Creative Evolution

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In the Authorized Translation

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CHAPTER I

THE EVOLUTION OF LIFE—MECHANISM AND TELEOLOGY

THE existence of which we are most assured and which we know best is unquestionably our own, for of every other object we have notions which may be considered external and superficial, whereas, of ourselves, our perception is internal and profound. What, then, do we find? In this privileged case, what is the precise meaning of the word "exist"? Let us recall here briefly the conclusions of an earlier work.

I find, first of all, that I pass from state to state. I am warm or cold, I am merry or sad, I work or I do nothing, I look at what is around me or I think of something else. Sensations, feelings, volitions, ideas—such are the changes into which my existence is divided and which color it in turns. I change, then, without ceasing. But this is not saying enough. Change is far more radical than we are at first inclined to suppose.

For I speak of each of my states as if it formed a block and were a separate whole. I say indeed that I change, but the change seems to me to reside in the passage from one state to the next: of each state, taken separately, I am apt to think that it remains the same during all the time that it prevails. Nevertheless, a slight effort of attention would reveal to me that there is no feeling, no idea, no volition which is not undergoing change every moment: if a mental state ceased to vary, its duration would cease to flow. Let us take the most stable of internal states, the visual perception of a motionless external object. The object may remain the same, I may look at it from the same side, at the same angle, in the same light; nevertheless the vision I now have of it differs from that which I have just had, even if only because the one is an instant older than the other. My memory is there, which conveys something of the past into the present. My mental state, as it advances on the road of time, is continually swelling with the duration which it accumulates: it goes on increasing—rolling upon itself, as a snowball on the snow. Still more is this the case with states more deeply internal, such as sensations, feelings, desires, etc., which do not correspond, like a simple visual perception, to an unvarying external object. But it is expedient to disregard this uninterrupted change, and to notice it only when it becomes sufficient to impress a new attitude on the body, a new direction on the attention. Then, and then only, we find that our state has changed. The truth is that we change without ceasing, and that the state itself is nothing but change.

This amounts to saying that there is no essential difference between passing from one state to another and persisting in the same state. If the state which "remains the same" is more varied than we think, on the other hand the passing from one state to another resembles, more than we imagine, a single state being prolonged; the transition is continuous. But, just because we close our eyes to the unceasing variation of every psychical state, we are obliged, when the change has become so considerable as to force itself on our attention, to speak as if a new state were placed alongside the previous one. Of this new state we assume that it remains unvarying in its turn, and so on endlessly. The apparent discontinuity of the psychical life is then due to our attention being fixed on it by a series of separate acts: actually there is only a gentle slope; but in following the broken line of our acts of attention, we think we perceive separate steps. True, our psychic life is full of the unforeseen. A thousand incidents arise, which seem to be cut off from those which precede them, and to be disconnected from those which follow. Discontinuous though they appear, however, in point of fact they stand out against the continuity of a background on which they are designed, and to which indeed they owe the intervals that separate them; they are the beats of the drum which break forth here and there in the symphony. Our attention fixes on them because they interest it more, but each of them is borne by the fluid mass of our whole psychical existence. Each is only the best illuminated point of a moving zone which comprises all that we feel or think or will—all, in short, that we are at any given moment. It is this entire zone which in reality makes up our state. Now, states thus defined cannot be regarded as distinct elements. They continue each other in an endless flow.

But, as our attention has distinguished and separated them artificially, it is obliged next to reunite them by an artificial bond. It imagines, therefore, a formless *ego*, indifferent and unchangeable, on which it threads the psychic states which it has set up as independent entities. Instead of a flux of fleeting shades merging into each other, it perceives distinct and, so to speak, *solid* colors, set side by side like the beads of a necklace; it must perforce then suppose a thread, also itself solid, to hold the beads together. But if this colorless substratum is perpetually colored by that which covers it, it is for us, in its indeterminateness, as if it did not exist, since we only perceive what is colored, or, in other words, psychic states. As a matter of fact, this substratum has no reality; it is merely a symbol intended to recall unceasingly to our consciousness the artificial character of the process by which the attention places clean-cut states side by side, where actually there is a continuity which unfolds. If our existence were composed of separate states with an impassive ego to unite them, for us there would be no duration. For an ego which does not change does not *endure*, and a psychic state which remains the same so long as it is not replaced by the following state does not *endure* either. Vain, therefore, is the attempt to range such states beside each other on the ego supposed to sustain them: never can these solids strung upon a solid make up that duration which flows. What we actually obtain in this way is an artificial imitation of the internal life, a static equivalent which well lend itself better to the requirements of logic and language, just because we have eliminated from it the element of real time. But, as regards the psychical life unfolding beneath the symbols which conceal it, we readily perceive that time is just the stuff it is made of.

There is, moreover, no stuff more resistant nor more substantial. For our duration is not merely one instant replacing another; if it were, there would never be anything but the present—no prolonging of the past into the actual, no evolution, no concrete duration. Duration is the continuous progress of the past which gnaws into the future and which swells as it advances. And as the past grows without ceasing, so also there is no limit to its preservation. Memory, as we have tried to prove,[1] is not a faculty of putting away recollections in a drawer, or of inscribing them in a register. There is no register, no drawer; there is not even, properly speaking, a faculty, for a faculty works intermittently, when it will or when it can, whilst the piling up of the past upon the past goes on without relaxation. In reality, the past is preserved by itself, automatically. In its entirety, probably, it follows us at every instant; all that we have felt, thought and willed from our earliest infancy is there, leaning over the present which is about to join it, pressing against the portals of consciousness that would fain leave it outside. The cerebral mechanism is arranged just so as to drive back into the unconscious almost the whole of this past, and to admit beyond the threshold only that which can cast light on the present situation or further the action now being prepared—in short, only that which can give *useful* work. At the most, a few superfluous recollections may succeed in smuggling themselves through the half-open door. These memories, messengers from the unconscious, remind us of what we are dragging behind us unawares. But, even though we may have no distinct idea of it, we feel vaguely that our past remains present to us. What are we, in fact, what is our *character*, if

[1] *Matière et mémoire*, Paris, 1896, chaps. ii. and iii.

not the condensation of the history that we have lived from our birth—nay, even before our birth, since we bring with us prenatal dispositions? Doubtless we think with only a small part of our past, but it is with our entire past, including the original bent of our soul, that we desire, will and act. Our past, then, as a whole, is made manifest to us in its impulse; it is felt in the form of tendency, although a small part of it only is known in the form of idea.

From this survival of the past it follows that consciousness cannot go through the same state twice. The circumstances may still be the same, but they will act no longer on the same person, since they find him at a new moment of his history. Our personality, which is being built up each instant with its accumulated experience, changes without ceasing. By changing, it prevents any state, although superficially identical with another, from ever repeating it in its very depth. That is why our duration is irreversible. We could not live over again a single moment, for we should have to begin by effacing the memory of all that had followed. Even could we erase this memory from our intellect, we could not from our will.

Thus our personality shoots, grows and ripens without ceasing. Each of its moments is something new added to what was before. We may go further: it is not only something new, but something unforeseeable. Doubtless, my present state is explained by what was in me and by what was acting on me a moment ago. In analyzing it I should find no other elements. But even a superhuman intelligence would not have been able to foresee the simple indivisible form which gives to these purely abstract elements their concrete organization. For to foresee consists of projecting into the future what has been perceived in the past, or of imagining for a later time a new grouping, in a new order, of elements already perceived. But that which has never been perceived, and which is at the same time simple, is necessarily unforeseeable. Now such is the case with each of our states, regarded as a moment in a history that is gradually unfolding: it is simple, and it cannot have been already perceived, since it concentrates in its indivisibility all that has been perceived and what the present is adding to it besides. It is an original moment of a no less original history.

The finished portrait is explained by the features of the model, by the nature of the artist, by the colors spread out on the palette; but, even with the knowledge of what explains it, no one, not even the artist, could have foreseen exactly what the portrait would be, for to predict it would have been to produce it before it was produced—an absurd hypothesis which is its own refutation. Even so with regard to the moments of our life, of which we are the artisans. Each of them is a kind of creation. And just as the talent of the painter is formed or deformed—in any case, is modified—under the very influence of the works he produces, so each of our states, at the moment of its issue, modifies our personality, being indeed the new form that we are just assuming. It is then right to say that what we do depends on what we are; but it is necessary to add also that we are, to a certain extent, what we do, and that we are creating ourselves continually. This creation of self by self is the more complete, the more one reasons on what one does. For reason does not proceed in such matters as in geometry, where impersonal premises are given once for all, and an impersonal conclusion must perforce be drawn. Here, on the contrary, the same reasons may dictate to different persons, or to the same person at different moments, acts profoundly different, although equally reasonable. The truth is that they are not quite the same reasons, since they are not those of the same person, nor of the same moment. That is why we cannot deal with them in the abstract, from outside, as in geometry, nor solve for another the problems by which he is faced in life. Each must solve them from within, on his own account. But we need not go more deeply into this. We are seeking only the precise meaning that our consciousness gives to this word "exist," and we find that, for a conscious being, to exist is to change, to change is to mature, to mature is to go on creating oneself endlessly. Should the same be said of existence in general?

A material object, of whatever kind, presents opposite characters to those which we have just been describing. Either it remains as it is, or else, if it changes under the influence of an external force, our idea of this change is that of a displacement of parts which themselves do not change. If these parts took to changing, we should split them up in their turn. We should thus descend to the molecules of which the fragments are made, to the atoms that make up the molecules, to the corpuscles that generate the atoms, to the "imponderable" within which the corpuscle is perhaps a mere vortex. In short, we should push the division or analysis as far as necessary. But we should stop only before the unchangeable.

Now, we say that a composite object changes by the displacement of its parts. But when a part has left its position, there is nothing to prevent its return to it. A group of elements which has gone through a state can therefore always find its way back to that state, if not by itself, at least by means of an external cause able to restore everything to its place. This amounts to saying that any state of the group may be repeated as often as desired, and consequently that the group does not grow old. It has no history.

Thus nothing is created therein, neither form nor matter. What the group will be is already present in what it is, provided "what it is" includes all the points of the universe with which it is related. A superhuman intellect could calculate, for any moment of time, the position of any point of the system in space. And as there is nothing more in the form of the whole than the arrangement of its parts, the future forms of the system are theoretically visible in its present configuration.

All our belief in objects, all our operations on the systems that science isolates, rest in fact on the idea that time does not bite into them. We have touched on this question in an earlier work, and shall return to it in the course of the present study. For the moment, we will confine ourselves to pointing out that the abstract time *t* attributed by science to a material object or to an isolated system consists only in a certain number of simultaneities or more generally of correspondences, and that this number remains the same, whatever be the nature of the intervals between the correspondences. With these intervals we are never concerned when dealing with inert matter; or, if they are considered, it is in order to count therein fresh correspondences, between which again we shall not care what happens. Common sense, which is occupied with detached objects, and also science, which considers isolated systems, are concerned only with the ends of the intervals and not with the intervals themselves. Therefore the flow of time might assume an infinite rapidity, the entire past, present, and future of material objects or of isolated systems might be spread out all at once in space, without there being anything to change either in the formulae of the scientist or even in the language of common sense. The number *t* would always stand for the same thing; it would still count the same number of correspondences between the states of the objects or systems and the points of the line, ready drawn, which would be then the "course of time."

Yet succession is an undeniable fact, even in the material world. Though our reasoning on isolated systems may imply that their history, past, present and future, might be instantaneously unfurled like a fan, this history, in point of fact, unfolds itself gradually, as if it occupied a duration like our own. If I want to mix a glass of sugar and water, I must, willy-nilly, wait until the sugar melts. This little fact is big with meaning. For here the time I have to wait is not that mathematical time which would apply equally well to the entire history of the material world, even if that history were spread out instantaneously in space. It coincides with my impatience, that is to say, with a certain portion of my own duration, which I cannot protract or contract as I like. It is no longer something *thought*, it is something *lived*. It is no longer a relation, it is an absolute. What else can this mean than that the glass of water, the sugar, and the process of the sugar's melting in the water are abstractions, and that the Whole within which they have been cut out by my senses and understanding progresses, it may be in the manner of a consciousness?

Certainly, the operation by which science isolates and closes a system is not altogether artificial. If it had no objective foundation, we could not explain why it is clearly indicated in some cases and impossible in others. We shall see that matter has a tendency to constitute *isolable* systems, that can be treated geometrically. In fact, we shall define matter by just this tendency. But it is only a tendency. Matter does not go to the end, and the isolation is never complete. If science does go to the end and isolate completely, it is for convenience of study; it is understood that the so-called isolated system remains subject to certain external influences. Science merely leaves these alone, either because it finds them slight enough to be negligible, or because it intends to take them into account later on. It is none the less true that these influences are so many threads which bind up the system to another more extensive, and to this a third which includes both, and so on to the system most objectively isolated and most independent of all, the solar system complete. But, even here, the isolation is not absolute. Our sun radiates heat and light beyond the farthest planet. And, on the other hand, it moves in a certain fixed direction, drawing with it the planets and their satellites. The thread attaching it to the rest of the universe is doubtless very tenuous. Nevertheless it is along this thread that is transmitted down to the smallest particle of the world in which we live the duration immanent to the whole of the universe.

The universe *endures*. The more we study the nature of time, the more we shall comprehend that duration means invention, the creation of forms, the continual elaboration of the absolutely new. The systems marked off by science *endure* only because they are bound up inseparably with the rest of the universe. It is true that in the universe itself two opposite movements are to be distinguished, as we shall see later on, "descent" and "ascent." The first only unwinds a roll ready prepared. In principle, it might be accomplished almost instantaneously, like releasing a spring. But the ascending movement, which corresponds to an inner work of ripening or creating, *endures* essentially, and imposes its rhythm on the first, which is inseparable from it.

There is no reason, therefore, why a duration, and so a form of existence like our own, should not be attributed to the systems that science isolates, provided such systems are reintegrated into the Whole. But they must be so reintegrated. The same is even more obviously true of the objects cut out by our perception. The distinct outlines which we see in an object, and which give it its individuality, are only the design of a certain kind of *influence* that we might exert on a certain point of space: it is the plan of our eventual actions that is sent back to our eyes, as though by a mirror, when we see the surfaces and edges of things. Suppress this action, and with it consequently those main directions which by perception are traced out for it in the entanglement of the real, and the individuality of the body is reabsorbed in the universal interaction which, without doubt, is reality itself.

Now, we have considered material objects generally. Are there not some objects privileged? The bodies we perceive are, so to speak, cut out of the stuff of nature by our *perception*, and the scissors follow, in some way, the marking of lines along which *action* might be taken. But the body which is to perform this action, the body which marks out upon matter the design of its eventual actions even before they are actual, the body that has only to point its sensory organs on the flow of the real in order to make that flow crystallize into definite forms and thus to create all the other bodies—in short, the *living* body—is this a body as others are?

Doubtless it, also, consists in a portion of extension bound up with the rest of extension, an intimate part of the Whole, subject to the same physical and chemical laws that govern any and every portion of matter. But, while the subdivision of matter into separate bodies is relative to our perception, while the building up of closed-off systems of material points is relative to our science, the living body has been separated and closed off by nature herself. It is composed of unlike parts that complete each other. It performs diverse functions that involve each other. It is an *individual*, and of no other object, not even of the crystal, can this be said, for a crystal has neither difference of parts nor diversity of functions. No doubt, it is hard to decide, even in the organized world, what is individual and what is not.

The difficulty is great, even in the animal kingdom; with plants it is almost insurmountable. This difficulty is, moreover, due to profound causes, on which we shall dwell later. We shall see that individuality admits of any number of degrees, and that it is not fully realized anywhere, even in man. But that is no reason for thinking it is not a characteristic property of life. The biologist who proceeds as a geometrician is too ready to take advantage here of our inability to give a precise and general definition of individuality. A perfect definition applies only to a *completed* reality; now, vital properties are never entirely realized, though always on the way to become so; they are not so much *states* as *tendencies*. And a tendency achieves all that it aims at only if it is not thwarted by another tendency. How, then, could this occur in the domain of life, where, as we shall show, the interaction of antagonistic tendencies is always implied? In particular, it may be said of individuality that, while the tendency to individuate is everywhere present in the organized world, it is everywhere opposed by the tendency toward reproduction. For the individuality to be perfect, it would be necessary that no detached part of the organism could live separately. But then reproduction would be impossible. For what is reproduction, but the building up of a new organism with a detached fragment of the old? Individuality therefore harbors its enemy at home. Its very need of perpetuating itself in time condemns it never to be complete in space. The biologist must take due account of both tendencies in every instance, and it is therefore useless to ask him for a definition of individuality that shall fit all cases and work automatically.

But too often one reasons about the things of life in the same way as about the conditions of crude matter. Nowhere is the confusion so evident as in discussions about individuality. We are shown the stumps of a Lumbriculus, each regenerating its head and living thenceforward as an independent individual; a hydra whose pieces become so many fresh hydras; a sea-urchin's egg whose fragments develop complete embryos: where then, we are asked, was the individuality of the egg, the hydra, the worm?—But, because there are several individuals now, it does not follow that there was not a single individual just before. No doubt, when I have seen several drawers fall from a chest, I have no longer the right to say that the article was all of one piece. But the fact is that there can be nothing more in the present of the chest of drawers than there was in its past, and if it is made up of several different pieces now, it was so from the date of its manufacture. Generally speaking, unorganized bodies, which are what we have need of in order that we may act, and on which we have modeled our fashion of thinking, are regulated by this simple law: *the present contains nothing more than the past, and what is found in the effect was already in the cause.* But suppose that the distinctive feature of the organized body is that it grows and changes without ceasing, as indeed the most superficial observation testifies, there would be nothing astonishing in the fact that it was *one* in the first instance, and afterwards *many*. The reproduction of unicellular organisms consists in just this—the living being divides into two halves, of which each is a complete individual. True, in the more complex animals, nature localizes in the almost independent sexual cells the power of producing the whole anew. But something of its power may remain diffused in the rest of the organism, as the facts of regeneration prove, and it is conceivable that in certain privileged cases the faculty may persist integrally in a latent condition and manifest itself on the first opportunity. In truth, that I may have the right to speak of individuality, it is not necessary that the organism should be without the power to divide into fragments that are able to live. It is sufficient that it should have presented a certain systematization of parts before the division, and that the same systematization tend to be reproduced in each separate portion afterwards. Now, that is precisely what we observe in the organic world. We may conclude, then, that individuality is never perfect, and that it is often difficult, sometimes impossible, to tell what is an individual, and what is not, but that life nevertheless manifests a search for individuality, as if it strove to constitute systems naturally isolated, naturally closed.

By this is a living being distinguished from all that our perception or our science isolates or closes artificially. It would therefore be wrong to compare it to an *object*. Should we wish to find a term of comparison in the inorganic world, it is not to a determinate material object, but much rather to the totality of the material universe that we ought to compare the living organism. It is true that the comparison would not be worth much, for a living being is observable, whilst the whole of the universe is constructed or reconstructed by thought. But at least our attention would thus have been called to the essential character of organization. Like the universe as a whole, like each conscious being taken separately, the organism which lives is a thing that *endures*. Its past, in its entirety, is prolonged into its present, and abides there, actual and acting. How otherwise could we understand that it passes through distinct and well-marked phases, that it changes its age—in short, that it has a history? If I consider my body in particular, I find that, like my consciousness, it matures little by little from infancy to old age; like myself, it grows old. Indeed, maturity and old age are, properly speaking, attributes only of my body; it is only metaphorically that I apply the same names to the corresponding changes of my conscious self. Now, if I pass from the top to the bottom of the scale of living beings, from one of the most to one of the least differentiated, from the multicellular organism of man to the unicellular organism of the Infusorian, I find, even in this simple cell, the same process of growing old. The Infusorian is exhausted at the end of a certain number of divisions, and though it may be possible, by modifying the environment, to put off the moment when a rejuvenation by conjugation becomes necessary, this cannot be indefinitely postponed.[1] It is true that between these two extreme cases, in which the organism is completely individualized, there might be found a multitude of others in which the individuality is less well marked, and in which, although there is doubtless an aging somewhere, one cannot say exactly what it is that grows old. Once more, there is no universal biological law which applies

[1] Calkins, *Studies on the Life History of Protozoa* (*Archiv f. Entwicklungsmechanik*, vol. xv., 1903, pp. 139-186).

precisely and automatically to every living thing. There are only *directions* in which life throws out species in general. Each particular species, in the very act by which it is constituted, affirms its independence, follows its caprice, deviates more or less from the straight line, sometimes even remounts the slope and seems to turn its back on its original direction. It is easy enough to argue that a tree never grows old, since the tips of its branches are always equally young, always equally capable of engendering new trees by budding. But in such an organism—which is, after all, a society rather than an individual—*something* ages, if only the leaves and the interior of the trunk. And each cell, considered separately, evolves in a specific way. *Wherever anything lives, there is, open somewhere, a register in which time is being inscribed.*

This, it will be said, is only a metaphor.—It is of the very essence of mechanism, in fact, to consider as metaphorical every expression which attributes to time an effective action and a reality of its own. In vain does immediate experience show us that the very basis of our conscious existence is memory, that is to say, the prolongation of the past into the present, or, in a word, *duration,* acting and irreversible. In vain does reason prove to us that the more we get away from the objects cut out and the systems isolated by common sense and by science and the deeper we dig beneath them, the more we have to do with a reality which changes as a whole in its inmost states, as if an accumulative memory of the past made it impossible to go back again. The mechanistic instinct of the mind is stronger than reason, stronger than immediate experience. The metaphysician that we each carry unconsciously within us, and the presence of which is explained, as we shall see later on, by the very place that man occupies amongst the living beings, has its fixed requirements, its ready-made explanations, its irreducible propositions: all unite in denying concrete duration. Change *must* be reducible to an arrangement or rearrangement of parts; the irreversibility of time *must* be an appearance relative to our ignorance; the impossibility of turning back *must* be only the inability of man to put things in place again. So growing old can be nothing more than the gradual gain or loss of certain substances, perhaps both together. Time is assumed to have just as much reality for a living being as for an hour-glass, in which the top part empties while the lower fills, and all goes where it was before when you turn the glass upside down.

True, biologists are not agreed on what is gained and what is lost between the day of birth and the day of death. There are those who hold to the continual growth in the volume of protoplasm from the birth of the cell right on to its death.[1] More probable and more profound is the theory according to which the diminution bears on the quantity of nutritive substance contained in that "inner environment" in which the organism is being renewed, and the increase on the quantity of unexcreted residual substances which, accumulating in the body, finally "crust it over." [2] Must we however—with

[1] Sedgwick Minot, *On Certain Phenomena of Growing Old* (*Proc. Amer. Assoc. for the Advancement of Science*, 39th Meeting, Salem, 1891, pp. 271-288).

[2] Le Dantec, *L'Individualité et l'erreur individualiste*, Paris, 1905, pp. 84 ff.

an eminent bacteriologist—declare any explanation of growing old insufficient that does not take account of phagocytosis?[1] We do not feel qualified to settle the question. But the fact that the two theories agree in affirming the constant accumulation or loss of a certain kind of matter, even though they have little in common as to what is gained and lost, shows pretty well that the frame of the explanation has been furnished *a priori.* We shall see this more and more as we proceed with our study: it is not easy, in thinking of time, to escape the image of the hour-glass.

The cause of growing old must lie deeper. We hold that there is unbroken continuity between the evolution of the embryo and that of the complete organism. The impetus which causes a living being to grow larger, to develop and to age, is the same that has caused it to pass through the phases of the embryonic life. The development of the embryo is a perpetual change of form. Anyone who attempts to note all its successive aspects becomes lost in an infinity, as is inevitable in dealing with a continuum. Life does but prolong this prenatal evolution. The proof of this is that it is often impossible for us to say whether we are dealing with an organism growing old or with an embryo continuing to evolve; such is the case, for example, with the larvae of insects and crustacea. On the other hand, in an organism such as our own, crises like puberty or the menopause, in which the individual is completely transformed, are quite comparable to changes in the course of larval or

[1] Metchnikoff, *La Dégénérescence sénile* (*Année biologique*, iii., 1897, pp. 249 ff.). Cf. by the same author, *La Nature humaine*, Paris, 1903, pp. 312 ff.

embryonic life—yet they are part and parcel of the process of our aging. Although they occur at a definite age and within a time that may be quite short, no one would maintain that they appear then *ex abrupto*, from without, simply because a certain age is reached, just as a legal right is granted to us on our one-and-twentieth birthday. It is evident that a change like that of puberty is in course of preparation at every instant from birth, and even before birth, and that the aging up to that crisis consists, in part at least, of this gradual preparation. In short, what is properly vital in growing old is the insensible, infinitely graduated, continuance of the change of form. Now, this change is undoubtedly accompanied by phenomena of organic destruction: to these, and to these alone, will a mechanistic explanation of aging be confined. It will note the facts of sclerosis, the gradual accumulation of residual substances, the growing hypertrophy of the protoplasm of the cell. But under these visible effects an inner cause lies hidden. The evolution of the living being, like that of the embryo, implies a continual recording of duration, a persistence of the past in the present, and so an appearance, at least, of organic memory.

The present state of an unorganized body depends exclusively on what happened at the previous instant; and likewise the position of the material points of a system defined and isolated by science is determined by the position of these same points at the moment immediately before. In other words, the laws that govern unorganized matter are expressible, in principle, by differential equations in which time (in the sense in which the mathematician takes this word) would play the role of independent variable. Is it so with the laws of life? Does the state of a living body find its complete explanation in the state immediately before? Yes, if it is agreed *a priori* to liken the living body to other bodies, and to identify it, for the sake of the argument, with the artificial systems on which the chemist, physicist and astronomer operate. But in astronomy, physics and chemistry the proposition has a perfectly definite meaning: it signifies that certain aspects of the present, important for science, are calculable as functions of the immediate past. Nothing of the sort in the domain of life. Here calculation touches, at most, certain phenomena of organic *destruction*. Organic *creation*, on the contrary, the evolutionary phenomena which properly constitute life, we cannot in any way subject to a mathematical treatment. It will be said that this impotence is due only to our ignorance. But it may equally well express the fact that the present moment of a living body does not find its explanation in the moment immediately before, that *all* the past of the organism must be added to that moment, its heredity—in fact, the whole of a very long history. In the second of these two hypotheses, not in the first, is really expressed the present state of the biological sciences, as well as their direction. As for the idea that the living body might be treated by some superhuman calculator in the same mathematical way as our solar system, this has gradually arisen from a metaphysic which has taken a more precise form since the physical discoveries of Galileo, but which, as we shall show, was always the natural metaphysic of the human mind. Its apparent clearness, our impatient desire to find it true, the enthusiasm with which so many excellent minds accept it without proof —all the seductions, in short, that it exercises on our thought, should put us on our guard against it. The attraction it has for us proves well enough that it gives satisfaction to an innate inclination. But, as will be seen further on, the intellectual tendencies innate today, which life must have created in the course of its evolution, are not at all meant to supply us with an explanation of life: they have something else to do.

Any attempt to distinguish between an artificial and a natural system, between the dead and the living, runs counter to this tendency at once. Thus it happens that we find it equally difficult to imagine that the organized has duration and that the unorganized has not. When we say that the state of an artificial system depends exclusively on its state at the moment before, does it not seem as if we were bringing time in, as if the system had something to do with real duration? And, on the other hand, though the whole of the past goes into the making of the living being's present moment, does not organic memory press it into the moment immediately before the present, so that the moment immediately before becomes the sole cause of the present one?—To speak thus is to ignore the cardinal difference between *concrete* time, along which a real system develops, and that *abstract* time which enters into our speculations on artificial systems. What does it mean, to say that the state of an artificial system depends on what it was at the moment immediately before? There is no instant immediately before another instant; there could not be, any more than there could be one mathematical point touching another. The instant "immediately before" is, in reality, that which is connected with the present instant by the interval *dt*. All that you mean to say, therefore, is that the present state of the system is defined by equations into which differential coefficients enter, such as $ds|dt$, $dv|dt$, that is to say, at bottom, *present* velocities and *present* accelerations. You are therefore really speaking only of the present—a present, it is true, considered along with its *tendency*. The systems science works with are, in fact, in an instantaneous present that is always being renewed; such systems are never in that real, concrete duration in which the past remains bound up with the present. When the mathematician calculates the future state of a system at the end of a time t, there is nothing to prevent him from supposing that the universe vanishes from this moment till that, and suddenly reappears. It is the t-th moment only that counts—and that will be a mere instant. What will flow on in the interval—that is to say, real time—does not count, and cannot enter into the calculation. If the mathematician says that he puts himself inside this interval, he means that he is placing himself at a certain point, at a particular moment, therefore at the extremity again of a certain time t'; with the interval up to T' he is not concerned. If he divides the interval into infinitely small parts by considering the differential dt, he thereby expresses merely the fact that he will consider accelerations and velocities—that is to say, numbers which denote tendencies and enable him to calculate the state of the system at a given moment. But he is always speaking of a given moment—a static moment, that is—and not of flowing time. In short, *the world the mathematician deals with is a world that dies and is reborn at every* *instant—the world which Descartes was thinking of when he spoke of continued creation.* But, in time thus conceived, how could evolution, which is the very essence of life, ever take place? Evolution implies a real persistence of the past in the present, a duration which is, as it were, a hyphen, a connecting link. In other words, to know a living being or *natural system* is to get at the very interval of duration, while the knowledge of an *artificial* or *mathematical system* applies only to the extremity.

Continuity of change, preservation of the past in the present, real duration—the living being seems, then, to share these attributes with consciousness. Can we go further and say that life, like conscious activity, is invention, is unceasing creation?

It does not enter into our plan to set down here the proofs of transformism. We wish only to explain in a word or two why we shall accept it, in the present work, as a sufficiently exact and precise expression of the facts actually known. The idea of transformism is already in germ in the natural classification of organized beings. The naturalist, in fact, brings together the organisms that are like each other, then divides the group into sub-groups within which the likeness is still greater, and so on: all through the operation, the characters of the group appear as general themes on which each of the sub-groups performs its particular variation. Now, such is just the relation we find, in the animal and in the vegetable world between the generator and the generated: on the canvas which the ancestor passes on, and which his descendants possess in common, each puts his own original embroidery. True, the differences between the descendant and the ancestor are slight, and it may be asked whether the same living matter presents enough plasticity to take in turn such different forms as those of a fish, a reptile and a bird. But, to this question, observation gives a peremptory answer. It shows that up to a certain period in its development the embryo of the bird is hardly distinguishable from that of the reptile, and that the individual develops, throughout the embryonic life in general, a series of transformations comparable to those through which, according to the theory of evolution, one species passes into another. A single cell, the result of the combination of two cells, male and female, accomplishes this work by dividing. Every day, before our eyes, the highest forms of life are springing from a very elementary form. Experience, then, shows that the most complex has been able to issue from the most simple by way of evolution. Now, has it arisen so, as a matter of fact? Paleontology, in spite of the insufficiency of its evidence, invites us to believe it has; for, where it makes out the order of succession of species with any precision, this order is just what considerations drawn from embryogeny and comparative anatomy would lead anyone to suppose, and each new paleontological discovery brings transformism a new confirmation. Thus, the proof drawn from mere observation is ever being strengthened, while, on the other hand, experiment is removing the objections one by one. The recent experiments of H. de Vries, for instance, by showing that important variations can be produced suddenly and transmitted regularly, have overthrown some of the greatest difficulties raised by the theory. They have enabled us greatly to shorten the time biological evolution seems to demand. They also render us less exacting toward paleontology. So that, all things considered, the transformist hypothesis looks more and more like a close approximation to the truth. It is not rigorously demonstrable; but, failing the certainty of theoretical or experimental demonstration, there is a probability which is continually growing, due to evidence which, while coming short of direct proof, seems to point persistently in its direction: such is the kind of probability that the theory of transformism offers.

Let us admit, however, that transformism may be wrong. Let us suppose that species are proved, by inference or by experiment, to have arisen by a discontinuous process, of which today we have no idea. Would the doctrine be affected in so far as it has a special interest or importance for us? Classification would probably remain, in its broad lines. The actual data of embryology would also remain. The correspondence between comparative embryogeny and comparative anatomy would remain too. Therefore biology could and would continue to establish between living forms the same relations and the same kinship as transformism supposes today. It would be, it is true, an *ideal* kinship, and no longer a *material* affiliation. But, as the actual data of paleontology would also remain, we should still have to admit that it is successively, not simultaneously, that the forms between which we find an ideal kinship have appeared. Now, the evolutionist theory, so far as it has any importance for philosophy, requires no more. It consists above all in establishing relations of ideal kinship, and in maintaining that wherever there is this relation of, so to speak, *logical* affiliation between forms, there is also a relation of *chronological* succession between the species in which these forms are materialized. Both arguments would hold in any case. And hence, an evolution *somewhere* would still have to be supposed, whether in a creative Thought in which the ideas of the different species are generated by each other exactly as transformism holds that species themselves are generated on the earth; or in a plan of vital organization immanent in nature, which gradually works itself out, in which the relations of logical and chronological affiliation between pure forms are just those which transformism presents as relations of real affiliation between living individuals; or, finally, in some unknown cause of life, which develops its effects *as if* they generated one another. Evolution would then simply have been *transposed,* made to pass from the visible to the invisible. Almost all that transformism tells us today would be preserved, open to interpretation in another way. Will it not, therefore, be better to stick to the letter of transformism as almost all scientists profess it? Apart from the question to what extent the theory of evolution describes the facts and to what extent it symbolizes them, there is nothing in it that is irreconcilable with the doctrines it has claimed to replace, even with that of special creations, to which it is usually opposed. For this reason we think the language of transformism forces itself now upon all philosophy, as the dogmatic affirmation of transformism forces itself upon science.

But then, we must no longer speak of *life in general* as an abstraction, or as a mere heading under which all living beings are inscribed. At a certain moment, in certain points of space, a visible current has taken rise; this current of life, traversing the bodies it has organized one after another, passing from generation to generation, has become divided amongst species and distributed amongst individuals without losing anything of its force, rather intensifying in proportion to its advance. It is well known that, on the theory of the "continuity of the germ-plasm," maintained by Weismann, the sexual elements of the generating organism pass on their properties directly to the sexual elements of the organism engendered. In this extreme form, the theory has seemed debatable, for it is only in exceptional cases that there are any signs of sexual glands at the time of segmentation of the fertilized egg. But, though the cells that engender the sexual elements do not generally appear at the beginning of the embryonic life, it is none the less true that they are always formed out of those tissues of the embryo which have not undergone any particular functional differentiation, and whose cells are made of unmodified protoplasm.[1] In other words, the genetic power of the fertilized ovum weakens, the more it is spread over the growing mass of the tissues of the embryo; but, while it is being thus diluted, it is concentrating anew something of itself on a certain special point, to wit, the cells, from which the ova or spermatozoa will develop. It might therefore be said that, though the germ-plasm is not continuous, there is at least continuity of genetic energy, this energy being expended only at certain instants, for just enough time to give the requisite impulsion to the embryonic life, and

[1] Roule, *L'Embryologie générale*, Paris, 1893, p. 319.

being recouped as soon as possible in new sexual elements, in which, again, it bides its time. Regarded from this point of view, *life is like a current passing from germ to germ through the medium of a developed organism*. It is as if the organism itself were only an excrescence, a bud caused to sprout by the former germ endeavoring to continue itself in a new germ. The essential thing is the *continuous progress* indefinitely pursued, an invisible progress, on which each visible organism rides during the short interval of time given it to live.

Now, the more we fix our attention on this continuity of life, the more we see that organic evolution resembles the evolution of a consciousness, in which the past presses against the present and causes the upspringing of a new form of consciousness, incommensurable with its antecedents. That the appearance of a vegetable or animal species is due to specific causes, nobody will gainsay. But this can only mean that if, after the fact, we could know these causes in detail, we could explain by them the form that has been produced; foreseeing the form is out of the question.[1] It may perhaps be said that the form could be foreseen if we could know, in all their details, the conditions under which it will be produced. But these conditions are built up into it and are part and parcel of its being; they are peculiar to that phase of its history in which life finds itself at the moment of producing the form: how could we know be-

[1] The irreversibility of the series of living beings has been well set forth by Baldwin (*Development and Evolution*, New York, 1902; in particular p. 327).

forehand a situation that is unique of its kind, that has never yet occurred and will never occur again? Of the future, only that is foreseen which is like the past or can be made up again with elements like those of the past. Such is the case with astronomical, physical and chemical facts, with all facts which form part of a system in which elements supposed to be unchanging are merely put together, in which the only changes are changes of position, in which there is no theoretical absurdity in imagining that things are restored to their place; in which, consequently, the same total phenomenon, or at least the same elementary phenomena, can be repeated. But an original situation, which imparts something of its own originality to its elements, that is to say, to the partial views that are taken of it, how can such a situation be pictured as given before it is actually produced? [1] All that can be said is that, once produced, it will be explained by the elements that analysis will then carve out of it. Now, what is true of the production of a new species is also true of the production of a new individual, and, more generally, of any moment of any living form. For, though the variation must reach a certain importance and a certain generality in order to give rise to a new species, it is being produced every moment, continuously and insensibly, in every living being. And it is evident that even the sudden "mutations" which we now hear of are possible only if a process of incubation, or rather of maturing, is going on throughout a series of generations that do not seem

[1] We have dwelt on this point and tried to make it clear in the *Essai sur les données immédiates de la conscience*, pp. 140-151.

to change. In this sense it might be said of life, as of consciousness, that at every moment it is creating something.[1]

But against this idea of the absolute originality and unforeseeability of forms our whole intellect rises in revolt. The essential function of our intellect, as the evolution of life has fashioned it, is to be a light for our conduct, to make ready for our action on things, to foresee, for a given situation, the events, favorable or unfavorable, which may follow thereupon. Intellect therefore instinctively selects in a given situation whatever is like something already known; it seeks this out, in order that it may apply its principle that "like produces like." In just this does the prevision of the future by common sense consist, Science carries this faculty to the highest possible degree of exactitude and precision, but does not alter its essential character. Like ordinary knowledge, in dealing with things science is concerned only with the aspect of *repetition.* Though the whole be original, science will always manage to analyze it into elements or aspects which are approximately a reproduction of the past. Science can work only on what is supposed to re-

[1] In his fine work on *Genius in Art* (*Le Génie dans l'art*), M. Séailles develops this twofold thesis, that art is a continuation of nature and that life is creation. We should willingly accept the second formula; but by creation must we understand, as the author does, a *synthesis* of elements? Where the elements pre-exist, the synthesis that will be made is virtually given, being only one of the possible arrangements. This arrangement a superhuman intellect could have perceived in advance among all the possible ones that surround it. We hold, on the contrary, that in the domain of life the elements have no real and separate existence. They are manifold mental views of an indivisible process. And for that reason there is radical contingency in progress, incommensurability between what goes before and what follows—in short, duration.

peat itself—that is to say, on what is withdrawn, by hypothesis, from the action of real time. Anything that is irreducible and irreversible in the successive moments of a history eludes science. To get a notion of this irreducibility and irreversibility, we must break with scientific habits which are adapted to the fundamental requirements of thought, we must do violence to the mind, go counter to the natural bent of the intellect. But that is just the function of philosophy.

In vain, therefore, does life evolve before our eyes as a continuous creation of unforeseeable form: the idea always persists that form, unforeseeability and continuity are mere appearance—the outward reflection of our own ignorance. What is presented to the senses as a continuous history would break up, we are told, into a series of successive states. "What gives you the impression of an original state resolves, upon analysis, into elementary facts, each of which is the repetition of a fact already known. What you call an unforeseeable form is only a new arrangement of old elements. The elementary causes, which in their totality have determined this arrangement, are themselves old causes repeated in a new order. Knowledge of the elements and of the elementary causes would have made it possible to foretell the living form which is their sum and their resultant. When we have resolved the biological aspect of phenomena into physico-chemical factors, we will leap, if necessary, over physics and chemistry themselves; we will go from masses to molecules, from molecules to atoms, from atoms to corpuscles: we must indeed at last come to something that can be treated as a kind of solar system, astronomically. If you deny it, you oppose the very principle of scientific mechanism, and you arbitrarily affirm that living matter is not made of the same elements as other matter."—We reply that we do not question the fundamental identity of inert matter and organized matter. The only question is whether the natural systems which we call living beings must be assimilated to the artificial systems that science cuts out within inert matter, or whether they must not rather be compared to that natural system which is the whole of the universe. That life is a kind of mechanism I cordially agree. But is it the mechanism of parts artificially isolated within the whole of the universe, or is it the mechanism of the real whole? The real whole might well be, we conceive, an indivisible continuity. The systems we cut out within it would, properly speaking, not then be *parts* at all; they would be *partial views* of the whole. And, with these partial views put end to end, you will not make even a beginning of the reconstruction of the whole, any more than, by multiplying photographs of an object in a thousand different aspects, you will reproduce the object itself. So of life and of the physico-chemical phenomena to which you endeavor to reduce it. Analysis will undoubtedly resolve the process of organic creation into an ever-growing number of physico-chemical phenomena, and chemists and physicists will have to do, of course, with nothing but these. But it does not follow that chemistry and physics will ever give us the key to life.

A very small element of a curve is very near being a straight line. And the smaller it is, the nearer. In the limit, it may be termed a part of the curve or a part of the straight line, as you please, for in each of its points a curve coincides with its tangent. So likewise "vitality" is tangent, at any and every point, to physical and chemical forces; but such points are, as a fact, only views taken by a mind which imagines stops at various moments of the movement that generates the curve. In reality, life is no more made of physico-chemical elements than a curve is composed of straight lines.

In a general way, the most radical progress a science can achieve is the working of the completed results into a new scheme of the whole, by relation to which they become instantaneous and motionless views taken at intervals along the continuity of a movement. Such, for example, is the relation of modern to ancient geometry. The latter, purely static, worked with figures drawn once for all; the former studies the varying of a function—that is, the continuous movement by which the figure is described. No doubt, for greater strictness, all considerations of motion may be eliminated from mathematical processes; but the introduction of motion into the genesis of figures is nevertheless the origin of modern mathematics. We believe that if biology could ever get as close to its object as mathematics does to its own, it would become, to the physics and chemistry of organized bodies, what the mathematics of the moderns has proved to be in relation to ancient geometry. The wholly superficial displacements of masses and molecules studied in physics and chemistry would become, by relation to that inner vital movement (which is transformation and not translation) what the position of a moving object is to the movement of that object in space. And, so far as we can see, the procedure by which we should then pass from the definition of a certain vital action to the system of physico-chemical facts which it implies would be like passing from the function to its derivative, from the equation of the curve (*i.e.* the law of the continuous movement by which the curve is generated) to the equation of the tangent giving its instantaneous direction. Such a science would be a *mechanics of transformation,* of which our *mechanics of translation* would become a particular case, a simplification, a projection on the plane of pure quantity. And just as an infinity of functions have the same differential, these functions differing from each other by a constant, so perhaps the integration of the physico-chemical elements of properly vital action might determine that action only in part—a part would be left to indetermination. But such an integration can be no more than dreamed of; we do not pretend that the dream will ever be realized. We are only trying, by carrying a certain comparison as far as possible, to show up to what point our theory goes along with pure mechanism, and where they part company.

Imitation of the living by the unorganized may, however, go a good way. Not only does chemistry make organic syntheses, but we have succeeded in reproducing artificially the external appearance of certain facts of organization, such as indirect cell-division and protoplasmic circulation. It is well known that the protoplasm of the cell effects various movements within its envelope; on the other hand, indirect cell-division is the outcome of very complex operations, some involving the nucleus and others the cytoplasm. These latter commence by the doubling of the centrosome, a small spherical body alongside the nucleus. The two centrosomes thus obtained draw apart, attract the broken and doubled ends of the filament of which the original nucleus mainly consisted, and join them to form two fresh nuclei about which the two new cells are constructed which will succeed the first. Now, in their broad lines and in their external appearance, some at least of these operations have been successfully imitated. If some sugar or table salt is pulverized and some very old oil is added, and a drop of the mixture is observed under the microscope, a froth of alveolar structure is seen whose configuration is like that of protoplasm, according to certain theories, and in which movements take place which are decidedly like those of protoplasmic circulation.[1] If, in a froth of the same kind, the air is extracted from an alveolus, a cone of attraction is seen to form, like those about the centrosomes which result in the division of the nucleus.[2] Even the external motions of a unicellular organism—of an amoeba, at any rate—are sometimes explained mechanically. The displacements of an amoeba in a drop of water would be comparable to the motion to and fro of a grain of dust in a draughty room. Its mass is all the time absorbing certain soluble matters contained in the surrounding water, and giving back to it certain others; these continual exchanges, like those between two vessels separated by a porous partition, would create an ever-changing vortex around the little organism. As for the temporary prolongations or pseudopodia which the amoeba seems to make, they would be not so much given out by it as at-

[1] Bütschli, *Untersuchungen über mikroskopische Schäume und das Protoplasma*, Leipzig, 1892, First Part.

[2] Rhumbler, *Versuch einer mechanischen Erklärung der indirekten Zell- und Kernteilung* (*Roux's Archiv*, 1896).

tracted from it by a kind of inhalation or suction of the surrounding medium.[1] In the same way we may perhaps come to explain the more complex movements which the Infusorian makes with its vibratory cilia, which, moreover, are probably only fixed pseudopodia.

But scientists are far from agreed on the value of explanations and schemata of this sort. Chemists have pointed out that even in the organic—not to go so far as the organized—science has reconstructed hitherto nothing but waste products of vital activity; the peculiarly active plastic substances obstinately defy synthesis. One of the most notable naturalists of our time has insisted on the opposition of two orders of phenomena observed in living tissues, *anagenesis* and *katagenesis*. The role of the anagenetic energies is to raise the inferior energies to their own level by assimilating inorganic substances. They *construct* the tissues. On the other hand, the actual functioning of life (excepting, of course, assimilation, growth and reproduction) is of the katagenetic order, exhibiting the fall, not the rise, of energy. It is only with these facts of katagenetic order that physico-chemistry deals—that is, in short, with the dead and not with the living.[2] The other kind of facts certainly seem to defy physico-chemical analysis, even if they are not anagenetic in the proper sense of the word. As for the artificial imitation of the outward appearance of protoplasm, should a real theoretic importance be attached to this when the question of the phys-

[1] Berthold, *Studien über Protoplasmamechanik*, Leipzig, 1886, p. 102. Cf. the explanation proposed by Le Dantec, *Théorie nouvelle de la vie*, Paris, 1896, p. 60.

[2] Cope, *The Primary Factors of Organic Evolution, Chicago*, 1896, pp. 475-484.

ical framework of protoplasm is not yet settled? We are still further from compounding protoplasm chemically. Finally, a physico-chemical explanation of the motions of the amoeba, and *a fortiori* of the behavior of the Infusoria, seems impossible to many of those who have closely observed these rudimentary organisms. Even in these humblest manifestations of life they discover traces of an effective psychological activity.[1] But instructive above all is the fact that the tendency to explain everything by physics and chemistry is discouraged rather than strengthened by deep study of histological phenomena. Such is the conclusion of the truly admirable book which the histologist E. B. Wilson has devoted to the development of the cell: "The study of the cell has, on the whole, seemed to widen rather than to narrow the enormous gap that separates even the lowest forms of life from the inorganic world." [2]

To sum up, those who are concerned only with the functional activity of the living being are inclined to believe that physics and chemistry will give us the key to biological processes.[3] They have chiefly to do, as a fact, with phenomena that are *repeated* continually in the living being, as in a chemical retort. This explains,

[1] Maupas, "Etude des infusoires ciliés" (*Arch. de zoologie expérimentale*, 1883, pp. 47, 491, 518, 549, in particular). P. Vignon, *Recherches de cytologie générale sur les épithéliums*, Paris, 1902, p. 655. A profound study of the motions of the Infusoria and a very penetrating criticism of the idea of tropism have been made recently by Jennings (*Contributions to the Study of the Behavior of Lower Organisms*, Washington, 1904). The "type of behavior" of these lower organisms, as Jennings defines it (pp. 237-252), is unquestionably of the psychological order.

[2] E. B. Wilson, *The Cell in Development and Inheritance*, New York, 1897, p. 330.

[3] Dastre, *La Vie et la mort*, p. 43.

in some measure, the mechanistic tendencies of physiology. On the contrary, those whose attention is concentrated on the minute structure of living tissues, on their genesis and evolution, histologists and embryogenists on the one hand, naturalists on the other, are interested in the retort itself, not merely in its contents. They find that this retort creates its own form through a *unique* series of acts that really constitute a *history*. Thus, histologists, embryogenists, and naturalists believe far less readily than physiologists in the physico-chemical character of vital actions.

The fact is, neither one nor the other of these two theories, neither that which affirms nor that which denies the possibility of chemically producing an elementary organism, can claim the authority of experiment. They are both unverifiable, the former because science has not yet advanced a step toward the chemical synthesis of a living substance, the second because there is no conceivable way of proving experimentally the impossibility of a fact. But we have set forth the theoretical reasons which prevent us from likening the living being, a system closed off by nature, to the systems which our science isolates. These reasons have less force, we acknowledge, in the case of a rudimentary organism like the amoeba, which hardly evolves at all. But they acquire more when we consider a complex organism which goes through a regular cycle of transformations. The more duration marks the living being with its imprint, the more obviously the organism differs from a mere mechanism, over which duration glides without penetrating. And the demonstration has most force when it applies to the evolution of life as a whole, from its humblest origins to its highest forms, inasmuch as this evolution constitutes, through the unity and continuity of the animated matter which supports it, a single indivisible history. Thus viewed, the evolutionist hypothesis does not seem so closely akin to the mechanistic conception of life as it is generally supposed to be. Of this mechanistic conception we do not claim, of course, to furnish a mathematical and final refutation. But the refutation which we draw from the consideration of real time, and which is, in our opinion, the only refutation possible, becomes the more rigorous and cogent the more frankly the evolutionist hypothesis is assumed. We must dwell a good deal more on this point. But let us first show more clearly the notion of life to which we are leading up.

The mechanistic explanations, we said, hold good for the systems that our thought artificially detaches from the whole. But of the whole itself and of the systems which, within this whole, seem to take after it, we cannot admit *a priori* that they are mechanically explicable, for then time would be useless, and even unreal. The essence of mechanical explanation, in fact, is to regard the future and the past as calculable functions of the present, and thus to claim that *all is given.* On this hypothesis, past, present and future would be open at a glance to a superhuman intellect capable of making the calculation. Indeed, the scientists who have believed in the universality and perfect objectivity of mechanical explanations have, consciously or unconsciously, acted on a hypothesis of this kind. Laplace formulated it with the greatest precision: "An intellect which at a given instant knew all the forces with which nature is animated, and the respective situations of the beings that compose nature—supposing the said intellect were vast enough to subject these data to analysis—would embrace in the same formula the motions of the greatest bodies in the universe and those of the slightest atom: nothing would be uncertain for it, and the future, like the past, would be present to its eyes." [1] And Du Bois-Reymond: "We can imagine the knowledge of nature arrived at a point where the universal process of the world might be represented by a single mathematical formula, by one immense system of simultaneous differential equations, from which could be deduced, for each moment, the position, direction, and velocity of every atom of the world." [2] Huxley has expressed the same idea in a more concrete form: "If the fundamental proposition of evolution is true, that the entire 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 nebulosity of the universe was composed, it is no less certain that the existing world lay, potentially, in the cosmic vapor, and that a sufficient intellect could, from a knowledge of the properties of the molecules of that vapor, have predicted, say the state of the Fauna of Great Britain in 1869, with as much certainty as one can say what will happen to the vapor of the breath in a cold winter's day." In such a doctrine, time is still spoken of: one pronounces the word, but one does not

[1] Laplace, *Introduction à la théorie analytique des probabilités* (*Œuvres complètes*, vol. vii., Paris, 1886, p. vi.).

[2] Du Bois-Reymond, *Über die Grenzen des Naturerkennens*, Leipzig, 1892.

think of the thing. For time is here deprived of efficacy, and if it *does* nothing, it *is* nothing. Radical mechanism implies a metaphysic in which the totality of the real is postulated complete in eternity, and in which the apparent duration of things expresses merely the infirmity of a mind that cannot know everything at once. But duration is something very different from this for our consciousness, that is to say, for that which is most indisputable in our experience. We perceive duration as a stream against which we cannot go. It is the foundation of our being, and, as we feel, the very substance of the world in which we live. It is of no use to hold up before our eyes the dazzling prospect of a universal mathematic; we cannot sacrifice experience to the requirements of a system. That is why we reject radical mechanism.

But radical finalism is quite as unacceptable, and for the same reason. The doctrine of teleology, in its extreme form, as we find it in Leibniz for example, implies that things and beings merely realize a program previously arranged. But if there is nothing unforeseen, no invention or creation in the universe, time is useless again. As in the mechanistic hypothesis, here again it is supposed that *all is given*. Finalism thus understood is only inverted mechanism. It springs from the same postulate, with this sole difference, that in the movement of our finite intellects along successive things, whose successiveness is reduced to a mere appearance, it holds in front of us the light with which it claims to guide us, instead of putting it behind. It substitutes the attraction of the future for the impulsion of the past.

But succession remains none the less a mere appearance, as indeed does movement itself. In the doctrine of Leibniz, time is reduced to a confused perception, relative to the human standpoint, a perception which would vanish, like a rising mist, for a mind seated at the center of things.

Yet finalism is not, like mechanism, a doctrine with fixed rigid outlines. It admits of as many inflections as we like. The mechanistic philosophy is to be taken or left: it must be left if the least grain of dust, by straying from the path foreseen by mechanics, should show the slightest trace of spontaneity. The doctrine of final causes, on the contrary, will never be definitively refuted. If one form of it be put aside, it will take another. Its principle, which is essentially psychological, is very flexible. It is so extensible, and thereby so comprehensive, that one accepts something of it as soon as one rejects pure mechanism. The theory we shall put forward in this book will therefore necessarily partake of finalism to a certain extent. For that reason it is important to intimate exactly what we are going to take of it, and what we mean to leave.

Let us say at once that to thin out the Leibnizian finalism by breaking it into an infinite number of pieces seems to us a step in the wrong direction. This is, however, the tendency of the doctrine of finality. It fully realizes that if the universe as a whole is the carrying out of a plan, this cannot be demonstrated empirically, and that even of the organized world alone it is hardly easier to prove all harmonious: facts would equally well testify to the contrary. Nature sets living beings at discord with one another. She everywhere presents disorder alongside of order, retrogression alongside of progress. But, though finality cannot be affirmed either of the whole of matter or of the whole of life, might it not yet be true, says the finalist, of each organism taken separately? Is there not a wonderful division of labor, a marvelous solidarity among the parts of an organism, perfect order in infinite complexity? Does not each living being thus realize a plan immanent in its substance?—This theory consists, at bottom, in breaking up the original notion of finality into bits. It does not accept, indeed it ridicules, the idea of an *external* finality, according to which living beings are ordered with regard to each other: to suppose the grass made for the cow, the lamb for the wolf—that is all acknowledged to be absurd. But there is, we are told, an *internal* finality: each being is made for itself, all its parts conspire for the greatest good of the whole and are intelligently organized in view of that end. Such is the notion of finality which has long been classic. Finalism has shrunk to the point of never embracing more than one living being at a time. By making itself smaller, it probably thought it would offer less surface for blows.

The truth is, it lay open to them a great deal more. Radical as our own theory may appear, finality is external or it is nothing at all.

Consider the most complex and the most harmonious organism. All the elements, we are told, conspire for the greatest good of the whole. Very well, but let us not forget that each of these elements may itself be an organism in certain cases, and that in subordinating the existence of this small organism to the life of the great one we accept the principle of an *external* finality. The idea of a finality that is *always* internal is therefore a self-destructive notion. An organism is composed of tissues, each of which lives for itself. The cells of which the tissues are made have also a certain independence. Strictly speaking, if the subordination of all the elements of the individual to the individual itself were complete, we might contend that they are not organisms, reserve the name organism for the individual, and recognize only internal finality. But every one knows that these elements may possess a true autonomy. To say nothing of phagocytes, which push independence to the point of attacking the organism that nourishes them, or of germinal cells, which have their own life alongside the somatic cells—the facts of regeneration are enough: here an element or a group of elements suddenly reveals that, however limited its normal space and function, it can transcend them occasionally; it may even, in certain cases, be regarded as the equivalent of the whole.

There lies the stumbling-block of the vitalistic theories. We shall not reproach them, as is ordinarily done, with replying to the question by the question itself: the "vital principle" may indeed not explain much, but it is at least a sort of label affixed to our ignorance, so as to remind us of this occasionally,[1] while mechanism in-

[1] There are really two lines to follow in contemporary neo-vitalism: on the one hand, the assertion that pure mechanism is insufficient, which assumes great authority when made by such scientists as Driesch or Reinke, for example; and, on the other hand, the hypotheses which this vitalism superposes on mechanism (the "entelechies" of Driesch, and the "dominants" of Reinke, etc.). Of these two parts, the former is perhaps the more interesting. See the admirable studies of Driesch—*Die Lokalisation morphogenetischer Vorgänge*, Leipzig, 1899; *Die organischen Regulationen*, Leipzig, 1901; *Naturbegriffe und Natururteile*, Leipzig, 1904; *Der Vitalismus als Geschichte und als Lehre*, Leipzig,

vites us to ignore that ignorance. But the position of vitalism is rendered very difficult by the fact that, in nature, there is neither purely internal finality nor absolutely distinct individuality. The organized elements composing the individual have themselves a certain individuality, and each will claim its vital principle if the individual pretends to have its own. But, on the other hand, the individual itself is not sufficiently independent, not sufficiently cut off from other things, for us to allow it a "vital principle" of its own. An organism such as a higher vertebrate is the most individuated of all organisms; yet, if we take into account that it is only the development of an ovum forming part of the body of its mother and of a spermatozoon belonging to the body of its father, that the egg (*i.e.* the ovum fertilized) is a connecting link between the two progenitors since it is common to their two substances, we shall realize that every individual organism, even that of a man, is merely a bud that has sprouted on the combined body of both its parents. Where, then, does the vital principle of the individual begin or end? Gradually we shall be carried further and further back, up to the individual's remotest ancestors: we shall find him solidary with each of them, solidary with that little mass of protoplasmic jelly which is probably at the root of the genealogical tree of life. Being, to a certain extent, one with this primitive ancestor, he is also solidary with all that descends from the ancestor in divergent directions. In this sense each individual may be said to remain united

1905; and of Reinke—*Die Welt als Tat*, Berlin, 1899; *Einleitung in die theoretische Biologie*, Berlin, 1901; *Philosophie der Botanik*, Leipzig, 1905.

with the totality of living beings by invisible bonds. So it is of no use to try to restrict finality to the individuality of the living being. If there is finality in the world of life, it includes the whole of life in a single indivisible embrace. This life common to all the living undoubtedly presents many gaps and incoherences, and again it is not so mathematically *one* that it cannot allow each being to become individualized to a certain degree. But it forms a single whole, none the less; and we have to choose between the out-and-out negation of finality and the hypothesis which co-ordinates not only the parts of an organism with the organism itself, but also each living being with the collective whole of all others.

Finality will not go down any easier for being taken as a powder. Either the hypothesis of a finality immanent in life should be rejected as a whole, or it must undergo a treatment very different from pulverization.

The error of radical finalism, as also that of radical mechanism, is to extend too far the application of certain concepts that are natural to our intellect. Originally, we think only in order to act. Our intellect has been cast in the mold of action. Speculation is a luxury, while action is a necessity. Now, in order to act, we begin by proposing an end; we make a plan, then we go on to the detail of the mechanism which will bring it to pass. This latter operation is possible only if we know what we can reckon on. We must therefore have managed to extract resemblances from nature, which enable us to anticipate the future. Thus we must, consciously or unconsciously, have made use of the law of causality. Moreover, the more sharply the idea of efficient causality is defined in our mind, the more it takes the form of a *mechanical* causality. And this scheme, in its turn, is the more mathematical according as it expresses a more rigorous necessity. That is why we have only to follow the bent of our mind to become mathematicians. But, on the other hand, this natural mathematics is only the rigid unconscious skeleton beneath our conscious supple habit of linking the same causes to the same effects; and the usual object of this habit is to guide actions inspired by intentions, or, what comes to the same, to direct movements combined with a view to reproducing a pattern. We are born artisans as we are born geometricians, and indeed we are geometricians only because we are artisans. Thus the human intellect, inasmuch as it is fashioned for the needs of human action, is an intellect which proceeds at the same time by intention and by calculation, by adapting means to ends and by thinking out mechanisms of more and more geometrical form. Whether nature be conceived as an immense machine regulated by mathematical laws, or as the realization of a plan, these two ways of regarding it are only the consummation of two tendencies of mind which are complementary to each other, and which have their origin in the same vital necessities.

For that reason, radical finalism is very near radical mechanism on many points. Both doctrines are reluctant to see in the course of things generally, or even simply in the development of life, an unforeseeable creation of form. In considering reality, mechanism regards only the aspect of similarity or repetition. It is therefore dominated by this law, that in nature there is only *like* reproducing *like*. The more the geometry in mechanism is emphasized, the less can mechanism admit that anything is ever created, even pure form. In so far as we are geometricians, then, we reject the unforeseeable. We might accept it, assuredly, in so far as we are artists, for art lives on creation and implies a latent belief in the spontaneity of nature. But disinterested art is a luxury, like pure speculation. Long before being artists, we are artisans; and all fabrication, however rudimentary, lives on likeness and repetition, like the natural geometry which serves as its fulcrum. Fabrication works on models which it sets out to reproduce; and even when it invents, it proceeds, or imagines itself to proceed, by a new arrangement of elements already known. Its principle is that "we must have like to produce like." In short, the strict application of the principle of finality, like that of the principle of mechanical causality, leads to the conclusion that "all is given." Both principles say the same thing in their respective languages, because they respond to the same need.

That is why again they agree in doing away with time. Real duration is that duration which gnaws on things, and leaves on them the mark of its tooth. If everything is in time, everything changes inwardly, and the same concrete reality never recurs. Repetition is therefore possible only in the abstract: what is repeated is some aspect that our senses, and especially our intellect, have singled out from reality, just because our action, upon which all the effort of our intellect is directed, can move only among repetitions. Thus, concentrated on that which repeats, solely preoccupied in welding the same to the same, intellect turns away from the vision of time. It dislikes what is fluid, and solidifies everything it touches. We do not *think* real time. But we *live* it, because life transcends intellect. The feeling we have of our evolution and of the evolution of all things in pure duration is there, forming around the intellectual concept properly so-called an indistinct fringe that fades off into darkness. Mechanism and finalism agree in taking account only of the bright nucleus shining in the center. They forget that this nucleus has been formed out of the rest by condensation, and that the whole must be used, the fluid as well as and more than the condensed, in order to grasp the inner movement of life.

Indeed, if the fringe exists, however delicate and indistinct, it should have more importance for philosophy than the bright nucleus it surrounds. For it is its presence that enables us to affirm that the nucleus is a nucleus, that pure intellect is a contraction, by condensation, of a more extensive power. And, just because this vague intuition is of no help in directing our action on things, which action takes place exclusively on the surface of reality, we may presume that it is to be exercised not merely on the surface, but below.

As soon as we go out of the encasings in which radical mechanism and radical finalism confine our thought, reality appears as a ceaseless upspringing of something new, which has no sooner arisen to make the present than it has already fallen back into the past; at this exact moment it falls under the glance of the intellect, whose eyes are ever turned to the rear. This is already the case with our inner life. For each of our acts we shall easily find antecedents of which it may in some sort be said to be the mechanical resultant. And it may equally well be said that each action is the realization of an intention. In this sense mechanism is everywhere, and finality everywhere, in the evolution of our conduct. But if our action be one that involves the whole of our person and is truly ours, it could not have been foreseen, even though its antecedents explain it when once it has been accomplished. And though it be the realizing of an intention, it differs, as a present and *new* reality, from the intention, which can never aim at anything but recommencing or rearranging the past. Mechanism and finalism are therefore, here, only external views of our conduct. They extract its intellectuality. But our conduct slips between them and extends much further. Once again, this does not mean that free action is capricious, unreasonable action. To behave according to caprice is to oscillate mechanically between two or more ready-made alternatives and at length to settle on one of them; it is no real maturing of an internal state, no real evolution; it is merely—however paradoxical the assertion may seem—bending the will to imitate the mechanism of the intellect. A conduct that is truly our own, on the contrary, is that of a will which does not try to counterfeit intellect, and which, remaining itself—that is to say, evolving—ripens gradually into acts which the intellect will be able to resolve indefinitely into intelligible elements without ever reaching its goal. The free act is incommensurable with the idea, and its "rationality" must be defined by this very incommensurability, which admits the discovery of as much intelligibility within it as we will. Such is the character of our own evolution; and such also, without doubt, that of the evolution of life.

Our reason, incorrigibly presumptuous, imagines itself possessed, by right of birth or by right of conquest, innate or acquired, of all the essential elements of the knowledge of truth. Even where it confesses that it does not know the object presented to it, it believes that its ignorance consists only in not knowing which one of its time-honored categories suits the new object. In what drawer, ready to open, shall we put it? In what garment, already cut out, shall we clothe it? Is it this, or that, or the other thing? And "this," and "that," and "the other thing" are always something already conceived, already known. The idea that for a new object we might have to create a new concept, perhaps a new method of thinking, is deeply repugnant to us. The history of philosophy is there, however, and shows us the eternal conflict of systems, the impossibility of satisfactorily getting the real into the ready-made garments of our ready-made concepts, the necessity of making to measure. But, rather than go to this extremity, our reason prefers to announce once for all, with a proud modesty, that it has to do only with the relative, and that the absolute is not in its province. This preliminary declaration enables it to apply its habitual method of thought without any scruple, and thus, under pretense that it does not touch the absolute, to make absolute judgments upon everything. Plato was the first to set up the theory that to know the real consists in finding its Idea, that is to say, in forcing it into a pre-existing frame already at our disposal—as if we implicitly possessed universal knowledge. But this belief is natural to the human intellect, always engaged as it is in determining under what former heading it shall catalogue any new object; and it may be said that, in a certain sense, we are all born Platonists.

Nowhere is the inadequacy of this method so obvious as in theories of life. If, in evolving in the direction of the vertebrates in general, of man and intellect in particular, life has had to abandon by the way many elements incompatible with this particular mode of organization and consign them, as we shall show, to other lines of development, it is the totality of these elements that we must find again and rejoin to the intellect proper, in order to grasp the true nature of vital activity. And we shall probably be aided in this by the fringe of vague intuition that surrounds our distinct—that is, intellectual—representation. For what can this useless fringe be, if not that part of the evolving principle which has not shrunk to the peculiar form of our organization, but has settled around it unasked for, unwanted? It is there, accordingly, that we must look for hints to expand the intellectual form of our thought; from there shall we derive the impetus necessary to lift us above ourselves. To form an idea of the whole of life cannot consist in combining simple ideas that have been left behind in us by life itself in the course of its evolution. How could the part be equivalent to the whole, the content to the container, a by-product of the vital operation to the operation itself? Such, however, is our illusion when we define the evolution of life as a "passage from the homogeneous to the heterogeneous," or by any other concept obtained by putting fragments of intellect side by side. We place ourselves in one of the points where evolution comes to a head—the principal one, no doubt, but not the only one; and there we do not even take all we find, for of the intellect we keep only one or two of the concepts by which it expresses itself; and it is this part of a part that we declare representative of the whole, of something indeed which goes beyond the concrete whole, I mean of the evolution movement of which this "whole" is only the present stage! The truth is, that to represent this the entire intellect would not be too much—nay, it would not be enough. It would be necessary to add to it what we find in every other terminal point of evolution. And these diverse and divergent elements must be considered as so many extracts which are, or at least which were, in their humblest form, mutually complementary. Only then might we have an inkling of the real nature of the evolution movement; and even then we should fail to grasp it completely, for we should still be dealing only with the evolved, which is a result, and not with evolution itself, which is the act by which the result is obtained.

Such is the philosophy of life to which we are leading up. It claims to transcend both mechanism and finalism; but, as we announced at the beginning, it is nearer the second doctrine than the first. It will not be amiss to dwell on this point, and show more precisely how far this philosophy of life resembles finalism and wherein it is different.

Like radical finalism, although in a vaguer form, our philosophy represents the organized world as a harmonious whole. But this harmony is far from being as perfect as it has been claimed to be. It admits of much discord, because each species, each individual even, retains only a certain impetus from the universal vital impulsion and tends to use this energy in its own interest. In this consists *adaptation.* The species and the individual thus think only of themselves—whence arises a possible conflict with other forms of life. Harmony, therefore, does not exist in fact; it exists rather in principle; I mean that the original impetus is a *common* impetus, and the higher we ascend the stream of life the more do diverse tendencies appear complementary to each other. Thus the wind at a street corner divides into diverging currents which are all one and the same gust. Harmony, or rather "complementarity," is revealed only in the mass, in tendencies rather than in states. Especially (and this is the point on which finalism has been most seriously mistaken) harmony is rather behind us than before. It is due to an identity of impulsion and not to a common aspiration. It would be futile to try to assign to life an end, in the human sense of the word. To speak of an end is to think of a pre-existing model which has only to be realized. It is to suppose, therefore, that all is given, and that the future can be read in the present. It is to believe that life, in its movement and in its entirety, goes to work like our intellect, which is only a motionless and fragmentary view of life, and which naturally takes its stand outside of time. Life, on the contrary, progresses and *endures* in time. Of course, when once the road has been traveled, we can glance over it, mark its direction, note this in psychological terms and speak as if there had been pursuit of an end. Thus shall we speak ourselves. But, of the road which was going to be traveled, the human mind could have nothing to say, for the road has been created *pari passu* with the act of traveling over it, being nothing but the direction of this act itself. At every instant, then, evolution must admit of a psychological interpretation which is, from our point of view, the best interpretation; but this explanation has neither value nor even significance except retrospectively. Never could the finalistic interpretation, such as we shall propose it, be taken for an anticipation of the future. It is a particular mode of viewing the past in the light of the present. In short, the classic conception of finality postulates at once too much and too little: it is both too wide and too narrow. In explaining life by intellect, it limits too much the meaning of life: intellect, such at least as we find it in ourselves, has been fashioned by evolution during the course of progress; it is cut out of something larger, or, rather, it is only the projection, necessarily on a plane, of a reality that possesses both relief and depth. It is this more comprehensive reality that true finalism ought to reconstruct, or, rather, if possible, embrace in one view. But, on the other hand, just because it goes beyond intellect—the faculty of connecting the same with the same, of perceiving and also of producing repetitions—this reality is undoubtedly creative, *i.e.* productive of effects in which it expands and transcends its own being. These effects were therefore not given in it in advance, and so it could not take them for ends, although, when once produced, they admit of a rational interpretation, like that of the manufactured article that has reproduced a model. In short, the theory of final causes does not go far enough when it confines itself to ascribing some intelligence to nature, and it goes too far when it supposes a pre-existence of the future in the present in the form of idea. And the second theory, which sins by excess, is the outcome of the first, which sins by defect. In place of intellect proper must be substituted the more comprehensive reality of which intellect is only the contraction. The future then appears as expanding the present: it was not, therefore, contained in the present in the form of a represented end. And yet, once realized, it will explain the present as much as the present explains it, and even more; it must be viewed as an end as much as, and more than, a result. Our intellect has a right to consider the future abstractly from its habitual point of view, being itself an abstract view of the cause of its own being.

It is true that the cause may then seem beyond our grasp. Already the finalist theory of life eludes all precise verification. What if we go beyond it in one of its directions? Here, in fact, after a necessary digression, we are back at the question which we regard as essential: can the insufficiency of mechanism be proved by facts? We said that if this demonstration is possible, it is on condition of frankly accepting the evolutionist hypothesis. We must now show that if mechanism is insufficient to account for evolution, the way of proving this insufficiency is not to stop at the classic conception of finality, still less to contract or attenuate it, but, on the contrary, to go further.

Let us indicate at once the principle of our demonstration. We said of life that, from its origin, it is the continuation of one and the same impetus, divided into divergent lines of evolution. Something has grown, something has developed by a series of additions which have been so many creations. This very development has brought about a dissociation of tendencies which were unable to grow beyond a certain point without becoming mutually incompatible. Strictly speaking, there is nothing to prevent our imagining that the evolution of life might have taken place in one single individual by means of a series of transformations spread over thousands of ages. Or, instead of a single individual, any number might be supposed, succeeding each other in a unilinear series. In both cases evolution would have had, so to speak, one dimension only. But evolution has actually taken place through millions of individuals, on divergent lines, each ending at a crossing from which new paths radiate, and so on indefinitely. If our hypothesis is justified, if the essential causes working along these diverse roads are of psychological nature, they must keep something in common in spite of the divergence of their effects, as school-fellows long separated keep the same memories of boyhood. Roads may fork or by-ways be opened along which dissociated elements may evolve in an independent manner, but nevertheless it is in virtue of the primitive impetus of the whole that the movement of the parts continues. Something of the whole, therefore, must abide in the parts; and this common element will be evident to us in some way, perhaps by the presence of identical organs in very different organisms. Suppose, for an instant, that the mechanistic explanation is the true one: evolution must then have occurred through a series of accidents added to one another, each new accident being preserved by selection if it is advantageous to that sum of former advantageous accidents which the present form of the living being represents. What likelihood is there that, by two entirely different series of accidents being added together, two entirely different evolutions will arrive at similar results? The more two lines of evolution diverge, the less probability is there that accidental outer influences or accidental inner variations bring about the construction of the same apparatus upon them, especially if there was no trace of this apparatus at the moment of divergence. But such similarity of the two products would be natural, on the contrary, in a hypothesis like ours: even in the latest channel there would be something of the impulsion received at the source. *Pure mechanism, then, would be refutable, and finality, in the special sense in which we understand it, would be demonstrable in a certain aspect, if it could be proved that life may manufacture the like apparatus, by unlike means, on divergent lines of evolution; and the strength of the proof would be proportional both to the divergency between the lines of evolution thus chosen and to the complexity of the similar structures found in them.*

It will be said that resemblance of structure is due to sameness of the general conditions in which life has evolved, and that these permanent outer conditions may have imposed the same direction on the forces constructing this or that apparatus, in spite of the diversity of transient outer influences and accidental inner changes. We are not, of course, blind to the rôle which the concept of *adaptation* plays in the science of today. Biologists certainly do not all make the same use of it. Some think the outer conditions capable of causing change in organisms in a *direct* manner, in a definite direction, through physico-chemical alterations induced by them in the living substance; such is the hypothesis of Eimer, for example. Others, more faithful to the spirit of Darwinism, believe the influence of conditions works *indirectly* only, through favoring, in the struggle for life, those representatives of a species which the chance of birth has best adapted to the environment. In other words, some attribute a *positive* influence to outer conditions, and say that they actually *give rise to* variations, while the others say these conditions have only a *negative* influence and merely *eliminate* variations. But, in both cases, the outer conditions are supposed to bring about a precise adjustment of the organism to its circumstances. Both parties, then, will attempt to explain mechanically, by adaptation to similar conditions, the similarities of structure which we think are the strongest argument against mechanism. So we must at once indicate in a general way, before passing to the detail, why explanations from "adaptation" seem to us insufficient.

Let us first remark that, of the two hypotheses just described, the latter is the only one which is not equivocal. The Darwinian idea of adaptation by automatic elimination of the unadapted is a simple and clear idea. But, just because it attributes to the outer cause which controls evolution a merely negative influence, it has great difficulty in accounting for the progressive and, so to say, rectilinear development of complex apparatus such as we are about to examine. How much greater will this difficulty be in the case of the similar structure of two extremely complex organs on two entirely different lines of evolution! An accidental variation, however minute, implies the working of a great number of small physical and chemical causes. An accumulation of accidental variations, such as would be necessary to produce a complex structure, requires therefore the concurrence of an almost infinite number of infinitesimal causes. Why should these causes, entirely accidental, recur the same, and in the same order, at different points of space and time? No one will hold that this is the case, and the Darwinian himself will probably merely maintain that identical effects may arise from different causes, that more than one road leads to the same spot. But let us not be fooled by a metaphor. The place reached does not give the form of the road that leads there; while an organic structure is just the accumulation of those small differences which evolution has had to go through in order to achieve it. The struggle for life and natural selection can be of no use to us in solving this part of the problem, for we are not concerned here with what has perished, we have to do only with what has survived. Now, we see that identical structures have been formed on independent lines of evolution by a gradual accumulation of effects. How can accidental causes, occurring in an accidental order, be supposed to have repeatedly come to the same result, the causes being infinitely numerous and the effect infinitely complicated?

The principle of mechanism is that "the same causes produce the same effects." This principle, of course, does not always imply that the same effects must have the same causes; but it does involve this consequence in the particular case in which the causes remain visible in the effect that they produce and are indeed its constitutive elements. That two walkers starting from different points and wandering at random should finally meet, is no great wonder. But that, throughout their walk, they should describe two identical curves exactly superposable on each other, is altogether unlikely. The improbability will be the greater, the more complicated the routes; and it will become impossibility, if the zigzags are infinitely complicated. Now, what is this complexity of zigzags as compared with that of an organ in which thousands of different cells, each being itself a kind of organism, are arranged in a definite order?

Let us turn, then, to the other hypothesis, and see how it would solve the problem. Adaptation, it says, is not merely elimination of the unadapted; it is due to the positive influence of outer conditions that have molded the organism on their own form. This time, similarity of effects will be explained by similarity of cause. We shall remain, apparently, in pure mechanism. But if we look closely, we shall see that the explanation is merely verbal, that we are again the dupes of words, and that the trick of the solution consists in taking the term "adaptation" in two entirely different senses at the same time.

If I pour into the same glass, by turns, water and wine, the two liquids will take the same form, and the sameness in form will be due to the sameness in adaptation of content to container. Adaptation, here, really means mechanical adjustment. The reason is that the form to which the matter has adapted itself was there, ready-made, and has forced its own shape on the matter. But, in the adaptation of an organism to the circumstances it has to live in, where is the pre-existing form awaiting its matter? The circumstances are not a mold into which life is inserted and whose form life adopts: this is indeed to be fooled by a metaphor. There is no form yet, and the life must create a form for itself, suited to the circumstances which are made for it. It will have to make the best of these circumstances, neutralize their inconveniences and utilize their advantages—in short, respond to outer actions by building up a machine which has no resemblance to them. Such adapting is not *repeating*, but *replying*,—an entirely different thing. If there is still adaptation, it will be in the sense in which one may say of the solution of a problem of geometry, for example, that it is adapted to the conditions. I grant indeed that adaptation so understood explains why different evolutionary processes result in similar forms: the same problem, of course, calls for the same solution. But it is necessary then to introduce, as for the solution of a problem of geometry, an intelligent activity, or at least a cause which behaves in the same way. This is to bring in finality again, and a finality this time more than ever charged with anthropomorphic elements. In a word, if the adaptation is passive, if it is mere repetition in the relief of what the conditions give in the mold, it will build up nothing that one tries to make it build; and if it is active, capable of responding by a calculated solution to the problem which is set out in the conditions, that is going further than we do—too far, indeed, in our opinion—in the direction we indicated in the beginning. But the truth is that there is a surreptitious passing from one of these two meanings to the other, a flight for refuge to the first whenever one is about to be caught *in flagrante delicto* of finalism by employing the second. It is really the second which serves the usual practice of science, but it is the first that generally provides its philosophy. In any *particular* case one talks as if the process of adaptation were an effort of the organism to build up a machine capable of turning external circumstances to the best possible account: then one speaks of adaptation *in general* as if it were the very impress of circumstances, passively received by an indifferent matter.

But let us come to the examples. It would be interesting first to institute here a general comparison between plants and animals. One cannot fail to be struck with the parallel progress which has been accomplished, on both sides, in the direction of sexuality. Not only is fecundation itself the same in higher plants and in animals, since it consists, in both, in the union of two nuclei that differ in their properties and structure before their union and immediately after become equivalent to each other; but the preparation of sexual elements goes on in both under like conditions: it consists essentially in the reduction of the number of chromosomes and the rejection of a certain quantity of chromatic substance.[1] Yet vegetables and animals have evolved on independent lines, favored by unlike circumstances, opposed by unlike obstacles. Here are two great series which have gone on diverging. On either line, thousands and thousands of causes have combined to determine the morphological and functional evolution. Yet these infinitely complicated causes have been consummated, in each series, in the same effect. And this effect could hardly be called a phenomenon of "adaptation": where is the adaptation, where is the pressure of external circumstances? There is no striking utility in sexual generation; it has been interpreted in the most diverse ways; and some very acute enquirers even

[1] P. Guérin, *Les Connaissances actuelles sur la fécondation chez les phanérogames*, Paris, 1904, pp. 144-148. Cf. Delage, *L'Hérédité*, 2nd edition, 1903, pp. 140 ff.

regard the sexuality of the plant, at least, as a luxury which nature might have dispensed with.[1] But we do not wish to dwell on facts so disputed. The ambiguity of the term "adaptation," and the necessity of transcending both the point of view of mechanical causality and that of anthropomorphic finality, will stand out more clearly with simpler examples. At all times the doctrine of finality has laid much stress on the marvelous structure of the sense-organs, in order to liken the work of nature to that of an intelligent workman. Now, since these organs are found, in a rudimentary state, in the lower animals, and since nature offers us many intermediaries between the pigment-spot of the simplest organisms and the infinitely complex eye of the vertebrates, it may just as well be alleged that the result has been brought about by natural selection perfecting the organ automatically. In short, if there is a case in which it seems justifiable to invoke adaptation, it is this particular one. For there may be discussion about the function and meaning of such a thing as sexual generation, in so far as it is related to the conditions in which it occurs; but the relation of the eye to light is obvious, and when we call this relation an adaptation, we must know what we mean. If, then, we can show, in this privileged case, the insufficiency of the principles invoked on both sides, our demonstration will at once have reached a high degree of generality.

Let us consider the example on which the advocates of finality have always insisted: the structure of such an organ as the human eye. They have had no difficulty in

[1] Möbius, *Beiträge zur Lehre von der Fortpflanzung der Gewächse*, Jena, 1897, pp. 203-206 in particular. Cf. Hartog, "Sur les phénomènes de reproduction" (*Année biologique*, 1895, pp. 707-709).

showing that in this extremely complicated apparatus all the elements are marvelously co-ordinated. In order that vision shall operate, says the author of a well-known book on *Final Causes,* "the sclerotic membrane must become transparent in one point of its surface, so as to enable luminous rays to pierce it . . . ; the cornea must correspond exactly with the opening of the socket . . . ; behind this transparent opening there must be refracting media . . . ; there must be a retina[1] at the extremity of the dark chamber . . . ; perpendicular to the retina there must be an innumerable quantity of transparent cones permitting only the light directed in the line of their axes to reach the nervous membrane,"[2] etc., etc. In reply, the advocate of final causes has been invited to assume the evolutionist hypothesis. Everything is marvelous, indeed, if one consider an eye like ours, in which thousands of elements are co-ordinated in a single function. But take the function at its origin, in the Infusorian, where it is reduced to the mere impressionability (almost purely chemical) of a pigment-spot to light: this function, possibly only an accidental fact in the beginning, may have brought about a slight complication of the organ, which again induced an improvement of the function. It may have done this either directly, through some unknown mechanism, or indirectly, merely through the effect of the advantages it brought to the living being and the hold it thus offered to natural selection. Thus the progressive formation of an eye as well contrived as ours would be explained by an almost infinite number of actions and reactions between the function

[1] Paul Janet, *Les Causes finales*, Paris, 1876, p. 83.
[2] *Ibid.* p. 80.

and the organ, without the intervention of other than mechanical causes.

The question is hard to decide, indeed, when put directly between the function and the organ, as is done in the doctrine of finality, as also mechanism itself does. For organ and function are terms of different nature, and each conditions the other so closely that it is impossible to say *a priori* whether in expressing their relation we should begin with the first, as does mechanism, or with the second, as finalism requires. But the discussion would take an entirely different turn, we think, if we began by comparing together two terms of the same nature, an organ with an organ, instead of an organ with its function. In this case, it would be possible to proceed little by little to a solution more and more plausible, and there would be the more chance of a successful issue the more resolutely we assumed the evolutionist hypothesis.

Let us place side by side the eye of a vertebrate and that of a mollusk such as the common Pecten. We find the same essential parts in each, composed of analogous elements. The eye of the Pecten presents a retina, a cornea, a lens of cellular structure like our own. There is even that peculiar inversion of retinal elements which is not met with, in general, in the retina of the invertebrates. Now, the origin of mollusks may be a debated question, but, whatever opinion we hold, all are agreed that mollusks and vertebrates separated from their common parent-stem long before the appearance of an eye so complex as that of the Pecten. Whence, then, the structural analogy?

Let us question on this point the two opposed systems of evolutionist explanation in turn—the hypothesis of purely accidental variations, and that of a variation directed in a definite way under the influence of external conditions.

The first, as is well known, is presented today in two quite different forms. Darwin spoke of very slight variations being accumulated by natural selection. He was not ignorant of the facts of sudden variation; but he thought these "sports," as he called them, were only monstrosities incapable of perpetuating themselves; and he accounted for the genesis of species by an accumulation of *insensible* variations.[1] Such is still the opinion of many naturalists. It is tending, however, to give way to the opposite idea that a new species comes into being all at once by the simultaneous appearance of several new characters, all somewhat different from the previous ones. This latter hypothesis, already proposed by various authors, notably by Bateson in a remarkable book,[2] has become deeply significant and acquired great force since the striking experiments of Hugo de Vries. This botanist, working on the *Œnothera Lamarckiana,* obtained at the end of a few generations a certain number of new species. The theory he deduces from his experiments is of the highest interest. Species pass through alternate periods of stability and transformation. When the period of "mutability" occurs, unexpected forms spring forth in a great number of different directions.[3]—We will not attempt to take sides between this hypoth-

[1] Darwin, *Origin of Species*, chap. ii.

[2] Bateson, *Materials for the Study of Variation*, London, 1894, especially pp. 567 ff. Cf. Scott, "Variations and Mutations" (*American Journal of Science*, Nov. 1894).

[3] De Vries, *Die Mutationstheorie*, Leipzig, 1901-1903. Cf., by the same author, *Species and Varieties*, Chicago, 1905.

esis and that of insensible variations. Indeed, perhaps both are partly true. We wish merely to point out that if the variations invoked are accidental, they do not, whether small or great, account for a similarity of structure such as we have cited.

Let us assume, to begin with, the Darwinian theory of insensible variations, and suppose the occurrence of small differences due to chance, and continually accumulating. It must not be forgotten that all the parts of an organism are necessarily co-ordinated. Whether the function be the effect of the organ or its cause, it matters little; one point is certain—the organ will be of no use and will not give selection a hold unless it functions. However the minute structure of the retina may develop, and however complicated it may become, such progress, instead of favoring vision, will probably hinder it if the visual centers do not develop at the same time, as well as several parts of the visual organ itself. If the variations are accidental, how can they ever agree to arise in every part of the organ at the same time, in such way that the organ will continue to perform its function? Darwin quite understood this; it is one of the reasons why he regarded variation as insensible.[1] For a difference which arises accidentally at one point of the visual apparatus, if it be very slight, will not hinder the functioning of the organ; and hence this first accidental variation can, in a sense, *wait for* complementary variations to accumulate and raise vision to a higher degree of perfection. Granted; but while the insensible variation does not hinder the functioning of the eye, neither does it help it, so long as the variations that are complementary do not

[1] Darwin, *Origin of Species*, chap. vi.

occur. How, in that case, can the variation be retained by natural selection? Unwittingly one will reason as if the slight variation were a toothing stone set up by the organism and reserved for a later construction. This hypothesis, so little conformable to the Darwinian principle, is difficult enough to avoid even in the case of an organ which has been developed along one single main line of evolution, *e.g.* the vertebrate eye. But it is absolutely forced upon us when we observe the likeness of structure of the vertebrate eye and that of the mollusks. How could the same small variations, incalculable in number, have ever occurred in the same order on two independent lines of evolution, if they were purely accidental? And how could they have been preserved by selection and accumulated in both cases, the same in the same order, when each of them, taken separately, was of no use?

Let us turn, then, to the hypothesis of sudden variations, and see whether it will solve the problem. It certainly lessens the difficulty on one point, but it makes it much worse on another. If the eye of the mollusk and that of the vertebrate have both been raised to their present form by a relatively small number of sudden leaps, I have less difficulty in understanding the resemblance of the two organs than if this resemblance were due to an incalculable number of infinitesimal resemblances acquired successively: in both cases it is chance that operates, but in the first case chance is not required to work the miracle it would have to perform in the second. Not only is the number of resemblances to be added somewhat reduced, but I can also understand better how each could be preserved and added to the others; for the elementary variation is now considerable enough to be an advantage to the living being, and so to lend itself to the play of selection. But here there arises another problem, no less formidable, viz., how do all the parts of the visual apparatus, suddenly changed, remain so well co-ordinated that the eye continues to exercise its function? For the change of one part alone will make vision impossible, unless this change is absolutely infinitesimal. The parts must then all change at once, each consulting the others. I agree that a great number of unco-ordinated variations may indeed have arisen in less fortunate individuals, that natural selection may have eliminated these, and that only the combination fit to endure, capable of preserving and improving vision, has survived. Still, this combination had to be produced. And, supposing chance to have granted this favor once, can we admit that it repeats the self-same favor in the course of the history of a species, so as to give rise, every time, all at once, to new complications marvelously regulated with reference to each other, and so related to former complications as to go further on in the same direction? How, especially, can we suppose that by a series of mere "accidents" these sudden variations occur, the same, in the same order—involving in each case a perfect harmony of elements more and more numerous and complex—along two independent lines of evolution?

The law of correlation will be invoked, of course; Darwin himself appealed to it.[1] It will be alleged that a change is not localized in a single point of the organism, but has its necessary recoil on other points. The examples cited by Darwin remain classic: white cats with blue

[1] Darwin, *Origin of Species*, chap. i.

eyes are generally deaf; hairless dogs have imperfect dentition, etc.—Granted; but let us not play now on the word "correlation." A collective whole of *solidary* changes is one thing, a system of *complementary* changes—changes so co-ordinated as to keep up and even improve the functioning of an organ under more complicated conditions—is another. That an anomaly of the pilous system should be accompanied by an anomaly of dentition is quite conceivable without our having to call for a special principle of explanation; for hair and teeth are similar formations,[1] and the same chemical change of the germ that hinders the formation of hair would probably obstruct that of teeth: it may be for the same sort of reason that white cats with blue eyes are deaf. In these different examples the "correlative" changes are only *solidary* changes (not to mention the fact that they are really *lesions*, namely, diminutions or suppressions, and not additions, which makes a great difference). But when we speak of "correlative" changes occurring suddenly in the different parts of the eye, we use the word in an entirely new sense: this time there is a whole set of changes not only simultaneous, not only bound together by community of origin, but so co-ordinated that the organ keeps on performing the same simple function, and even performs it better. That a change in the germ, which influences the formation of the retina, may affect at the same time also the formation of the cornea, the iris, the lens, the visual centers, etc., I admit, if necessary, although they are formations that differ much more

[1] On this homology of hair and teeth, see Brandt, "Über . . . eine mutmassliche Homologie der Haare und Zahne" (*Biol. Centralblatt*, vol. xviii., 1898, especially pp. 262 ff.).

from one another in their original nature than do probably hair and teeth. But that all these simultaneous changes should occur in such a way as to improve or even merely maintain vision, this is what, in the hypothesis of sudden variation, I cannot admit, unless a mysterious principle is to come in, whose duty it is to watch over the interest of the function. But this would be to give up the idea of "accidental" variation. In reality, these two senses of the word "correlation" are often interchanged in the mind of the biologist, just like the two senses of the word "adaptation." And the confusion is almost legitimate in botany, that science in which the theory of the formation of species by sudden variation rests on the firmest experimental basis. In vegetables, function is far less narrowly bound to form than in animals. Even profound morphological differences, such as a change in the form of leaves, have no appreciable influence on the exercise of function, and so do not require a whole system of complementary changes for the plant to remain fit to survive. But it is not so in the animal, especially in the case of an organ like the eye, a very complex structure and very delicate function. Here it is impossible to identify changes that are simply solidary with changes which are also complementary. The two senses of the word "correlation" must be carefully distinguished; it would be a downright paralogism to adopt one of them in the premises of the reasoning, and the other in the conclusion. And this is just what is done when the principle of correlation is invoked in explanations of *detail* in order to account for complementary variations, and then correlation *in general* is spoken of as if it were any group of variations provoked by any variation of the germ. Thus, the notion of correlation is first used in current science as it might be used by an advocate of finality; it is understood that this is only a convenient way of expressing oneself, that one will correct it and fall back on pure mechanism when explaining the nature of the principles and turning from science to philosophy. And one does then come back to pure mechanism, but only by giving a new meaning to the word "correlation"—a meaning which would now make correlation inapplicable to the detail it is called upon to explain.

To sum up, if the accidental variations that bring about evolution are insensible variations, some good genius must be appealed to—the genius of the future species—in order to preserve and accumulate these variations, for selection will not look after this. If, on the other hand, the accidental variations are sudden, then, for the previous function to go on or for a new function to take its place, all the changes that have happened together must be complementary. So we have to fall back on the good genius again, this time to obtain the *convergence* of *simultaneous* changes, as before to be assured of the *continuity of direction* of *successive* variations. But in neither case can parallel development of the same complex structures on independent lines of evolution be due to a mere accumulation of accidental variations. So we come to the second of the two great hypotheses we have to examine. Suppose the variations are due, not to accidental and inner causes, but to the direct influence of outer circumstances. Let us see what line we should have to take, on this hypothesis, to account for the resemblance of eye-structure in two series that are independent of each other from the phylogenetic point of view.

Though mollusks and vertebrates have evolved separately, both have remained exposed to the influence of light. And light is a physical cause bringing forth certain definite effects. Acting in a continuous way, it has been able to produce a continuous variation in a constant direction. Of course it is unlikely that the eye of the vertebrate and that of the mollusk have been built up by a series of variations due to simple chance. Admitting even that light enters into the case as an instrument of selection, in order to allow only useful variations to persist, there is no possibility that the play of chance, even thus supervised from without, should bring about in both cases the same juxtaposition of elements co-ordinated in the same way. But it would be different supposing that light acted directly on the organized matter so as to change its structure and somehow adapt this structure to its own form. The resemblance of the two effects would then be explained by the identity of the cause. The more and more complex eye would be something like the deeper and deeper imprint of light on a matter which, being organized, possesses a special aptitude for receiving it.

But can an organic structure be likened to an imprint? We have already called attention to the ambiguity of the term "adaptation." The gradual complication of a form which is being better and better adapted to the mold of outward circumstances is one thing, the increasingly complex structure of an instrument which derives more and more advantage from these circumstances is another. In the former case, the matter merely receives an imprint; in the second, it reacts positively, it solves a problem. Obviously it is this second sense of the word "adapt" that is used when one says that the eye has become better and better adapted to the influence of light. But one passes more or less unconsciously from this sense to the other, and a purely mechanistic biology will strive to make the *passive* adaptation of an inert matter, which submits to the influence of its environment, mean the same as the *active* adaptation of an organism which derives from this influence an advantage it can appropriate. It must be owned, indeed, that Nature herself appears to invite our mind to confuse these two kinds of adaptation, for she usually begins by a passive adaptation where, later on, she will build up a mechanism for active response. Thus, in the case before us, it is unquestionable that the first rudiment of the eye is found in the pigment-spot of the lower organisms; this spot may indeed have been produced physically, by the mere action of light, and there are a great number of intermediaries between the simple spot of pigment and a complicated eye like that of the vertebrates.—But, from the fact that we pass from one thing to another by degrees, it does not follow that the two things are of the same nature. From the fact that an orator falls in, at first, with the passions of his audience in order to make himself master of them, it will not be concluded that to *follow* is the same as to *lead*. Now, living matter seems to have no other means of turning circumstances to good account than by adapting itself to them passively at the outset. Where it has to direct a movement, it begins by adopting it. Life proceeds by insinuation. The intermediate degrees between a pigment-spot and an eye are nothing to the point: however numerous the degrees, there will still be the same interval between the pigment-spot and the eye as between a photograph and a photographic apparatus. Certainly the photograph has been gradually turned into a photographic apparatus; but could light alone, a physical force, ever have provoked this change, and converted an impression left by it into a machine capable of using it?

It may be claimed that considerations of utility are out of place here; that the eye is not made to see; but that we see because we have eyes; that the organ is what it is, and "utility" is a word by which we designate the functional effects of the structure. But when I say that the eye "makes use of" light, I do not merely mean that the eye is capable of seeing; I allude to the very precise relations that exist between this organ and the apparatus of locomotion. The retina of vertebrates is prolonged in an optic nerve, which, again, is continued by cerebral centers connected with motor mechanisms. Our eye makes use of light in that it enables us to utilize, by movements of reaction, the objects that we see to be advantageous, and to avoid those which we see to be injurious. Now, of course, as light may have produced a pigment-spot by physical means, so it can physically determine the movements of certain organisms; ciliated Infusoria, for instance, react to light. But no one would hold that the influence of light has physically caused the formation of a nervous system, of a muscular system, of an osseous system, all things which are continuous with the apparatus of vision in vertebrate animals. The truth is, when one speaks of the gradual formation of the eye, and, still more, when one takes into account all that is inseparably connected with it, one brings in something entirely different from the direct action of light. One implicitly attributes to organized matter a certain capacity *sui generis,* the mysterious power of building up very complicated machines to utilize the simple excitation that it undergoes.

But this is just what is claimed to be unnecessary. Physics and chemistry are said to give us the key to everything. Eimer's great work is instructive in this respect. It is well known what persevering effort this biologist has devoted to demonstrating that transformation is brought about by the influence of the external on the internal, continuously exerted in the same direction, and not, as Darwin held, by accidental variations. His theory rests on observations of the highest interest, of which the starting-point was the study of the course followed by the color variation of the skin in certain lizards. Before this, the already old experiments of Dorfmeister had shown that the same chrysalis, according as it was submitted to cold or heat, gave rise to very different butterflies, which had long been regarded as independent species, *Vanessa levana* and *Vanessa prorsa*: an intermediate temperature produces an intermediate form. We might class with these facts the important transformations observed in a little crustacean, *Artemia salina,* when the salt of the water it lives in is increased or diminished.[1] In these various experiments the external agent seems to act as a cause of transformation. But

[1] It seems, from later observations, that the transformation of Artemia is a more complex phenomenon than was first supposed. See on this subject Samter and Heymons, "Die Variation bei Artemia Salina" (*Anhang zu den Abhandlungen der k. preussischen Akad. der Wissenschaften,* 1902).

what does the word "cause" mean here? Without undertaking an exhaustive analysis of the idea of causality, we will merely remark that three very different meanings of this term are commonly confused. A cause may act by *impelling*, *releasing*, or *unwinding*. The billiard ball that strikes another determines its movement by *impelling*. The spark that explodes the powder acts by *releasing*. The gradual relaxing of the spring that makes the phonograph turn *unwinds* the melody inscribed on the cylinder: if the melody which is played be the effect, and the relaxing of the spring the cause, we must say that the cause acts by *unwinding*. What distinguishes these three cases from each other is the greater or less solidarity between the cause and the effect. In the first, the quantity and quality of the effect vary with the quantity and quality of the cause. In the second, neither quality nor quantity of the effect varies with quality and quantity of the cause: the effect is invariable. In the third, the quantity of the effect depends on the quantity of the cause, but the cause does not influence the quality of the effect: the longer the cylinder turns by the action of the spring, the more of the melody I shall hear, but the nature of the melody, or of the part heard, does not depend on the action of the spring. Only in the first case, really, does cause *explain* effect; in the others the effect is more or less given in advance, and the antecedent invoked is—in different degrees, of course—its occasion rather than its cause. Now, in saying that the saltness of the water is the cause of the transformations of Artemia, or that the degree of temperature determines the color and marks of the wings which a certain chrysalis will assume on becoming a butterfly, is the word "cause" used in the first sense? Obviously not: causality has here an intermediary sense between those of unwinding and releasing. Such, indeed, seems to be Eimer's own meaning when he speaks of the "kaleidoscopic" character of the variation,[1] or when he says that the variation of organized matter works in a definite way, just as inorganic matter crystallizes in definite directions.[2] And it may be granted, perhaps, that the process is a merely physical and chemical one in the case of the color-changes of the skin. But if this sort of explanation is extended to the case of the gradual formation of the eye of the vertebrate, for instance, it must be supposed that the physico-chemistry of living bodies is such that the influence of light has caused the organism to construct a progressive series of visual apparatus, all extremely complex, yet all capable of seeing, and of seeing better and better.[3] What more could the most confirmed finalist say, in order to mark out so exceptional a physico-chemistry? And will not the position of a mechanistic philosophy become still more difficult, when it is pointed out to it that the egg of a mollusk cannot have the same chemical composition as that of a vertebrate, that the organic substance which evolved toward the first of these two forms could not have been chemically identical with that of the substance which went in the other direction, and that, nevertheless, under the influence of light, the same organ has been constructed in the one case as in the other?

The more we reflect upon it, the more we shall see that

[1] Eimer, *Orthogenesis der Schmetterlinge*, Leipzig, 1897, p. 24. Cf. *Die Entstekung der Arten*, p. 53.

[2] Eimer, *Die Entstehung der Arten*, Jena, 1888, p. 25.

[3] *Ibid.* pp. 165 ff.

this production of the same effect by two different accumulations of an enormous number of small causes is contrary to the principles of mechanistic philosophy. We have concentrated the full force of our discussion upon an example drawn from phylogenesis. But ontogenesis would have furnished us with facts no less cogent. Every moment, right before our eyes, nature arrives at identical results, in sometimes neighboring species, by entirely different embryogenic processes. Observations of "heteroblastia" have multiplied in late years,[1] and it has been necessary to reject the almost classical theory of the specificity of embryonic gills. Still keeping to our comparison between the eye of vertebrates and that of mollusks, we may point out that the retina of the vertebrate is produced by an expansion in the rudimentary brain of the young embryo. It is a regular nervous center which has moved toward the periphery. In the mollusk, on the contrary, the retina is derived from the ectoderm directly, and not indirectly by means of the embryonic encephalon. Quite different, therefore, are the evolutionary processes which lead, in man and in the Pecten, to the development of a like retina. But, without going so far as to compare two organisms so distant from each other, we might reach the same conclusion simply by looking at certain very curious facts of regeneration in one and the same organism. If the crystalline lens of a Triton be removed, it is regenerated by the iris.[2] Now, the original

[1] Salensky, "Heteroblastie" (*Proc. of the Fourth International Congress of Zoology*, London, 1899, pp. 111-118). Salensky has coined this word to designate the cases in which organs that are equivalent, but of different embryological origin, are formed at the same points in animals related to each other.

[2] Wolff, "Die Regeneration der Urodelenlinse" (*Arch. f. Entwickelungsmechanik*, i., 1895, pp. 380 ff.).

lens was built out of the ectoderm, while the iris is of mesodermic origin. What is more, in the *Salamandra maculata,* if the lens be removed and the iris left, the regeneration of the lens takes place at the upper part of the iris; but if this upper part of the iris itself be taken away, the regeneration takes place in the inner or retinal layer of the remaining region.[1] Thus, parts differently situated, differently constituted, meant normally for different functions, are capable of performing the same duties and even of manufacturing, when necessary, the same pieces of the machine. Here we have, indeed, the same effect obtained by different combinations of causes.

Whether we will or no, we must appeal to some inner directing principle in order to account for this convergence of effects. Such convergence does not appear possible in the Darwinian, and especially the neo-Darwinian, theory of insensible accidental variations, nor in the hypothesis of sudden accidental variations, nor even in the theory that assigns definite directions to the evolution of the various organs by a kind of mechanical composition of the external with the internal forces. So we come to the only one of the present forms of evolution which remains for us to mention, viz., neo-Lamarckism.

It is well known that Lamarck attributed to the living being the power of varying by use or disuse of its organs, and also of passing on the variation so acquired to its descendants. A certain number of biologists hold a doctrine of this kind today. The variation that results in a new species is not, they believe, merely an accidental

[1] Fischel, "Uber die Regeneration der Linse" (*Anat. Anzeiger*, xiv., 1898, pp. 373-380).

variation inherent in the germ itself, nor is it governed by a determinism *sui generis* which develops definite characters in a definite direction, apart from every consideration of utility. It springs from the very effort of the living being to adapt itself to the circumstances of its existence. The effort may indeed be only the mechanical exercise of certain organs, mechanically elicited by the pressure of external circumstances. But it may also imply consciousness and will, and it is in this sense that it appears to be understood by one of the most eminent representatives of the doctrine, the American naturalist Cope.[1] Neo-Lamarckism is therefore, of all the later forms of evolutionism, the only one capable of admitting an internal and psychological principle of development, although it is not bound to do so. And it is also the only evolutionism that seems to us to account for the building up of identical complex organs on independent lines of development. For it is quite conceivable that the same effort to turn the same circumstances to good account might have the same result, especially if the problem put by the circumstances is such as to admit of only one solution. But the question remains, whether the term "effort" must not then be taken in a deeper sense, a sense even more psychological than any neo-Lamarckian supposes.

For a mere variation of size is one thing, and a change of form is another. That an organ can be strengthened and grow by exercise, nobody will deny. But it is a long way from that to the progressive development of an eye like that of the mollusks and of the vertebrates. If this development be ascribed to the influence of light, long

[1] Cope, *The Origin of the Fittest*, 1887; *The Primary Factors of Organic Evolution*, 1896.

continued but passively received, we fall back on the theory we have just criticized. If, on the other hand, an internal activity is appealed to, then it must be something quite different from what we usually call an effort, for never has an effort been known to produce the slightest complication of an organ, and yet an enormous number of complications, all admirably co-ordinated, have been necessary to pass from the pigment-spot of the Infusorian to the eye of the vertebrate. But, even if we accept this notion of the evolutionary process in the case of animals, how can we apply it to plants? Here, variations of form do not seem to imply, nor always to lead to, functional changes; and even if the cause of the variation is of a psychological nature, we can hardly call it an effort, unless we give a very unusual extension to the meaning of the word. The truth is, it is necessary to dig beneath the effort itself and look for a deeper cause.

This is especially necessary, we believe, if we wish to get at a cause of regular hereditary variations. We are not going to enter here into the controversies over the transmissibility of acquired characters; still less do we wish to take too definite a side on this question, which is not within our province. But we cannot remain completely indifferent to it. Nowhere is it clearer that philosophers cannot today content themselves with vague generalities, but must follow the scientists in experimental detail and discuss the results with them. If Spencer had begun by putting to himself the question of the hereditability of acquired characters, his evolutionism would no doubt have taken an altogether different form. If (as seems probable to us) a habit contracted by the individual were transmitted to its descendants only in very exceptional cases, all the Spencerian psychology would need re-making, and a large part of Spencer's philosophy would fall to pieces. Let us say, then, how the problem seems to us to present itself, and in what direction an attempt might be made to solve it.

After having been affirmed as a dogma, the transmissibility of acquired characters has been no less dogmatically denied, for reasons drawn *a priori* from the supposed nature of germinal cells. It is well known how Weismann was led, by his hypothesis of the continuity of the germ-plasm, to regard the germinal cells—ova and spermatozoa—as almost independent of the somatic cells. Starting from this, it has been claimed, and is still claimed by many, that the hereditary transmission of an acquired character is inconceivable. But if, perchance, experiment should show that acquired characters are transmissible, it would prove thereby that the germ-plasm is not so independent of the somatic envelope as has been contended, and the transmissibility of acquired characters would become *ipso facto* conceivable; which amounts to saying that conceivability and inconceivability have nothing to do with the case, and that experience alone must settle the matter. But it is just here that the difficulty begins. The acquired characters we are speaking of are generally habits or the effects of habit, and at the root of most habits there is a natural disposition. So that one can always ask whether it is really the habit acquired by the soma of the individual that is transmitted, or whether it is not rather a natural aptitude, which existed prior to the habit. This aptitude would have remained inherent in the germ-plasm which the individual bears within him, as it was in the individual himself and consequently in the germ whence he sprang. Thus, for instance, there is no proof that the mole has become blind because it has formed the habit of living underground; it is perhaps because its eyes were becoming atrophied that it condemned itself to a life underground.[1] If this is the case, the tendency to lose the power of vision has been transmitted from germ to germ without anything being acquired or lost by the soma of the mole itself. From the fact that the son of a fencing master has become a good fencer much more quickly than his father, we cannot infer that the habit of the parent has been transmitted to the child; for certain natural dispositions in course of growth may have passed from the plasma engendering the father to the plasma engendering the son, may have grown on the way by the effect of the primitive impetus, and thus assured to the son a greater suppleness than the father had, without troubling, so to speak, about what the father did. So of many examples drawn from the progressive domestication of animals: it is hard to say whether it is the acquired habit that is transmitted or only a certain natural tendency—that, indeed, which has caused such and such a particular species or certain of its representatives to be specially chosen for domestication. The truth is, when every doubtful case, every fact open to more than one interpretation, has been eliminated, there remains hardly a single unquestionable example of acquired and transmitted peculiarities, beyond the famous experiments of Brown-Séquard, repeated and confirmed by other physi-

[1] Cuénot, "La Nouvelle Théorie transformiste" (*Revue générale des sciences*, 1894). Cf. Morgan, *Evolution and Adaptation*, London, 1903, p. 357.

ologists.[1] By cutting the spinal cord or the sciatic nerve of guinea pigs, Brown-Séquard brought about an epileptic state which was transmitted to the descendants. Lesions of the same sciatic nerve, of the restiform body, etc., provoked various troubles in the guinea pig which its progeny inherited sometimes in a quite different form: exophthalmia, loss of toes, etc. But it is not demonstrated that in these different cases of hereditary transmission there had been a real influence of the soma of the animal on its germ-plasm. Weismann at once objected that the operations of Brown-Séquard might have introduced certain special microbes into the body of the guinea pig, which had found their means of nutrition in the nervous tissues and transmitted the malady by penetrating into the sexual elements.[2] This objection has been answered by Brown-Séquard himself;[3] but a more plausible one might be raised. Some experiments of Voisin and Peron have shown that fits of epilepsy are followed by the elimination of a toxic body which, when injected into animals,[4] is capable of producing convulsive symptoms. Perhaps the trophic disorders following the nerve lesions made by Brown-Séquard correspond to the formation of precisely this convulsion-causing poison. If so, the toxin passed from the guinea pig to its spermatozoon or ovum,

[1] Brown-Séquard, "Nouvelles recherches sur l'épilepsie due à certaines lésions de la moelle épiniéere et des nerfs rachidiens" (*Arch. de physiologie*, vol. ii., 1866, pp. 211, 422, and 497).

[2] Weismann, *Aufsätze über Vererbung*, Jena, 1892, pp. 376-378, and also *Vorträge über Descendenztheorie*, Jena, 1902, vol. ii., p. 76.

[3] Brown-Séquard, "Hérédité d'une affection due à une cause accidentelle" (*Arch. de physiologie*, 1892, pp. 686 ff.).

[4] Voisin and Peron, "Recherches sur la toxicité urinaire chez les épileptiques" (*Arch. de neurologie*, vol. xxiv., 1892, and xxv., 1893. Cf. the work of Voisin, *L'Épilepsie*, Paris, 1897, pp. 125-133).

and caused in the development of the embryo a general disturbance, which, however, had no visible effects except at one point or another of the organism when developed. In that case, what occurred would have been somewhat the same as in the experiments of Charrin, Delamare and Moussu, where guinea pigs in gestation, whose liver or kidney was injured, transmitted the lesion to their progeny, simply because the injury to the mother's organ had given rise to specific "cytotoxins" which acted on the corresponding organ of the foetus.[1] It is true that, in these experiments, as in a former observation of the same physiologists,[2] it was the already formed foetus that was influenced by the toxins. But other researches of Charrin have resulted in showing that the same effect may be produced, by an analogous process, on the spermatozoa and the ova.[3] To conclude, then: the inheritance of an acquired peculiarity in the experiments of Brown-Séquard can be explained by the effect of a toxin on the germ. The lesion, however well localized it seems, is transmitted by the same process as, for instance, the taint of alcoholism. But may it not be the same in the case of every acquired peculiarity that has become hereditary?

There is, indeed, one point on which both those who affirm and those who deny the transmissibility of ac-

[1] Charrin, Delamare and Moussu, "Transmission expérimentale aux descendants de lésions développées chez les ascendants" (*C. R. de l'Acad. des sciences*, vol. cxxxv., 1902, p. 191). Cf. Morgan, *Evolution and Adaptation*, p. 257, and Delage, *L'Hérédité*, 2nd edition, p. 388.

[2] Charrin ad Delamare, "Hérédité cellulaire" (*C. R. de l'Acad. des sciences*, vol. cxxxiii., 1901, pp. 69-71).

[3] Charrin, "L'Hérédité pathologique" (*Revue générale des sciences*, 15 janvier 1896).

quired characters are agreed, namely, that certain influences, such as that of alcohol, can affect at the same time both the living being and the germ-plasm it contains. In such case, there is inheritance of a defect, and the result is *as if* the soma of the parent had acted on the germ-plasm, although in reality soma and plasma have simply both suffered the action of the same cause. Now, suppose that the soma can influence the germ-plasm, as those believe who hold that acquired characters are transmissible. Is not the most natural hypothesis to suppose that things happen in this second case as in the first, and that the direct effect of the influence of the soma is a *general* alteration of the germ-plasm? If this is the case, it is by exception, and in some sort by accident, that the modification of the descendant is the same as that of the parent. It is like the hereditability of the alcoholic taint: it passes from father to children, but it may take a different form in each child, and in none of them be like what it was in the father. Let the letter C represent the change in the plasm, C being either positive or negative, that is to say, showing either the gain or loss of certain substances. The effect will not be an exact reproduction of the cause, nor will the change in the germ-plasm, provoked by a certain modification of a certain part of the soma, determine a similar modification of the corresponding part of the new organism in process of formation, unless all the other nascent parts of this organism enjoy a kind of immunity as regards C: the same part will then undergo alteration in the new organism, because it happens that the development of this part is alone subject to the new influence. And, even then, the part might be altered in an entirely different way from that in which the corresponding part was altered in the generating organism.

We should propose, then, to introduce a distinction between the hereditability of *deviation* and that of *character*. An individual which acquires a new character thereby *deviates* from the form it previously had, which form the germs, or oftener the half-germs, it contains would have reproduced in their development. If this modification does not involve the production of substances capable of changing the germ-plasm, or does not so affect nutrition as to deprive the germ-plasm of certain of its elements, it will have no effect on the offspring of the individual. This is probably the case as a rule. If, on the contrary, it has some effect, this is likely to be due to a chemical change which it has induced in the germ-plasm. This chemical change might, by exception, bring about the original modification again in the organism which the germ is about to develop, but there are as many and more chances that it will do something else. In this latter case, the generated organism will perhaps deviate from the normal type *as much as* the generating organism, but it will do so *differently*. It will have inherited deviation and not character. In general, therefore, the habits formed by an individual have probably no echo in its offspring; and when they have, the modification in the descendants may have no visible likeness to the original one. Such, at least, is the hypothesis which seems to us most likely. In any case, in default of proof to the contrary, and so long as the decisive experiments called for by an eminent biologist[1] have not been made, we must keep to the actual results of ob-

[1] Giard, *Controverses transformistes*, Paris, 1904, p. 147.

servation. Now, even if we take the most favorable view of the theory of the transmissibility of acquired characters, and assume that the ostensible acquired character is not, in most cases, the more or less tardy development of an innate character, facts show us that hereditary transmission is the exception and not the rule. How, then, shall we expect it to develop an organ such as the eye? When we think of the enormous number of variations, all in the same direction, that we must suppose to be accumulated before the passage from the pigment-spot of the Infusorian to the eye of the mollusk and of the vertebrate is possible, we do not see how heredity, as we observe it, could ever have determined this piling-up of differences, even supposing that individual efforts could have produced each of them singly. That is to say that neo-Lamarckism is no more able than any other form of evolutionism to solve the problem.

In thus submitting the various present forms of evolutionism to a common test, in showing that they all strike against the same insurmountable difficulty, we have in no wise the intention of rejecting them altogether. On the contrary, each of them, being supported by a considerable number of facts, must be true in its way. Each of them must correspond to a certain aspect of the process of evolution. Perhaps even it is necessary that a theory should restrict itself exclusively to a particular point of view, in order to remain scientific, *i.e.* to give a precise direction to researches into detail. But the reality of which each of these theories takes a partial view must transcend them all. And this reality is the special object of philosophy, which is not constrained to scientific precision because it contemplates no practical application. Let us therefore indicate in a word or two the positive contribution that each of the three present forms of evolutionism seems to us to make toward the solution of the problem, what each of them leaves out, and on what point this threefold effort should, in our opinion, converge in order to obtain a more comprehensive, although thereby of necessity a less definite, idea of the evolutionary process.

The neo-Darwinians are probably right, we believe, when they teach that the essential causes of variation are the differences inherent in the germ borne by the individual, and not the experiences or behavior of the individual in the course of his career. Where we fail to follow these biologists, is in regarding the differences inherent in the germ as purely accidental and individual. We cannot help believing that these differences are the development of an impulsion which passes from germ to germ across the individuals, that they are therefore not pure accidents, and that they might well appear at the same time, in the same form, in all the representatives of the same species, or at least in a certain number of them. Already, in fact, the theory of *mutations* is modifying Darwinism profoundly on this point. It asserts that at a given moment, after a long period, the entire species is beset with a tendency to change. The *tendency to change*, therefore, is not accidental. True, the change itself would be accidental, since the mutation works, according to De Vries, in different directions in the different representatives of the species. But, first we must see if the theory is confirmed by many other vegetable species (De Vries has verified it only by the *Œnothera Lamarck-*

iana),[1] and then there is the possibility, as we shall explain further on, that the part played by chance is much greater in the variation of plants than in that of animals, because, in the vegetable world, function does not depend so strictly on form. Be that as it may, the neo-Darwinians are inclined to admit that the periods of mutation are determinate. The direction of the mutation may therefore be so as well, at least in animals, and to the extent we shall have to indicate.

We thus arrive at a hypothesis like Eimer's, according to which the variations of different characters continue from generation to generation in definite directions. This hypothesis seems plausible to us, within the limits in which Eimer himself retains it. Of course, the evolution of the organic world cannot be predetermined as a whole. We claim, on the contrary, that the spontaneity of life is manifested by a continual creation of new forms succeeding others. But this indetermination cannot be complete; it must leave a certain part to determination. An organ like the eye, for example, must have been formed by just a continual changing in a definite direction. Indeed, we do not see how otherwise to explain the likeness of structure of the eye in species that have not the same history. Where we differ from Eimer is in his claim that combinations of physical and chemical causes are enough to secure the result. We have tried to prove, on the contrary, by the example of the eye,

[1] Some analogous facts, however, have been noted, all in the vegetable world. See Blaringhem, "La Notion d'espèce et la théorie de la mutation" (*Année psychologique*, vol. xii., 1906, pp. 95 ff.), and De Vries, *Species and Varieties*, p. 655.

that if there is "orthogenesis" here, a psychological cause intervenes.

Certain neo-Lamarckians do indeed resort to a cause of a psychological nature. There, to our thinking, is one of the most solid positions of neo-Lamarckism. But if this cause is nothing but the conscious effort of the individual, it cannot operate in more than a restricted number of cases—at most in the animal world, and not at all in the vegetable kingdom. Even in animals, it will act only on points which are under the direct or indirect control of the will. And even where it does act, it is not clear how it could compass a change so profound as an increase of complexity: at most this would be conceivable if the acquired characters were regularly transmitted so as to be added together; but this transmission seems to be the exception rather than the rule. A hereditary change in a definite direction, which continues to accumulate and add to itself so as to build up a more and more complex machine, must certainly be related to some sort of effort, but to an effort of far greater depth than the individual effort, far more independent of circumstances, an effort common to most representatives of the same species, inherent in the germs they bear rather than in their substance alone, an effort thereby assured of being passed on to their descendants.

So we come back, by a somewhat roundabout way, to the idea we started from, that of an *original impetus* of life, passing from one generation of germs to the following generation of germs through the developed organisms which bridge the interval between the generations.

This impetus, sustained right along the lines of evolution among which it gets divided, is the fundamental cause of variations, at least of those that are regularly passed on, that accumulate and create new species. In general, when species have begun to diverge from a common stock, they accentuate their divergence as they progress in their evolution. Yet, in certain definite points, they may evolve identically; in fact, they must do so if the hypothesis of a common impetus be accepted. This is just what we shall have to show now in a more precise way, by the same example we have chosen, the formation of the eye in mollusks and vertebrates. The idea of an "original impetus," moreover, will thus be made clearer.

Two points are equally striking in an organ like the eye: the complexity of its structure and the simplicity of its function. The eye is composed of distinct parts, such as the sclerotic, the cornea, the retina, the crystalline lens, etc. In each of these parts the detail is infinite. The retina alone comprises three layers of nervous elements—multipolar cells, bipolar cells, visual cells—each of which has its individuality and is undoubtedly a very complicated organism: so complicated, indeed, is the retinal membrane in its intimate structure, that no simple description can give an adequate idea of it. The mechanism of the eye is, in short, composed of an infinity of mechanisms, all of extreme complexity. Yet vision is one simple fact. As soon as the eye opens, the visual act is effected. Just because the act is simple, the slightest negligence on the part of nature in the building of the infinitely complex machine would have made vision impossible. This contrast between the complexity of the organ and the unity of the function is what gives us pause.

A mechanistic theory is one which means to show us the gradual building-up of the machine under the influence of external circumstances intervening either directly by action on the tissues or indirectly by the selection of better-adapted ones. But, whatever form this theory may take, supposing it avails at all to explain the detail of the parts, it throws no light on their correlation.

Then comes the doctrine of finality, which says that the parts have been brought together on a preconceived plan with a view to a certain end. In this it likens the labor of nature to that of the workman, who also proceeds by the assemblage of parts with a view to the realization of an idea or the imitation of a model. Mechanism, here, reproaches finalism with its anthropomorphic character, and rightly. But it fails to see that itself proceeds according to this method—somewhat mutilated! True, it has got rid of the end pursued or the ideal model. But it also holds that nature has worked like a human being by bringing parts together, while a mere glance at the development of an embryo shows that life goes to work in a very different way. *Life does not proceed by the association and addition of elements, but by dissociation and division.*

We must get beyond both points of view, both mechanism and finalism being, at bottom, only standpoints to which the human mind has been led by considering the work of man. But in what direction can we go beyond them? We have said that in analyzing the structure of an organ, we can go on decomposing forever, although the function of the whole is a simple thing. This contrast between the infinite complexity of the organ and the extreme simplicity of the function is what should open our eyes.

In general, when the same object appears in one aspect as simple and in another as infinitely complex, the two aspects have by no means the same importance, or rather the same degree of reality. In such cases, the simplicity belongs to the object itself, and the infinite complexity to the views we take in turning around it, to the symbols by which our senses or intellect represent it to us, or, more generally, to elements *of a different order*, with which we try to imitate it artificially, but with which it remains incommensurable, being of a different nature. An artist of genius has painted a figure on his canvas. We can imitate his picture with many-colored squares of mosaic. And we shall reproduce the curves and shades of the model so much the better as our squares are smaller, more numerous and more varied in tone. But an infinity of elements infinitely small, presenting an infinity of shades, would be necessary to obtain the exact equivalent of the figure that the artist has conceived as a simple thing, which he has wished to transport as a whole to the canvas, and which is the more complete the more it strikes us as the projection of an indivisible intuition. Now, suppose our eyes so made that they cannot help seeing in the work of the master a mosaic effect. Or suppose our intellect so made that it cannot explain the appearance of the figure on the canvas except as a work of mosaic. We should then be able to speak simply of a collection of little squares, and we should be under the mechanistic hypothesis. We might add that, besides the materiality of the collection, there must be a plan on which the artist worked; and then we should be expressing ourselves as finalists. But in neither case should we have got at the real process, for there are no squares brought together. It is the picture, *i.e.* the simple act, projected on the canvas, which, by the mere fact of entering into our perception, is *de*composed before our eyes into thousands and thousands of little squares which present, as *re*composed, a wonderful arrangement. So the eye, with its marvelous complexity of structure, may be only the simple act of vision, divided *for us* into a mosaic of cells, whose order seems marvelous to us because we have conceived the whole as an assemblage.

If I raise my hand from A to B, this movement appears to me under two aspects at once. Felt from within, it is a simple, indivisible act. Perceived from without, it is the course of a certain curve, AB. In this curve I can distinguish as many positions as I please, and the line itself might be defined as a certain mutual co-ordination of these positions. But the positions, infinite in number, and the order in which they are connected, have sprung automatically from the indivisible act by which my hand has gone from A to B. Mechanism, here, would consist in seeing only the positions. Finalism would take their order into account. But both mechanism and finalism would leave on one side the movement, which is reality itself. In one sense, the movement is *more* than the positions and than their order; for it is sufficient to make it in its indivisible simplicity to secure that the infinity of the successive positions as also their order be given at once—with something else which is neither order nor position but which is essential, the mobility. But, in another sense, the movement is *less* than the series of positions and their connecting order; for, to arrange points in a certain order, it is necessary first to conceive the order and then to realize it with points; there must be the work of assemblage and there must be intelligence, whereas the simple movement of the hand contains nothing of either. It is not intelligent, in the human sense of the word, and it is not an assemblage, for it is not made up of elements. Just so with the relation of the eye to vision. There is in vision *more* than the component cells of the eye and their mutual co-ordination: in this sense, neither mechanism nor finalism go far enough. But, in another sense, mechanism and finalism both go too far, for they attribute to Nature the most formidable of the labors of Hercules in holding that she has exalted to the simple act of vision an infinity of infinitely complex elements, whereas Nature has had no more trouble in making an eye than I have in lifting my hand. Nature's simple act has divided itself automatically into an infinity of elements which are then found to be co-ordinated to one idea, just as the movement of my hand has dropped an infinity of points which are then found to satisfy one equation.

We find it very hard to see things in that light, because we cannot help conceiving organization as manufacturing. But it is one thing to manufacture, and quite another to organize. Manufacturing is peculiar to man. It consists in assembling parts of matter which we have cut out in such manner that we can fit them together and obtain from them a common action. The parts are arranged, so to speak, around the action as an ideal center. To manufacture, therefore, is to work from the periphery to the center, or, as the philosophers say, from the many to the one. Organization, on the contrary, works from the center to the periphery. It begins in a point that is almost a mathematical point, and spreads around this point by concentric waves which go on enlarging. The work of manufacturing is the more effective, the greater the quantity of matter dealt with. It proceeds by concentration and compression. The organizing act, on the contrary, has something explosive about it: it needs at the beginning the smallest possible place, a minimum of matter, as if the organizing forces only entered space reluctantly. The spermatozoon, which sets in motion the evolutionary process of the embryonic life, is one of the smallest cells of the organism; and it is only a small part of the spermatozoon which really takes part in the operation.

But these are only superficial differences. Digging beneath them, we think, a deeper difference would be found.

A manufactured thing delineates exactly the form of the work of manufacturing it. I mean that the manufacturer finds in his product exactly what he has put into it. If he is going to make a machine, he cuts out its pieces one by one and then puts them together: the machine, when made, will show both the pieces and their assemblage. The whole of the result represents the whole of the work; and to each part of the work corresponds a part of the result.

Now I recognize that positive science can and should proceed as if organization was like making a machine. Only so will it have any hold on organized bodies. For its object is not to show us the essence of things, but to furnish us with the best means of acting on them. Physics and chemistry are well advanced sciences, and living matter lends itself to our action only so far as we can treat it by the processes of our physics and chemistry. Organization can therefore only be studied scientifically if the organized body has first been likened to a machine. The cells will be the pieces of the machine, the organism their assemblage, and the elementary labors which have organized the parts will be regarded as the real elements of the labor which has organized the whole. This is the standpoint of science. Quite different, in our opinion, is that of philosophy.

For us, the whole of an organized machine may, strictly speaking, represent the whole of the organizing work (this is, however, only approximately true), yet the parts of the machine do not correspond to parts of the work, because *the materiality of this machine does not represent a sum of means employed, but a sum of obstacles avoided*: it is a negation rather than a positive reality. So, as we have shown in a former study, vision is a power which should attain *by right* an infinity of things inaccessible to our eyes. But such a vision would not be continued into action; it might suit a phantom, but not a living being. The vision of a living being is an *effective* vision, limited to objects on which the being can act: it is a vision that is *canalized*, and the visual apparatus simply symbolizes the work of canalizing. Therefore the creation of the visual apparatus is no more explained by the assembling of its anatomic elements than the digging of a canal could be explained by the heaping-up of the earth which might have formed its banks. A mechanistic theory would maintain that the earth had been brought cart-load by cart-load; finalism would add that it had not been dumped down at random, that the carters had followed a plan. But both theories would be mistaken, for the canal has been made in another way.

With greater precision, we may compare the process by which nature constructs an eye to the simple act by which we raise the hand. But we supposed at first that the hand met with no resistance. Let us now imagine that, instead of moving in air, the hand has to pass through iron filings which are compressed and offer resistance to it in proportion as it goes forward. At a certain moment the hand will have exhausted its effort, and, at this very moment, the filings will be massed and coordinated in a certain definite form, to wit, that of the hand that is stopped and of a part of the arm. Now, suppose that the hand and arm are invisible. Lookers-on will seek the reason of the arrangement in the filings themselves and in forces within the mass. Some will account for the position of each filing by the action exerted upon it by the neighboring filings: these are the mechanists. Others will prefer to think that a plan of the whole has presided over the detail of these elementary actions: they are the finalists. But the truth is that there has been merely one indivisible act, that of the hand passing through the filings: the inexhaustible detail of the movement of the grains, as well as the order of their final arrangement, expresses negatively, in a way, this undivided movement, being the unitary form of a resistance, and not a synthesis of positive elementary actions. For this reason, if the arrangement of the grains is termed an "effect" and the movement of the hand a "cause," it may indeed be said that the whole of the effect is explained by the whole of the cause, but to parts of the cause parts of the effect will in no wise correspond. In other words, neither mechanism nor finalism will here be in place, and we must resort to an explanation of a different kind. Now, in the hypothesis we propose, the relation of vision to the visual apparatus would be very nearly that of the hand to the iron filings that follow, canalize and limit its motion.

The greater the effort of the hand, the farther it will go into the filings. But at whatever point it stops, instantaneously and automatically the filings co-ordinate and find their equilibrium. So with vision and its organ. According as the undivided act constituting vision advances more or less, the materiality of the organ is made of a more or less considerable number of mutually co-ordinated elements, but the order is necessarily complete and perfect. It could not be partial, because, once again, the real process which gives rise to it has no parts. That is what neither mechanism nor finalism takes into account, and it is what we also fail to consider when we wonder at the marvelous structure of an instrument such as the eye. At the bottom of our wondering is always this idea, that it would have been possible for *a part only* of this co-ordination to have been realized, that the complete realization is a kind of special favor. This favor the finalists consider as dispensed to them all at once, by the final cause; the mechanists claim to obtain it little by little, by the effect of natural selection; but both see something positive in this co-ordination, and consequently something fractionable in its cause—something which admits of every possible degree of achievement. In reality, the cause, though more or less intense, cannot produce its effect except in one piece, and completely finished. According as it goes further and further in the direction of vision, it gives the simple pigmentary masses of a lower organism, or the rudimentary eye of a Serpula, or the slightly differentiated eye of the Alciope, or the marvelously perfected eye of the bird; but all these organs, unequal as is their complexity, necessarily present an equal co-ordination. For this reason, no matter how distant two animal species may be from each other, if the progress toward vision has gone equally far in both, there is the same visual organ in each case, for the form of the organ only expresses the degree in which the exercise of the function has been obtained.

But, in speaking of a progress toward vision, are we not coming back to the old notion of finality? It would be so, undoubtedly, if this progress required the conscious or unconscious idea of an end to be attained. But it is really effected in virtue of the original impetus of life; it is implied in this movement itself, and that is just why it is found in independent lines of evolution. If now we are asked why and how it is implied therein, we reply that life is, more than anything else, a tendency to act on inert matter. The direction of this action is not predetermined; hence the unforeseeable variety of forms which life, in evolving, sows along its path. But this action always presents, to some extent, the character of contingency; it implies at least a rudiment of choice. Now a choice involves the anticipatory idea of several possible actions. Possibilities of action must therefore be marked out for the living being before the action itself. Visual perception is nothing else:[1] the visible outlines of

[1] See, on this subject, *Matière et mémoire*, chap. i.

bodies are the design of our eventual action on them. Vision will be found, therefore, in different degrees in the most diverse animals, and it will appear in the same complexity of structure wherever it has reached the same degree of intensity.

We have dwelt on these resemblances of structure in general, and on the example of the eye in particular, because we had to define our attitude toward mechanism on the one hand and finalism on the other. It remains for us to describe it more precisely in itself. This we shall now do by showing the divergent results of evolution not as presenting analogies, but as themselves mutually complementary.