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LAMARCK AND DARWIN IN THE HISTORY OF SCIENCE

By CHARLES COULSTON GILLISPIE

I

FOR myself, as for many historians of science, the first reading of Professor Lovejoy's *The Great Chain of Being* came as a revelation of what the philosophical history of ideas about nature might accomplish. So, too, in a more restricted sense, did his articles on early evolutionists introduce us to the history, or perhaps the pre-history, of the concept of evolution. And I am sure it will be taken as a testimonial to the stimulus afforded by Professor Lovejoy's scholarship if I say that *The Great Chain of Being* appears to leave a gap, which his evolutionary papers do not fill, between the "temporalizing" of the principle of plenitude as the program of nature, and the actual establishment of the concept of evolution on a scientific footing in the work of Charles Darwin. It is this gap across which I shall try to toss a line, and I make bold to hope that Professor Lovejoy may recognize his own guidance in the direction it takes, for it may be that my paper will bring the question back to the starting point of *The Great Chain of Being*. My purpose is to define the sense in which Darwin did, and the sense in which he did not, have predecessors. And since the foremost of the pre-Darwinian evolutionists was certainly Lamarck, this may best be accomplished by comparing the places which they occupy in the whole structure of the history of science.

Most students will agree that Darwin's work had two aspects, empirical and theoretical. First, it definitively established the mutability of organic species in their descent out of the past. Secondly, it explained these variations by the concept of natural selection. Religious fundamentalists might deny the fact of evolution. But this reaction was intellectually trivial, and where philosophical offense was taken it was rather the view of the world implicit in the theory of natural selection which wounded humane sensibilities more deeply, and which was repudiated as inadmissible or meaningless or both, for the two complaints come down to the same thing and turn on the eternal question of what a scientific explanation really says.

There is, perhaps, a certain inconsequence which besets controversy of this sort. Having rejected Darwin's evolutionary principles, most of his opponents thought it worthwhile to impugn his originality. Among

EDITORS' NOTE: We are pleased to present this article which is one of a series of essays entitled FORERUNNERS OF DARWIN, edited by Bentley Glass, to be published in the spring by the Johns Hopkins Press for the History of Ideas Club of the Johns Hopkins University.
moralists Samuel Butler, and among scientists (though for different reasons) the French, put it about that Lamarck had had everything essential to an evolutionary biology. And it would be difficult indeed to claim the fact of the evolutionary variation of species as a Darwinian discovery. It is true that Darwin disposed of a greater fund of species than had Lamarck. Moreover, the seating of the chronology of earth history in paleontological indices gave biologists by way of return the succession of species in geological time. It was for lack of this information that Lamarck had had to establish his order in the scale of increasing morphological complexity.

It is to be doubted, however, whether the uniformitarian philosophy of Charles Lyell was as essential to Darwin’s success as is usually said, or as I once said myself. For Lamarck had been his own Lyell. His *Hydrogéologie* prepared the ground for his theory of evolution with a uniformitarian earth history as uncompromising as Lyell’s, if not so well founded. More generally, it might be argued—indeed, I do argue—that in the relative cogency with which the two theories organize actual biological information, Lamarck’s presentation in the great *Histoire naturelle des animaux sans vertèbres* is the more interesting and elegant.

It is analytical and informs a systematic taxonomy, whereas Darwin simply amassed detail and pursued his argument through the accumulated observations in a naturalist’s commonplace-book. To be single-minded and relentless is not necessarily to be systematic, and the merit of Darwin’s approach must be sought elsewhere.

Nevertheless, despite the greater formal elegance of Lamarck’s ultimate presentation, his theory failed to compel assent. It scarcely even won attention. Those most competent to judge, Lamarck’s own scientific colleagues, treated his ventures into theory as the embarrassing aberrations of a gifted observer, to be passed over in silence. “I know full well,” he once observed bitterly, “that very few will be interested in what I am going to propose, and that among those who do read this essay, the greater part will pretend to find in it only systems, only vague opinions, in no way founded in exact knowledge. They will say that: but they will not write it.” Cuvier and Lamarck were able to work together in actual taxonomy. But they could never agree on the structure of nature.

No such humiliating judgment of irrelevance awaited Darwin’s theory. (Even though my argument is that Darwin’s original contribution was the theory and not the evidence, I shall in the interests of economy perpetuate the injustice which makes Wallace’s role in the history of science little more than an object lesson in the agonizing

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1 *Genesis and Geology* (Cambridge, 1951).
2 Paris, 1802.
3 Paris, 1815–1822.
generosity of creative minds.) Huxley's description of his own reaction is well known. Once stated, the force of the concept leapt out at him like the pattern from the pieces of the puzzle of adaptation, so that all he could say to himself was, "How extremely stupid not to have thought of that." The right answer, it presented itself in that combination of unlookedness and irresistibility which has often been the hallmark of a truly new concept in scientific history.

One sometimes reads, however, that the force of Darwin's ideas derived from their mechanistic character in an age which identified the scientific with the mechanistic. I cannot think this quite correct. The one thing Darwin did not, and could not, specify was the mechanism of variation or heredity. All he could do was postulate its naturalistic mode. Ultimately, of course, his hypothesis was vindicated by discoveries in genetics of a materialistic character. But that is quite another matter—the bête-machine belongs to the 18th century (or to the 20th), but not to the 19th. It was through no metaphor or analogy that Darwin prevailed. He prevailed because his work turned the study of the whole of living nature into an objective science. In the unlikely guise of a Victorian sermon on self-help in nature, on profit and loss, on progress through competition, there was clothed nothing less than a new natural philosophy, as new in its domain as Galileo's in physics. Darwin, indeed, abolished the distinction which had divided biology from physics at least since Newton, and which rested on the supposition (or defense) that the biologist must characteristically study the nature and the wisdom of the whole rather than the structure of the parts.

II

Lamarck, too, conveyed a philosophy of nature in his theory of the development of life, but it stands in the same relationship to Darwin's as does Hegel's historical dialectic to that of Marx. It is no compliment to Lamarck's own conception of his lifework, therefore, to make him out an unappreciated forerunner of Darwin. I recently asked a friend who is a biologist specializing in evolution what he and his colleagues understood by Lamarckism, and the first thing he said was the inheritance of acquired characteristics, and after that a lingering temptation in biology generally to indulge in an "Aristotelian vitalism." Now, vitalism and the mode of acquisition and transmission of variations were, indeed, the points on which scientific discussion of evolution turned in the

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6 I wish to acknowledge the kindness of the colleague in question, Dr. Colin S. Pittendrigh, who explained to me very patiently various aspects of the outlook of modern evolutionists. Section V of this essay has specially profited from this discussion—though I should be distressed if any mistakes which remain were attributed to anyone but me.
LAMARCK AND DARWIN IN THE HISTORY OF SCIENCE 391

later decades of the 19th century before the establishment of modern genetics. And it is most natural that biologists should have looked upon Lamarck in the perspective of their science, which takes the shape of evolution from Darwin. But in doing so they have first missed and then misrepresented the point of Lamarck’s work, which was neither Aristotelian nor vitalistic, and which instead was meant to establish, not simply the subordinate fact of transmutation, but a view of the world. For Lamarck’s theory of evolution was the last attempt to make a science out of the instinct, as old as Heraclitus and deeply hostile to Aristotelian formalization, that the world is flux and process, and that science is to study, not the configurations of matter, nor the categories of form, but the manifestations of that activity which is ontologically fundamental as bodies in motion and species of being are not. This is no longer a familiar view. It is not even recognizable. And it may be helpful, therefore, to reconstitute it by moving from what is familiar in Lamarck to what is less so, and by this means to trace the formation of his theory of evolution backward from its definitive formulation in taxonomy to its origin in an insufficiently understood pattern of 18th-century resistance to the implications of Newtonian physical science. Moreover, since Lamarck was himself sympathetic to the idéologues, and a disciple of Condillac in relating mind to nature through the associationist psychology, a genetic analysis of his theory of evolution will conform to his own conception of scientific explanation.7

For Lamarck began as a theorist and only ended as a taxonomist. The great Histoire naturelle des animaux sans vertèbres appeared between 1815 and 1822. It is presented as exemplifying the evolutionary theory, which was already fully developed in Philosophie zoologique, published in 1809. But Lamarck had first adumbrated the notion of transmutation of living species in his course at the Muséum d’histoire naturelle in 1800. The date is significant. Since we know that in 1797 he still believed in the immutability of species, this interval of three years has always been taken as the critical and creative period in Lamarck’s life, when he revolutionized his concepts and founded evolutionary thought.8 The circumstance is curious for another reason. Although Lamarck was fifty-seven years old in 1800, he was only beginning his career as a zoologist. Since 1793 when, known to science only as a botanist, he was appointed to the new chair of zoology at the reorganized Muséum, his thoughts had been absorbed by writings on chemistry, geology, and meteorology. These interests still figure in Philosophie zoologique, and

7 I have already published the substance of this section as “The Formation of Lamarck’s Evolutionary Theory,” Archives internationales d’histoire des sciences, IX (1956), pp. 323-338, where the reader will find somewhat more circumstantial and bibliographical detail. The conclusions were revised somewhat to publish in Actes du VIIIe Congrès International d’Histoire des Sciences (Florence, 1956), pp. 544-548.

8 Marcel Landrieu, Lamarck (Paris, 1909), pp. 287-302. This work contains a complete bibliography of Lamarck.
are usually ignored by scientific readers. That book has three divisions. Part I treats of natural history, Part II of physiology, and Part III of psychology. But under the inspiration of Cabanis, the latter two divisions handle a single theme, the physical basis of life and consciousness.

Concise statement was never Lamarck's own way. It is, nevertheless, possible to abstract from Part I of Philosophie zoologique a summary of the evolutionary theory in its final form. In living nature, according to this zoological philosophy, inheres a plastic force—indeed living nature is a plastic force—forever producing all varieties of animals from the most rudimentary to the most advanced by the progressive differentiation and perfection of their organization. If this action of organic nature were omnipotent, the sequence would be altogether regular, a perfect continuum of organic forms from protozoa to man. But the innate tendency to complication is not the only factor at work. Over against it, constraining it into certain channels of necessity which we mistakenly take for natural species, works the influence of the physical environment. The dead hand of inorganic nature causes discontinuities in what the organic drive toward perfection would alone achieve. These appear as gaps between the forms of life. Changes in the environment lead to changes in needs; changes in needs produce changes in behaviour; changes in behaviour become new habits which may lead to alterations in particular organs and ultimately in general organization. But the environment cannot be said to act directly on life. On the contrary, in Lamarck only life can act, for life and activity are ultimately one. Rather, the environment is a shifting set of circumstances and opportunities to which the organism responds creatively, not precisely as the expression of its will (although Lamarck's admirers interpreted him in that fashion) but as an expression of its whole nature as a living thing. And it was rather as a consequence than as a statement of his view of nature that Lamarck laid down two corollaries which he described as laws: that of the development or decay of organs through use or disuse, and that of the inheritance of the characteristics acquired by organisms in reacting to the environment.  

According to Lamarck himself, Philosophie zoologique was the elaboration of an earlier work, Recherches sur l'organisation des corps vivants of 1802. Here, too, the main evolutionary principles may all be found, though it is even less possible than in the later work to take them for the point of the argument. The body of the treatise is devoted to physiology and psychology, and the theory of evolution appears as a preface. Moreover, the emphasis is different. The position is rather that species do not exist than that they are mutable. What interested Lamarck at this stage in the development of his opinions was the whole tableau of the

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9 The best summary is in E. Guyénot, Les sciences de la vie en France au 17e et 18e siècles (Paris, 1941), pp. 418–439.
animal series. We are to see it, not as the chain or ladder, but as the escalator of being. For nature is constantly creating life at the bottom. And life fluids are ever at work differentiating organs and complicating and perfecting structures. And there is a perpetual circulation of organic matter up the moving staircase of existence, and of its lifeless residue spilling as chemical husks back down the other side, the inorganic side. Here, too, Lamarck states laws. But they are different laws from those of 1809. They generalize the facts, not about evolution in time, but about the whole zoological scale of being, which exists both in time and at any time. The first law states that there is indeed a regular series in nature, and the second that it resides, not in species, but in organic “masses” which he defined as the life stuff distributed among the different systems of organization.10

Moving back again, two years this time to the inaugural lecture of 1800, in which Lamarck first spoke of transmutation, one meets with yet another emphasis. He there advanced the evolutionary thesis, so he tells us, as a pedagogical device, by which to lead his students’ minds back down the path which nature herself had followed in (so to say) producing them. Consistently enough, he presents the animal series as a study in degradation, not development. The theses of 1802 do appear, as do most of the evolutionary principles of 1809, but they occur only as very summary propositions in support of the main contention. This is that natural history must begin with the fundamental distinction between living and non-living bodies, between organic and physical nature.11

Now, not only was this the argument of Lamarck’s debut as a zoologist. It was also the argument of his final assault upon the new chemistry, the Mémoires de physique et d’histoire naturelle of 1797, in which he referred in passing to the unchanging character of species.12 The Mémoires resumed the attack which as a young man he had launched twenty years before in the Recherches sur les causes des principaux faits physiques. The central dynamical proposition is that which he later developed into the escalator of being: that all inorganic composites are residues of life processes, perpetually repairing the decay and disintegration which are all that physical nature holds in the way of process, and as perpetually doomed by mortality in their drive to bring living order to a world of chaotic physical necessity. Returning for a moment to Philosophie zoologique, this is perfectly consistent with the theory of evolution, in which irregularities in the animal scale mark the casualties in the conflict between organism and the brute environment. This relationship between organic nature as order and physical nature as disorder, a situation

12 Recherches sur les causes des principaux faits physiques (2 v., 1794), II, 214, to which compare Mémoires de physique et d’histoire naturelle (1797), pp. 270–271.
of both opposition and dependence, is fundamental to Lamarck's thought which in this respect is almost dialectical.

Nor is the inconsistency on species other than trivial. In a short essay of 1802, Lamarck himself tells us how he came to alter his view on what he then saw as a detail. All he did between 1797 and 1800 was to assimilate the question of animal species—or rather their non-existence—to that of species in general. For in Lamarck the word has not lost its broader connotations. It still carries the sense of all the forms into which nature casts her manifold productions in all three kingdoms (or rather in both divisions). He had long been impressed with the perpetual crumbling decay of the surface of the earth. He had long shared Daubenton's opinion that there are no permanent species among minerals. The only entities in inorganic nature are the "molécules intégrantes" and the masses which form in the play of circumstance and universal attraction.

This makes a striking parallel to the view that Lamarck came to hold of the living world. In both organic and inorganic nature, there is nothing but process linking the individual—the particular animal, the particular molecule—and the system of organization—mammalian quadruped, granitic structure—into which it is temporarily cast. This explains Lamarck's pleasure in the concept of masses as links in the double chain of systems along which materials move, from molluse to man, from limestone to granite. It is natural enough to think of the principle of granite as mass. What Lamarck did was to think of the principle of mammal in the same fashion. For the notion was still very widespread in the 18th century that minerals are molded by some plastic force, that they are bred in the womb of the earth. Lamarck did not express this old instinct. But he cannot have been unaware of it, and it is implicit in his chemistry, where he refused to believe that a molecule can be "as ancient as the world." And the interest of this chemistry is that in asserting the indefinite variability of chemical composition, it contained the germ of what, when it was transferred to natural history, was to become Lamarck's evolutionary theory.

In Paris, Lamarck complained, the chemists teach that the integral molecule of every compound is invariant, and consequently that it is as old as nature. It followed that species are constant among minerals. As for himself, he was convinced that the integral molecule of every compound can change in its nature, that is to say in the number and proportion of the principles which constitute it. To deny this is to deny the phenomena of chemistry—the fermentations, the dissolutions, the combustions—which leave the molecules in some different condition.14

Furthermore, if attention be turned from evolutionary natural

13 Recherches sur l'organisation des corps vivants, pp. 141–156.
14 Ibid., pp. 150–152.
history to the other aspects of the *Philosophie zoologique*, the physiology and psychology, these too emerge as derivative from an archaic chemistry of qualities, both in manner and substance. The cardinal principle of this chemistry was that only life can synthesize. Conversely, in the life process the physiology of growth consists in retention during youth of what is needed from the materials which the organism passes through its system. Aging and death follow on the progressive hardening of the pliant organs by their lifelong digestion of the environment. Later on, Lamarck adapted his principle of an equilibrium balancing life against mass to provide evolution with a mechanism. It was analogous to erosion, no doubt because Lamarck was writing his uniformitarian treatise on geology at the time when he first put forward his evolutionary view of life.\(^{16}\) The property of life fluids is to wear away new channels, new reservoirs, and new organs in the soft tissues, and thereby to differentiate structures and specialize functions.\(^{16}\) The individual organism silts up after a time and dies, but it leaves more highly complicated descendants.

Lamarck's first scientific essay was a chemical treatise of 1776. It contains an interesting note. In order to explain physically the origin and mechanism of the universe (and he aspired to nothing less), we need to understand three things: the cause of matter, the cause of life, and the cause of that activity everywhere manifest.\(^{17}\) Having dealt, therefore, with Lamarck's views on the origin and essence of matter and organism, let us turn briefly to the third problem of this trilogy, the problem of activity. In all his chemistry Lamarck attached primary importance to the element of fire. Later on he was to attack oxygen as a perfectly gratuitous postulate. Not only has it never been seen, but combustion is explicable as the action of fire, which can be seen in the act of burning or shimmering over a hot stove or a tile roof in the sun of a summer day.\(^{18}\) But this was not simply a disagreement over the most common chemical reaction. For fire is the principle of activity. It exists in many states, of which Lamarck undertook, characteristically enough, a taxonomy.\(^{19}\) In the fixed state, in coal, wood, or what will burn, fire is the principle of combustion. Conflagration is fire in its state of violent expansion, penetrating the pores of a burning body and ripping it to shreds. Evaporation occurs when fire in a state of moderate expansion surrounds molecules of water and bears them upward, so many tiny molecular balloons, to rejoin the clouds where the specific gravity of the

\(^{16}\) It cannot be too much emphasized that Lamarck saw his own work as a single body of thought. His original plan was to follow his "physique terrestre" with the *Hydrogéologie* (1802), a *Météorologie*, and a *Biologie*. It was material which he had originally reserved for the latter that he drew on for the *Philosophie zoologique* and its predecessors. But he never did draw his mineralogical writings together.


\(^{19}\) This is the subject of most of volume I of the *Causes*: see too *Réfutation de la théorie pneumatique*, pp. 31, 36.
water molecule encased in its light shell of fire balances that of air. (Lamarck also aspired to found the science of meteorology.) Finally—not to follow fire into all its states—there is a natural state, to which fire strives ever to return. And all the phenomena of light and heat, all the effects of sun and atmosphere, are manifestations of fire in its different states, forever striving to regain that which is natural.

Nor did Lamarck ever abandon his commitment to fire. It provided him with a physical basis of feeling and of life itself, and this will make clear the mistake of those who have taken him for a vitalist. His dichotomy of organic and inorganic nature provides no escape into transcendent-alism, and that has always been the door through which vitalists have slipped from science into mystery. Life is a purely physical phenomenon in Lamarck, and it is only because science has (quite rightly) left behind his conception of the physical that he has been systematically misunderstood and assimilated to a theistic or vitalistic tradition which in fact he held in abhorrence. In his view spontaneous generation was no continuing miracle. Life was activated by the stirring of fluids. Lamarck hinted that this process is quickened by fire, and on the mechanism of sentience he was explicit. Its physical basis is the nervous fluid, the same substance as the electrical fluid, which itself is only a special state of fire. The pyrotic theory, therefore, embraces matter, life, and activity, and in that theory lay the common origin of the three aspects of the Philosophie zoologique—its psychology, its physiology, and its evolutionary view of species.

Moreover, the emergence of Lamarck's evolutionary views from his chemistry is more than a curious adventure of ideas. For chemistry was then the locus of the continuing scientific revolution. Lavoisier carried out Lagrange's dictum that the future of chemistry must lie in turning it into a kind of material algebra. Lamarck's notion of chemistry was different. Not only was his chemistry contemplative rather than experimental and analytical, but it contemplated a different sort of world, a world of which the ultimate sizable characteristic is continuity rather than that susceptibility to analysis which depends on objectification of discrete entities. Lamarck's nature is continuous both in structure and operation. Thus, matter itself is something infinitely plastic, however inert, and he escapes the consequences of the particulate views everywhere accepted by denying to the molecule, the ultimate particle, that permanence required by the doctrine of chemical fixity. So, too, when he considered the history of nature, his conception of process was uniformitarian even before the geological issue was fairly raised. In this question, only accident found him on the side of sobriety.

Mind itself, finally, is continuous with nature. For Lamarck, scientific

20 See, e.g., Corps vivants, pp. 163-4, 195.
explanation cannot assume the posture of standing outside the subject. Unless an explanation is causal and graphic, it is nothing, and the business of physics is to bring each problem back to some inherent principle or tendency to perfection, carried out by the agency of a subtle fluid, which is distinguishable only in its effects, but which must exist lest the effects remain inexplicable. He criticized the chemists for holding that addition of some substance to another can form a new one. This presents the product as preexistent in the reagents. If that is true, nothing has happened. If it is not true, nothing has been explained. To invoke “affinity” is to conjure up an occult force. Instead, the chemist must describe how active principles permeate and alter bodies in reactions. Principles are what combine and always in total blending. For Lavoisier, on the other hand, materials are what combine, even though he did see caloric as a real body. The issue was deeper than the argument over phlogiston, and Lamarck lumped Priestley with Lavoisier in the “pneumatic school.” Before them all, he flung down the pyrotec theory and the old retort invoked against Galileo and Newton in their day, and to be invoked against Darwin in his: that to describe is not to explain. At the same time, he implied the newer retort of romanticism: that to analyze and quantify is to denature. His attack upon Lavoisier is of a piece with Goethe’s Farbenlehre and with the writings of Marat, from whom Lamarck drew a certain inspiration, extending even to their mutual resentment of the claims of mathematics to speak as the language of science.

Lamarck’s philosophy, therefore, is no anticipation of Darwin but a medley of dying echoes: a striving toward perfection; an organic principle of order over against brute nature; a life process as the organism digesting its environment; a primacy of fire, seeking to return to its own; a world as flux and as becoming. He is the last important scientist to give them back, these old echoes; and it is no biologist, it is Sainte-Beuve, who has best caught the spirit of this philosophy.

M. de Lamarck was the last representative of that great school of naturalists and general observers who held sway from Thales and Democritus right down to Buffon. He was the mortal enemy of the chemists, of experimentalists and petty analysts, as he called them. No less severe was his philosophical hostility amounting to hatred for the tradition of the Deluge and the Biblical creation story, indeed for everything which recalled the Christian theory of nature. His own conception of things was simple, austere, and full of pathos. He constructed the world out of the smallest possible number of elements, and with the fewest crises and the longest duration imaginable. . . . Similarly in the organic realm, once he had admitted the mysterious power of life, in as minimal and elementary a form as possible, he supposes it developing on its own, building itself up, complicating itself little by little. Various

21 Mémoires, pp. 7–20; Réfutation, pp. 69–77.
22 See the suggestive discussion of G. Bachelard, La Formation de l’esprit scientifique (Paris, 1938), pp. 226–228. For Lamarck’s references to Marat, see Causes, I, pp. 343–368.
organisms were born of unconscious needs, of simple habit working in the different environments against the constant destroying power of nature. For M. de Lamarck separated life from nature. Nature in his eyes was cinder and stone, the granite of the tomb, death itself. Life intervenes only accidentally, as a strange but singularly industrious intruder, fighting a perpetual battle with some little success, achieving here and there a certain equilibrium, but always vanquished in the end.

III

If Lamarck's lifework had been only the last of the Greek philosophies of nature, it might be resigned with other anachronistic vagaries to the keeping of the antiquarian of ideas rather than the historian. But it has, perhaps, a wider significance, not to be sure for its content, but as an epitome of the problem of the tension between science and the culture that creates it as its most dynamic and distinctive activity. From Newton to Darwin the preference of romantic thinkers for the sciences of life is as striking as the predilection of rationalistic thinkers for the physical sciences. So it was that Voltaire popularized physics and Rousseau botany. So it was that Paley referred a moral philosophy to astronomy and Bernardin de Saint-Pierre to natural history. It is no accident that the Jardin des Plantes was the one scientific institution to flourish in the radical democratic phase of the French Revolution, which struck down all the others.

In the interaction between life and matter which Lamarck saw as the dynamical process of the world, he asserted the qualitative primacy of life in the organism's monopoly of chemical creativity. And down to Darwin, who subjected life to nature, the idea of evolution held great appeal for the romantic mind. Goethe's view of nature, to take the most notable example, is in all essentials the same as Lamarck's, ministering to the same needs and drawn from the same moral and humane tradition: the unity of nature triumphs over the diversity of the world in universal metamorphosis. And perhaps the humanist attempt to understand nature through self-knowledge, though never again to be the way of science, will always be the way of art. Not only of art, but of history, or rather of historicism, for the consonance of the Lamarckian and the Hegelian dialectic is obvious. More importantly, Herder's philosophy of history presupposes the same idea of nature as Lamarck's philosophy of evolution. Its reality is process and unfolding. Its laws are universal extensions of those which govern the birth, growth, and life course of the single organism. It transposes the correspondence of microcosm and macrocosm from space to time, and its model of order is the organism and not the machine, the wisdom of the whole and not the precision and predictable motion of the parts.

In a book on conservatism I recently came upon the following state-

ment appreciatively underlined by a succession of student readers: "Without the creative principle of voluntary action and a healthy degree of self-organization the organic life of society perishes in the arms of an efficient despotism, even though it takes unto itself the sacred name of democracy. The purpose of government is not to concentrate but to diffuse power. Diffusion of power is the characteristic of organic life, just as the concentration of power is the characteristic of mechanism." And if one follows this lead from pure to political romanticism, where the nexus of authority running between the one and the many really matters, it is almost alarming to think for a moment of the vast structures of reasoning about the state and society which depend upon substituting the metaphor of organism for atomism and mechanism. Where is Burke left without it? Where is the whole conservative apologia of the 19th century if it read the wrong science when it assimilated the notion of the body politic to naturalism? What becomes of socialism if the idea of society as a collectivity, which it lifted from romantic conservatism, crumbles into atomistic (or individualistic) dust? Nothing of course, would happen to political realities, but at least political apologists would be deprived of the right to draw dogmas from the nature of things and thrown upon their own resources.

Deep interests, then, have been bound up with the view of nature which Lamarck expressed, deep interests and deep feelings. What German, for example, could quite break loose from the spell of Naturphilosophie? Not at any rate the greatest of the Darwinians, for Ernest Haeckel celebrated the 50th anniversary of On the Origin of Species with an essay in syncretism. And if one looks behind Lamarck into the 18th-century sense of nature, there, too, it will appear how his evolutionary theory is to be taken as a link between the Enlightenment and romanticism, and not as a way station between the Newtonian spirit and the Darwinian. I have recently had occasion to suggest, in connection with another argument, that Lamarck's writings are the last, though one of the most explicit, of a whole series of attempts, some sad, some moving, some angry, to escape the consequences for naturalistic humanism of Newtonian theoretical physics. For the significance of Newtonian physics for human affairs is that it has none.

Since this argument calls into question the usual view of the Enlighten-

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27 For a full discussion of this topic with a documentation and further elaboration of Diderot's philosophy of science, see my paper, "The Encyclopédie and the Jacobin Philosophy of Science," Critical Problems in the History of Science, Marshall Clagett, ed. (Madison, Wis., in press).
ment as rising in the Newtonian triumph, I may, perhaps, be permitted to summarize it here. Lamarck's mentor, of course, was Buffon. But Lamarck's significance for intellectual history is more neatly apparent in the adumbration of his evolutionary theory in the speculations of a greater and more sensitive mind than Buffon's or his own. For that theory was an elaboration, and ultimately an application to taxonomy, of the major themes in Diderot's philosophy of nature.

Diderot, too, has often been taken as a forerunner of Darwin and a prophet of some rightful leadership which biological science was to assume in the 19th century. His famous allusion to the imminent decline of mathematics in science is forgiven as the momentary enthusiasm of one who would restore ordinary sight to eyes temporarily dazzled by the glamour of Newtonianism. But as often when he spoke lightly, Diderot meant this seriously as a repudiation of abstract conceptualization. For mathematicization he would substitute at the heart of science that subjective sense of organism which merges nature into consciousness. Like Lamarck, like Marat, like Goethe (and before any of them) Diderot objected to the claims of mathematics to be the language of science. His grounds were ontological, mechanical, and moral. Mathematics idealizes and falsifies real situations. Mathematics deprives bodies of the perceptible qualities in which alone they have existence for an empirical, sympathetic science. Mathematics has turned mechanics into trivial description by mistaking the measurement of bodies for understanding the activity which animates them. Mathematics tempts the mind out into the meaningless infinite, whereas science like everything related to man must be limited by his interest and his good.

Diderot, therefore, will save nature from the blight of mathematics by investing matter with sentience and assimilating it to organism. In the Dream of d'Alembert, the mathematician is put into a delirium in order to speak out truths. But it is the doctor, seeing nature in the perspective of human nature, who recognizes this stream of innocent consciousness as truth, and even anticipates its findings. He knew the answers all the time, and rejecting the conceptual obscurity of a Newton, Diderot makes scientific explanation into that illumination by nature which through ordinary understanding can penetrate the common breast. For nature is the combination of her elements, of which man is the chief, and not just an aggregate. Diderot, therefore, addresses himself to continuity, not divisibility. He, like Lamarck after him, writes of the transience of molecules, not of their existence. In genetics, he rejects the atomistic as well as the providential implications of embolism. For nature knows no limits. Sex blends into sex, mineral into mineral,

one living species into another. Individual animals are only moments of tightly organized activity, borne along a stream of seminal fluid, a great river of organic process flowing from the matrix womb of nature herself.

"Tout change; tout passe; il n’y a que le tout qui reste." and Diderot uses two metaphors to express this unity. In one the universe is a cosmic polyp. Time is the unrolling of its life. Space is where it lives. Continuity is its structure. This is the more frequently quoted of his figures, for it associates in one the ideas of evolution and universal sensibility in matter. This latter, of course, Diderot took from Buffon and Maupertuis. But in a very curious way, in a way reminiscent of what is said of Heraclitus, he treats development as a continuum consequent upon the impossibility of dividing time into discrete instants, and it is clear, therefore, that his time could never be a dimension, either of motion or of history, for it is the time of biological subjectivity (as, indeed, is his whole natural philosophy). Properly understood, therefore, Diderot gives us no reason to think of Darwin. And when we, on the contrary, do think of Hegel, or of Marx, it is the second of Diderot’s metaphors which seems the more significant. This evokes the swarm of bees. Therein, the solidarity of the universe is social. It is a cosmic anthill, a cosmic hive, where the laws of community are laws of nature. And here, in this social naturalism and not in evolution, Diderot expressed a really prescient (and to the liberal an alarming) concordance between the one and the many, the whole and the parts.

It is clear that this is the same natural philosophy as Lamarck’s, not only in itself but in its source. Diderot, too, drew it from chemistry, from the archaic chemistry of qualities and principles best epitomized in the work of Venel. The object of this chemistry was to restore body to that matter which Newtonian mechanics deprived of every attribute but dimension and location—but body in the original sense of internal organization. For until Newton, or at least until Galileo, “body” implied organism in some sense, and this defense of chemistry, therefore, was a defense of organic against inorganic science, of life against the doom of physics. The question, then, as Venel himself wrote on one occasion, was the structure of nature: “The majority of the qualities in bodies which physics regards as modes, are in fact real substances which the chemist knows how to separate out and either restore or incorporate in other bodies. Such among others are color, inflammability, taste, odor, etc.” And the congruence of Lamarck’s natural philosophy with Diderot’s may, therefore, suggest a final consideration on its significance. For the whole point of Diderot’s conception of science, as of much of the natural philosophy of the Enlightenment, was to abolish what he thought

30 Ibid., pp. 299–300.
31 See his article “Chimie” in the Encyclopédie.
the unreal distinction between the physical and the moral worlds, to make virtue rise from nature as the object of science. And reciprocally, it is moral insight into nature which is the arm of science, not the conceptual objectification of nature which alienates man, the creator of science, from his own creation.

IV

What fundamental scientific generalization ever came into the world in so unassuming a guise as Darwin's theory of evolution? Is there any "great book" about which one secretly feels so guilty as *On the Origin of Species*? None in the history of science gives me, at any rate, such uphill work with students. There is, perhaps, a certain cruelty about student judgments, arising from the failure of skeptical young minds to perceive greatness where the scholar and the teacher say it resides. But to have to test our own enthusiasms according to our power to impart them may, perhaps, help maintain a sense of proportion, or at least force us to examine the grounds of what we say. If facts be faced, neither does a truly compelling interest shine spontaneously out of the law of falling bodies, or Newton's laws, or Lavoisier's theory of combustion. But there at least, the teacher is assisted by the arresting force of Galileo's vision of science, by the daemonic quality of Newton's genius, or by the dramatic shadow of Lavoisier's destiny. Darwin gives one no such help. He claims for himself not power of abstract thought, but the worthiest and dullest of intellectual virtues—patience, accuracy, devotion. His might be taken as the classic illustration of what Duhem meant when he described the English mind in science as weak and comprehensive. Nothing in the history of science is more familiar than his theory, or than the steps which led him to it by way of the Galapagos Islands and Malthusian political economy.

Like the law of falling bodies, the theory of natural selection is so widely taken for granted that its magnitude is not on the face of it apparent. And rather than rehearse it once again, it may perhaps set Darwin off to better advantage to consider briefly what his theory did not do and what it forbade others to do. For Darwin's opponents—the serious ones, not the theologians, who were only pathetic—did not deny the fact of evolutionary variation. But they did want things from biology which science cannot give without ceasing to be science and becoming moral or social philosophy. And this perspective will make apparent the justice of the judgment which attributes to Darwin the importance for biology that Newton has for physics, so that his rather numbing humility becomes, not the attribute of inferiority, but only the quality fitted to a science in which observation plays a larger role than abstract formalization.
Both Newton and Darwin, to begin with, were criticized for ingratitude to their predecessors. This is not just a question of scholarly manners: once the theory—gravitation, natural selection—is repudiated, then what is left is the evidence—the inverse square relationship, the fact of variation—in which intellectual property might indeed be claimed for predecessors. But in both cases the theory was rejected, not as mistaken, but as meaningless. For Newton and Darwin had a way of simply accepting the phenomena as given. They excluded reason and purpose, according to this complaint, not in any dogmatic or positive way, but simply as an abdication of judgment which prevents philosophy from coming to grips with science.

Fontenelle, for example, dismissed Newton's geometric manner of proof on the same grounds that led Darwin's critics to deny merit to the concept of fitness in the organism. These are not scientific demonstrations, say the critics. Nor can they be, because they come out precisely even. They are simply tautologies which circle through the phenomena right back to their starting point. What is causation in Newton and what in Darwin?—only a formless sequence of results extending backward or outward endlessly into a metaphysical limbo. Newton purports to unite his system with the principle of gravity, and Darwin with the principle of natural selection. But if either is asked what causes gravity, or what causes the variations that are selected, he does not know. Nor did the theory depend upon his trying to say. Indeed, its success hinged precisely on dropping that question. Of Darwin, too, it could be said, "Hypotheses non fingo," and in the same sense in which it is true of Newton: not as a sterile assertion of empiricism, but as a statement that theories (speculations are another matter) must just embrace the evidence. The Cartesians of the 18th century, however, and after them the romantics of the 19th century, wanted a science which would account at once for the behavior and the cause of phenomena, which would see nature steadily and see it whole. They wanted a science which would seize on the unity of nature instead of fragmenting it into discrete events connected only by chance and circumstance, and not by reason or purpose. And in the case of Driesch—the most self-revealing of Darwin's critics—the heart of the position is that Darwin simply impoverishes biology, that he gives no rational insight into events, that he is simply a recorder posing as a philosopher, and all this because he and his followers will not see that the laws of life are absolutely different from the laws of physics, and that in the organism purpose is all.32

Biological romanticism never made much impression in the world of English letters, where Samuel Butler and Shaw have been the most widely read of Darwin's critics. In their case, too, a comparison with certain themes of the 18th-century Enlightenment is instructive, for it makes clear that the question is no biological discussion, but simply the continuing expression of a moral resentment which wants more out of nature than science finds there. To read Diderot and Butler together is a curious experience, itself almost a vindication of Butler's *Unconscious Memory*. For one has the impression that this and Butler's other writings upon nature were products of his own rather painful and labored reflection, and yet how unoriginal they are! These, for example, are the four principles of Butler's *Life and Habit*: "The oneness of personality between parents and offspring; memory on the part of offspring of certain actions which it did when in the persons of its forefathers; the latency of that memory until it is rekindled by a recurrence of the associated ideas; and the unconsciousness with which habitual actions come to be performed."  

But from the point of view of one who admires the intellectual achievements of science, it is Shaw rather than Butler who, by contrast to his pretensions, seems drastically diminished in stature by his ventures into scientific criticism. The famous preface to *Back to Methuselah* presents clichés with the air of lordly malice that Shaw knew how to assume as the right of a superior intelligence which did not mind pointing to its own perversity. But it was an intelligence which, far from transcending science, had never given itself the trouble to understand the force or limitations of scientific demonstrations, and in the perspective of history, Shaw on Darwin will surely find a place side by side with Bellarmine and the papal jury setting the astronomers right about natural philosophy. It does not appear that Shaw ever thought to ask the biologists whether natural selection was true. It was simply "a blasphemy, possible to many for whom Nature is nothing but a casual aggregation of inert and dead matter, but eternally impossible to the spirits and souls of the righteous."  

Darwin is forbidden to banish mind from the universe: "For 'Natural Selection' has no moral significance: it deals with that part of evolution which has no purpose, no intelligence, and might more appropriately be

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34 Ibid., p. 15.  
called accidental selection, or better still, Unnatural Selection, since nothing is more unnatural than an accident. If it could be proved that the whole universe had been produced by such Selection, only fools and rascals could bear to live." And the Shavian word on evolution, therefore, is in fact only a diatribe, another expression of the anti-vivisectionism—and in a certain sense the vegetarianism—of a personality whose Rousseauist attitude to nature involved more of sentimental hostility to intellect (as to any aristocracy) than is generally appreciated.

With this background in mind, one might almost have predicted that the latest thrust back to Lamarckism would have occurred in a Marxist context. And though the science of genetics will, unlike certain geneticists, survive its misadventures in the Soviet Union, this episode should stand as a warning that ideas have consequences, and that to succumb to the very natural and often well-intentioned temptation to bend science to the socializing or the moralizing of nature is to invite its subjection to social authority, which is to say to politics. For your moralist knows what kind of nature he wants science to give him, and if it does not, he will either, like Shaw, repudiate it, or if like Lysenko he has the power, he will change it. Once again, as in Diderot, as in Goethe, as in Lamarck, resentment of mathematics (which expresses quantity and not the good) reveals the moralist beneath the natural philosopher—the Michurin school rejects in principle the mathematicization of biology in favor of the autonomy of organism. Lysenko's purported findings may, therefore, be taken as the nadir of the history of Lamarckism, and (one hopes) the end of the story. For in his demagoguery the humane view of nature is vulgarized by way of a humanitarian naturalism into the careerist's opportunity. But there is nothing new about it. It is only the most recent expression of that pattern of resistance to science which has attended its entire history in reaction against the objectification of nature.

So far as the intellectual and cultural significance of evolutionary theory is concerned, therefore, Darwin had no predecessor in Lamarck. Lamarck's theory of evolution belongs to the contracting and self-defeating history of subjective science, and Darwin's to the expanding and conquering history of objective science. In the concept of natural selection, Darwin put an end to the opposition between mechanism and organism through which the humane view of nature, ultimately the

36 Ibid., pp. lxi- lxii.
Greek view, had found refuge from Newton in biology. Lamarck's theory, on the other hand, originated as the transfer to natural history of that old view for which Lavoisier had made chemistry, the science of matter, uninhabitable. It is for this reason that Darwin was the orderer of biological science, as Newton was of physics and Galileo of mechanics. He was the first to frame objective concepts widely enough to embrace the whole range of phenomena studied by his science. And it may be worthwhile to consider the theory of natural selection analytically for a moment, in order to specify what were the elements of its success, and how it was that, schematically speaking, Darwinian evolutionary theory stands in the same relation to Lamarckian in the overall structure of the history of science as does Galilean to Aristotelian mechanics.

In mechanics Galileo achieved objectivity by accepting motion as natural, and considering its quantity as something to be measured independently of the moving body. This he accomplished by treating time as a dimension, after which motion in physics is no longer taken as a substantial change. In Darwin—to begin drawing out the parallel—natural selection treats that sort of change which expresses itself in organic variation in the same way. Instead of explaining variation, he begins with it as a fundamental fact of nature. Variations are assumed to occur at random, requiring no further explanation and presupposing no causative agent for science to seek out. This is what opened the breach through which biology could follow physics into objectivity, because it introduced the distinction, which Darwin was the first to make, between the origin of variations and their preservation. Variations arise by chance. But they are preserved according as they work more or less effectively in objective circumstance. In Lamarck, on the other hand, the two problems are handled as a single question, which in effect is begged by its solution in the inheritance of acquired characteristics. Lamarck, therefore, could no more have distinguished the study of variations from the study of the organism as a whole than the impetus school could separate motion from the missile.

In another and even more impressive respect, Darwinian evolutionary change is analytically analogous to Galilean motion. There is direction in it, whereas in Lamarck's formulation life simply circles endlessly through nature. H. F. Blum has recently advanced the interesting argument that time as it enters into thermodynamic processes may be considered as a coordinate of evolution. This amounts to saying, on the one hand, that evolution is capable of vectorial description, and on the other, that biological time is a dimensional component of a physical situation and ceases thereby to be a refuge of becoming or a locus of flux. Quite generally, in fact, Darwin's work, though not of course quantitative in result, was nevertheless quantitative in method and

manner of thought. Thus, that he began with the Malthusian ratio was
of far more significance for his success than was the question of its
validity. It was, indeed, of utmost significance. What selection does in
Darwin is to determine the quantity of living beings which can survive
in any given set of objective circumstances. This aspect of the approach
is more evident, perhaps, in Wallace’s essay than in Darwin’s more diffuse
account. For example:

Wild cats are prolific and have few enemies: why then are they never as abundant
as rabbits?
The only intelligible answer is, that their supply of food is more precarious. It
appears evident, therefore, that so long as a country remains physically unchanged,
the numbers of its animal population cannot materially increase. If one species
does so, some others requiring the same kind of food must diminish in proportion. . . .
It is, as we commenced by remarking, “a struggle for existence,” in which the weakest
and least perfectly organized must always succumb. 39

And even more striking is Wallace’s passage on natural selection as
accounting

. . . for that balance so often observed in nature—a deficiency in one set of organs
always being compensated by an increased development of some others—powerful
wings accompanying weak feet, or great velocity making up for the absence of
defensive weapons; for it has been shown that all varieties in which an unbalanced
deficiency occurred could not long continue their existence. The action of this principle
is exactly like that of the centrifugal governor of the steam engine, which checks
and corrects any irregularities almost before they become evident; and in like manner
no unbalanced deficiency in the animal kingdom can ever reach any conspicuous
magnitude, because it would make itself felt at the very first step, by rendering exist-
ence difficult and extinction almost sure soon to follow. 40

It has sometimes been remarked as a paradox that it should have been
Darwin (and Wallace), the old-fashioned naturalists, and not the em-
brologists or physiologists of the continental laboratories, who brought
the revolution in biology. But the reason is clear. It does not lie in the
nature of their empirical contributions. It lies in the nature of their
reasoning, which was concerned with quantity and circumstance. This
is why it was they who liberated biology from its limiting dependence on
classification and dissection, with the gulf between bridged insubstan-
tially by that metaphor of goal-directed organism which the evidence
never could control.

Missing the point of Mendel’s work, all the eminent and puzzled
biologists of the late nineteenth century who had to grapple with
Darwin’s legacy put themselves in a position like that of the Cartesians
trying to explain the cause and describe the operation of gravity by a
single concept. Whether of a romantic and speculative disposition like
Nägeli, or of sober and ingenious temper like Weismann, this was the
essential fault in their approach. In the structure of theory, both Nägeli’s

reprints both the Darwin and Wallace papers of 1858.
40 Ibid., pp. 106–107.
ideoplasm and Weismann's germ plasm were analogous to that Lamarckian inheritance of acquired characters which they repudiated. They gave at once a theory of heredity and development. Even Weismann's "ids" never proved capable of objectification. The historian of science may be pardoned for wondering what might have been the influence on biology had these scientists known the history of science, and whether they might then have noticed the interest of Mendel's work. Suppose they had thought to compare his ratios with Dalton's, by which the revolution in chemical theory was reduced to numerical terms. Suppose, like Maupertuis, who had the insight from physics but lacked the information from biology, they had known of the relationship of the corpuscular philosophy of the 17th century to the Newtonian synthesis. Might they not have saved themselves much unprofitable reasoning, and advanced the progress of their science by some decades? For nothing is more notable in the comparison of the biological to the Newtonian revolution than the reduction of the concept of natural selection to material atomism in the science of genetics. Just as the discontinuity of matter in atoms-and-the-void liberates motion from subjectivity, so biological objectivity was firmly seated in the discontinuity of the hereditary patrimony where inheritance could be comprised in number. (And as if to prove that this was the right track, genetics immediately gave that offense to moralizers and socializers of nature which throughout the history of science each successive step in objectification seems to have been bound to give.) In this perspective, therefore, it may appear as a kind of wisdom in Darwin, rather than as a failing, that his theoretical work began as an application to biology of the individualistic assumptions of classical political economy. He had, after all, no other basis for atomism. And the outcome is a conception of biological order no different from the order assumed by contemporary atomic physics—an order of chance to be analyzed by the techniques appropriate to mathematical probability.41

Darwin and Lamarck, therefore, speak their parts in that endless debate between atoms and the continuum, the multiplicity of events and the unity of nature, which is what has given the history of science its dialectic since its opening in Greece. Who seeks unity in nature believes in the continuum. Nor is it simply the wrong side, for it has been espoused by men worthy of attention: by Plato and Descartes, by Goethe and Einstein. For Lamarck the rational continuum resided in life. This was the root of his opposition to atomizing chemistry and of his emanationist evolutionary theory. At a time when he still believed in the immutability of species, he nevertheless expressed opposition to the Linnaean system, hostility to which is the touchstone of romantic or metamorphosizing

tendencies in taxonomy as rejection of atomism is in physics.

In one sense, therefore, the hiatus that one feels in Professor Lovejoy’s work between the temporalizing of the chain of being and the foundation of evolutionary theory is inevitable. The latter is not the outcome of the former. For the continuum as the program of nature goes back to that aspect of classical philosophy which was a prolongation of cosmogony, back through the Stoics and Heraclitus to fire and the world as flux and process. But it is cosmology, the opposite of this, from which science derives, rather from the contemplation of being in the light of reason than of becoming in the light of process. And this resolves, perhaps, another apparent paradox, i.e., that providentialism and belief in fixity and divine design have in effect been more conducive to positive scientific work—in Newton, for example, in Linnaeus, or in Cuvier—than has belief in process. For though ultimately untenable, providentialism establishes a reason in things for science to find. It posits the existence of specific entities which may serve as the term of analysis. But in becoming everything blends into everything, and nothing may ever be defined. It is a mistake, therefore, to say with Cassirer that Darwin brought becoming within the pale of science. What he did was to treat that whole range of nature which had been relegated to becoming rather as a problem in being, an infinite set of objective situations reaching back through time. He treated scientifically the historical evidence for evolution, which had been marshalled often enough before him but more as a travesty than an extension of science. Rightly understood, therefore, the question does come back to the starting point of Professor Lovejoy’s treatment: the Darwinian theory of evolution turned the problem of becoming into a problem of being and permitted the eventual mathematicalization of that vast area of nature which until Darwin had been protected from logos in the wrappings of process.