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Life as a Puzzle

by Bertrand Vaillant

The complexity of contemporary biology is a source of wonder, fear, and misunderstanding. Thierry Hoquet reviews the major biological theories to help us think through the social implications of a science that is opening up fascinating, though not inevitable, horizons.

About: Thierry Hoquet, *Le nouvel esprit biologique,* Puf 2022. 288 p., 17 €.

Are we in the midst of a scientific revolution in biology? If we are to believe newspaper headlines and bestselling titles, our knowledge of life seems always on the verge of a major upheaval: Epigenetics are overturning genetics by establishing the importance of the environment; the microbiota is a "second brain" as important as the first; trees talk to each other; etc. In addition, many of today's eminent biologists are calling for a renewal of the science of life, for a broadening of old theoretical frameworks that favors the development of an "inclusive evolutionary synthesis" (Danchin, 2022), or for a more radical reorientation towards an "extended evolutionary synthesis" that makes ample room for the phenomena of developmental plasticity, ecological niche construction, and cultural evolution (Laland *et al*., 2015).

What are these calls for reform or revolution based on and what can we expect from them? What dogmas do they seek to overcome and what disparate elements do they seek to unite? According to philosopher of science Thierry Hoquet, these questions must be addressed, not only out of scientific curiosity, but also because biology has dethroned physics as the central science of our cultural universe. As a

purveyor of concepts, words, images, and representations of the social world (let us think of the ubiquitous "DNA" of companies and political parties), biology also carries the promise and fear of a new mastery of nature, and indeed of our very nature.

To help non-specialists makes sense of these developments, Hoquet proposes in *Le nouvel esprit biologique* (The new biological spirit) an open map of the major theoretical frameworks in biology and of the main discoveries said to challenge these frameworks today. He endeavors to highlight the accompanying philosophical questions and the tensions these reveal within the very disciplines that seek to explain life—noting that these questions manage to grasp several aspects of life without being able to piece together the entire puzzle.

The Fiction of a Unified Biology

The first part of the book provides a clear, well-informed presentation of the major theories that constitute, if not an undisputed paradigm, the "general theoretical frameworks" of contemporary biology, which Jean Gayon (quoted by Hoquet) has described as "powerful heuristic models associated with robust empirical generalizations." The most important are the synthetic theory of evolution (STE) and molecular biology, both of them based on genetics.

Without going into too much detail, let us recall that the STE was born with the unification of Darwinian evolutionary theory and population genetics in the 1930s, as illustrated in particular by the work of Julian Huxley (1942). The STE's preferred scale of analysis is the population, understood as a delimited set of individuals of the same species whose genetic variations, frequencies, and effects are observable. The observation of this microevolution allows to understand the macroevolution of all species—which is in principle unobservable—through a process of inference based on the entire fossil record and accumulated genetic knowledge.

Molecular biology emerged in the 1960s-1970s as an explanatory framework for embryonic development and the metabolism on the basis of the concept of genetic program and the works of Jacques Monod and François Jacob (Monod 1972, Jacob 1993). Following Watson and Crick's discovery of the structure of DNA in 1953, Jacob and Monod conducted investigations into protein synthesis, which led them to formulate the "central dogma" of molecular biology: Information flows from DNA to

protein synthesis through the transcription of DNA into RNA[1] and the translation of this RNA into a series of amino acids. Jacob and Monod's research paved the way for the computer analogy of the development-regulating "genetic program," and later for the sequencing of entire genomes—including the "human genome project" (HGP), which was completed in 2003 without providing the hoped-for revelations on the specificities of the human species.

In presenting these conceptual frameworks and their history, Hoquet clearly highlights the double tension inherent in biology. On the one hand, biology, although fragmented into multiple sub-disciplines, strives to preserve the fiction of its unity, both in the expectation of a grand unifying theory and in order to maintain its autonomy in the face of the pretensions of physics and chemistry and the interference of capitalist industry. On the other hand, each major theoretical current or sub-discipline of biology feels the need to encompass the others and to flatten, in the name of unification, the diversity of techniques and levels of analysis that is no doubt essential for grasping the complexity of life. Thus, Hoquet compares biology to Humpty Dumpty, Lewis Carroll's fictional character who represents both the unity of the egg under constant threat of bursting and the tendency to impose on the rest of the world the totalizing unity of one's own representations (since Humpty Dumpty makes the absurd claim that he can give words any meaning he wishes).

If there is tension, it is because each sub-discipline or theoretical framework has its own preferred level of explanation: In the case of the STE, the level of explanation is the population rather than the organism. In the case of molecular biology, it is the molecule: Here the organism, which was central for Darwin, is considered either as an element of a statistical whole or as the result of molecular interactions regulated by a genetic program. However, in viewing population primarily as a set of genes and allele frequencies subject to Darwinian selection, a certain neo-Darwinism has made genes the preferred level of explanation, thereby treating the organism as no more than a vehicle for their replication. This was Richard Dawkins's famous and polemical move in *The Selfish Gene* (1976). Be that as it may, Hoquet's presentation suggests that the complexity of life renders impossible any unified theory or definitive reduction of one level of observation to another, at least for the time being: Hence the persistence of a desire for unification, and even of a "physics envy," among certain biologists (p. 39), along with the incessant threat of splintering.

[1] Specifically, the RNA molecule "copies" information from a portion of DNA and transports it to the cell's organelles, which then transform this information into proteins useful to the organism.

As Hoquet points out, these attempts at synthesis contain both riches to be seized and dangers to be averted. On the one hand, the jointly historical and anti-essentialist approach of contemporary biology—which is the philosophical tendency of Darwinism—has largely renewed, if not superseded, classical concepts such as species or sex, and its discoveries appear here as a welcome challenge to rigid popular or philosophical categories (on sex, see also Hoquet, 2016). On the other hand, by reducing the organism to its chromosomes, even to its genetic code, and by searching for a molecular mechanism in every vital process, contemporary biology runs the risk of confusing its methodological reductionism with a dogmatic ontological reductionism and of reconnecting with forms of essentialism and preformism[2] that are rather un-Darwinian.

Reforms or Revolutions?

It is in the second part of the book that Hoquet truly addresses the new discoveries he claims are challenging these now overly rigid theoretical frameworks. These discoveries are organized around five major distinctions: macro/micro, endo/exo, horizontal/vertical, machine/process, genetics/epigenetics.

The macro/micro distinction is linked to the growing interest in the world of microbes, in particular that of unicellular prokaryotes. It is now established that bacteria and archaea constitute by far the largest proportion of the biomass, to the point of challenging the classical primacy of macroorganisms: "This 'micro' revolution purports to change not just the *scale*, but the *resolution* or *grain* at which biology observes life" (p. 140). The focus on the microbial world also presents a challenge to the STE: Not only does it turn the existence of macroorganisms into an enigma (why did life not remain unicellular?), but it also undermines the classical representation of the "tree of life." Horizontal gene transfer, which enables genetic mixing between organisms without reproduction, is indeed so common among microorganisms that it calls into question the very relevance of the notion of species—a notion that has already been cast in doubt at the level of macroorganisms. These characteristics

[2] In the eighteenth century, preformism referred to a doctrine whereby all living things are created by God as "preformed" germs that merely need to grow during embryonic development. The term was taken up by biologists who criticized the reduction of development to the execution of a fully written genetic program.

"support the idea, not of a vertical tree (or even bush), but of horizontal reticular patterns" reminiscent of the "rhizomes" dear to Deleuze and Guattari (p. 149).

Interest in the microbial world—which is not new but consubstantial with biology since at least the nineteenth century, as the author helpfully reminds us—has increasingly revealed the importance of symbioses and co-developments among living organisms, to the point of blurring the distinction between individuals or between that which is external/exogenous and internal/endogenous to them. All multicellular organisms likely require vast populations of unicellular organisms for their development and their metabolism:

> We may therefore be tempted to replace the term "organism" by the term "holobiont," which designates the totality formed by the individual and its integrated bacteria. Cows, for instance, would not be able to feed themselves without the help of the microorganisms that live in their rumen; one could indeed argue that they are not herbivores but feed on microorganisms which themselves feed on plants through fermentation (p. 161).

This omnipresence of symbiotic partnerships also implies a new conception of immunity: Long conceived in terms of the self/non-self opposition, and indeed as the "science of the rejection of the foreign" (p. 165), immunology must now "redefine the subject not as a closed identity but as an open subject": "The self is not insular and its development is never complete" (p. 166). While the author is careful not to draw simplistic political analogies from this, he repeatedly highlights (following Canguilhem) the play of mirrors through which the biological and political representations of an era can reciprocally influence each other.

The "vertical/horizontal" distinction is an opportunity for the author to raise the more classical philosophical question of the hierarchical dimension of the organism. As Hoquet makes clear, this dimension leads to the opposition between a holistic perspective and a reductionist perspective, each depending on whether or not one considers this organized whole to be entirely reducible to the sum of its parts, that is, ultimately, to molecular interactions and even to physico-mathematical laws. The problem then arises as to how the complex capacities of organisms, particularly those related to consciousness, can emerge from atoms and molecules that lack such capacities. Faced with this problem that has given rise to myriad souls, archaea, guiding Ideas, and other mysterious vital principles, biologists such as Denis Noble (2006) have endeavored to develop a "theory of complex systems" that goes beyond narrow reductionism (especially in terms of genetic coding) without leaving the field of science. Their conceptions of organisms as complex and dynamic systems also

challenge the view of organisms as machines, and thus favor the notion of process which has its philosophical counterpart in processual ontologies like Whitehead's. However, as Hoquet points out, it is not certain that this binary distinction will do much to advance the debate, since we can just as easily endorse a neo-mechanism that integrates the dynamic and processual dimension of biological mechanisms without sticking to the clocks and pulleys dear to the seventeenth century.

Finally, the book offers a useful review of one of the most widely publicized "revolutions" of the last decade: epigenetics. By revealing the considerable impact of the environment on genome expression, the epigenetics revolution has challenged the tendency towards unidirectional preformism, which treated the organism as the rigid expression of a genetic heritage unaffected by the environment. Accordingly, modifications in genome expression are now said to be transmitted over several generations without modifying the genetic code itself. As Hoquet reminds us, however, this exciting enrichment of genetics does not put an end to the centrality of the genome. The broader concept of phenotypic plasticity central to proposals for an extended evolutionary synthesis receives little attention from the author, who nevertheless recalls that this concept is related to the idea that a genotype can correspond to a wide range of phenotypes depending on developmental conditions. Hoquet is more concerned with the entry of biology into a "post-genomic era," in which the sequencing of entire genomes has become easy and inexpensive, with already sequenced genomes feeding gigantic databases. Beyond the genome, scientists are seeking to collect multiple biological profiles of individuals from various viewpoints: The proteome, interactome, metabolome, microbiome, transcriptome, and even methylome could form the basis of a predictive and comparative medicine that raises both hopes and fears. Indeed, while this influx of data opens up prospects for fundamental research, it also whets the appetite of countless biotech companies, which could sell these costly individualized profiles to the wealthiest (or to the highest bidders).

Society and the New Horizons of Biology

In his lengthy conclusion, the author moves away from the fiction of a biology that develops largely autonomously, and examines instead the social uses to which this science is being put. His central thesis, which he presented earlier in his work on biological sex and gender (Hoquet, 2016), is that society imposes questions and

research orientations on biology and derives applications from it for its own justification. As Hoquet points out, to believe that biology holds the ultimate key to explaining all of our individual and collective behaviors would be to sink into a dangerous "biologism" (p. 229)—namely, an excessive scientism and a failure to remember that biological research and its applications are always socially oriented. From the perspective of its social applications (medicine, agriculture, biotechnologies, transhumanism, etc.), biology is not so much a science of "why?" as a science of "why not?," which is to say, a science that opens up possibilities that society can decide to realize or not. For Hoquet, biologism entails a form of unaccountability of the social and political sphere, which wrongly considers that the realization of all scientific and technical possibilities is inevitable. As regards the nature of the social relations that shape or instrumentalize biology, the part played by capitalist industries and their accompanying political ideologies, and the role of social institutions and ethical theories in allowing for a sound assessment of the possibilities opened up by science, the author is content to raise questions without answering them—even though the entanglement of biological models and political representations is mentioned several times in the book.

Generally speaking, Hoquet proceeds by way of open-ended questions and formulas such as "one is tempted to argue that...," "some do not hesitate to say that..." In so doing, he highlights the ongoing debates and the always open nature of biology, each current of which tries to impose a certain hegemony over others without ever fully succeeding. Yet, in the midst of all these unanswered questions, the "new biological spirit" evoked in the title seems rather indeterminate: Is it to be found in the classical theoretical frameworks, in the many criticisms levelled at them, in the never-ending drive to unify biological science, or even in biology's tendency to descend into biologism? Likewise, the reasons for choosing one side or the other of numerous alternatives are not always obvious; moreover, the presentation of these alternatives, though often clear and synthetic, may sometimes seem allusive and elliptical, especially for those who are not well versed in biology. While this may leave readers unsatisfied, the wealth of references cited will certainly encourage them to delve deeper into the issues covered. A great strength of the book is that it presents the state of the debate without seeking to propose a grand unifying solution—any such solution still clearly eluding biology. Similar to Bachelard in *The New Scientific Spirit*, Hoquet seeks above all to capture a moment in the history of biology that is characterized by the complexity of models and concepts: Like Bachelard's post-1905 physics that broke with Descartes's "simple natures" and presented an ever more complex picture of the universe, contemporary biology breaks with common conceptions of the individual,

the species, the self, and the environment as much as with simplistic mechanism and vitalism, and it grows more elaborate as the irreducible complexity of life itself is revealed.

However, the absence of ecology in this picture—not only as a major social issue, but also as an important sub-discipline of biology—may seem surprising. Ecology is indeed rich in concepts, many of which have likewise permeated ordinary social representations: ecosystem, ecological niche, adaptation to the environment, trophic chains, invasive species, etc. The challenges of unifying ecology and integrating it with the main theoretical frameworks (in particular Darwinian evolution) are nonetheless very real and perfectly echo the book's theses (Delord, 2008).

The fact remains that *Le Nouvel esprit biologique* is a very useful guide to the conceptual labyrinth of biological theories and the philosophical problems they pose. It manages to present them in a sober and clear manner, avoiding sensationalism while also raising many stimulating questions. Hoquet rightly invites all citizens to take an interest in these theories that implicitly inform our representations of the world (often in simplistic versions) and whose ethical and political stakes are absolutely "fundamental."

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First published in laviedesidees.fr, 9 March 2023. Translated by Arianne Dorval, with the support of Cairn.info. Published in booksandideas.net, 19 September 2024.