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The French Neo-Lamarckian Project (1880-1910)

Laurent LOISON*

Abstract: It is generally acknowledged that the Darwinian and especially Neo-Darwinian theses had a difficult reception in the French scientific community. A different sort of transformism, generally qualified as Neo-Lamarckian, fueled the opposition with which they met. This French brand of transformism has often been described – and sometimes by the scientists themselves – as a heterogeneous entity, a simple juxtaposition of critical conceptions without any general unity. We would like to defend a different interpretation of this history. The main object of this paper is to present the positive aspect of French Neo-Lamarckism. This implies that, on the one hand, this transformism had a certain internal consistency, and that, on the other hand, this consistency was not reducible to a general form, the French case of which would be merely a geographical demarcation. French Neo-Lamarckism was driven by a specific project, that of rendering the transformist hypothesis scientific. This aim called for a theoretical basis, that is, the inclusion of this evolutionism in the causal and mechanical explanation of the material universe. It also required an empirical aspect, that is, the development of what was called experimental transformism. Behind this project, we read the desire to build a transformism similar to the model of scientificity that Bernardian physiology had acquired at the end of the nineteenth century.

Keywords: French Neo-Lamarckism ; transformism ; determinism ; experimental physiology.

Résumé : *Il est acquis que les thèses darwiniennes et surtout néodarwiniennes connurent une implantation difficile dans la communauté scientifique française. L'opposition qu'elles rencontrèrent participa à structurer un transformisme différent, généralement qualifié de néolamarckien. Ce transformisme français fut souvent décrit – et parfois par les scientifiques eux-mêmes – comme une entité hétérogène, simple juxtaposition*

* Université de Nantes, Centre François-Viète, Faculté des sciences et des techniques.

de conceptions critiques sans unité générale. Nous défendons ici une interprétation inverse de cette histoire. L'objet de ce texte est de présenter la positivité propre du néolamarckisme français. Ceci sous-entend que, d'une part, ce transformisme disposait d'une certaine cohérence interne, et que, d'autre part, celle-ci n'est pas réductible à une forme générale dont le cas français ne serait qu'une délimitation simplement géographique. Le néolamarckisme français fut cohéré par un projet, celui de rendre scientifique l'hypothèse transformiste. Il fallait à cette ambition une assise théorique, soit l'inscription de cet évolutionnisme dans l'explication causaliste mécanique de l'univers matériel. Il lui fallait également une projection empirique, soit le développement de ce que l'on appela alors le transformisme expérimental. Derrière ce projet, on lit le désir de construire un transformisme analogue au modèle de scientificité qu'était à la fin du XIXe siècle la physiologie bernardienne.

Mots-clés : *néolamarckisme français ; transformisme expérimental ; déterminisme ; physiologie expérimentale.*

Introduction

The publication of Charles Darwin's *On the Origin of Species* in 1859 drew a split reaction from the scientific community of the time. While the sum of the arguments collected by the English scientist quickly convinced most naturalists that it was now reasonable to accept evolution as a fact, Darwin's explanation for it, based on the mechanism of natural selection, was greeted with much less enthusiasm. The century between Darwin's publications and the synthetic theory of evolution which emerged in the 1940s was a period which may be viewed as a long crisis in evolutionary thought, during which many heated debates were enjoined concerning the precise mechanisms responsible for the transformation of species. This complex period has many foundations – certain historians have shown that alternative explanations to Darwinism, many of which originated in pre-transformist conceptions of nature, were more in line with the biological thought of the time,[1] while others have emphasized the inherent limitations of Darwin's theory, especially related to the fact that the operation of the principle of selection called upon a very particular conception of heredity.[2]

1 - Peter J. Bowler, *The Eclipse of Darwinism* (London: The Johns Hopkins University Press, 1992).

2 - Jean Gayon, *Darwin et l'après-Darwin: Une histoire de l'hypothèse de sélection naturelle* (Paris: Kimé, 1992).

For more than seventy years, these debates led to the "eclipse" of Darwinism, with most biologists holding the mechanism of natural selection to be insufficient to explain the entire evolutionary process. It was at best a secondary factor, a supplementary force unable to drive the course of evolution unaided. In this context, and sometimes in an exaggerated manner, France is often presented as the home of the rebirth of the ideas of Jean-Baptiste Lamarck. Indeed, from the early 1880s, we see the emergence of what we might call *neo-Lamarckism*, a reappropriation and reworking of certain concepts borrowed, sometimes abusively, from Lamarck.[3] Far from being the only feature of French biology, neo-Lamarckism, which was essentially based on the idea that the evolution of species may be explained by the summation of individual transformations, would see, or had already seen at that time, many avatars in most Western countries. In the United States, it formed a dominant explanatory paradigm very early on, around the figures of Alpheus Hyatt (1838-1902), Edward D. Cope (1840-1897), and Alpheus Packard (1839-1905),[4] the latter of whom seems to have been the first to propose the term "neo-Lamarckism" to describe their way of explaining evolution, which they claimed was a modernization of the views of Lamarck. An important issue, as already noted by Yvette Conry,[5] is to understand if the adjective "French," when speaking of French neo-Lamarckism, is a simple geographic restriction of a general ideology, or, on the contrary, a description of a distinct theoretical form. Very often historians are content with accusing French neo-Lamarckism of heterogeneity – transformism being nothing but a conjunction of disparate conceptions, with no unifying generalities.[6] The idea we wish to defend in this article is quite different. We believe that there existed a specifically French transformism. This specificity is based partly (but not entirely) on the ways these biologists addressed the issue of the evolution of species. To meet the epistemological standards of their time, they tried to develop a resolutely experimental

3 - Regarding the differences between the theories of Lamarck himself and those of neo-Lamarckians, see Laurent Loison, *Qu'est-ce que le Neo-Lamarckism? Les Biologistes français et la question de l'évolution des espèces* (Paris: Vuibert, 2010).

4 - In addition to Bowler, *The Eclipse,* one may also read Edward J. Pfeifer, "The Genesis of American Neo-Lamarckism," *Isis* LVI (1965): 156-67.

5 - Yvette Conry, "Comment a-t-on pu être néo-lamarckien en France (1843-1930)?" *Nuncius* VIII (1993): 487-520.

6 - Among other sources, this judgment may be found formulated in Jacques Roger, "Les Positions philosophiques des neo-Lamarckians français," in *Pour une histoire des sciences à part entière* (Paris: Albin Michel, 1995), 394-405.

transformism, which could then lay claim to the same level of scientificity as physiology. It was this project, above all, which gave French neo-Lamarckism its unity.

The Possibility of a Scientific Transformism

The publication of Darwin's masterpiece, and the following translation into French by Clémence Royer (1830-1902) in 1862[7] made little impression on the convictions of French scholars. Their opposition not only concerned the mechanism of natural "*election*," but the fact of evolution itself. One of the most strident attacks was to be found in the work of the physiologist Pierre Flourens (1794-1867), who published several articles in 1864 as a collection, in which he laid out his strong opposition to transformist ideas.[8] Flourens, a disciple of Georges Cuvier, took the same care to point out the weaknesses of Darwin's thesis that his master had taken when addressing those of Lamarck. We should note immediately that throughout most of this story, the specificity of Darwin's proposed evolutionism was rarely understood, and that *On the Origin of Species* was almost always read as a poor repetition of Lamarck's *Philosophie zoologique*.

The main criticism formulated by Flourens against Darwin smoldered for many years. Darwin, he said, had only argued his thesis indirectly; in particular, he had never been able to offer a single case of true transformation of one species into another. The transformist hypothesis lacked the positive facts needed if the assumptions made were to be accepted – notably, any control cases showing the modification of a species. This was clearly not the only reason for the delay in the acceptance of evolutionism by the French community – many others have been mentioned, and participate fully in any complete explanation.[9] Nevertheless, for our purposes, we believe that this was the reason that would lead the French transformism along its particular path, and which

7 - Charles Darwin, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (London: John Murray, 1859). French translation cited by the author: *De l'origine des espèces ou des lois du progrès chez les êtres organisés* (Paris: Masson, 1862).

8 - Pierre Flourens, *Examen du livre de M. Darwin sur l'origine des espèces* (Paris: Garnier Frères, 1864).

9 - John Farley, "The Initial Reactions of French Biologists to Darwin's *Origin of Species*," *Journal of the History of Biology* VII (1974): 275-300.

made French neo-Lamarckism decidedly different from the versions which took shape in other countries, notably in the United States.

In 1870, the zoologist Armand de Quatrefages (1810-1892), one of the most respected figures in the life sciences in France, took his turn to propose a critical reading of Darwin's work.[10] His analysis was both far less acerbic in form and also more relevant. It showed unequivocally that he was better able to understand than Flourens the scientific and epistemological issues of transformism, and that he intended to enter into a sincere dialogue with the Darwinian text. Quatrefages concluded that for this theory to be accepted, like any other scientific theory, it should be required to have the support of hard, that is to say positive, facts. As Darwin saw it sufficient to arrange the existing facts, scientific objectivity forbade, at the moment, any venture into the unknown – "the desert without lights where science strays when she undertakes to push her studies into living things into questions of origin."[11] This is especially the case since, as this quote shows, the object of transformism was not yet clearly understood. Was it a theory of the distant origins of life or simply a theory of its transformation? The title of Darwin's book did little to resolve this confusion. Did its concept refer to the first origin of living matter, or to the process of origination of species at any time during the evolutionary process?[12] As Louis Pasteur (1822-1895) had just won his duel with Felix Pouchet (1800-1872), for many, the failure of the "spontaneous generation" hypothesis had directly led to all transformist theses being considered futile. Since life could not arise from inanimate matter, its origin was therefore inaccessible to experiment, and therefore outside the realm of the expertise of positive science. The scientist must turn away from these issues and surrender them to scholasticism or metaphysics.

Very early, however, some naturalists outside Parisian circles brought favorable echoes to the movement for the reconsideration

10 - Armand Quatrefages, *Charles Darwin et ses précurseurs français* (Paris: Baillière, 1870).
11 - Quatrefages, *Charles Darwin*, 373.
12 - Since writing this text, in October 2008, we have been made aware of the excellent work of Thierry Hocquet on some of the internal problems of Darwin's major opus. Thierry Hocquet, *Darwin contre Darwin: Comment lire L'Origine des espèces?* (Paris: Seuil, 2009). One of the chapters of this book explores the problems of translation that presented themselves in the early 1860s, especially when it came to finding an equivalent to the term "origin" – the key word in the title of the book.

of transformist ideas. Among those few adventurous thinkers, the botanist Charles Martins (1806-1889), director of the botanical garden of Montpellier, would play an important role. In 1873, he participated in the reissue of Lamarck's key work, *La Philosophie zoologique*.[13] Sixty-four years after its first publication, the famous French scholar's text was once more available to the scientific community, as well as to the educated general public. A long biographical introduction by Martins did more than simply make this text accessible – he proposed that it must have significant consequences. Martins writes that science now provides the means to update the ideas of Lamarck by resting upon solid evidence that Lamarck himself had not been in a position to produce. In this introduction, Martins went to some length to include evidence already available, and which, in his opinion, lent support to the transformist position. Above all, the introduction invites experimental biologists to seize the issue and treat it as the physiologist would. Claude Bernard (1813-1878) is appealed to as a reference, and experimental physiology henceforth becomes the model to be followed in transformist studies.

Martins insists on the fact that the biologist must follow in the footsteps of the physician, because the evolution of life is a continuation of that of the material world.[14] Transformism cannot be scientific unless this premise is accepted. In France, when the Third Republic came into being, and at least until the early twentieth century, evolutionism would be the standard of materialistic thinking, and was often accompanied by an uncompromising atheism.[15]

Placing biological evolution within the realm of the physical universe became a foundational theme of the nascent neo-Lamarckism. Jean Lanessan (1843-1919), physician, naturalist, and

13 - Jean-Baptiste Lamarck, *Philosophie zoologique*, 1809. Text preceded by a biographical introduction written by Charles Martins (Paris: Librairie F. Savy, 1873).

14 - Notably the passage "Transformation of physical forces, transformation of organized species organized the same phenomenon seen from two perspectives in two ways, or rather, a premise in the case of the first, and a consequence in the case of the second. To affirm one and deny the other is completely illogical. The physicist and naturalist cannot contradict each other, and experimental physiology confirms the judgments of natural history." Lamarck, *Philosophie zoologique*, 48.

15 - An atheism which was particularly sensitive in the case of Alfred Giard, Jean Lanessan, and Félix Le Dantec. See Laurent Loison, "L'Engagement matérialiste du transformism français (1880-1910)," in *Théorie de l'évolution et religions*, ed. Philippe Portier, Michael Wilt, and Jean-Paul Willaime (Paris: Riveneuve, 2011), 79-88.

politician, entitled his most important book *Le Transformisme: Évolution de la matière et des êtres vivants* (1883).[16] A few years earlier, the zoologist Edmond Perrier (1844-1921), among the most influential French neo-Lamarckians,[17] published an article that may be seen as the constitutional act of French transformist thought.[18] In this text, purposefully entitled "Transformism and the Physical Sciences," the author declares that it is indeed possible to develop a fully scientific transformism that does not require the existence of a continuous process of spontaneous generation. For this, it is necessary to accept that biological evolution is only a moment in the general energetic and material evolution of the universe. It cannot therefore, as the vitalists would have it, violate the classical laws of material science. It becomes strictly causal and mechanical, in the Cartesian sense, and is therefore a phenomenon which is open to study. The determinism of Bernard, the success of which had allowed physiology to be elevated to the status of a true science, guaranteed the feasibility of this enterprise. The scientist could now hope to reveal the determinants of evolution. Here, then, is the challenge faced by the French biologists – to make the transformist hypothesis a scientific one.

The Obligation of Transformism to be Experimental

During the 1870s and 1880s, the prestige of experimental physiology was at its peak, which contributed greatly to making "experimentability" the principal criterion of "scientificity." This powerful influence, amplified by the welcome given to the *Introduction à l'étude de la médecine expérimentale* in 1865, even extended the scope of the experimental method beyond the scientific domain. We see it in literature by Emile Zola (1840-1902) in particular, who presented his project of "Roman expérimental" (1879) as an attempt to overcome the scientific naturalism of his predecessors. In the field of politics, it did not take long for the experimental method to be called upon as a guarantee of the veracity

16 - Jean Lanessan, *Le Transformisme: Évolution de la matière et des êtres vivants* (Paris: Octave Doin, 1883).

17 - Edmond Perrier occupied the highest positions in the French sciences. He was a professor at the *Muséum d'histoire naturelle* and a member of the *Académie des sciences*. At the end of his life, he directed the *Muséum* for a time. He was recognized as being a leading specialist in echinoderms and annelids (invertebrate animals, often marine).

18 - Edmond Perrier, "Le Transformisme et les sciences physiques," *Revue Scientifique* XVII (1879): 890-95.

of speeches. Paris councilman Leon Donnat (1832-1893) – who also held a key role in the implementation of transformist ideas in France[19] – proposed, in his 1885 book,[20] an experimental policy program that aimed to attain a more highly advanced level of democracy. What is of particular interest to the historian of science is that these two attempts to extend the domain of the experimental method are both explicitly linked to the figure of Claude Bernard. It is not, then, just any experimental method that finds such a wide audience, but precisely that which the illustrious physiologist had imposed in his major text of 1865. Obviously, the references do not guarantee the accuracy of the readings, and it is often a rather distorted Claude Bernard which is to be found in works by many of his emulators.

This was the case for most of the first French transformists, who claimed their place as the successors of Bernard.[21] Nonetheless, physiology itself was projected into the possibilities of transformism offered by the new experimental method. Thus, in 1849, in the inaugural text of the *Societé de biologie*, Charles Robin (1821-1885), however fierce an opponent of transformism he was, called for future biologists to reassess the importance of the environment (*milieu*) for the understanding of vital mechanics,[22] and it was precisely this orientation which underpinned the organization of French neo-Lamarckian transformism. In 1867, while writing his report on the progress and work of general physiology in France, Claude Bernard himself – and although he included few cases of heredity in his biological considerations[23] – invited his successors to observe experimentally the influence of "cosmic actions" upon the constitution of beings, influences which may eventually induce

19 - He was the originator of the course "*Évolution des êtres organisés*" [Evolution of Organized Beings] at the Sorbonne (1888), which became a chair [*chaire*] in 1892. See Marc Vire, "La Création de la chaire d'étude de 'l'évolution des êtres organisés' à la Sorbonne en 1888," in *Les Néo-Lamarckiens français, Revue de synthèse*, ed. Jacques Roger, 3rd series, C/95-96, 1979), 377-91.

20 - Léon Donnat, *La Politique expérimentale* (Paris: C. Reinwald, 1885).

21 - See, for example, Gaston Bonnier, "L'Anatomie expérimentale," *Revue Scientifique* XXXI (1893): 225-31.

22 - Charles Robin, "Sur la direction que se sont proposée en se réunissant les membres fondateurs de la Société de biologie pour répondre au titre qu'ils ont choisi," *Comptes Rendus de la Société de Biologie* I (1849): 1-11.

23 - Jean Gayon, "Un Objet singulier dans la philosophie biologique bernardienne: L'Hérédité," in *La Nécessité de Claude Bernard: Actes du colloque de Saint-Julien-en-Beaujolais des 8, 9 et 10 décembre 1989*, ed. Jacques Michel (Paris: Méridiens-Klincksieck, 1991), 169-82.

heritable variations.[24] Finally, but certainly not exhaustively, we note that the physiologist Jules Marey (1830-1904), successor of Flourens at the *Collège de France* (1867), also called, in 1873, for the extension of experimental physiology to transformist considerations.[25] The title of the article in which he proposes to renew the question of the mutability of species is an entire research program in itself: "Transformism and Experimental Physiology."

It is resolutely within this experimental and physiological framework that the first French research on the evolution of species was conducted. From the early 1880s, this driving force found concrete incarnations in several fields of biology. Botany and microbiology were the first two domains in which the transformist hypothesis could be said to have been tested. In botany, the development of these questions was initially the work of Gaston Bonnier[26] (1853-1922), who was later joined by his colleague and brother-in-law Julien Costantin[27] (1857-1936). In 1878, Bonnier carried out a scientific mission to Sweden and Norway. This trip, during which he carefully studied the Arctic flora, revealed the close similarity of Arctic plants to flora found in the Alps, higher than a certain altitude. As physicochemical environmental conditions vary identically according to latitude and altitude, Bonnier proposed that the similar aspects of the two flora were the result of a prolonged influence of "cosmic agents."[28] Back in France, he became convinced that this question deserved an experimental response, which he believed might illuminate the evolution of species. By 1882, Bonnier had established protocols of comparative cultures – cuttings from single stems of herbaceous species were planted in soil artificially given the conditions found at increasing altitudes in Fontainebleau and in the Alps.[29] The results

24 - Claude Bernard, *Rapport sur les progrès et la marche de la physiologie générale en France* (Paris: 1867), 110-13.

25 - Jules Marey, "Le Transformisme et la physiologie expérimentale," *Revue Scientifique* XI (1873): 813-22.

26 - Gaston Bonnier was professor of botany at the Sorbonne and a member of the *Académie des sciences*. His influence on plant biology was very strong around 1900, and his various publications on flora remained the preferred models for many years.

27 - Julien Costantin enjoyed a career equally as brilliant as that of Bonnier, but at the *Muséum d'histoire naturelle*. Like Bonnier, he was a pupil of Philippe Van Tieghem.

28 - Gaston Bonnier and Charles Flahault, "Observations sur les modifications des végétaux suivant les conditions physiques du milieu," *Annales des Sciences Naturelles, Botanique* VII (1878): 93-125.

29 - Gaston Bonnier, "Recherches expérimentales sur l'adaptation des plantes au climat alpin," *Annales des Sciences Naturelles, Botanique* XX (1895): 217-360.

were rapid and dramatic. Many lowland species of plants showed the altitude characteristics of related mountain species as early as the first year of cultivation, sometimes to the point that they became indistinguishable. However much insight these experiments produced, they were unsatisfactory, not supplying any means of definitively identifying the cosmic agents responsible for the changes induced. It was necessary to perform parallel controlled laboratory experiments to ensure the validity of the conclusions. Although Bonnier also participated in this kind of research,[30] it was Costantin who produced the most significant work during the 1880s.[31] It was necessary to show how, by varying the physico-chemical conditions of plant growth, it was possible to profoundly modify their morphology, anatomy, and physiology, to the extent that one might expect to be able to transform a stem into a root, or an aerial plant into an aquatic one. This type of work, which showed plainly the "plasticity" of organisms, was facilitated by the specific characteristics of plants that could never escape the new environmental conditions imposed on them. The results of this work were systematized by Costantin in two later books,[32] and they clearly comprise, for their authors, an equal number of arguments in favor of a neo-Lamarckian understanding of the transformation of life.[33]

Meanwhile, the emerging science of microbiology was also the scene of much experimental work on transformism. As it did for plants, this work took advantage of the inability of the living material under experiment to escape the environment imposed upon it. Better still, as Auguste Chauveau (1827-1917) had clearly shown in 1885,[34] the extreme rapidity of the reproduction of microorganisms could allow the experimenter to expect to see real evolution occurring over a relatively short time. Note that work

30 - Gaston Bonnier, "Influence de la lumière électrique sur la structure des plantes herbacées," *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences* CXV (1892): 475-78.

31 - Julien Costantin, "Étude sur les feuilles des plantes aquatiques," *Annales des Sciences Naturelles* III (1886): 94-162.

32 - Julien Costantin, *Les Végétaux et les milieux cosmiques* (Paris: Alcan, 1898); *La Nature tropicale* (Paris: Alcan, 1899).

33 - In the first pages of his book, Costantin announces: "The two concepts of Lamarck can both be true and applicable to both kingdoms. The problem of the moment is to find experimental evidence that this scientist was unable to collect or failed to find." Costantin, *Les Végétaux*, 12.

34 - Auguste Chauveau, "L'Atténuation des virus," *Revue Scientifique* XXIII (1885): 614-23.

in microbiology, often the work of Pasteur's followers or Pasteur himself,[35] did not give rise, most of the time, to neo-Lamarckian interpretations as marked and assured as those we saw in botany. We nevertheless occasionally find such references made explicitly, and the general appearance of explanations indicates that they were often constructed on the theoretical foundation of the inheritance of acquired characteristics. Émile Duclaux (1840-1904), for example, interpreted certain work on microbial cultures[36] and immunology, including the results obtained by his younger colleague, Etienne Wasserzug[37] (1860-1888), in an overtly Lamarckian manner. The work in question had shown that the morphology of certain microorganisms could be made to vary as a function of various parameters of the culture medium.[38] Duclaux saw in this the first positive results of experimental transformism.[39] Thereafter, Costantin, Bonnier, and later Félix Le Dantec[40] (1869-1917) and Etienne Rabaud[41] (1868-1956), continued to refer to the work of Wasserzug.

In other fields of biology, the development of an experimental transformism was more problematic. In metazoans particularly, disruptions of environmental conditions during ontogeny often resulted in non-viable or even quite monstrous individual beings. This is one of the reasons why, in 1891, the zoologist Henri de Varigny (1855-1934) regrettably announced that the "demonstration [of

35 - Louis Pasteur, Charles Chamberland, and Émile Roux, "De l'atténuation des virus et de leur retour à la virulence," *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences* XCII (1881): 429-35.

36 - Concerning the work of Pasteur, Duclaux said bluntly: "[…] there exists a hereditary transmission of acquired faculties." Emile Duclaux, *Traité de microbiologie*, vol. I: *Microbiologie générale* (Paris: Masson, 1898), 257.

37 - Étienne Wasserzug was a laboratory technician at the Pasteur Institute, and a protégé of Pasteur himself. His scientific career was highly promising until scarlet fever put an abrupt end to his days.

38 - Étienne Wasserzug, "Variations durables de la forme et de la fonction chez les bactéries," *Annales de l'Institut Pasteur* II (1888): 153-57.

39 - Duclaux, *Traité de microbiologie*, 254.

40 - Félix Le Dantec, a pupil of Alfred Giard, occupies a special place in the French neo-Lamarckian movement as the only contributor to abandon experimental work early for pure theory. Although he died young because of poor health, he left a very large quantity of written work – at least forty books.

41 - Etienne Rabaud, who worked in the laboratories of Alfred Giard after the death of his master, Camille Dareste, tried to develop certain theories of his colleague Félix Le Dantec. In many respects, his work is very similar to that of Le Dantec. However, unlike Le Dantec, he did not abandon experimentation, and worked particularly in the fields of teratology, embryology, and entomology.

transformation] has not yet been made."[42] It was partly in order to fill this gap that experimental teratology was developed. This type of work, first seen in France in the experiments of Camille Dareste (1822-1899), was mainly pursued by his pupil Rabaud. Much of his research in this area was aimed at producing physicochemical perturbations – altering temperature, mechanical vibrations, and so forth – in the environment of developing bird embryos, and observing the defects that resulted. This is, of course, a reprise in the field of zoology of the botanist's protocols, and indeed one member of Rabaud's doctoral dissertation committee was Bonnier himself. Based on some of the results he was able to obtain, Rabaud campaigned vigorously for "monstrosity" to be understood as a simple variation, and not as a deformation of a predetermined ontogeny.[43] He built an entire neo-Lamarckian epigenetic explanatory system, which he adhered to with virtually no modifications until his death in 1956. Although this field of research was less rich than the previous two,[44] it managed to bring positive, experimental facts to light, showing the direct transformation of living organisms according to the constraints of their environment.[45]

The experimentalism that took over all branches of science, including biology, during the second half of the nineteenth century was thus the ideal occasion for the revival of transformism in France. But for the project to be fully realized, it also required the new biologists to have adequate tools, most importantly an adequately equipped laboratory. Although, by 1888, the new Pasteur Institute offered working conditions of the first order to microbiologists, there was no equivalent then available to botanists or zoologists. They were obliged to undertake the difficult task of finding the necessary funds to render their respective disciplines scientific, that is to say, experimental. In botany, Bonnier showed astounding efficiency in this matter; by 1890, he had established a

42 - Henri Varigny, "Le Transformisme expérimental," *Revue Scientifique* XXIX (1891): 769-77, here 769.

43 - Étienne Rabaud, *Le Transformisme et l'expérience* (Paris: Alcan, 1911).

44 - In botany, equivalent teratology work was undertaken by Louis Blaringhem (a student of Costantin), and gave rise to interpretations combining the mutationist hypothesis and the etiology of environment. Works to be consulted include that of Marion Thomas, "De nouveaux territoires d'introduction du mendélisme en France: Louis Blaringhem (1878-1958), un généticien néolamarckien sur le terrain agricole," *Revue d'Histoire des Sciences* 57 (2004): 65-100.

45 - Étienne Rabaud, *La Tératogenèse: Étude des variations de l'organisme* (Paris: Octave Doin, 1914).

research laboratory at Fontainebleau, aptly named the Laboratory of Experimental Botany. In zoology, while Alfred Giard[46] (1846-1908) was chosen in 1888 to be the first occupant of what would become the chair of *Évolution des êtres organisés* at the Sorbonne, it was not until 1923 that this institution finally found the wherewithal to fund a working laboratory. Giard, who died in 1908, incessantly repeated the need for such equipment if the great questions concerning the mechanisms of evolution of the species were to be settled.[47]

We see clearly that the transformism which developed in France in the 1880s was precisely what the detractors of *On the Origin of Species* had outlined: a transformism based on direct experiment, thus able to claim positive facts proving transformation; a transformism designed from the outset as an extension of physiological science, even if ignoring the many warnings given by its master, Claude Bernard;[48] and a transformism which, because of the project to which it was devoted, did not ask the same questions as neo-Darwinism.

What It Means to "Explain" Evolution

Even today, it is particularly difficult to precisely define the criteria that must be met for an explanation in science to be considered "good." Habit and scientific education are, in this regard, undeniably important factors in the attraction offered by any particular mode of explanation.[49] The habit of the French biologist, at the

46 - On the theoretical positions taken by Giard, see Laurent Loison, "Les Conceptions embryologiques et phylogénétiques d'Alfred Giard (1846-1908) et Edmond Perrier (1844-1921), deux appropriations de la loi biogénétique fondamentale," *Bulletin d'Histoire et d'Épistémologie des Sciences de la Vie* 16 (2009): 165-83, and Laurent Loison, "Les Conceptions évolutionnistes d'Alfred Giard (1846-1908)," in *Observation des écosystèmes marin et terrestre de la Côte d'Opale: Du naturalisme à l'écologie*, ed. François G. Schmitt (Paris: Union des océanographes de France, 2011), 37-47.

47 - Alfred Giard, "Histoire du transformisme," in *Controverses transformistes* (Paris: C. Naud, 1904), 1-26.

48 - One of the main difficulties that the French neo-Lamarckians had with Bernard's precepts was in trying to negotiate the necessary link between the shape of the body and its substance. Such a link between morphology and physiology would allow the application of the experimental method – strictly confined to physiology by Claude Bernard – to transformism. For more information about the complex relationship between French neo-Lamarckianism and Bernardian physiology, see Loison, *Qu'est-ce que le neo-Lamarckism*.

49 - Michel Morange, *Les Secrets du vivant: Contre la pensée unique en biologie* (Paris: La Découverte, 2005).

time when transformist philosophy emerged, was undoubtedly that of the experimental physiologist. The French biologists were scientific positivists who focused their attention on the elucidation of the determinism of phenomena. Illuminating the determinism of vital phenomena meant exposing the physicochemical parameters of environments which, when varied, may mechanically induce changes in the vital activity of the organism.

The French neo-Lamarckism made this mode of explanation its own, and sought tirelessly for the determinism of organic transformations.[50] The immediate and determining causes of morphological or physiological changes were obstinately reduced to changes in the abiotic properties of the surrounding medium – temperature, brightness, concentration of certain elements, mechanical forces, and so on. The neo-Lamarckian environment, the proximal mechanical cause of organic changes, was conceived in a radically different way from Darwin's environment, being entirely reduced to its abiotic dimension. While in Darwin, what counts is the biological interaction between living things,[51] in French neo-Lamarckism only physicochemical action was deemed worthy of being able to deform the protoplasm of the body, and capable, over the long term, of leaving a potentially indelible impression on it.

This objectified environment, identical for all living things, is the "dream element" of any analytical explanation, because it allows and perhaps even calls for consideration of each organic change as a direct expression of a change in a number of its quantifiable parameters. We understand the benefit that the experimental biologist would be able to draw from this idea, so quick to provide endless possibilities for explanation. From one end to the other of this story, regardless of the author we consider, we find the following

50 - Alfred Giard, "Les Facteurs de l'évolution," in *Controverses transformistes*, (Paris: C. Naud, 1904), 109-34.

51 - Georges Canguilhem noted: "These two authentic biologists [Lamarck and Darwin] are complementary. Lamarck considers life in terms of its duration, and Darwin rather according to interdependence in which a living form supposes a plurality of other forms with which it is associated. The synoptic vision at the heart of Darwin's genius is lacking in Lamarck. Darwin is more akin to a geographer, and we know how much he owes to his travels and explorations. The environment in which Darwin sees the life of living things is essentially a bio-geographical environment." Georges Canguilhem, "Le Vivant et son milieu," in *La Connaissance de la vie, 1965*, (Paris: Vrin, 2003), 165-97, here 177.

theoretical commitment prominently expressed: explaining evolution can be reduced to finding evidence for the determinism of individual variations.[52]

We must measure the distance that separates this mode of explanation from that called for by August Weismann (1834-1914) and the neo-Darwinians. That certain environmental parameters may be the conditions for triggering specific organic responses was well understood. Yet identifying these conditions with explanatory causes for evolution demonstrated, for Weismann at least, an insufficiency, if not total incompetence. Weismann was to discuss these issues with German biologists who, in some respects, can be considered as the counterparts of the French neo-Lamarckians. He rebuked them for not understanding that explaining evolution required far more than this, primarily because the specificity of the reaction – we would say the adaptation – is in no way illuminated by a simple review of its determinism.[53] Only a reasoning based on selection, referring to past causes, allows adaptation to be explained[54] – the experimental biologist will have a hard time applying himself to the unraveling of determining factors whose historical reasons necessarily remain inaccessible to him.

Although Weismann's texts were available in French by 1892, the critique he addressed to experimental evolutionists was barely

52 - See Rabaud for example (as late as 1935): Étienne Rabaud, *Titres et travaux scientifiques de M. Étienne Rabaud* (Laval, France: 1935), 3.

53 - Weismann writes: "If we turn the branches of a *Thuja* upside down, the anatomical structure of the bud is modified accordingly. The side that was, strictly speaking, to form the lower end, but by an artificial process takes the upper position, takes on the structure of the upper end and develops the characteristic palisade parenchyma. What was originally intended to form the upper end now takes the characteristics of the spongy parenchyma proper to the lower end. Detmer draws the conclusion that the dorsal-ventral bud structure of *Thuja* is the result of an external influence, and that 'from everything we know, light must be regarded as the deciding factor.'" "*This conclusion is simply based on a confusion of ideas. That light, in the experiment in question, is a deciding factor of structural change, nobody doubts, but what is in doubt is that this is the cause that gave the* Thuja *bud the faculty of forming a palisade and a spongy parenchyma in the first place*." August Weismann, "Des Prétendues preuves botaniques de l'hérédité des caractères acquis," in *Essais sur l'hérédité et la sélection naturelle*, (Paris: C. Reinwald, 1892), translated into French from German by Henri de Varigny, 513-41, here 517-18. Our emphasis.

54 - "In this regard, the idea would occur to no one that a direct influence of green light in the frog's usual environment has colored its skin. *We must recognize that here and in all similar cases, there is only one possible explanation – that of the selection process*." Weismann, "Des prétendues preuves," 519. Our emphasis.

noticed by the Parisian neo-Lamarckians. The origin of the adaptive nature of organic responses was generally not considered a relevant question, because it seemed to go far beyond the potential offered by the science of the late nineteenth century.[55] Undoubtedly, Le Dantec, a leading French neo-Lamarckian theorist, showed serious attention to this thorny issue, but the response he developed, based solely on considerations of internal selection processes made during the life of an organism,[56] remained a physician's response, requiring nothing other than the maintenance of the known laws of nature. For the French neo-Lamarckians, a "long time" meant an indefinite extension of the life of an organism, and was never applied to the depths of history. Hence, when Yves Delage (1854-1920) proposed a theory of "*causes actuelles*" to account for the adaptation of living organisms to their environment,[57] it was not to present an "actualistic" reading of nature, such as that Charles Lyell (1797-1895) had given in the field of geology, but, on the contrary, to compress the temporal explanation to the scope of an individual life. If an organism presents a morphology adapted to the needs of its environment, this adaptation owes little or nothing to the past of the species (heredity), and everything to the developmental processes that have been carried out via the hypothetical mechanism of "functional excitation."[58]

In this opposition of explanatory modes there is simply no symmetry between the neo-Darwinians and the neo-Lamarckians. Indeed, it would be wrong to think that these two paradigms can be related by any ratio of commensurability. Without a doubt, the neo-Lamarckian "physicalist biologists" were baffled by Weismann's considerations, which were sometimes literally incomprehensible to them. The converse is not true. Many neo-Darwinians, Weismann first among them, perfectly integrated the neo-Lamarckian experimental results into their explanations. However, unlike the Lamarckians, they see nothing in them as directly relevant to the causes of evolution – they are reduced to the rank of indicators

55 - Costantin, *Les Végétaux*, 88-89.

56 - Félix Le Dantec, *Bactéridie charbonneuse, assimilation – variation – sélection* (Paris: Masson, 1897); and *Évolution individuelle et hérédité* (Paris: Alcan, 1898).

57 - Yves Delage, *La Structure du protoplasma et les théories sur l'hérédité* (Paris: C. Reinwald, 1895).

58 - On the conceptions of Delage and his relationship with French neo-Lamarckism, see Laurent Loison, "Yves Delage (1854-1920) et l'hétérogénéité du néolamarckisme français," *Bulletin d'Histoire et d'Épistémologie des Sciences de la Vie* XIII (2006): 143-67.

of the external parameters which control variation at the level of the individual. They had already completely incorporated the demarcation of the frontier between what we now distinguish as the mechanisms of *adaptation* and *acclimatization*. There was, therefore, more to the Darwinian explanation, which entirely absorbed the neo-Lamarckian view, while illuminating genuine problems that so often remained completely invisible to the positivist and arid questioning of the French biologists.

Conclusion

The French neo-Lamarckian project, particularly salient during the apogee of its history between 1880 and 1910, did well to provide the transformist hypothesis with a solid and unquestionable basis proceeding from the experimental method, as vindicated by the successes of Bernardian physiology. Its incarnation as an operational research program was attempted in several branches of the life sciences, including botany and microbiology. It aimed to show how variations in the physicochemical parameters of the environment could lead to the modification of an individual organism. The organism was conceived as a vast protoplasmic entity endowed with great plasticity, whatever its own level of organization may be. Evolution was thus reduced to the ensemble of individual variations, and these were considered to have been explained as soon as their determinants had been shown. Although neo-Lamarckism could not survive without the doctrine of the inheritance of acquired characteristics, it remained far more interested in the acquisition of those characteristics than in their potential transmission. Even when this concept of flexible heredity was subjected to Weismann's harsh criticism, the attention of the first French transformists was never turned away from the attraction of experiment, with all its determinable plasticity of forms. It was still possible to argue with the party of Weismann that their theoretical constructions, while clever, exceeded – by far, for many of them – that which the experimental results seemed to indicate.

Nevertheless, in the early years of the new century, it became increasingly urgent to prove that the modifications acquired could survive the individual organism and be incorporated into its inheritance. In France, even if this necessity was well understood, the

parties involved always preferred to call upon the results obtained elsewhere rather than daring to engage in research that might shed light on the issue.[59] On the theoretical side, the historian finds an equally remarkable void. Not one of the principal neo-Lamarckians ever presented a consistent hypothesis capable of explaining the process of inheritance of acquired characteristics. We thus confirm that experimental research into the determinism of variations was indeed the ultimate goal of this group of biologists.

The absence of any positive developments indicating the possibility of the inheritance of acquired characteristics, and even more so concerning the inheritance of required – or adaptive – characteristics, ultimately led to a severe weakening of this version of transformism. This weakening manifested itself in several ways. For example, Maurice Caullery (1868-1958), pupil and successor of Giard at the Sorbonne, proposed to abandon the principle of "actualism" in the hope of saving neo-Lamarckian transformism.[60] The idea here is that the present-day absence of positive results should not be interpreted as evidence that the inheritance of acquired characteristics did not exist as a mechanism in the past, simply that it no longer existed. The laws of evolution had been different in the past, and had led to the complex adaptations of existing organisms, which were now incapable of further transformations.[61] His colleague at the Sorbonne, Rabaud, opted for an equally radical alternative, which was to deny the reality of any morphological adaptation of living organisms to their environments. At the heart of his concept, adaptation remained nothing more than a minimal metabolic equilibration between the individual and its nutritive medium. This depleted version of transformism has no need for an inheritance of acquired characteristics, merely a heredity of acquired *constitution*.[62]

It is precisely at the moment when these *ad hoc* explanations were crystallizing, that we see other neo-Lamarckisms emerging in

59 - For example, the results obtained by Max Standfuss concerning the potentially hereditary action of temperature on butterflies were regularly evoked by the French neo-Lamarckians.

60 - Laurent Loison, "La Question de l'hérédité de l'acquis dans la conception transformiste de Maurice Caullery: Premières réflexions sur la spécificité de la pensée néolamarckienne française," in *Embryologie et évolution (1880-1950): Histoire générale et figures lyonnaises*, Michel Morange and Olivier Perru (Paris: Vrin, 2008), 99-127.

61 - Maurice Caullery, *Le Problème de l'évolution* (Paris: Payot, 1931).

62 - Étienne Rabaud, *L'Adaptation et l'évolution* (Paris: Étienne Chiron, 1922).

French biological thinking, which were often far removed from the principles that had driven the original transformism.[63] It is therefore not appropriate to consider them as being of the same tradition.[64] Above all, perhaps, the two movements were clearly separated by an event that would come to be seen as pivotal: the 1907 publication of Henri Bergson's *L'Évolution créatrice* [*Creative Evolution*].

63 - For example, those of Albert Vandel (1894-1980) and Pierre-Paul Grasse (1895-1985).
64 - Laurent Loison, "French Roots of French Neo-Lamarckisms, 1879-1985, *Journal of the History of Biology* 44 (2011): 713-44.