



Jacques Monod – A theorist in the era of molecular biology / Un théoricien à l'ère de la biologie moléculaire

Monod's conception of chance: Its diversity and relevance today



La conception du hasard selon Monod : sa diversité et sa pertinence aujourd'hui

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ABSTRACT

In his famous book *Le hasard et la nécessité* (1970), Monod claims that natural evolution is based on the interplay between chance and necessity bringing about adaptive evolutionary change. This article addresses a set of related questions about Monod's conception of chance: what does he mean when he uses the term "chance"? Does he invoke one or many different concepts of chance? What are the implications of his conception about the issue of the deterministic or indeterministic nature of the biological world? Is Monod's view of what chance is relevant in contemporary biology? This paper, structured by these four questions, aims at providing a synthetic study of the way Monod conceptualizes chance, particularly highlighting the metaphysical and epistemological implications of his conception and its value in biology today.

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RÉSUMÉ

Dans son fameux livre *Le hasard et la nécessité* (1970), Monod soutient que l'évolution naturelle est basée sur l'interaction du hasard et de la nécessité produisant du changement évolutif adaptatif. Cet article soulève un ensemble relié de questions au sujet de la conception du hasard chez Monod : qu'est-ce qu'il entend par le terme « hasard » ? Invoque-t-il un ou plusieurs concepts différents de hasard ? Quelles sont les implications de sa conception quant à la question de la nature déterministe ou indéterministe du monde biologique ? Sa vision de ce qu'est le hasard est-elle pertinente en biologie contemporaine ? Cet article, structuré par ces quatre questions, vise à fournir une étude synthétique de la manière dont Monod conceptualise le hasard, en soulignant tout particulièrement les implications métaphysiques et épistémologiques de sa conception ainsi que sa valeur en biologie aujourd'hui.

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1. Introduction

In his famous book *Le hasard et la nécessité. Essai sur la philosophie naturelle de la biologie moderne* (1970),¹ Jacques Monod claims that the evolution of living systems is based on chance and necessity, which are both required for the interplay of perturbations and invariance to result in evolutionary adaptive change. More precisely, on the one hand, if there was no chance, there would be no new variation because of the intrinsic rigorous invariance of living beings, and so no evolution. On the other hand, with no necessity (i.e., the intrinsic conservative character of living beings), life on Earth would die out driven by the negative effects of chance; anyway, the novelty produced by chance could not be integrated into living systems (the reign of necessity) and would fail to be conserved over evolutionary time.

What does precisely Monod mean when he talks about chance and necessity in the natural world? His conception of chance is the focus of the present article. Before starting to deal with it, and in order to fully understand the origin and role of chance in Monod's view of evolution, three main points about what he means by the term "necessity" should be recalled.

First, according to Monod, the macroscopic level of the organism, where natural selection works, is the reign of necessity, of coherence and rigorous requirements [1]: chance is excluded at this level. In particular, necessity is the characteristic of what he calls the "teleonomic system" or "teleonomic apparatus" (i.e., the organism), whose structures, performances and activities (in particular, the conservative perfection of the DNA replicative apparatus) all contribute to the success of the same essential project: the transmission of the species-specific content of invariance from one generation to the next (i.e., the "teleonomic project" – *ibid.* [1], p. 27).

Second, Monod identifies three main general properties of living systems that, together, allow one to distinguish them from every other kind of objects, especially from artifacts (*ibid.* [1], pp. 22–25):

- *teleonomy*: living systems are objects endowed with a project, which is the transmission of the content of invariance specific to the species. All activities linked to reproduction, as well as to survival and multiplication, can participate in the transfer of the quantity of information that ensures the realization of such teleonomic project;
- *autonomy*: living systems are machines able to perform autonomous morphogenesis, i.e., they can build themselves autonomously via deterministic, internal, morphogenetic interactions and nearly no input from the outside;
- *invariance (or invariant reproduction)*: living systems are able to reproduce and transmit without variation the

information for their complex macroscopic structure, conserving it from one generation to the next.

Third, as said above, Monod claims that the macroscopic structure of living systems is the result of complex processes that have nearly nothing to do with the action of external forces. The entire structure, from its general form to the details, is rather the result of internal morphogenetic interactions. He qualifies them as "autonomous, precise, rigorous determinism implying a nearly total freedom with respect to external agents or external conditions" (*ibid.* [1], pp. 23–24). Thus, according to him, the structure of living systems attests to their internal determinism, which turns out to be a defining property of their own organization. Monod also implicitly seems to conceive forces external to organisms as indeterministic, or chancy, which sends me back to the main question of this article about his conception of chance.²

The analysis I provide here is mainly based on Monod's book *Le hasard et la nécessité* (1970). Similar analyses can be developed with reference to the paper he wrote in 1973 in order to react to the criticisms provoked by the publication of his book, as well as to the conference he gave at the Rockefeller Foundation, in Italy, in 1972 (then published in 1974). I like to point out that I do not intend to deal with Monod's view about the role of chance in the origin of human species and, more generally, in the origin of life. So, for instance, I will not discuss Monod's claim that life and the evolution of human species are very improbable and even unique events.

The present study is driven by the following interconnected questions: what does Monod mean when he uses the term "chance"? Does he invoke one or many different concepts of chance? Then, if he mobilizes several concepts, what are the similarities and differences among them, in particular as concepts of subjective or objective chance and on their implications about the issue of the deterministic or indeterministic nature of the biological world? Finally, is Monod's view of what chance is still relevant today in biology, in particular with respect to the research advances of the last 20 years?

The article is structured in four sections. The first introduces the usual answer to the question of what chance is according to Monod. In the second section, I identify three concepts of chance in his writings (mainly, in *Le hasard et la nécessité*) and analyze their main features, their differences and analogies, as well as the connections among them. The third section is focused on some specific features of Monod's concepts of chance that are particularly controversial or puzzling, and so could be put into question. Finally, in the fourth section, I evaluate the current empirical relevance of Monod's concepts of chance in the light of the research advances, in biology, of the last 20 years. My objective is to provide a synthetic study of the way Monod conceptualizes chance, which highlights its metaphysical and epistemological implications and helps to perceive its actual value in contemporary biology.

¹ All the passages quoted in this article come from the original edition of Monod's book, published in French in 1970. Unless otherwise indicated, translations are mine.

² I will come back later on to the question of whether Monod actually attributes indeterminism to forces external to living systems.

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