The Cosmos

1936

ONE

From a Scientific Point of View

Aestimabat abyssum quasi senescentem.
—Job 42:21

1. The Universe in Expansion

Einstein, in his celebrated theory of relativity, shows an entire universe in profile: a universe closed on itself, its total volume finite, but without limits like the surface of an egg. We thus rid our minds of the vague diffused infinite that obsessed the imagination of our fathers, and which has exercised such a profound influence on romantic literature. In the new physical theory of Einstein, we make a tour of space.

The genial theory of the expansion of the universe of the young abbé Georges Lemaître, a theory explanatory of the constant evolution of the astronomical world, not only describes for us a universe bent into itself in space and time, it leads us to the beginning of time.

The principal experimental basis for this theory is given us by the recession of nebulous spirals, some of which move away from us with a speed many thousands of miles per second.[1] This flight of the nebulae will be an indication of an evolution of the universe by expansion. They will depart proportionally from one another like points on the surface of an inflated rubber balloon. Lemaître estimates at only a dozen billion years the entire duration of this evolution of the universe such as we know it today.

The traditional cosmogonies of Laplace and Kant posed, as point of departure for this evolution, a diffuse nebula filling space and progressively condensing into partial nebula, then into stars. To this evolution of the diffuse to the condensed, Lemaître opposes an inverse evolution of the diffuse by brusque and prodigious explosions.

At the beginning, the entire universe finds itself condensed into a sort of giant primitive atom, containing in a state of extreme concentration all the matter now diffused. The primitive nebula would be formed from fragments of that primitive atom which exploded. "The rapid expansion of the primitive nebula resembles rather the smoke produced by some colossal explosion, by a sort of gigantic artificial firework having dispersed, at the same time as space, the matter primitively condensed."[2]

Two forces[3] rule the evolution of the universe: the gravity by which bodies attract one another and the cosmic repulsion (its measure is designated by the symbol λ, and is called a cosmological constant), which tends to distance bodies proportionally from one another. Gravity tends to maintain or diminish the radius of the universe; cosmic repulsion tends to increase it. When the two forces are neutralized, the universe is in a state of equilibrium.[4]

The phenomenon of the recessions of nebulae allows us to affirm that cosmic repulsion has gained the upper hand. But once it has taken the upper hand it will maintain it, since the attraction of gravity lessens by reason of the growing distance which separates the bodies dispersed by repulsion.

> We can conceive that space began with the primitive atom and the beginning of space marked the beginning of time. The radius of space began from zero; the first stages of expansion consisted in a rapid expansion determined by the mass of the initial atom, equal to just about the actual mass of the universe. If this mass is sufficient, and the estimate that we have been able to make suggests that it is indeed such, the initial expansion was sufficient to permit the radius to surpass the value of the radius of the equiliberate.[5]

Nonetheless, it is the braking exercised by the force of gravity that explains the formation of nebulae from the matter left in a homogenous fashion by a first explosion.

> But this homogeneity can only be global. Indeed, both the density and the speed of expansion will vary a little from one region to another. It is easy to take into account that these local fluctuations will have little importance as long as the speed of expansion is great.

> It will not be the same during a period of slowing. If in a particular region matter is a little more dense than usual, the attraction of gravity will be greater and it could happen that the expansion would be arrested a little sooner or that attraction again takes the upper hand from cosmic repulsion.
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> During the second period of expansion, matter will be agglomerated in places; it is the system of conglomerations that will stretch itself out; the conglomerations will separate themselves from one another. We will obtain a state of things that very much resembles the real universe where matter is agglomerated into dispersing nebulae.
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> We are thus led to identify these agglomerations with the nebulae. Hubble has been able to estimate that the mass of the average nebula is in the neighborhood of a billion suns.[6]

These agglomerations, increasing their relative distances by their concentration, at the same time create conditions advantageous for the cosmic repulsion which speeds it up, thus giving birth to the third stage of the evolution of the universe which has so accelerated as to attain its actual value—the first stage being constituted by the rapid expansion from the primitive atom, and separated from the third by a period of slowing down during which the nebulae are formed.

A word more on the formation of suns in the interior of the nebula. Suppose that the matter of the nebula existed

> under the form of meteorites of dust, or gas in free circulation of sufficiently small average, one can see that shocks will be inevitable. These things would have absorbed the kinetic energy and progressively impede the nebulae from rebounding.
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> At the same time these shocks will have agglomerated matter into considerable and warm masses, that is, the stars.
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> The nebula will be the crucible in which the stars are agglomerated.[7]

2. The Formation of Planetary Systems[8]

The existence of double stars is a perfectly normal phenomenon. A star gives birth to a double star when, by its rotation or by the exaggerated pressure of its heat, it breaks into two spheres which remain coupled.

The distances that separate the two million suns circulating in our galaxy are so vast that one can compare them to the dimensions of our terrestrial globe inside which fly about four tennis balls. The risk of a collision is so low that normally a star can count on traveling without danger throughout its whole existence. However, if the risk of an accident is negligible for any given star individually, it is far from being nil.

Our sun must have been victim of one of those rare celestial catastrophes: it is to such a collision that we owe the formation of the little planet we inhabit. A more massive star came too close to our sun, bringing to its surface an enormous flood of matter. (Think of the tides caused by the moon.) This shaft of matter extracted from the sun circled around it and as it cooled it was cut into small globes, one of them ours.

It is thanks to such accidents that life is possible in the universe. As long as matter remained agglomerated in enormous masses, as in the stars, it is maintained at a temperature of ten million degrees and more. The lower temperature and the atmosphere which are the conditions of life exist only on a few rare planets. The existence of life on other planets actually has no scientific proof in its favor.[9]

3. Chemical Elements and Preparation for Life

Lately come in the universe, we find the 92 chemical elements already constructed. But no doubt they resulted from an evolution whose history remains almost unknown. We know that their differences are pronounced in the relatively cooled regions of the universe, and in this regard we on earth are especially privileged.

All are constructed on the basis of simpler elements forming structures which from the point of view of the elements differ only numerically. Thus, the chemical properties of the 79th body (gold) arise from its capacity to group around itself 79 negative electrons, whereas the 82nd (lead) has 82.

From a biological point of view, it is the number 6 that is the privileged number: carbon, which gathers around its nucleus 6 negative electrons. While the other atoms form small chains of 2 to 10 members, the carbon atoms assemble by the millions. It is these complex edifices which furnish us the matter necessary for life.

4. The Degradation of the Physical Universe[10]

The pre-astronomic state of the universe can be considered a state of extreme concentration and physical organization. When it is said that no energy in the universe can be lost, a most important distinction must be made. A liter of water at 0 degrees and a liter of water of 100 degrees when mixed will level to a temperature of 50 degrees. However, although the sum of the calories of the mixture is preserved (first law of thermodynamics: the conservation of energy), it is impossible to reestablish the initial disymmetry of 0 degrees and 100 degrees by means of the calories of the mixture. (Second principle of thermodynamics: the irreversibility of utilized energy). As Eddington says, "When Humpty Dumpty had a great fall 'All the king's horses and all the king's men / Cannot put Humpty Dumpty together again.' "

Without the numerical value of the total energy of the universe being lessened, its utilization changes in an irreparable fashion. Whatever happens in the universe is done at the expense of energy: the fall of a stone, the flight of a fly, the flow of rivers, the movement of the stars. Energy is not annihilated, it is disorganized. This degradation of energy introduces into the physical world a growing disorder which at the same time is an impoverishing equilibrium.

It is the irreversible direction taken by this progressive denouement which gives time its arrow, its unique direction. The measure of the disorder of the growing chance which leads to the utilization of energy is called *entropy*. It is entropy that allows us to discern the flow of the universe.

Time bears the universe toward a state of complete exhaustion: thermodynamic equilibrium whose image resembles that provided by the partisans of the primitive nebula, diffused, homogeneous, and uniformly distributed in space.

5. The Degradation of Energy and the Expansion of the Universe

A constant relation exists between the law of degradation and the expansion of the universe: the entropy of the universe is proportional to its volume. The scattering of energy permits the growth of the universe: more and more space is needed for the increasing disorder. A building toy cannot be put into its box unless all its parts have been put in order. "The increase of entropy which characterizes the direction of evolution is the progressive fragmentation of the energy which existed at the beginning in a single package."[11]

While the expansion of a given gentleman can only come about thanks to borrowing from his milieu, the expansion of the universe, since it is not in a milieu—it is its own place—cannot come about at the expense of a milieu. There are for it no reserves of space and time: it cannot borrow volume from some volume. It cannot make a snowball. It must inflate from its own substance like a soap bubble.

The tumbling down of the universe ought to bring something *new*, but a 'new' that must be drawn from the interior of the universe. (Still, the idea of the future is not only a logical dilution of the present.) This 'new' cannot be spatio-temporally determined in the present world unless the new were always present and time did not advance. The new of the future can only be true in the present possibility of a future disorder. The denouement of the present order is a condition of the new. But all that involves a certain dose of indetermination in the present with respect to the future. It is this indetermination that makes the physical world malleable to life.[12]

6. Physical Disorganization and Biological Organization

Just as a building toy is not made in order to remain in a box, but to make little houses, the physical universe, too, serves for a higher end that it approaches by losing its initial state of organization. (See 3 above.) The universe unpacks its matter with a view to a higher construction.

While the physicist observes in the physical world a greater and greater disorganization and diffusion, the biologist encounters living islands heading toward a more and more elevated organization, toward a more intense concentration. Life seems to progress against the grain and at the expense of the current of degradation that carries the physical world toward extinction, like trout or salmon which climb the current of the rapids.

Its ascending impulse vegetates on the physical universe and consumes it. Nutrition, assimilative and enriching from the biological point of view, is combustion from the physical point of view. One might say that the inorganic universe is assumed into life by sacrificing itself to it. It disappears before life.

In a general fashion, these two opposed currents can serve as an experimental basis for distinguishing biology from experimental physics.

The vegetal borrows directly from air, water, and earth the elements necessary for its maintenance under their mineral form. The animal, on the contrary, can nourish itself from these elements only if they have been fixed for it in organic substances by plants or animals.[13] The forms of higher lives vegetate on the lower forms. Lower living things feed the higher. Life is organized by disorganizing that which is lower than the level attained.

7. The Physical World and the Biological World

All the beings we encounter on earth are composed of atoms: rocks, potatoes, dogs, prime ministers, etc. But atoms are physical entities. Therefore all living beings are composed of purely physical elements.

Yes. But, while covering all the beings of our universe from the physical point of view, that does not mean to say that the physical point of view covers the *whole* of beings—that it is an exclusive and exhaustive point of view.

Nothing of the living goes counter to the principle of the conservation of energy. The atoms of a gentleman are as truly physical atoms as those of a rock. But the atoms are not parts of beings as bricks are of a house. The physical world is a *metric* and extrinsic aspect of the world. Atoms exist in the way a smile does.[14]

How to distinguish the biological world from the physical world? Life is not inserted into the physical world like a wedge. They are not distinct like two juxtaposed or superposed things. A living being is not opposed to a physical being, but to a non-living being. A physical being can be either living or non-living.

Most authors always confuse the physical world with the inorganic world. But this confusion can be explained. Although from the experimental point of view physical laws sufficiently explain inorganic phenomena, these same laws, while being verified in the living being, do not suffice to explain the whole from the metrical and experimental aspect of the living things. There are phenomena which, without being against physics, oblige us to formulate laws proper to living beings: the formally biological laws.

This distinction should have an ontological foundation, but that foundation cannot interest the experimental sciences as such. We will come back to this.

Moreover, one can already say that the whole of the physical word is carried along by the ascending movement of life, that it is the same impulse that passes through the living and which prepares the inorganic for life.

8. The Spontaneity of Living Things

The physical world, even among living things, tends to disorder: the nutrition-combustion from the physical point of view is a disintegration. There is also from the physical point of view more and more chance in the universe, for example, the ensemble making up a cigarette in its integral condition is more determined than the smoke it disperses. The primitive atom was more determined, more ordered than are its dispersed fragments. The more this universe is released and scattered, the more difficult it becomes to predict the behavior of physical entities. Let us say that this scale of unforeseeability is proportional to the degree of entropy, entropy being a measure of disorder. At a given moment t, there is less chance in the universe that at any later moment t'. There is today more disorder and chance in the universe than there was yesterday.

The biologist observes an analogous phenomenon. But for him *unforeseeability is proportional to the degree of organization.* The behavior of infusoria is more difficult to follow than that of a plant. And the behavior of a dog is more difficult to predict than that of infusoria which are still very mechanical. The more organization, the more spontaneity, which, like chance, escapes the grasp of metrical rigor. When we come to man, who presents a maximum of biological organization, his characteristic behavior becomes undetermined: his liberty gives him a degree of spontaneity that entirely escapes the grasp of the metric.[15] One might object that the behavior of a colony of insects is even more, and better, organized that are human societies. But this organization is due rather to a departure from spontaneity and thus resembles the sterile organization of the physical. In physics, disorganization is a condition of progress. There must be distinguished in the living, accordingly, the amount of physical organization retained, conserved, from the measure of biological organization, growing as opposed to the former.

It is thus possible to say that there runs through the scale of cosmic living things a tendency toward the liberty realized in man.

Not that there exists already in an inchoate state a true liberty in infrahumans. Freedom is a species of the genus of spontaneity, and the spontaneity of plants and animals differs. And the latter non-free spontaneity admits of degrees. Lower animals are less spontaneous than higher. There is in vegetable and animal realms ascending gradations of spontaneity, which, if it could be pushed high enough would become freedom. But freedom is proper to spiritual beings. We will come back to this. Between the perfection of living things, that is to say, their degree of organization, and their degree of spontaneity, there exists a constant relation. In living things spontaneity emanates from the subject, resulting from an interior integration: spontaneity is the measure of the degree of interiority. Take the species of spontaneity of which we have the most adequate idea, freedom. I say the most adequate idea, for people generally think that the activity of a non-free being must be like that of a machine. That shows that we can more easily form an idea of freedom than of a spontaneity without freedom. Take the most manifest case, our own freedom. I said that spontaneity emanates from the subject, and I do not mean anything mysterious by that. I can move my arm when I wish. That means that the determination of what I am going to do depends entirely on me. The movement you observe takes its origin from a free decision of which I am the author. The motion of the piston in a motor does not emanate from the piston. Its movement back and forth is due to explosions which drive it from outside. The piston has no interiority: it does not have the biological organization permitting it to execute motions which take their origin from it. It is not alive; it has no self. All living things have a certain self at an inchoate state. They affirm themselves, as is evident in their instinct for self-preservation.

9. Life and Time

The universe in scattering itself enlarges from the point of view of space and diffuses itself from the point of view of time. Time is a separator, a divider, distancing things from themselves, it parcels out and disperses. Time separates us from ourselves. We are separated from the past by an uncrossable abyss. Time divides our existence into distinct and perishing moments.

Physical time is a sign of the impoverishment and aging of the universe. The direction in which it advances leads to growing disorder in the physical world. It is centrifugal.

On the other hand, the biological world shows us an always growing concentration. Its movement is centripetal, arriving at a state of high organization and immanence. Life goes against time's dispersion. Time disperses, life gathers, tending toward structures that are more and more tight. It is a kind of triumph over the scattering of physical time. It is in the awareness of animals and men that we find the most obvious sign, and most specially in memory, the condition of awareness. That is not to say that awareness is memory or that consciousness is impossible without memory. But memory is a condition of consciousness for beings who live in time. Consciousness raises up, concentrating the past and the present above time. Thanks to memory, we conserve that which has been lost in time, which to the degree that it escapes life is the cause of forgetfulness. Memory is a remedy against time. Memory is obviously meta-temporal since it contains that which is no longer in time. Our memory does not merely preserve the past like a phonograph record; by memory we know in the present the past as past, and the past as past is in neither the past nor the present. Thus man not only lifts himself above time like other animals with memory, but he can lift himself above memory. He knows that in a sufficiently perfect being it is possible to know the past without having been caught in it; that there can be a being who sees directly and simultaneously in an immobile and indivisible instant the past, the present, and the future. This shows what a triumph spirit is over the dissipation of time.

Already in man the world is bent in on itself, and in God its extremes touch.

Even while touching it only from without, man, living on earth, already conceives this eternity.

10. Biology and Exact Science

Experimental biology is an exact science. Experimental sciences can be called exact to the degree that they allow us to make predictions. It is in this sense that physics can be called the most exact of the experimental sciences. In

astronomy we can predict eclipses which will not occur for centuries within a fraction of a second. Experimental science is essentially metric. It can only define properties by a description of the process of measuring them. No experimental law—an algebraic relation between two number-measures—is absolutely rigorous. However, as a group, strictly physical laws are more rigorous than biological laws.

This is no surprise. We have just noted that there is in living things an always growing spontaneity which in man arrives at true freedom. It is absolutely impossible for the physicist to predict in advance what arm movements I will make in the next five minutes, *if* I pay attention. He can measure the movement I make when I make it. But he cannot from this measurement deduce the next movement. Every moment I use my freedom is something absolutely new in the universe. Thus one can say that the more a living being is free, the more he escapes the reach of experimental science. Thus, of all the experimental sciences, experimental biology is the most inadequate and imperfect, even though it studies the highest form of natural organization.[16]

In philosophy, it is the opposite that is true. The more we move away from man and descend the scale of living things, the more their life becomes obscure. Thus, the life of plants is more obscure for us than animal life. We will come back to this. It is enough to say for the moment that there will be a certain compensatory complementarity between the two orders of knowledge linking them to one another. They are never so distant from one another than at the point where they touch: like points on a non-Euclidean line which are infinitely close but also infinitely distant.

11. The Scientific Problem of Evolution

We constantly use the expressions 'movement' or 'the rising elan of life.' Must we thereby understand a purely static scale of hierarchized beings? A series of beings of different species which would have been given at once as they are without the existence of any dynamic link among them, in such wise that the forms with more complex and elevated organization would have appeared last?

It is not to the philosopher that we put the question. Experimental science must answer it. Since it is a matter of responding to a question of fact, it is experimental science that undertakes the research. Even if the philosopher had already established what he has to establish, he would not for that reason be able to prevent the scientist from finding out what he finds out. And we should be disposed to believe every explicative theory of observed phenomena, insofar as they are within the bounds of experience and logic. But, since we are concerned with experimental phenomena, the theory itself must be formulated in experimental terms. Under these conditions, one finds it difficult to imagine a clash between philosopher and scientist. And when we say 'a theory explicative of observed phenomena' that does not mean that the scientist cannot introduce into his theory undemonstrated postulates which alone permit the theory to direct experimental research. The only thing required is what the scientific method itself requires, which is that the theory be formulated in terms which are strictly of the experimental order.

It would be equally absurd to want to consider an experimental theory only at the time when it is absolutely demonstrated. None of these theories is absolutely true. Like measurements and the relations between measurements from which they take off, the theories themselves are only approximative—but they are truly approximative. The disdain of certain philosophers for scientific hypotheses is an absolutely incontestable criterion not only of their ignorance of scientific matters, but above all of their intellectual incompetence, and competence ought to be greater in philosophy than in any other degree of knowledge. There are some who have furtively taken refuge in a domain where it is easy to speak without knowing of what one speaks and without others being able to perceive it.

12. The Facts to Explain

Let us listen to the word of a specialist in these matters, Brother Marie-Victorin of the University of Montreal.

> Paleontology . . . teaches us in an undeniable fashion that there has been, in organic types, a succession in time of such a kind that the more complex and elevated forms of organization have appeared last. To the testimony of paleontology, absolutely invulnerable, comes to be added the experience we have of the continuity of life: we know that the simplest organisms did not appear spontaneously. No biologist today would want to deny the following proposition: 'No living being can be born outside of continuity with the plasm of his ancestors.' If we add to this the equally undeniable testimony of paleontology, the conviction that the different living types ought to develop not only the one and the others, but the one from the others, it takes on the dimension of a positive logical postulate. The certitude of the reality of organic evolution would only be upset if experience taught us in the future that an individual organism could arise otherwise than by plasmic continuity, or that all the vital types, the living and the disappeared, existed at the same time at the beginning. No other argument could weaken the logic of the idea of organic evolution.[17]

13. The Evolutionist Theory

It is now a matter of constructing a theory from which one can deduce these established phenomena by way of conclusion.

Example of an experimental theory, the kinetic theory of gases. ${}_{P}\overset{V}{\triangle}{}_{T}$ constant relations.

Explanation: We imagine that the inner sides of the recipient which encloses the gas undergo on the part of the gas a pressure proportional to its temperature. But temperature is nothing but the disordered movement of molecules, the kinetic energy of molecules. If one lowers by half the volume occupied by a determined mass of gas, the pressure is doubled as well as the temperature, as one can observe in a simple tire pump.

The Vpt diminishes by half, that is, the number of shocks of the molecules among themselves is doubled, in other terms, the temperature is doubled.

The P is doubled, that is the number of shocks given by the molecules to the inner sides of the recipient is doubled.

This image allows us to *deduce one relation from the other.*

It will not suffice to deduce simply a statistical hierarchy, and I ask myself how such a deduction could deserve the name scientific: it is necessary that the theory allows us to explain the temporal and hierarchical succession of these types of organization. It is necessary to find the laws which govern this ascendant movement: laws which should be formulated in experimental terms, whatever be the ontological demands conditioning these laws. At no time can one have recourse to physical knowledge.

The explanation, or if you will the deduction, can be scientific only on condition of being evolutionist. No other theory could be scientific and explanatory. Since deduction is prohibited in advance, the deduction supposes, in effect, functional links. Either we must abstain from all explanation, from all science in the proper sense, stopping passively before the facts, confining ourselves to a quite material description and classification which make up precisely the givens to be explained, or one must try to deduce the succession. To speak rigorously, every classification is already made in function of a theory however elementary. One must accordingly forbid classification as well.

And if one succeeds in making a deduction sufficiently logical and confirmed by the facts which impose themselves, is it for the philosopher to tell us that it is not true? In doing so, he would thereby enter the scientific terrain: he would have to remove the base of the observed facts and at least suggest the possibility of another theory, which itself would have to explain the facts in experimental terms, not in philosophical terms. Even still he would have to demonstrate on the basis of experimental facts and not on the basis of any philosophical principle whatever that a theory is impossible. That is, he would have to demonstrate that the relations that exist do not exist. Thus, in doing so, he would not speak as philosopher any more than the scientist who appeals to philosophical principles speaks as a scientist. But this is just what has come about with many scientists. And from that arises the conflict between philosophers, scientists, and theologians which is still far from settled.

14. Lamarckism and Darwinism

Lamarck and Darwin tried to explain the ascendant movement of organized types by a process slow and continuous, analogous to the apparently continuous variation in height and color. Partisans of their theories are so convinced of the principle *natura non facit saltus* that they apply it in advance of the very classification of types, attaching by way of hypothetical filiation the forms which depart the least strongly from one another, forcing themselves thus to obtain, as much as possible, a continuous series.[18]

But the theories differ in the laws which govern this continuous ascension.

Lamarck formulated the four following laws which concern organization and which govern all the acts operated in it by the *forces of life.*

> FIRST LAW: Life, by its own powers, tends continually to increase the volume of all bodies that possess it, and to extend the dimension of its parts, to the term to which it leads itself.
>
> SECOND LAW: The production of a new organ in an animal body results from a new need which continues to make itself felt and of a new movement which this need gives birth to and maintains.
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> THIRD LAW: The development of organs and their power of action are constantly by reason of the use of these organs.
>
> FOURTH LAW: Whatever has been acquired, laid out, or changed in the organization of individuals during the course of their life is conserved by generation and transmitted to new individuals which come from those who have undergone these changes.

It is by these principles that Larmarck explained the long neck of the giraffe. His short-necked ancestors no longer finding food on the ground were obliged to turn to trees. The character partially acquired during the existence of giraffe A was transmitted to giraffe B, the lengthening acquired by B was passed on to C, and so on. One has done experiments with rats, cutting their tail, etc. Baby rats are born with full tails.

These formulations have had the advantage of directing research. But such research has given only a negative result. Thus the children of the Chinese who bound their feet for thousands of years persist in being born with normal feet. Guyénot asserts that we still await a correct proof of the inheritance of acquired characteristics, and that it is infinitely likely that it will never be forthcoming.[19]

Darwin proposed two principles which govern the slow and continuous evolution of forms:

> A *struggle for existence* inevitably follows from the high rate at which all organic bodies tend to increase. Every being, which during its natural lifetime produces several eggs or seeds, must suffer destruction during some period of its life, and during some season or occasional year,

otherwise, on the principle of geometrical increase, its numbers would quickly become so inordinately great that no country could support the product. Hence, as more individuals are produced than can possibly survive, there must be in every case a struggle for existence, either one individual with another of the same species, or with the individuals of a distinct species, or with the physical conditions of life.

Again, it may be asked, how is it that variations, which I have called incipient species, become ultimately converted into good and distinct species, which in most cases obviously differ from each other far more than do the varieties of the same species? How do those groups of species, which constitute what are called distinct genera, and which differ from each other more than do the species of the same genus, arise? All these results follow from the struggle for life. Owing to this struggle, variations, however slight and from whatever cause proceeding, if they be in any degree profitable to the individuals of a species, in their infinitely complex relations to other organic beings and to their physical conditions of life, will tend to the preservation of such individuals *and will generally be inherited by the offspring.* The offspring also will thus have a better chance of surviving, for, of the many individuals of any species which are periodically born, but a small number can survive. I have called this principle, by which each slight variation, if useful, is preserved, by the term *Natural Selection,* in order to mark its relation to man's power of selection.[20]

The gigantic combat which troubles the living world is a fact of observation which struck Darwin during his long voyage of exploration in South America and the islands of the Pacific Ocean. And it was necessary to have recourse to a fantastic principle of elimination to explain the relatively restricted number of survivors, for a simple Bacterium would give, by successive partitions, a mass of protoplasm much greater than the earth in less than a month.

But Cuénot has shown that the principle of elimination seems rather calculated on the law of large numbers, and that, far from assuring necessarily the survival of the fittest, would spare only the average type.

As for hereditary variations, they would undergo the sort of transmission of acquired characteristics of Lamarck.

15. Mutationism

Darwin felt the great difficulties that a slow and continuous evolution entail.[21] But the youth of paleontology allowed him free rein to his imagination. The research pursued is far from having encouraged this hope. The links that permit us to range types in a continuous series are defective in too systematic a manner. A regular irregularity calls for an explanation. Do you not seek links that *often* never existed? Has not a methodological error—a *petitio principii*—been committed in the classifications made on the basis of the principle of continuity, to which one appeals to confirm the same principle?

Guyénot cites a passage in the writings of Charles Naudin, founder of *Genetics,* dating 1867: "What the experience of observation teaches us is that the actual epoch of slight or profound anomalies, the alterations that we call, arbitrarily perhaps, specific types . . . are produced brusquely and without there ever having been transitory forms between them and the normal form."[22]

Almost half a century ago the Dutch biologist Hugo de Vries cultivated an enormous number of plants of a new species of Onagre discovered in 1875 and called *Oenothera Lamarckiana.* Among the thousands of these plants he observed that certain types present *new characteristics which are fixed and transmissible.* In other terms: he *observed* an evolution by bounds, sudden leaps, to which he gave the name 'mutation.'

For thirty years one has found mutations in great number and with an unexpected frequency in the animal kingdom as well as in the vegetable kingdom. Totals right off, immediately hereditary, and of whatever amplitude, they are produced by change, that is to say no individual is privileged, no individual of a group is specially disposed to produce a mutation. Moreover, their culture has allowed the drawing of statistical tables which allow us to foresee their approximate number. There is no doubt that we are confronted by a law.

Having no adaptive character, some are favorable, some indifferent, and when they are of great amplitude they realize truly hereditary monstrosities. Overflowing and prodigal nature is subject to a law which makes it deflect these too violent explosions. Evolution reminds us of the trials and errors of the learner. Life in expansion always puts itself on the edge of a precipice. It must go on by trying diverse formulas. The world is littered with the debris lost in the course of the journey. The conditions of survival are so rarely realized that they explain perfectly the elimination necessary if vital species are to be limited to a relatively restricted number over the course of history.[23]

Mutationism makes a blank slate of the active adaptation of organisms to the conditions of their milieu. No doubt the milieu works a selection in suffocating the most unfavorable mutations, it acts as a brake, but it does not form "the new entities by shaping them to its contours. It seems rather that the species, in virtue of a dynamism the essence of which still escapes us completely, and under the stimulus of the environment, produces by chance, in all directions, mutations which themselves have no relation at all to the milieu, and utility." What Brother Marie-Victorin says here of a particular case can be applied to every mutation.[24]

I cite a passage from the *Flore Laurentienne*: "The study of flora fossils, as well as of living flora generally, shows that the development of species does not proceed simultaneously in all points, nor at the same rate, like a wave approaching the shore, but development rather suggests the progression, apparently disordered, of troops over a long line of battle. There are explosions, sudden breakthroughs of some few: genera, families, orders, classes, which explore as it were all the possibilities of a certain formula of organization then return to relative or absolute immobility, and sometimes disappear entirely."[25]

I will not attempt to show how recent research on genes or factors, objects of mutations, let us foresee a general theory of evolution with the range of the most solid physical theories. I have neither the time nor competence for that.[26]

But already the simple *observed* facts sketch an image of a nature which advances by successive explosions in the manner of a rocket, rising to the sky and asking directly from the hands of its Creator the spiritual form of man to which nature has been destined and in which she is liberated.

In this new order, evolution is pursued always in the very interior of humanity. Men are also drawn by the current of degradation whereas the world will continue to fashion itself until the day it is assumed into eternity and we go to rejoin it.

Moreover, evolution which continues in humanity has taken on a different color. It no longer proceeds by essential jumps. We find ourselves from now on on a spiritual plane where plasticity is infinitely greater within the same essential degree. There rises now a quite new type of hierarchization, more profound, more essential. At a subhuman level the world could only enrich and hierarchize itself thanks to essential ruptures of equilibrium, thanks to violent changes, like those of an apprentice swimmer who has to make a noisy display of effort barely to keep afloat, whereas the expert swimmer advances rapidly by executing graceful movements.

Moreover, man seems to have rejected what should be his privilege: his equiliberating domination of nature. He seems to be subject, by the dissociation of his passions from reason, to the law of the corruption of the irrational creature which during millions of years groaned toward the liberation of spirits. He has re-engaged himself in that mortal struggle for life. The same law which is quite natural for subhuman beings—it is good that the lion devour the gazelle—is transformed into a law of hatred in spirits. Men destroy one another. Combat is all the more terrible because it is spirits who are engaged in it. And man, too, must groan for the liberation of his fallen nature.

16. Man and the Scientific Problem of Evolution

The last few paragraphs are of a kind to scandalize both the scientist and the philosopher. Have I not extended evolution to man himself? I remind you that in this part I am speaking from the scientific point of view. The philosopher can only reproach me if he confuses science and philosophy, a worse error, it seems to me, than that for which he reproaches me. The profound distinction between these two domains will appear more clearly when we will have studied the same problem from a strictly philosophical point of view.

Take any electron. What prevents me from following its trail[27] from the water of a spring through the grass eaten by a cow and the cow eaten in its turn by this gentleman? Will the electric charge of the electron undergo transformations as it passed from water to the tip of this gentleman's nose? Let the philosopher introduce as many transformations as he wants, the electron has not undergone any changes that could have an *experimental signification.* I wonder how one could introduce ontological transformations into a differential equation. And I even wonder what the phrase 'an ontological change of an electron' could mean. But what is true of the electron is true of the whole metric aspect of any cosmic being whatsoever.

Scientists and philosophers do not speak the same language. 'Matter,' 'force,' 'nature,' 'life,' 'transformation,' 'species,' etc. are so many absolutely equivocal terms. There is nothing sadder than the conflicts raised by scientists, philosophers, and theologians by assuming a univocal meaning of these expressions. Not that this would have been able to defeat the first evolutionist scientists, for it must be admitted, they gave to experimental science an exhaustive coverage of reality: science was their philosophy. The confusion of philosophers and theologians is more regrettable for they have not always been able to discern what is true in the pseudo-scientific generalizations of a Lamarck or Darwin.

St. Thomas, in the very place where he treats this question, cautions us against a blind zeal that invites the derision of non-believers: "ne quidquid verum aliquis esse crediderit, statim velit asserere, hoc ad veritatem fidei pertinere . . . quia ab infidelibus veritas fidei irridetur, cum ab aliquo simplici et fideli tamquam ad fidem pertinens proponitur quid certissimis documentis falsum esse ostenditur."[28]

The very progress of science involves a precision and purification of its vocabulary in a way that inspires hope. Soon all will see what is and what is not at issue.

Conclusion

Science, while being only a flat projection of what has relief and depth, enables us to foresee the immense effort and the prodigious cost nature invests in the preparation for the coming of man. And whether he knows it or not, everything that happens in the world is done for him. The scale of natural species is only a scale of assault. If man is the *ultimum in executione,* he is nonetheless the *primum in intentione.* The all too poor account that we have given enables us to suspect the richness of the human being who contains virtually all the degrees of perfection of that which is below him. And it is not only in the formidable display of power that we should look for this richness: the reaches of space, the unimaginable masses, the vertiginous speeds of astronomy are not worth a lily. But we have also seen that we have need of the stars to understand the lily. We will only be able to understand ourselves when we understand the universe. Our present is filled with the past.

The more profoundly we understand the world, the better we comprehend that we touch it only with the feet, and that with our head we touch the bottom rungs of another hierarchy of which nature is only a fleeting shadow.

TWO

The Philosophical Point of View

1. Preliminary Notions

a. Becoming

By the term 'nature,' taken in a general sense, we mean the coordinated ensemble of spatio-temporal things which surround us and of which we are a part. Becoming is the common and specific character of each thing in this ensemble. The universality of becoming is most obvious in temporal duration. The natural being which seems not to change or be changed in any other way can only continue its existence on condition that it be constantly renewed. Existence is received by it only in a successive and continuous manner. Successive and continuous duration is the definition of *time.* If this successive duration were not continuous the natural being could only exist by always becoming other. In this regard the whole of nature is in a state of constant flow.

Natural being changes in many other respects. But the other changes, whatever they be, always involve time. Moreover, these other ways of changing are not particular or special cases of temporal duration. It cannot therefore be time which expresses this general mobility of the natural being, a mobility of which time is only a particular case, for even though it is implicated in the other cases, it is distinct from them. Let us say then that a natural being is a *mobile being.* And that nature is an ensemble of *fluxibilia.*

Manifestly we are dupes of a verbal trick when we say that a mobile being is a natural being. 'Natural' is after all a vague term. And to take 'nature' in a strict sense, as we will see in what follows, we must define it in terms of mobility.

It is *mobile being,* not as being, but under the precise angle of mobility, *ens mobile in quantum mobile,* mobile being precisely as mobile, that is the formal object of the Philosophy of Nature.

Note that we have not yet mentioned 'matter' and 'body.'