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Lamarck and the prehistory of ecology

Introduction

At least three generations separate Lamarck from 1866, when the term "ecology" was coined by Ernst Haeckel, and three additional generations until the period when ecology became a self-sufficient science (from the 1920s to the 1940s). Therefore, all attempts to trace the direct influence of Lamarckian ideas on the development of this science appear to be highly speculative. However, besides an undisputed history, ecology also has a long prehistory, with remarkable forerunners. Thus Alexander von Humboldt, Alphonse de Candolle, and certainly Charles Darwin, were "ecologists" in a period when ecology did not exist as a science (either as a word!). The role of Lamarck in the prehistory of ecology is not so obvious, though some believe that if Lamarck assumes a direct influence of environment on the evolving organism, he can certainly be called the pioneer of ecology. However, two other lines of reasoning are worth further investigation.

First, if we believe that, in the 19th century, Lamarck's works had been important for the development of biology in the framework of which ecology later originated, we indirectly admit his contribution to the "preparation" of the scientific community for the acceptance of ecology. Second, Lamarck has created a speculative but very interesting concept of the Earth's crust dynamics, paying special attention to the activity of living organisms. In fact, it was a sketch of ideas that in some respects resembles that exposed a century later by Vladimir Vernadsky in his works of *Biosphere*. Moreover, in some aspects, Vernadsky's view seems to be closer to the Lamarckian tradition than to some later conceptions (e.g., Darwinian natural selection).

Natural History and Biology

The turn of the 18th century was a very interesting period marked by the coexistence of two forms of inquiry into living nature: classical "Natural History" (that had begun to fade already at that time), and young "Biology" (that had just begun to develop in opposition to Natural History). If the former can be defined in Michel Foucault's words as the "nomination of the visible" [3], the latter is rather the "understanding of the invisible."

The term "biology" was proposed in the very beginning of the 19th century by Lamarck, and —independently— by G. P. Treviranus. For Lamarck, biology was a "theory of living organisms" (*la théorie des corps vivants*), the study of the general principles of both plants and animals. Treviranus considered it as the "study of the different forms and phenomena of life, the conditions and laws under which they occur and the causes by means of which they are brought into being." Despite some differences in the understanding of the neologism "biology" by Lamarck and Treviranus [8], it seems that both realized that natural history, which was a spread of interests across three separate kingdoms of natural objects, i.e., mineral, plants and animals, was not able to concentrate on the deep study of living organisms.

Developing gradually in the 19th century, biology became a fundamental science. Among its achievements we can mention the basic principles of physiology, revealed by Claude Bernard; the cell theory of M. J. Schleiden and Th. Schwann; the new view of living body, proposed by Rudolf Virchow; and other important conceptions. The term "ecology" was coined by Haeckel [7] also in the framework of biology, as a name for a special science that was considered as a part of physiology (defined very broadly even for that time), or to be more exact, as the "physiology of relationships." In the general scheme for the classification of biological disciplines proposed by Haeckel, physiology was assumed to be the general study of processes (at different levels). Its other name was "biodynamics", which in Haeckel's scheme was used in contrast to "biostatics," or morphology, i.e., the study of structure. Later the relations between physiology and ecology became considerably deeper; and some branches of ecology, e.g., "autoecology," popular in the beginning of the 20th century, were in fact the continuation of physiology which had left the laboratories and began being carried out in the field.

The term "natural history" gradually became old-fashioned in the 19th century. However, the traditions of natural history were still of great importance. The great increase in material collected by naturalists across the entire world and accumulated in the museums of natural history stimulated the rapid development of systematics, and the inevitable specialization of researchers. It appeared that the attempt to arrange all this enormous diversity of objects in the framework of one system demanded some new idea which was more fruitful and deep than simple "nomination of the visible," and could provide the foundation for transformed natural history of the 19th century. Such an idea was found: it was evolution, and later, distribution—of organisms [2]. Although "The Origin of Species" by Charles Darwin played the leading role in the popularization of evolutionary ideas, the works of Lamarck obviously contributed also to this process. We must realize that, for most specialists, the emphasis was on evolution, and not on natural selection (a notion which began to be practically applied only in the 20th century) .

A part of natural history which was transformed into the systematics of various groups, another part dealing with plants and animals in their natural environment whereas formed the necessary step for the development of ecology. When, in 1927, Charles Elton declared in his "Animal Ecology" that "Ecology... simply means scientific natural history" [1, p. 1], he evidently meant not the classical natural history of 18th century (the nomination of the visible) but rather the study of living organisms under natural conditions, i.e., the continuation of a tradition that was already well established by the end of the 19th century.

Coining the term "biology," Lamarck was not inclined against natural history. Moreover, he contributed personally to its development, primarily in his botanical works. In general, the role of Lamarck in the prehistory of ecology does not seem to have been very influential. However, Lamarck's works, related to traditions of the natural history as well as to the new "biological" approach, certainly were important for preparing the scientific community for the understanding of ecology.

The casual unity of nature

The end of the 18th century was marked by the emergence of a new approach, or *episteme*, in the terminology of Foucault. As Malcolm Nicolson aptly remarked, "in natural history the emphasis moved from the scrutiny of the external features of objects to the study of internal features and processes" [15, p. 170]. Certainly "biology" can be considered an example of new episteme. However, the changes touched not only the study of organisms but also the general understanding of Nature as a whole, embracing both living and non-living objects.

Several attempts were undertaken to understand how the various elements of nature are interconnected. Immanuel Kant was perhaps among the most outstanding forerunners of that new approach. In his lectures on *Physische Geographie* (Physical Geography), delivered at the University of Königsberg in the 1760s, he tried to underlie "an idea of the whole in terms of area." The Kantian tradition with its assuming "the existence of a functional inter-relation between all the individual phenomena of the earth's surface" [15], were of great importance for later development of the historical geology by Abraham Gottlib Werner, and the geography of plants (or more exactly - vegetation) by Alexander von Humboldt. While Werner used the term "geognosy" to designate the synthetic science about "animate and inanimate" nature, Humboldt proposed the "*physique générale*" (general physics), which must consider nature as a holistic unity.

According to Humboldt [9] [Cited in 15]: "*physique générale*… can progress… by the bringing together of all the phenomena and creations which the surface of the earth has to offer. In this great sequence of cause and effect, nothing can be considered in isolation. The general equilibrium which reigns amongst disturbances and apparent turmoil, is the result of an infinity of mechanical forces and chemical attractions balancing each other out."

Thus, the appearance of *Hydrogéologie*, the book in which Lamarck (1802) expounded in great length his synthetic view of nature, cannot be considered as an isolated scientific event of that time. As others concepts of the late 18th–early 19th century, Lamarckian presentation was speculative in many aspects. However, it is not surprising if we take into consideration the state of geology, chemistry and biology of that time. For us, this work by Lamarck is interesting primarily by its emphasis on the leading role of living organisms in the cycling of matter in Earth's crust.

The main points of the the Lamarckian concept

According to Lamarck's view [10] the entire surface of the earth, the masses of water and the atmosphere represent an enormous field for the incessant work of nature, destroying the complex substances that composes a considerable part of Earth's crust. This destruction is caused by inner natural reasons (and therefore it does not need additional explanation) though various external factors (*les provocateurs externes*), e.g., warm (*le calorique*), water and saline substances, influence its rate. Actually in any particular place we can find the mixture of substances that are subject to different degree of decomposition.

As the age of Earth is assumed to be enormous, all complex substances are to be sooner or later completely decomposed up to basic simple elements (*les principes* in Lamarckian language). Therefore, the widespread occurrence of complex substances in the Earth's crust can be explained only by a special force constantly acting in the opposite direction. This force, or, as Lamarck calls it, "*une cause particuliére puissante et continuellement active*," is the activity of living organisms. By

the functions of their organs (*par le moyen des fonctions de leurs organs*) all living beings are capable of creating complex compounds directly from the "free" basic elements (as plants do it), or to modify complex compounds, mainly through the changes in proportions of basic elements (as animals do it). Lamarck underlines that plants and animals have to feed during all their life to maintain their existence while the substances that form their bodies are perpetually renewed [10].

The plants can consume the necessary substances only with water. However, this process is influenced positively by air, heat and light. The compounds that form the body of the plant or the compound which plants excrete (e.g., mucilage or resin) are not consumed in ready form from the soil. Thus it was proposed that manure is important rather for retaining water and creating optimal moisture, than for providing directly necessary substances. According to Lamarck, even carbon (*le carbone des chimistes*) cannot be consumed from environment, and plants form themselves this substance which is so needed for "repairing" their bodies. Thus the enormous quantities of combustible substances are being created while later they are transported to the deepness of the Earth's crust, providing material for volcanoes. The considerable amounts of carbon are being destroyed by fires thus passing in the warm, or are transformed in the process of fermentation.

Lamarck assumes [10] that all complex substances that can be found in free state in nature are the remains of living organisms, or the products of their excretion. This continuing activity of organisms changes permanently the face of Earth's crust, and as Lamarck remarks, it is quite surprising that this strikingly obvious truth (*la vérité frappante*) has not yet been accepted by most naturalists. Like Werner and Humboldt, Lamarck tried to consider the nature as a whole, emphasizing the close interconnections of abiotic and biotic compounds. He even declared that there must be one integrative science *Physique terrestre* (the physics of the Earth) which would be able to embrace the *Météorologie* (the study of the atmosphere), *Hydrogéologie* (the study of Earth's crust), and *Biologie* (the study of living organisms).

The Lamarckian concept of Earth's crust's function is a natural continuation of his philosophical views that are expressed most comprehensively in *Système analytique des connaissances positives de l'homme* [11]. This system implies the existence of a God, but his role is limited only to the creation of matter (which is assumed to be indestructible and finite) and the order of things (*ordre des choses*). The nature is just the order of things and it works by its owns without additional stimuli. Life manifesting itself in certain bodies is considered as a power (*puissance*) which does not have any goal nor any intention, but makes what it can make. It is rather the assemblage of acting causes (*ensemble de causes agissantes*) than a particular being.

The view of Lamarck is strikingly different from the ideas of "Economy of Nature" typical of the Natural History of the 18th century, e.g., expressed by Linnaeus [12]. Creationism of Lamarckian concept was strictly restrained while the classical paradigm of "economy of nature" implied God's interference literally in all facets of the being. For instance, Lamarck (1820) underlines that nature itself is not a God but only an order of things, and it can be "proved" because Nature always needs time (sometimes considerable) to do something while for Creator everything is possible and doesn't need time to achieve desirable results.

Some authors [e.g., 4] believed that Lamarckian concept of dynamic nature, with its emphasis on the "power of life", was a necessary step to advancing his idea of biological evolution. However, this conclusion seems not sufficiently grounded. In fact, biological evolution itself is not necessary to explain the role of living organisms in the framework of concepts developed in *Hydrogéologie*. The only thing which is important both for evolutionary and "biospheric" ideas of Lamarck is time, the temporal duration of the processes that take place inside organisms, or on the surface of the Earth.

In many aspects, the system of Lamarck's views on the functioning of the Earth's crust looks naive, and it is clear now that Lamarck was not correct in his underestimation of achievements of contemporary chemists (e.g. the works of Lavoisier). However, we have to admit in one aspect his concept was ahead of time: I am referring to the great importance he attributed to the powerful activity of living organisms (*pouvoir de la vie*) as the force determining the face of our planet.

The Biosphere and Gaia

The questions posed by Lamarck in *Hydrogéologie* were perhaps too general for that time and therefore often appeared to be unanswerable.[1] However, it is well known that some aspects of this concept of Earth's crust were highly appreciated by Lyell. The recognition of life as a major geological force occurred only in the 20th century, and was closely connected with the idea of "Biosphere". Though the very term was coined by the famous Austrian geologist Suess in 1875, the whole concept was elaborated by Russian mineralogist and the founder of biogeochemistry Vladimir Vernadsky [16, 17].

According to Vernadsky [16] the biosphere is a "special cover of Earth's crust embraced by life" and constantly modified by the living organisms, or, in Vernadsky's words, by "living matter," whose activity is the most powerful chemical force on

[1] As Weisskopf [18] in his essay on physics development aptly remarked, the real progress in science began to be achieved approximately 50 centuries ago when men "began to restrain themselves not to ask general questions such as: What is matter made of? How was the Universe created? What is the essence of life?… [and] asked limited questions as: How does an object fall? How does water flow in tube? etc. Instead of asking general questions and receiving limited answers, they asked limited questions and found general answers" [p. 352].

the Earth. Vernadsky repeatedly emphasized that life is not a "superficial," or "accidental" phenomenon. Moreover, it is deeply connected with the structure of Earth's crust, participating in its mechanisms and performing extremely important functions. As Vernadsky [16] remarks, "there is no great chemical equilibrium in Earth's crust without a considerable influence by biological processes."

These and some other statements look very similar to Lamarck's conclusions though they were formulated a century later and based on much more solid empirical ground. Vernadsky also underlines the great age of life on Earth (though he categorically denies abiogenesis) and claims that "it is not necessary to consider all issues concerning the beginning of life on Earth… or the cosmogenic hypotheses about the past state of the Earth without life" [16]. Some aspects of the methodology used by Vernadsky remind that of Lamarck. Thus both underlined the meaning of observations and of empirical knowledge in general, both are inclined to generalizations, and both are rather skeptical of analytical approaches (Lamarck in his relation to contemporary chemistry while Vernadsky to contemporary biology).

For Vernadsky, the direct referring to Lamarck, as well as to Buffon, Goethe, Humboldt and other great naturalists (his favorite word) of the past was very characteristic. He criticizes the position of contemporary biologists because in his opinion they consider organisms as autonomous entities and do not pay sufficient attention to the meaning of life from the geological, or planetary point of view.

Vernadsky often emphasized the non-accidental character of the structure and function of the biosphere, and in general his approach was deeply deterministic. Thus, despite all his respect for Darwin and Wallace, he treated their concept rather as a general theory of evolution than as a hypothesis of the origin of species by natural selection. The ideas of stochastic variation, undirectedness, and unpredictability were alien to Vernadsky [5, 6], as well as to Lamarck! It seems that the idea of natural selection, even being well established, was not necessary for a concept aimed to organize the knowledge about the biosphere structure and matter cycling.

The relation of the scientific community to Vernadsky's concept was unbalanced [6]. While in Russia and former USSR the idea of the Biosphere was appreciated, in the West it was often ignored or undervalued, partially because of linguistic barriers (though *The Biosphere* was published in French in 1929), but also because it was considered speculative or even because of the dogmatic character of many statements. It is characteristic that fifty years after *The Biosphere* was published James Lovelock [13], advancing his concept of *Gaia*, did not know anything about Vernadsky and only later [14] did he recognize the meaning of Vernadsky's *Biosphere*.

Thus the idea of Earth's crust that is not only embraced by life, but is under its strict control, can be considered as such sort of ideas that periodically emerge in the scientific community (*Hydrogéologie* by Lamarck, *Biosphere* by Vernadsky, and *Gaia* by Lovelock are just the examples of such emergence), encountering not only approval but also highly critical (or even skeptical) acceptance. It seems that all these concepts inevitably contain remarkably speculative elements, and what is even more important —they remain untestable. Only now the level achieved by empirical science, equipped with appropriate technique of measuring, allows us to hope that the relation of the scientific community to the global ecosystem (i.e. the Biosphere) problem is changing. Recognizing the way that science passed to this state, we must not forget the role of Lamarck as a forerunner of the biosphere approach in ecology.

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