the importance of the chromosomes in determining cellular fate. The investigations of Weismann, Driesch, Boveri, Hertwig, and many others attest this. The geneticists have confirmed it and we are compelled to believe that the formed elements in the nucleus partly determine the growth and differentiation of cells. But the experimental embryologists have shown that intercellular relationships are no less important. Spemann and his students have demonstrated the dependence of cells on their local environment. The induction or organization hypothesis is an expression of their findings. To genetic constitution, then, there must be added local cellular environment as an important determiner of cell fate and therefore of the organization of the growing systems.

To Driesch, however, we owe the brilliant observation that the fate of any group of cells in an embryo is not only genetically conditioned but is also a function of the position of that group in the whole biological system. The mechanism by which position could determine cellular potencies was explained by Driesch through the assumption of an extra-biological guiding principle, an entelechy. It is at this point that the electrodynamic field theory proposed above provides a significant explanation of the well-recognized facts. In the physical world the nature of an atom is dependent upon the number of entities which comprise it and the field in which they lie, the position of the electron orbits being of fundamental importance. So, on a very much more complex scale in a biological system the fate of any group of cells is determined in part by the position those cells occupy in the electrodynamic field of the embryo. It is clear that if the above be granted, three factors are present in the normal development of an organism. The cells must possess a certain genetic constitution, a certain cellular environment, and a certain position in an electrodynamic field.

This is not the place to extend the application of the theory to many other problems of embryology, for another important aspect calls for attention. The pattern of the organization of the molecular and atomic constituents of protoplasm is an even more important problem to biology than the physicochemical nature of the entities themselves. It is not enough to know the chemical formula of protoplasm. It is of vital importance to understand how the elements are related to each other, how they are gathered together in a single "whole" system. If the electrodynamic theory is sound, the characteristic relationship of the elements of any biological system is a function of the field of the system. If this be true, then the great jump from living organic matter to nonliving physical matter is no longer inexplicable. The difference between the two is to be found in all probability in more complex fields and more complex molecular structure. Life, then, is not a special creation but an expression of fundamental law operating in living and nonliving matter alike.

The theoretical considerations here presented have led us to the conclusion, reached by nearly all other investigators, that pattern or organization is a fundamental characteristic of biological systems, or of physical systems, or of the universe. The electrodynamic theory provides a working hypothesis for a direct attack upon this problem. If accepted, it opens up a wide field of study based upon electrometric methods. It should be possible, therefore, to determine by objective experiment whether or not such fields exist. In other words, this theory can be put to experimental test. Finally, the theory makes it possible to place the investigation of the organization of living systems on the same objective and physical basis as the analysis of their chemical constituents.

It appears, therefore, that a hypothesis of this type is necessary to bring biological theory into line with physical theory. Moreover, biological considerations alone affirm a similar necessity and provide a sufficient amount of data to warrant putting to nature, by experimental and electrometric methods, the questions which this theory raises. These questions fall naturally into three categories. In the first of these are to be found questions as to the presence and character of potential and polar differences in living organisms. In the second are the questions dealing with the measurement of electrodynamic fields as concomitants of the potential differences. In the third are those questions which are associated with the impact of an altered field in the environment on developing mechanisms. In all probability new technical methods will have to be devised before definite answers can be obtained. Furthermore, if the theory is established, it makes possible the application of the mathematical methods being developed for field and wave physics to biological material, thereby placing the study of biological organization on a mathematical as well as an experimental basis.

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Outwitting the Stars

Paramahansa Yogananda

The ways that we are affected by cosmic energies has become a major research interest. In more esoteric literature the influence of celestial bodies is seen as strongly affecting an individual's total personality from conception.

Paramahansa Yogananda, founder of The Self-Realization Fellowship in America and master of Kriya Yoga, gives a personal account of an adventure in astrology.

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