RELATIVITY AND REALITY

I. THE PHILOSOPHICAL SIGNIFICANCE OF THE EVOLUTION OF VISION

THE present paper is concerned with what the philosophers call the "problem of reality." But instead of approaching this problem from the angle of philosophy, an attempt will be made to show how this problem grows out of the investigations of science, with the end in view of then considering what modern science has to offer by way of a solution to this problem.

In order to get launched into our subject, let us now raise the question, what is this problem of reality? Replying briefly, in the language of philosophy, we may say that the problem of reality is concerned with the question of what we mean when we say that a thing is *real.* Ordinarily a thing is said to be real when it *exists.* Then the question arises, When does a thing exist? What is the criterion we employ in distinguishing between the real and the unreal, the existent and the non-existent? For the present this question will be left unanswered, in order that we may first consider the conditions under which this problem is likely to arise in a clearly articulated form.

In the history of Occidental philosophy this problem did not make its appearance until the time of the early Greek philosophers, about 500 B. C. It seems to be agreed that primitive man was not much given to philosophical speculation, so that for him there was no problem of reality. It is also assumed by many philosophers that unsophisticated persons living today (the "men of the street") resemble more primitive men in their outlook on the world. The attitude of both is supposed to be similar in that neither primitive man nor the contemporary "man of the street" is supposed to be aware of the existence of any "problem of reality." The technical term which is used to designate this prephilosophical attitude towards the world is naive realism. The attitude of naive realism may be summed up in the following two propositions:

I. Things are what they are perceived to be. The rose is red, and the "redness" is as much a part of the rose (or is as objective) as the size or shape of the rose. A thing has in fact the qualities it appears to possess.

II. Perceiving or knowing an object makes no difference to the object that is perceived or sensed in any way.

These are the two propositions on which the attitude of unreflective individual is supposed to be based. Here there is no distinction between appearance and reality, and a thing is held to be what it appears to be.

In order to show that thinking about philosophical problems is not a waste of time, the philosopher next takes pleasure in demonstrating just why this attitude of naive realism cannot be maintained on a rational level. The philosopher proceeds to show how naive realism breaks down.

One way of showing the necessity for making a distinction between what a thing appears to be and what it really is consists in pointing to the various types of illusions to which men are subject. The psychologists have now classified many types of illusions (visual, auditory, etc), and in each case the principle that a thing is in fact what it appears to be is violated. In general the procedure consists in showing that the idea of the naive realist, that in the act of knowing the perceiver contributes nothing to the phenomenon observed, is false. The philosopher who denies the principles of naive realism tries to show that the world we live in arises out of two factors, the environment and the organism. Our ideas of reality are a function not only of the objective world, but also of the human individual. What we call reality, in other words, cannot be described completely in terms of external objects alone. Here is an analogy for the two-term relation we have in mind: The tides of the earth cannot be explained in terms of the earth alone, nor in terms of the influence of the moon alone. The tides are a function of the interrelation of the earth and the moon, and neither must neglected or reduced to terms of the other. In order to explain and amplify the statement that the perceived world arises out of the relational interdependence between individuals and their external worlds the following types of such relative effects will be set forth. The main types of relativity are: (1) Physical Relativity, (2) Biological Relativity, and (3) Psychological Relativity. It is possible, of course, that the third type of relativity is but a special case of the second, and that this, in turn, is reducible to the first type; but for the present we will consider each of them as *sui generis*. Let us first consider the bearing of physical relativity upon our problem of reality.

As an illustration of physical relativity consider the phenomenon of color. Astronomers classify stars into different groups, and a color classification would give us red, yellow, and blue stars. The naive realist would say that a star which appears red *is* red. But the astronomer knows that the color of a star depends in part upon the relative movement of the star with respect to an observer on the earth. Here what the physicist calls the Doppler effect manifests itself. If a star is moving away from the earth, fewer light waves will reach the observer in a unit interval of time than if the star were moving towards the earth. In this case there would be a shift in the spectrum towards the violet end. For the same reason, if an auto driver on the surface of the earth should approach with a sufficiently high velocity a traffic light which is showing red, the red light would turn to green for him. If he should accelerate his velocity still further, all the lights would be shifted into the ultraviolet (or invisible) region of the spectrum, and such nuisances as traffic lights would cease to exist for the autoist. We see, therefore, that the color of an object is not an absolute property of the thing perceived. This is physical relativity, because, as thus stated, it does not rest upon anything peculiar to the living organism. A photographic plate sensitive to color would react in the same way as an organism.

Modern physics now recognizes that in making a report about physical reality the rôle of the observer must be taken into account. In his book on *The Mathematical Theory of Relativity* Professor A. S. Eddington shows that one of the consequences of the theory of relativity has been to throw in doubt the assumption that such physical quantities as length, work, potential, etc., are objectively invariant existents. Physical magnitudes are not properties of external objects alone, but are relations between these objects and the particular frames of reference from which they may be view and measured.

This fact that the rôle of the observer is not to be ignored is brought out in a new and interesting way in the new quantum theory. We are now told that measuring, or even perceiving, a phenomenon alters it, for observation always involves an interaction of light between the observer and the observed. A thing that has been observed is different from what it would have been if it had not been observed. We must not forget, however, that this type of relativity can be corrected. For while physics may not be able to eliminate the rôle of the observer, it can standardize it. Indeed, it is commonly stated that the theory of relativity is itself a device for stating the laws of nature in such a fashion that they are independent of any particular physical frame of reference.

Let us now turn to biological relativity considerations. The first type of relativity is based upon the relation of the perceiver's frame of reference to that of the object perceived. The second type of relativity is based upon the biological constitution of the organism that does the perceiving. This means that the way in which the world appears is a function of the sensori-motor organization of the organism. In our discussion of this we will confine ourselves to vision, since it is this sense organ which contributes most to our information about the world, and consequently to the formulation of theories about the world.

We live in a world of physical objects, a world of trees, hills, rocks, stars, clouds, bodies of water, and so on. With the exception of clouds and running streams, these objects are fairly stable and solid. But progress in science has here again shown us that the properties of this "too, too solid" universe arise out of the limitations of our sense organs. The solid, impenetrable table, under the X-ray eye of science, dissolves into a mad dance of molecules as energetically active as the table itself appears to be passive and inert. Physics tells us that what we call solid matter is composed mostly of empty space. One therefore is led to ask how it happens that visual perception gives us one impression of the external world while physics, which in its imaginative constructions goes behind the gross world of the engineer, yields another account. Undoubtedly the necessity for survival has contributed to the development of a set of sense organs fitting the animal to get along as one physical object in an environing world of other physical objects.

Man lives in a middle-scale universe; in size he lies about mid-way between the infra-universe of atoms and the supra-universe of stars. Man's senses have apparently been evolved so that he is fitted to function efficiently in this middle-scale universe of the engineer. Hence he perceives the familiar bodies in the environment in such a way that he can act upon them as things. The brain, the eyes, and the musculature are mutually interacting systems. In phylogenetic evolution the development of vision has kept pace with the development of motility; and man, like other organisms, perceives best that world of objects in which he must move and survive. The eye tells us about those physical objects upon which the motor organs must act. Biologically, it would be of no advantage to an organism to be able to see things, like molecules, which it could not respond to tactually or kinaesthetically. In pragmatic terms, perception is seeing a thing in such a way as to make use of it.

In this account we have spoken in general terms about the function of vision. But actually vision differs widely in widely separated species, and one may well ask whether, and if so in what way, the acquisition of color vision is of value to an organism in enabling it to survive. A more thorough study of the rôle of color vision in those species of animals which possess it bears out this same general conclusion, namely, that the evolution of vision has been subordinated to the practical problem of adaptation and survival. To clarify and support this statement it is necessary to go into more detail.

The physicist tells us that the total span of radiation extends from the longest Hertzian waves used in radio broadcasing to the very shortest cosmic rays recently investigated by Professor R. A. Millikan. Lying between these limits are the various types of frequencies which, passing from the longer to the shorter wave lengths, are known as infra-red or heat rays, the visible spectrum, the ultra-violet, X-rays, gamma rays from radio-active substances, and then cosmic rays. An examination of this table shows that the eye selects out but a small sector of this total gamut of frequencies. Out of the total span of radiant energy the human eye responds to those waves lying between the relatively long rays in the red end of the visible spectrum (about 800 millionths of a millimeter in wave length) and the relatively short rays in the violet end (about 400 millionths of a millimeter in length). Thus the eye, efficient as it is within these limits, is capable of responding to but one octave of radiation out of a total of about seventy such octaves. And this gives rise to the question, Is it not a strange fact that while ultra-violet rays are physiologically more active than visible rays (being responsible for sunburn and the prevention of rickets), the human eye is nevertheless not adapted to function in that region of the spectrum? Similarly, that while heat (or infra-red) rays stimulate our temperature sense, our eyes are not capable of responding to heat radiation?

These facts concerning the sensitiveness of the human visual apparatus to the different types of visible light are summed up in what the psychologist calls the luminosity curve. A study of that curve shows that the average eye sees best in the middle region of the spectrum, about the yellow green (550 mμ) and will not respond to infra-red or ultra-violet radiation, no matter how great the intensity may be.

But this has not always been the case. Biologists and psychologists know that the eye, like other mechanisms of the body, has undergone an evolution, and that lower organisms do not have the same visual experiences as normal human individuals. But for that matter, not all human beings see colors in the same way. Such persons are either partially or totally color blind. It is supposed that these exceptional individuals are atavists in this respect, reversions to earlier types of visual response, where such colors as red and green (the second stage in the evolution of color vision, according to Dr. Christine Ladd-Franklin) or even yellow and blue (the first stage in the evolution of *color* vision) are not perceived. In lower animals, however, these deficiencies of vision in the region of humanly visible light are sometimes compensated for by vision in other regions of the spectrum of radiation, where the human retina does not respond. It has been suggested, for example, that the eyes of mosquitos respond to infra-red rays. No doubt everyone who has been bitten by these insects at night in the dark has wondered how they can find their intended victims with such apparent accuracy Perhaps it is because they can see the heat (infra-red) rays given off by the human body. In that case human beings would be "luminous" to mosquitos, when the temperature of the body is higher than that of the surrounding atmosphere. At the other end of the spectrum, some experts assert, there are reasons for believing that other organisms can "see" in the ultra-violet, where the human retina again refuses to respond. The claim has been made that not only fishes, but event ants and small Crustacea, may be able to see in the ultra-violet regions.

In spite of these differences between the human eye and the eyes of lower organisms, it seems to be generally agreed that the human eye, a relatively late product of biological evolution, is on the whole more effective as a visual instrument. And yet when we try to discover just what it is that constitutes this increased efficiency, we find it difficult to state the precise basis for such supposed superiority. In general we may say that the human eye is superior because it helps to give us a greater mastery over our material environment. We have secured this greater mastery because the human eye makes the best use of that which is at its disposal to be utilized. This is to say, since we regard vision as reaching its highest culmination in man, and since it is obvious that sight would be impossible without light acting as the adequate stimulus, any attempt at stating the direction of increased efficiency of visual evolution involves a consideration of how the eye could best use the available energy of sunlight.

Man, the lord of creation, functions normally in the daylight. The human eye will therefore function most efficiently in the sunlight if it is so equipped as to utilize most effectively the available energy of the sun's radiation. This idea has been clearly stated by Frederick Soddy in his article on "Rays" in the *Encyclopedia Britannica*. Professor Soddy states: "The surface temperature of the sun is estimated at about 6,000°C., and the maximum of energy emission at this temperature occurs at the yellow green. It is probably by no means mere coincidence that this is also the most vivid color, in the sense that light energy of this color is perceived by the eye in smaller amounts than that of any other. Probably the eye has adapted itself through the ages to make the most of that which there is the most of in the sun."

Another way of putting the same idea is to point out that there is a coincidence of the peak of the curve of the sun's radiation with the peak of the luminosity curve of the light-adapted eye. Recently G. I. Pokrowski[1] pointed out that this coincidence is not with the direct light of the sun, but with the spectrum of light *reflected* from the green leaves of plants in the environment. But this does not seem to call for any modification of Soddy's conclusion, but confirms it.

This problem of the explanation of the similarity oi the visibility curve of the human eye and the curve of the sun's radiation provided the occasion for a discussion in *Nature,* the English Weekly, several years ago. Sir John Parsons, an expert on visual science, came to a conclusion essentially identical with that of Soddy. In commenting upon the view of Sir John, Mr. T. Smith (*Nature,* 1928, p. 242) pointed out that the extension of vision into the longer and shorter wave lengths would be attended by the loss of sharpness of visual images. Both writers agree that *vision is now so constituted in human beings as to bring out as clearly as possible the sharpness of contours of bodies.*

This conclusion, while important, can hardly lay claim to novelty. It might be argued, for example, that Bergson had this idea in mind when he argued that the geometrizing intellect atomizes matter for purposes of action. The present writer[2] in 1925, taking his cue from Bergson, suggested the same interpretation of visual evolution: "In vision light has helped to build up the light-sensitive ele-

[1]*Physikalische Zeitschrift,* 1928, Vol. 29, p. 269.
[2]In *The Monist,* Vol. 35, p. 627.

ments in the retina, and, on the whole, the evolution of vision has gone in the direction of providing a mechanism for the sharpening of the meniscus between matter and the field [of energy] so that bodies take on sharper outlines."

We are now prepared to answer the question of why it is that the span of visible radiation is so narrow, why the human eye responds to but one octave, and why the visibility curve tapers off towards the longer and the shorter rays in the way it does. One answer is that if we saw more colors we would have to go outside the limits of the visible spectrum to find them (since the spectrum from red to violet is now filled with all the colors of the rainbow), and as we move outward from the yellow towards the opposite ends the amount of radiation which reaches the earth from the sun becomes less and less. This answer is entirely consistent with the statement that if we saw more colors we would have to sacrifice the apparent sharpness of outlines of bodies, which has hitherto been of advantage to organisms in the struggle for existence.

It will be observed that this conclusion does not deny that under special conditions (those not normal to us) vision in other regions would be advantageous to organisms. Thus in foggy conditions, or at night for mosquitos, vision in the infra-red might be of advantage to organisms. In foggy conditions photographic plates sensitive to the infra-red rays produce clearer images than does ordinary photography. But the point for us here is that human beings do not normally live in foggy atmospheres, and hence nature has not provided for this exceptional circumstance—though the inhabitants of London and Pittsburgh might feel that nature has not been as generous as she might, since she has not equipped the inhabitants of these cities with special infra-red visual mechanisms. If, in the course of time, the sun should cool down, vision might adapt itself accordingly, as Soddy indicates in the article previously referred to. In those days, as he says, "the people, if any were still alive, would see red most vividly. Our violet would have faded out and become ultra-violet, and our infra-red heat rays would become visible as light." But perhaps we will not have to rely upon the uncertain generosity of nature to produce this change in vision. Perhaps the technique for the production of mutations by exposure to X-rays (or some other frequencies) will then have been developed to the point where the biologist can make eyes to order! On the other hand, students working with the microscope find that they can sometimes get better results looking at small objects if they use ultra-violet rays rather than visible light. But human beings in normal circumstances do not have to react to microscopic objects, and hence nature has not provided for this circumstance.

And now we return to the problem of reality. What a significance does this evolution of vison have for the formulation of scientific and philosophical theories of reality? Is there any positive relation between the evolution of of vision and visions of evolution?

In the preceding argument we have emphasized the importance of vision in the *physical* orientation of organisms to their environment. Man is a space-eater by virtue of the dominance of vision. True it is that the eye selects out but a small sector of the total range of frequencies of radiation, but what a tremendously valuable band this is to man in his attempts at mastering his cosmic environment! And surely it does not require any prolonged argument to show that our *intellectual* interpretations of naure are also to a large extent dependent upon visual experience. In many ways we have our attention called to the central importance of sight and visual imaginery in the formulation of scientific doctrines. For example, explanation in science is usually supposed to consist in drawing a pictorial representation of the phenomenon to an understood. Here is the way we proceed.

We live our lives somewhere between the infinitely little and the infinitely great. Our sense organs, particularly the eyes, have been evolved so that objects in this middle scale universe will possess definite contours, or sharp outlines. If we want to know what the nature of the things lying on either side of us may be, in the micro-universes beneath us or in the macro-universes above us, we must imaginatively reconstruct our pictures from the forms and images that confront us in this middle scale universe, perceived through that little band of visible radiation transmitted by the way of the retina to the mind's eye. And then, by some kind of projective geometry of the mind, we draw in our imaginations the outlines of atomic solar systems and cosmic galaxies. And there's the rub! Our senses lead us astray, or at least are not reliable guides in these strange and unexplored regions. Our conceptual vision has been partially distorted by perceptual vision.

As we have seen, vision has evolved in such a fashion that the "atomicity" of matter has been accentuated. Is it not likely, therefore, that it was this reliance upon the validity of visual experience which led to the problems that have perplexed modern physical science? In support of this idea one illustration may be cited. Our eyes tell us that matter and empty space, in which the non-material waves of the various types of radiation are transmitted, have nothing in common; our brains have evolved around our eyes (or *vice versa*), and accordingly our thinking machinery has developed a logic of the physical world after the fashion of the engineer's notions. But now this world of intellectual constructions turns out to be wrong when applied to other reaches of reality.

In physics, the corpuscular notion of matter, of atoms made up of hard, impenetrable particles, inevitably supported the notion of 'force" as the active cause of the motions of the otherwise inert and passive material bodies made up of these atoms. This conceptual divorce between particles and energy (waves or radiation) undoubtedly illustrates the influence of perceptual experience in our thinking. But as the physicists are now telling us, this clear-cut distinction between waves and particles is breaking down. The physicist is therefore seeking to reconstruct his pictures, and in the new wave theory of matter the sharp opposition between particles and undulations is abandoned. But this calls for a rather radical modification of man's thinking processes. Eventually, however, another fossil of human intellectual evolution, the naive materialism which modern physical science inherited from Greek atomism, will take its place in the intellectual museum of deceased scientific doctrines.

But this very change in modes of thinking indicates that men are not entirely the victims of their senses. The situation was recently well summed up by Sir Jagadis Bose in these words: "Out of the imperfections of his senses man has built himself a raft of thought to venture into the sea of the unknown." And, we may add, the new regions explored from this raft of thought may be quite different from those with which we are already familiar. We are slowly emancipating ourselves from the engineer's constructions. We are beginning to see the way to correct some of the imaginative pictures which are the scaffolding of science. We are coming to see that the theoretical problems in some branches of natural science will be solved only after we unlearn some of the intellectual reactions that have been built up around perceptual experience. This conclusions appear to be in harmony with the view of Sir J. H. Jeans as summed up in his recent book, *The Mysterious Universe,* especially in the last chapter, "Into the Deep Waters." It is interesting to note that in this book (pp. 129-130 and p. 152), in oposition to the view that the multi-dimensional space required by wave mechanics for the more complicated physical events is but a clever mathematical dodge, Professor Jeans argues that, *e.g.,* a ten-dimensional space is no more real and no less real than our present three-dimensional space. The use of Cartesian geometry in physics is just as much a convention as the use of non-Cartesian coördinates or non-Euclidian geometry.

II. THE LOGICAL CONTRADICTIONS IN MODERN SCIENCE[3]

In the preceding pages we have seen how naive realism fails to provide for the fact of the relativity of reality as it arises out of the relation of the observer to the observed. We have also pointed out the apparently contradictory statements which science is forced to accept as a result of trying to transcend the limitations of sense experience in the field of foundational physical reality. However, the contradictions we have pointed to (the wave-particle opposition) is but one of a number of contradictions. In some respects these contradictions resemble the thesis-antithesis movement of the Hegelian dialectic, and,

[3]The present section consists of a further extension of ideas presented in the papers on "Mathematics and Emergent Evolution," in the *Monist,* Vol. XL, 1930, pp. 508-525, and "Gestalt Psychology and the Philosophy of Nature," *Philosophical Review,* Vol. 34, 1930, pp. 556-572.

taking Hegel's formula as a pattern, we may say that one of the major tasks of modern science is to discover the higher synthesis which reconciles present contradictions. For the sake of completeness let us set down the various antinomies we have referred to:

THESIS	ANTITHESIS
1. The electron is a corpuscle.	1. The electron is a wave phenomenon.
2. Radiation is undulatory (or non-corpuscular).	2. Radiation is corpuscular (or non-undulatory).
3. The ether exists.	3. The ether does not exist.
4. The ether is discrete.	4. The ether is continuous.
5. The velocity of light is constant.	5. The velocity of light is variable.
6. The earth gives rise to an electromagnetic field	6. The earth does not give rise to an electromagnetic field.
7. This solution is electro-negative.	7. This solution is not electro-negative.
8. This cortical neurone is active.	8. This cortical neurone is not active.
9. The color of this star is red.	9. The color of this star is not red.
10. The taste of this apple is sweet.	10. The taste of this apple is not sweet (sour).

Our proof for the thesis and the antithesis must in each case be brief.

The evidence for the first two sets of oppositions is a part of present physical knowledge. The evidence for the third antinomy is to be found in the theory of relativity (the ether does not exist) and the new wave mechanics, which employs the notion of a sub-ether, of which we will speak in a moment. The proof of the fourth antinomy may be found in the fact that both claims were made for the old ether, though in the present connection this antinomy is presupposed in the following pages in the definition (to be given later) which is employed. In the fifth antinomy the constancy of the velocity of light is an integral part of the theory of relativity, but, on the other hand, in the sub-ether of the new wave mechanics the velocity of radiation (in a super-dispersive medium) becomes variable and energy travels at velocities which become slower as the wave length is increased.[4] The proof for the statements in the sixth antinomy is given By A. S. Eddington in his book, *The Nature of the Physical World* (p. 22). The proof for the seventh antinomy is given by W. Koehler in his book, *Gestalt Psychology* (p. 218). The proof for the eighth antinomy is found in the results of S. H. Bartley[5] and E. B. Newman. Professor Bartley informs me that while psychologists are not yet done talking about certain sets of neurones doing this and certain other sets doing something else, results indicate that the same nervous tissue can be active and passive at the same time. Cerebral action currents are such only by virtue of a difference in potential at two points at a given time, and whether you will get such a current depends on where one electrode is with respect to the other on the brain. The proof for the ninth antinomy has been given in the earlier part of the present paper, and the proof for the tenth appears in another article by the author.[6] In general, Fechner's psycho-physical law is a law of psychological relativity, and in that respect is analogous to the law of diminishing utility (or returns) in economics.

One philosophical interpretation of these contradic-

[4]On this mattter see J. J. Thomson's *Beyond the Electron,* p. 14, G. P. Thomson's *The Atom* (Home University Library) pp. 185-186, and H. T. Flint's *Wave Mechanics,* p. 35.

[5]"Recording Cerebral Action Currents," *Science,* Vol. LXXI, 1930, p. 587.

[6]In the *Psychological Review,* Vol. 37, 1930, pp. 257-263.

tions is that they are the expression of the anthropomorphic character of scientific generalizations. That is to say, all scientific analyses of nature contain abstractions; the human element enters in the process of selection by which we study nature. Both pragmatism and idealism might well digest this modest and unoriginal conclusion, though a realistic philosophy might find it harder to assimilate.

But proceeding to further implications, our conclusion may point the way to more important consequences. What we have thus far suggested is that in reality nature contains more than any scientific statement or equation expresses, and in that sense transcends our intellectual abstractions. Every whole is a relative whole, contains subordinate parts, and is contained within a larger whole. Each whole is something more than the parts into which it is analyzed because analysis neglects the interstitial filling and wider context in which things are situated. In the case of the corpuscular-undulatory (discrete-continuous) opposition, nature does in fact contain both types of phenomena, but our analysis is unable to grasp in a single act of thought that wholeness in virtue of which both are relatively real.

Let us now pause for a moment to examine the psychology and the brain physiology which underlies the scientific theorizing which has led us into these contradictions. As is readily seen, our conclusion is in substantial agreement with that of Bergson when he tells us that the intellect atomizes. The concepts in terms of which we think are like the "figures" of Gestalt psychology, which stand out against their "grounds" because the energy of the figures enclosed within the boundaries is greater than that of the grounds. The interesting thing is, however, that while the intellect thus breaks up wholes into parts, it is inevitably driven to speculate about the binding forces which unify the parts. This intellectual transcendence of the terms of analysis (abstractions), by which the mind thus tries to envisage the wholes, must itself be the expression of some unifying agency within the brain of the thinker.

Our thesis is that in every intellectual analysis the whole vaguely precedes the parts and dimly foreshadows the conclusion, even though it does not explicitly enter into the conscious analysis. We have some independent evidence on the physiological side which indicates that this is true. Professor G. E. Coghill[7] has shown that in the development of reflexes the whole pattern precedes the parts, which are always differentiated out and articulated within the larger pattern (whole). If the physiology of brain development is similar to that of the development of reflexes (as Gestalt theory would lead us to expect), the whole pattern should determine the elements into which our scientific constructions are analyzed out. In our thinking we never reach the absolute whole towards which each inferior whole points, because mind is the process by which the incomplete strives towards completion. Mind is the temporal process as it tries to harmonize the part-processes with each other, as it strives to transcend the figure and the ground in a new Gestalt.

According to this view, the opposition between body and mind is paralleled on a lower level in the opposition between the corpuscular feature of the electron and the undulatory feature of the waves which show the electron where to go. In the human individual the transition from the objective (brain) to the subjective (consciousness)

[7] "The Genetic Interrelation of Instinctive Behavior and Reflexes," *Psychological Review*, Vol. 37, 1930, 264-266.

is a transition from the corpuscular to the undulatory, from the relatively discrete to the relatively continuous. It is obvious that from this point of view the terms "ether" and "mind' are supposed to refer to the same phenomenon. Let us enlarge upon this idea.

According to J. J. Thompson, each electron carries with it an ether in the form of waves, and these waves direct the motion of the electron. If we generalize this idea we come out with the conclusion that every material aggregate carries with it its own ether, in the sense that its behavior and motion are oriented along the lines or surfaces of potentials of which that ether is composed. That is to say, in so far as bodies exercise mutual influences upon each other they are bound together by an ether. Or better still, the ether is a name for the dynamic interaction of particles (or systems of particles), and represents the tendency of statistical ensembles to come to some common basis of functional pattern.

Consider, for example, a molecule of water. The aggregate of the molecular fields of force (ether) of many such H_2O molecules make possible a fluid, thus enabling the physicist to describe the behavior of the hydrodynamic whole in terms of differential equations, a mathematics of continuous quantities. Here, then, we have one type of ether. But the atoms also have a chemical affinity for each other. This means that the oxygen and hydrogen atoms are not indifferent to each other's presence, and the term ether is a name for this interaction. Thus "atomism" and "continuity" are relative terms, and it is the existence of an ether which makes possible this relativity. In accordance with our usage of the term, we may assert that in addition to the chemical ether and the molar ether there is the ether associated with organic systems. In the case of human beings this manifests itself as a "mental" ether. There appears to be no way of representing in a three-dimensional universe the properties of psychic life. Consciousness appears to be a new dimension; it may lie outside such a three-dimensional continuum, as Dr. Jeans suggests (*op. cit.,* p. 133), so that we should not make the mistake of trying to force happenings which occur in many dimensions into a smaller number of dimensions. Such a dimension (or dimensions) must be supplementary to the four-dimensional manifold of relativity in the same way in which the time coördinate of the Einsteinian continuum is the fourth dimension. In every case, for us, the time dimension, which binds the aggregates of a certain manifold together, is the ether of that manifold and represents its mind.

This multiplication of ethers will prove repugnant to those who are familiar with the viciousness of this type of thinking as it has recurred in the history of physics. If it helps, the terms gravitational field, electromagnetic field, etc., can be substituted. But it must be remembered that the notion of an ether cannot be used as an ultimate explanation; it is here used as a name for an empirical fact (a level of dynamic interaction of parts), which cannot at present be explained, because macroscopic Gestalten are not deducible from the sum of the properties of the parts (or sub-Gestalten.) Our former mode of statement, that *energy is the soul of matter,* was our way of summarising what Dr. S. Alexander seems to mean when he states that *time is the mind of space.* This view also appears to be in harmony with the suggestions of Dr. Jeans (*op. cit.*) when he tells us (p. 129) that "time figures as the mortar which binds the bricks of matter together much as, on the spiritual plane, the 'windowless monads' of Leibniz were bound together by the universal mind. Or, perhaps with a nearer aproach to actuality, we may think of the electrons as objects of thought, and time as the process of thinking," and Jeans suggests (p. 155) that "so little do we understand time that perhaps we ought to compare the whole of time to the act of creation, the materialization of thought."

At this point it becomes clear that while in some respects the present view is based upon relativity, there is another respect in which our theory of reality is out of harmony with a thoroughgoing relativity, in that we reject that version of relativity which in every case would substitute the notion of "local" time (and a complete relativity of all types of change) for the notion of absolute time and motion. It is here admitted that for certain types of motion relativity is the last word. Bu there are other types of motion (change) which may well lie outside this type of relativity. Let us get the various types of movement in mind:

- Types of Change
  - Motion
    - Translatory
      - Curvilinear
      - Rectilinear
    - Rotary
    - Vibratory and Undulatory
  - Growth

From our point of view, growth, which is one type of change involving progress through space and time, is always the expression of a movement along the time-axis, but the test of such growth (in the direction of increased complexity of parts and interdependence of function) is not relative in the sense in which translatory (or even rotary) motion is relative. The working out of the implications of this view would involve a complete theory of evolution (inorganic and organic), and even if such a synthesis were possible this would not be the proper occasion to present it.

ADDENDUM

To the foregoing reference to the doctrine of wave mechanics the following lines are added for purposes of clarification.

According to the latest ideas everything in this universe which is of a physical nature consists of waves. There are two kinds of waves, called *group waves* and *constituent waves.* Physical objects are sets of group waves, which have relatively slow velocities varying from the lower limit of zero to the upper limit of the velocity of light. Constituent waves have velocities higher than that of the velocity of light. The group waves possess all the energy and are what we perceive; the constituent waves, though they possess no energy, direct the behavior of the group waves and are imperceptible.

According to de Broglio the waves that guide the electron do not travel at the speed of light, but faster. In other words, the slower the group waves the faster the consituent waves. That is, if U is the velocity of the group waves and v the velocity of the constituent waves, then

$Uv = c^2$, where c is the velocity of light.

Since the medium required for wave mechanics is one in which waves travel at velocities which become slower as the wave length is increased, the old fashioned ether will not supply the demand. A sub-ether is therefore postulated having the required properties. It must be noted that this qualification to the doctrine of the constancy of the velocity of light does not contradict the theory of relativity in this circumstance.

In an article on the "Interaction of Life and Matter" (*Hibbert Journal,* April, 1931) Sir Oliver Lodge proposes to add to the physicist's conception of the electric and magnetic fields of force the notion of a "biological field," which would provide the physical medium whereby life and mind (themselves not material) would operate on and direct material particles. This dualism between the "field" and "corpuscles" arises out of the distinction between *form waves* (called constituent waves above) and *group waves.* Sir Oliver states that if either of these is more ultimate it is the form waves, for group waves (or particles) are due to the superposition of a set of form waves and in this respect are analogous to "beats" in music. The peculiarity of these form waves (Schroedinger's *psi* waves) is that they exert a controlling influence on matter without imparting energy. Thus we have at least a possible mechanism for understanding how life and mind may employ a bio-field to act on matter, thus functioning as directive agencies which do not upset the laws of mechanics.

In reviewing Sir Oliver Lodge's book, *Beyond Physics,* where the same idea is expounded, Professor F. C. S. Northrup asserts that Lodge is on the right path to find the solution to the mind-body problem. Recently Sir J. H. Jeans has also proposed that the wave-particle opposition is similar to the objective-subjective disjunction. The writer would like to point out the similarity of these ideas to his own view, except that for him the subjective is paired off with the relatively continuous aspect of the constituent waves directing the behavior of the group waves (matter).

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