THE LOGIC OF LIFE, THE CREATION OF THE EUROPEAN MOLECULAR BIOLOGY LABORATORY, AND THE RELATION BETWEEN MOLECULAR BIOLOGY AND PHYSICS

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In *The Logic of Life*, François Jacob reconstructed the history of heredity from the seventeenth century to the present, emphasizing the role of physics in the development of biology. Quantum mechanics provided questions, methods, and techniques to molecular biologists. In the 1960s, physics also provided the organizational model. Jacob worked on the creation of the European Molecular Biology Laboratory, on the model of CERN (European Organization for Nuclear Research). I argue that reflection on the relation between molecular biology and physics played a part in the making of *The Logic of Life*. Between the mid-1960s and the early 1970s, Jacob focused on relations between the "genealogy" of his molecular biology work and the development of physics at scientific, institutional, and historical levels. He thus brought molecular biology to the attention of a larger public, following the history of the Institut Pasteur, whose public mission had to be reaffirmed to grant its survival. With *The Logic of Life*, Jacob became an influential intellectual who engaged with scholars in human sciences. He promoted his view of the development of molecular biology as a model for a possible new discipline: bioanthropology.

1. *The Logic of Life* in Context

In 1970, the molecular biologist and cowinner of the 1965 Nobel Prize for physiology or medicine, François Jacob, published *La logique du vivant*. The book

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soon became a bestseller and was translated into several languages. The English translation appeared in 1973 under the title *The Logic of Life* (Jacob 1970/1973).[1] There were a number of reasons why the book enjoyed this enormous success. The fluidity of Jacob's prose caught the attention of the reader. Even if Jacob's narrative relied only on primary sources and not also on secondary sources, the book was widely read and appreciated by professional historians of science and philosophers.[2] In France, the book was well received by Althusser, Canguilhem, Foucault, and Lévy-Strauss, among others (Méthot 2020). Jacob's narrative turned out to be familiar to students of the history and philosophy of science, who were used to the conceptual history of science of the time. Some could see Gaston Bachelard's historical epistemology in Jacob's way of doing history of science; others could find an approach closer to that of Michel Foucault (Méthot 2020). *La logique du vivant* was often considered and reviewed together with Jacques Monod's (1965) *Le hazard et la nécessité*, but the former was much more appreciated than the latter. Jacob's ideas were not as controversial as Monod's. This article proposes a reading of *The Logic of Life* within the context of the goal of French molecular biologists, to create a space for their discipline in dialogue with physics at both the national and inter-European levels. Molecular biology has emerged in a complex dialogue with physics. Molecular biologists found in the organizational model of high-energy physics a source of inspiration for the institutional organization of their discipline. At the same time, they tended to stress the autonomy of their discipline from physics.

In this article, I argue that Jacob's search for the historical understanding of concepts and methods of molecular biology in *The Logic of Life* was not only rooted in his scientific experience but also a product of this cultural, scientific, and political environment that led Jacob to focus on the relations between the

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1. As stressed by Pierre-Olivier Méthot, the English translation slightly changed the meaning of the title, shifting from an object (*le vivant*, or "the living") to a more abstract concept, "life." As Jacob wrote to Ernst Mayr, he aimed to write a history of the objects that biologists talk about (Méthot 2020). The English title also, in a way, assimilated Jacob's approach to the debate on the origin of life that had been the focus of a debate between physicists since the 1930s.

2. The absence of secondary sources was remarked by professional historians who reviewed *La logique du vivant* (see Olby 1972; Holmes 1977; see also Méthot 2020).

"genealogy" of his work in molecular biology and the development of physics at different levels: scientific, institutional, and historical. With this focus, Jacob also brought molecular biology to the attention of a larger public, following a trend that was rooted in the history of the Institut Pasteur, whose public mission had to be reaffirmed to grant its survival. The years in which Jacob composed *The Logic of Life* were also a period of deep crisis for the Institut Pasteur, which, in the early 1970s, was on the verge of bankruptcy.

This article is structured with seven sections. The next section focuses on the complex relations between quantum mechanics and the origin of molecular biology. Section 3 analyzes how, in *The Logic of Life*, Jacob explained the history of biology in connection with that of modern physics. Section 4 deals with the development of molecular biology in France in connection with the project of creating an inter-European laboratory like that for high-energy physics, CERN (European Organization for Nuclear Research). The reconstruction refines that provided by Jean-Paul Gaudillière and John Krige and focuses on the role that Jacob played roughly in the years between the winning of the Nobel Prize and the publication of *The Logic of Life*. Section 5 places Jacob's *Logic of Life* in the context of the history of the relation of the Institut Pasteur with the public sphere. Section 6 focuses on the difficult situation of the Institut Pasteur in the late 1960s and early 1970s. The concluding remarks highlight the fact that Jacob's historical reconstruction in *The Logic of Life* led him to propose molecular biology as a model for the creation of a possible new research center and a new discipline, bioanthropology, which aimed to overcome the separation of "two cultures" and establish a dialogue between natural and human sciences.

2. Quantum Mechanics and the Origin of Molecular Biology

Many historians have focused on the cross-disciplinary circulation of concepts and methods. Marco Tamborini (2022a, 2022b) recently stressed that architects, morphologists, and philosophers coproduced a central issue of architecture: the possibility of transferring biological forms into architectural ones.

The relations between molecular biology and quantum mechanics date back to reflections from Niels Bohr and Erwin Schrödinger. In 1932, Bohr delivered a famous conference on "Light and Life," in which he established a parallelism between biology and physics. Bohr claimed that just as classic mechanics cannot explain atoms' stability, so current chemistry and physics cannot explain life. Thus, life should be taken as an elementary fact, like a quantum of action in physics. In biology, Bohr (1933) argued, one should look for an equivalent to the principle of complementarity (see Kay 1992, 1993 [133]; Joaquim, Freire, and El-Han 2015; Morange 2020, 72; on quantum mechanics and the question of the origin of life,

see also Delbrück 1986; Fox Keller 1990; McKaughan 2005; Domondon 2006; Sloan and Fogel 2011). A number of researchers were intrigued by Bohr's ideas, but it was hard to imagine how they could be translated into a research program. Among the attendees of Bohr's conference was a young physicist, Max Delbrück, who had previously worked in Bohr's laboratory. Several years later, Delbrück recalled that Bohr's conference played a decisive role in his decision to turn to biology (Delbrück 1976). In the 1930s, Delbrück, in collaboration with Nikolaï Timoffeev-Ressovsky and Karl G. Zimmer, irradiated *drosophilae* with X-rays to study the genetic mutations that were induced. Their approach recalled what nuclear physicists did in the 1930s when they bombed the nuclei of certain elements (Peyrieras and Morange 2002; Morange 2020). Delbrück, Timoffeev-Ressovsky, and Zimmer formulated a quantum model for the gene, which was intended as the transition from one stable state to another stable state (Morange 2020, 42; see Sloan and Fogel 2011). Delbrück, however, felt dissatisfied with his research, as he had not found a way of transforming Bohr's view into an experimental program. Thus, he focused on a different model, *phycomices* (Kay 1992, 12–13).

A different approach from that of Bohr to the relation between quantum mechanics and the phenomenon of life was advanced by Erwin Schrödinger. In 1944, Schrödinger published a short popular book, *What Is Life?*, in which he compared the discrete units of evolution, genes, with discrete quantum leaps (Schrödinger 1944). A quantum leap, he claimed, can explain the presence of an allele in a gene locus. Schrödinger remarked that Delbrück's model of the gene was compatible with quantum mechanics, but it required new physical principles.[3] Thus, there were two different views. The first one was proposed by Bohr—the search for some principle that could function in biology as complementarity in physics does. The second one was Schrödinger's idea of finding entirely new physical principles to explain life. The two perspectives mirrored Bohr's and Schrödinger's different views on quantum mechanics. But the whole matter was more complicated because researchers in the nascent field of molecular biology often tended to mix up the two approaches. Gunther Stent remembered that he found it difficult to understand Delbrück's view on the complementarity principle. Stent, James Watson, and other pioneers of molecular biology tended to interpret Bohr's "Light and Life" and Delbrück's insistence on the principle of complementary as the expectation of finding new physical principles (Kay 1993; McKaughan 2005). Most molecular biologists found it difficult to understand Bohr's and Schrödinger's approaches and to translate them into an experimental research program (Fox Keller 1990, 403; Morange 2020). Biologists took methods and techniques from quantum mechanics but tended to leave the

3. Delbrück's model had been discredited by H. J. Muller (Fox Keller 1990, 402).

whole debate on quantum mechanics and the origin of life to physicists (Morange 2020).

In the 1960s, molecular biologists were struggling to institutionalize their discipline. As stressed by Bruno Strasser, it was at the beginning of the decade in which researchers who had hitherto defined themselves as biophysicists, geneticists, microbiologists, or biochemists began talking of a new discipline that encompassed these different perspectives (Strasser 2002). Strasser has stated that the documents prepared by British, French, German, and Swiss researchers for their national funding agencies present a historical reconstruction of the origins of molecular biology. Such a reconstruction was instrumental in legitimizing the new discipline. One reason for researchers' success in creating an institutional space for molecular biology was that they persuaded national policymakers that the new discipline required large resources, equipment, and personnel, like certain sectors of contemporary physics (Strasser 2002).

It is worth noting that although molecular biologists in the 1960s often compared the situation of their discipline with that of physics after World War II, they were inclined to stress the theoretical autonomy of molecular biology from physics. The struggle for autonomy was part of the project of founding a new discipline. In a way, Jacob's *Logic of Life* was a systematic attempt to reconstruct the genealogy of the new discipline in connection with physics, without establishing a hierarchy between disciplines.

3. Pourquoi nous en étions arrivés là: Jacob's History of Biology and Its Relations with Physics

In *La Logique du vivant*, Jacob explained how he saw the complex relations between physics and biology in history. He stressed that both preformists and Buffon and Maupertuis were inspired by Newtonianism, but they did not directly apply Newton's mechanics to biology. Jacob distinguished between two different approaches to the history of science. The first aimed at reconstructing the history of how ideas came out and became, in a way, autonomous from the context in which they were born. The second approach focused on how objects became accessible to scientific analysis, allowing the constitution of new scientific disciplines. Jacob privileged the second approach. Jacob's own scientific work followed this path when his research on bacteriophages and that of Monod on enzymes converged (Peyrieras and Morange 2002; de Chadarevian 2002, 256; Morange 2020). Jacob's (1970, 1970/1973, 1970/1993) historical approach in *The Logic of Life* mirrored the above-mentioned desire of molecular biologists to explain where their discipline came from, and it was also likely more helpful to shed light

on the relations between physics and biology (see Méthot 2020, which connects this approach to Foucault's philosophical perspective).

Even if Jacob did not rely on the work of professional historians and philosophers of science, his work turned out to be familiar to them. He placed the history of biology within the broader context of the history of science and, above all, the history of physics and astronomy, which were the primary focus at that time of the most influential historians of science. Jacob's historical reconstruction of heredity from the seventeenth century to the present emphasized the role of Newtonianism in the development of the study on living beings and heredity in the eighteenth century. It also emphasized the role of Boltzmann's statistical mechanics. Jacob argued that the study of life had evolved throughout the seventeenth and eighteenth centuries in dialectical dialogue with Newtonianism. He stressed that "with Newton and the abandonment of a geometric universe, calculation lost its purely mathematical sense, but enabled the results of observation and measurement to serve for the derivation of the laws of nature. It was algebraic analysis of physical phenomena which provided the universe with its law of integration. Only the mathematical formulation of physical measurements could make respect able the intervention of another mysterious force—gravitation, whose origin was unknown, but which calculation required to link together the mechanics of heaven and of earth" (Jacob 1970/1993, 31).

According to Jacob, in the eighteenth century, natural scientists relegated the question of the origin of life to one of the metaphysical causes about which Newtonian experimental sciences cannot provide answers. Preformism was a first answer to the Newtonian requirement that all visible characters have to be visible. Maupertuis and Buffon thought that there was some secret structure beyond the visible forms. In the eighteenth century, the focus was on the internal relations connecting the elements of a living being rather than on the elements themselves. In the analysis of the living world, organization played the same role as Newton attractive force. In the following century, the emergence of the cellular theory opened a space for Darwin's evolutionary theory. Jacob argued that both Boltzmann's statistical mechanics and Darwin's and Alfred Russel Wallace's evolutionism stressed that the least frequent events are the most important ones. Darwin and Boltzmann introduced the notion of contingency in the explanation of nature. Darwin's theory also implicitly introduced time irreversibility, changing Newtonian mechanics before the first formulations of the second principle of thermodynamics. In the nineteenth century, thermodynamics allowed connecting biology with physics. It was, however, in the twentieth century that biology and physics became closer and molecular biology was born: "To become a science, biology had had to cut itself off radically from physics and chemistry. To continue investigation of the structure and functioning of living beings in the

middle of the twentieth century, biology had to cooperate closely with them. From this union, molecular biology was to be born" (Jacob 1970/1993, 245–46).

Some years after the publication of *The Logic of Life*, Jacob returned to the matter to address the specific issue of the relations between biology and physics and the problem of reductionism from the perspective he elaborated in *The Logic of Life*. He recalled that "scientific advances often come from uncovering a hitherto unseen aspect of things as a result, not so much of using some new instrument, but rather of looking at objects from different angle (Jacob 1977, 1161). Needless to say, Jacob's perspective sounded familiar to contemporary historians and philosophers. It echoed Thomas Kuhn's ideas, without the extremely controversial issue of incommensurability. Jacob accepted reductionism among disciplines but stressed that it does not require that the same concepts and methods be used by all disciplines. Every proposition that is valid in physics is also valid in biology, argued Jacob (1977, 1162), but it turns out that what is most important for one discipline is usually of no interest for another discipline. In this way, Jacob overcame (or avoided engaging with) the challenge posed by Bohr and Schrödinger. No equivalent to the principle of complementarity was required, nor were new physical principles to be formulated.

4. Jacob, History, and Historians

At the time of the publication of *The Logic of Life*, historians and philosophers of science were mostly focusing on the scientific revolution of the sixteenth and seventeenth centuries as the crucial event for the birth of modern science. Several years later, Jacob remembered that it was the historian Pierre Nora who asked him to write the book for a new collection (Méthot 2020). Besides Nora, Jacob was well acquainted with the historians George Duby, François Furet, and Emmanuel Le Roy Ladurie (Erdur 2018). Nonetheless, it is hard to find a direct influence of the work of such historians on *La logique du vivant*. This fact is not surprising, as it was (and still is) quite difficult even for professional historians of science to engage with the work and methods of social and political history. At that time, political historians were working on a spatial and temporal scale that could hardly fit those on which historians of science were working. Emmanuel Le Roy Ladurie's social history of the Languedoc peasants could hardly be a model for Jacob. Neither could the work of the other members of the École des Annales have inspired Jacob. Fernand Braudel's focus on the economic dimension and his reduction of science to technology was clearly in contrast with Jacob's conceptual history. The notion of *longue durée* could have inspired Jacob, as it was not intrinsically related to an economic history approach. Jacques Le Goff (1981) wrote a cultural history of the making of purgatory, in which he explained how in the

longue durée, between late antiquity and the twelfth century, purgatory was transformed from an ideal space into a spatialized notion.

After the publication of *The Logic of Life*, Jacob participated in the project of creating a new research institution for bioanthropology with several scholars, including Braudel, Furet, Le Goff, and Le Roy Ladurie. Nonetheless, a dialogue between the Annales historians and historians of science turned out to be complicated. In the 1970s, the Annales school tried to engage with the work of contemporary historians of science. In 1975, the Annales devoted a special issue to the history of science, inviting renamed historians of science to contribute. However, their articles did not really engage with the Annales methods, aims, and objects. In the introductory article, Jacques Revel showed goodwill but lack of acquaintance with the discipline of the history of science. He claimed that historians had hitherto been poorly interested in the work of historians of science because it has been primarily the work of scientists. But the methodological questions posed by Thomas Kuhn and Michel Foucault allow political, economic, and social historians to understand the centrality of science (Revel 1975).

5. Inter-European Collaboration in Molecular Biology and the Creation of the European Molecular Biology Organization

Pierre-Olivier Méthot has stressed that the years between 1963 and 1975 were a difficult period for molecular biologists because they did not find a way of extending their analyses from the micro level of bacteria, viruses, and other simple models to more complex organisms (Méthot 2020). To overcome this stalemate, a number of European molecular biologists decided in 1964 to create an inter-European structure, the European Molecular Biology Organization (EMBO). In 1967, European molecular biologists met in Geneva to discuss the possibility of creating an inter-European laboratory. In the proposal for the new European laboratory, they claimed that "the task of molecular biology is to explain living processes in detailed molecular terms. It is one of the greatest intellectual adventures of the twentieth century."[4] Molecular biology had discovered the general mechanisms and the control of living processes in bacteria. There were, however, new challenges:

> Even more important to man than the bacteria are the higher cells of plants and animals, their specialisations and their interactions. Our understanding of these is much more limited, but we already know that they

4. Proposal for a European Laboratory of Molecular Biology (ELMB), archives of the Institut Pasteur (Paris), Jacob's papers (henceforth AIP/ JAC), F5/07.

> are different in important ways from the more easily examined microbes upon which attention has so fare [*sic*] been concentrated. We must equally seek to understand these and their correlates such as the pathogenic viruses. These twin tasks—to achieve complete detailed understanding of a single bacterium—and general molecular comprehension of the special life processes of higher cells form two complementary facets of the next stage of advance of molecular biology.[5]

The achievement of these tasks required resources that no single European country could afford: "Response to the need therefore requires Governments collectively to install what is beyond the reach of any of them: a laboratory which is devoted jointly to the twin aims suggested."[6]

Jacob was one of the main promoters of a European molecular biology laboratory. As noted earlier, this was the period in which molecular biologists were working on the institutionalization of their discipline both at national and inter-European levels (see the special issue of *Studies in History and Philosophy of Science* on "Molecular Biology in Post-war Europe," above all Krige [2002] and Strasser [2002]; see also Kay 1993; Morange 2020). As Soraya de Chadarevian (2002, 247) convincingly argued, the national and international levels were intertwined. As stated, molecular biology was born in close connection with physics. Some physicists, like Leo Szilard, decided to give up physics to avoid being involved in research related to atomic bombs and began working on what would become later molecular biology. Methods and techniques of quantum mechanics had become essential for molecular biology (Morange 2020). In Britain, the two disciplines were closer at institutional levels too. As shown by de Chadarevian (2002, 248–49), the crystallography unit at Cambridge University and the biophysics research unit at King's College London were created in departments of physics. In the second half of the 1960s, it was the organization of research that physicists had created in the previous decade that served as a model for molecular biologists. In contrast, atomic physicists tended to integrate biologists in their venture. Bruno Strasser (2002, 531) stressed that research in biophysics was desirable to transform the bad image of physics after Hiroshima and Nagasaki. It is also worth noting that biology was considered to pose questions of broader interest. In 1971, Jeremy J. Stone asked Salvador E. Luria to become vice president of the Federation of American Scientists. Stone wrote Luria that they wanted to correct the image of the federation as a group of "arms race technocrats."[7] Stone explained

5. Proposal for an ELMB, AIP/JAC F5/07.

6. Proposal, AIP/JAC F5/07.

7. Letter from Jeremy J. Stone to Salvador E. Luria of March 3, 1971, Luria papers, box 39, Federation of American Scientists no. 2, American Philosophical Society, Phildelphia (henceforth APS).

his proposal with the following words: "I want you to help our philosophical and scholarly base into new 'science and society' problems and a new emphasis on other disciplines besides physics."[8]

At the beginning of the 1960s, molecular biology in Europe was growing up around some major centers and personalities. In 1961, Max Perutz created a new institute in Cologne. The LIGB (Laboratorio Internazionale di Genetica e Biofisica [International Laboratory of Genetics and Biophysics]) in Naples, directed by Adriano Buzzati-Traverso, was inaugurated in 1962. In Cambridge, the Medical Research Council Laboratory for Molecular Biology acquired new spaces (Capocci and Corbellini 2002; de Chadarevian 2002; Krige 2002; Morange 2020). In France, after Charles de Gaulle returned to power in 1958, the French government decided to heavily invest resources in science and technology. As stressed by Gaudillière (2002), France was experiencing a period of sustained economic growth, and investing in science and technology appeared to be a natural choice. De Gaulle's decision should also be understood in light of the evolution of the international picture. Two intertwined processes should be considered. One is "Sputnik shock," the perspective that the Soviet Union was gaining an advantage in certain scientific and technological sectors thanks to its better integration of science, industry, and the state (McDougall 1985; Leslie 1994; Wang 1999; Wolfe 2013). The other is the tormented decolonization process and the difficulty that France and Britain faced in transforming their colonial empires of rule into empires of influence, thus de Gaulle's determination to maintain consistent military power. The Suez Crisis of 1956 showed British and French weakness before the pressure of the United States (Darwin 2009). Both the Labour Party in Britain and the Gaullistes in France emphasized scientific and technological research when they returned to power. In France, de Gaulle's government established a new fund, the Fonds de Développement de la Délégation générale à la Recherche Scientifique et Technique, that was to carry out *actions concertées* (concerted actions) consisting of funding research and coordinating the activity of preexisting laboratories and institutions (Gaudillière 2002; de Chadarevian 2002, 254–59). In 1960, a Comité d'Études "Biologie Moléculaire" was established in which representatives of the government and scientists participated together. Researchers were warned that they were chosen for their expertise and advised that they did not represent their institutions. The minutes of the meetings of the committee were classified as "confidential."[9] Jacob joined the committee some years later. The goal of the committee was to write a report on the development of molecular

8. Letter from Stone to Luria of March 3, 1971, APS.
9. Minutes can be consulted in AIP/JAC F1.1.

biology that the government would use to include molecular biology in a law it was preparing on scientific research. In the first meeting, some researchers observed that molecular biology, as a fundamental discipline, seemed not to have practical applications at the time, but they advised that it would be a mistake to overlook it. Pierre Piganiol, the Délégué général à la recherche scientifique et technique, reassured the scientists, saying, on the contrary, the government was well aware of the importance of molecular biology. Scientists agreed on the importance of coordinating the different groups.[10] The committee was asked to coordinate the work of existing groups. It proposed a 5-year plan and a long-term plan. For the 5-year plan, the committee suggested concentrating resources on three major institutions: the Institut de Macromolecules in Strasbourg, the Institut de Génétique du CNRS in Gif, and the Institut Pasteur. In the long term, the committee proposed the creation of new research groups and institutions and a permanent committee. The three centers mentioned were to function as attraction poles, not as exclusive centers. As for the CNRS and the Institut Pasteur, researchers based in other laboratories would spend some time working there. The committee asked for the construction of new laboratories in an entirely new building at the Institut Pasteur. The government, however, did not follow the committee's suggestion. In 1965, when the committee was asked to prepare a new 5-year plan, it asked again for the construction of new laboratories at the Institut Pasteur.[11] The committee remembered that the lack of space did not allow for the hiring of more researchers to work at the Institute Pasteur. It was thought that the CNRS, along with American public and private institutions, could finance the venture.[12] After World War II, the Pasteur Institute, like many other European laboratories in biological and natural sciences, was funded by American public entities and private institutions.[13] Some years later, in 1965, Lyndon Johnson decided to cut off the funding of foreign laboratories.[14] In

10. Comité d'Études, "Biologie Moléculaire," meeting of January 14, 1960, AIP/ JAC F1.1.

11. Rapport du Comité d'Études préliminaire à l'action concertée Biologie Moléculaire, September 2, 1965, AIP/ JAC F1.1.

12. Rapport préliminaire de la situation présente et les actions concertées à envisager dans le domaine de la biologie moléculaire, AIP/ JAC F1.1; Projet de développement de la biologie moléculaire à l'Institut Pasteur, AIP/ JAC F1.1; Rapport Général sur la situation présente et l'action à envisager dans le domaine de la biologie moléculaire, AIP/ JAC F1.1.

13. André Lwoff's laboratory at the Institut Pasteur had been funded by the Rockefeller Foundation and the National Cancer Institute of the US National Institutes of Health (Peyrieras and Morange 2002, 422). In 1958, the US Senate envisioned the creation of a European Institute of Molecular Biology. A Senate subcommittee visited Paris and discussed the matter with Lwoff, but the project did not materialize (de Chadarevian 2002, 254–57).

14. In 1965, biology researchers in Italy decided to send a letter to US President Lyndon Johnson. "Ricercatori italiani in campi biologici e medici finanziati da enti internazionali e stranieri aderenti all'iniziativa," Milan, February 15, 1965, Buzzati-Traverso Papers, box 22, folder 88, archives of the Museum and History of Medicine, Section of Sapienza University of Rome.

1965, an Institute of Molecular Biology was finally created at the Institute Pasteur (Gaudillière 1991; de Chadarevian 2002, 258–59). In the same year, the Comité d'Études "Biologie Moléculaire" suggested supporting the proposal of creating an inter-European laboratory along the lines of CERN. Jacob was the author of the annex of the report on EMBO, and he became one of the major supporters of the European laboratory.[15]

CERN was created in 1954. Three years later, two treatises were signed in Rome. The first established the European Economic Community (EEC), and the second created Euratom (European Atomic Energy Community; Krige 2006; Lekarenko 2018). Biologists were later than physicists in creating an inter-European space. In 1964, EMBO was inaugurated. Jacob (1995) attributed the delay to the fact that molecular biologists did not need the huge resources and large accelerators of physicists. John Krige (2002) argued that most European biologists first wanted to boost research at home (see de Chadarevian 2002). In the 1965 report, Jacob suggested participating in the European laboratory but also warned officials not to reduce resources in national ventures. The report reminded its readers that the small staff of the European laboratory would protect against "brain draining." Jacob claimed that the two ventures were complementary, but he did not explain how.[16] When the Italian physicist Edoardo Amaldi, one of the "founding fathers" of CERN, promoted the creation of both a national institute of nuclear physics and the participation of Italy in CERN, he had a clear-cut vision of the relations between the two ventures. He thought of two different but complementary machines. At CERN, a proton accelerator was to be built, whereas in the National Laboratory (in Frascati) of the National Committee for Nuclear Energy, a neutron accelerator would be constructed. Amaldi envisioned Italian physicists carrying out research on electron and photon physics in Frascati and collaborating on international research on leptons and hadrons in Geneva. Furthermore, the Frascati particle accelerator could provide scientists and technicians with the technical and scientific expertise to collaborate with their European colleagues in Geneva.[17]

On April 4–6, 1967, the first European Conference on Molecular Biology (EMBC) was organized at CERN in Geneva to boost the creation of a European laboratory following the CERN model (on CERN and the CERN model, see Armin, Krige and Pestre [1987–96]; Kohlrausch and Trischler 2014; see also

15. Letter from Jacques Monod to the members of the Comité d'Études préliminaire "Biologie Moléculaire," AIP/ JAC F1.1.

16. Rapport du Comité d'Études, September 2, 1965, AIP/ JAC F1.1.

17. Edoardo Amaldi, "Gli Anni della Ricostruzione," Amaldi archives, box 89 folder 3, Department of Physics, Sapienza University of Rome.

Lalli 2020). The conference was called by the Swiss government.[18] The director-general of CERN, Bernard Gregory, reminded attendees that some 800 researchers worked at CERN but only 15% of them were permanent; the rest were based in European and university laboratories. Gregory stressed that researchers working at CERN were moved by a nationalist sentiment. They conceived of their stay at CERN as a way to foster research in their own countries.[19] Jacob participated in the EMBC. A few days after the first conference, he wrote to John Kendrew, one of the main promoters of the European laboratory, summarizing the discussion among researchers of the Institut Pasteur on the future European laboratory. All researchers of the institute deemed that a European laboratory was important to act as a formation center and thus could stop the brain drain to the United States. Jacob thought that if key figures of European origin in molecular biology who worked in the United States, such as Renato Dulbecco, Salvador Luria, and Max Delbrück, could state that they would spend some time in the new European laboratory, this could even produce a sort of "reverse" brain drain. Jacob proposed copying CERN's allocation of equipment use in the new laboratory to different research groups. According to Jacob, another advantage of the European laboratory was having an expensive apparatus to be used by many European research groups and having computers and biological software development concentrated there, thus avoiding the waste of time and resources of having many laboratories writing small software programs.[20] Nevertheless, there were "serious divergences" regarding the European laboratory. The French, the Germans and the Italians pushed for its creation, whereas the British did not want to be involved in long-term plans. They claimed that after 1968, private funds had to be relieved by public money.[21] As argued by Krige, in the 1960s, de Gaulle's opposition to the entrance of Britain into the EEC had complicated inter-European collaborative projects, as the British were opposing most such projects as a form of retaliation. It was only when the United Kingdom finally entered the EEC in 1973 that the European Molecular Biology Laboratory was established (Krige 2002). q11

When Jacob was writing *The Logic of Life*, he was also actively working on the creation of an inter-European laboratory for molecular biology, which entailed thinking about the organization of scientific research in physics and, above all,

18. Conférence Européenne de biologie moléculaire 1967, EMBO, Compte rendu Conférence Embo Genève, AIP/ JAC F5/07.

19. Conférence Européenne de biologie moléculaire, Comptes rendus analytiques provisoires des cinq séances tenues au CERN à Meyrin Genève, April 4–6, 1967, AIP/ JAC F5/07.

20. Letter from François Jacob to John Kendrew, April 17, 1967, AIP/ JAC F5/07.

21. Note from J. L. Dewost to Monsieur de délégué générale, June 9, 1967, in AIP/ JAC F5/07.

the CERN model. The creation of an inter-European laboratory along the lines of CERN was connected to a national necessity and to the needs of the Institut Pasteur.

6. The Institut Pasteur and the Public Sphere

Jacob's intervention in the public sphere with the publication of *The Logic of Life* was also deeply rooted in the history of the Institut Pasteur. From its inception, the Institut Pasteur (2021) had a special relationship with public opinion as a "fondation d'utilité publique." It was created by a public subscription that Pasteur launched in 1886 on the wave of public success after he healed a case of rabies for the first time. In 1885, an Alsatian woman brought her son, Joseph Meister, to Pasteur's laboratory at the École Normale Supérieure in rue d'Ulm. The child had been bitten by a supposedly rabid dog and his mother asked Pasteur to try the experimental vaccine on him that Pasteur and his coworkers had been working on for 5 years. The vaccine had not been tested in humans. After the treatment, the child recovered. The vaccine was tested in more patients, and some time later, Pasteur appeared before the Académie de Médicine and proposed the creation of a new institute devoted to research and production of vaccines. An international subscription was issued to raise funds for the new institute. The Council of Paris donated the land on which the institute would be built (on the history of the Institute Pasteur, see Delaunay [1962]; Salomon and Bayet 1986; Morange 1991; Löwy 1994; Moulin 2004; Velmet 2022). Soon the institute established affiliated institutes in the French colonies and areas of the world in which France had a strategic interest. Pasteur Institutes in the colonies were created upon request of the colonial administration to produce sera and vaccines against diseases affecting the colonies, but they often did original research. Consequently, the Pasteur Institute became a network of institutes (Moulin 1991, 1992, 2004; Dedet 2000; Velmet 2022).

The institute received financial aid from the state on single projects. In turn, it freely provided vaccines and sanitary control (Löwy 1994). Significant parts of its revenue came from the selling of vaccines and from private donations. The institute's public image was important for its survival, as it needed public funding and private donations. The "Pasteuriens" created a myth of Louis Pasteur and the institute itself by means of a number of publications. *The Life of Pasteur* by René Vallery-Radot (1900) and a selection of Pasteur's letters published by Vallery-Radot himself burnished Pasteur's image as both a universal hero of mankind and a national symbol of French science and medicine. Other books spread a positive image of the institute. The journalist M. de Fleury described the Institut Pasteur as a sort of secular convent. Émile Ducleaux wrote a biography of the master

and E. Lagrange one of Émile Roux, who directed the institute till 1922. In *Le Docteur Roux Mon oncle*, Mary Cressac portrayed her uncle as the character of a Tolstoy's novel: Roux injected himself with a culture of tuberculosis to test a vaccine and possibly infected his fiancée, who died. Feeling guilty, he never married and devoted himself to science and the direction of the institute (de Fleury 1895; Ducleaux 1896; Vallery-Radot 1941; Cressac 1951; Lagrange 1955; Delaunay 1962).

The Logic of Life brought to the attention of the public the subject of molecular biology, the importance of which was difficult to understand. As we have seen, French molecular biologists were concerned because their discipline was a fundamental one, with no linear visible connection with medical application. When Jacob published *The Logic of Life*, the institute was facing the worst period of its history. The current model was not sustainable any longer. As noted, in 1965, Lyndon Johnson cut off funding to foreign laboratories. Jacob and Monod had tried, unsuccessfully, to persuade the government to finance new laboratories on molecular biology at the institute. At the same time, Jacob was pushing for the creation of a European laboratory in molecular biology.

In 1971, Monod became director of the Institute Pasteur. Two years later, with the institute on the verge of bankruptcy, Monod proposed a shocking plan that involved selling the land on which the Pasteur Institute was built. The sale would have the institute to pay back its debt, and with the money left, Monod proposed rebuilding the institute outside Paris, in Garche, where it owned other land. Moreover, the plan foresaw the dismissal of several researchers and technicians. Monod aimed to avoid the nationalization of the institute. Interestingly, Monod referred to his project as "Operation Z," likely referring to Costa Gavras's film *Z*. In the end, the government saved the institute without nationalizing it.[22]

7. From Molecular Biology to a Science of Man

In *The Logic of Life*, Jacob aimed to reconstruct the historical development of heredity from the seventeenth century to his time. Like many molecular biologists, he felt the urge to understand his work in historical perspective. At the same time, *La logique du vivant* brought molecular biology to the attention of a French audience. The importance of this fundamental discipline was difficult to explain as it seemed not to have direct medical applications. When Jacob was working on *The Logic of Life*, French molecular biologists were working to create a new space for their discipline in Europe, and Jacob and Monod were struggling to gather the

22. The documents of the whole project are conserved in AIP/DIR MON 1 and AIP/DIR MON 2.

resources that the Institut Pasteur needed during the worse financial crisis of its existence.

It is also worth noting that the publication of *The Logic of Life* and *Chance and Necessity* made of Jacob and Monod public intellectuals who engaged with philosophers, sociologists, and historians. In 1971, Jacob, Monod, and Luria joined a committee that Philippe Daudy created to fund a research center on a new discipline: bioanthropology. As we read in the minutes of their first meeting, Jacob defended his view already expressed in *The Logic of Life*: "François Jacob thinks that it is a question of seeing if it is possible to identify objects, in the sense that experimentalists understand this term, which would be common to biological and anthropological studies, and if it is possible to envisage today scientific methods to effectively approach such objects. The great problem, as far as man is concerned, is that of recognising what, in intelligence, psychology, culture and society, is innate and what is acquired, i.e. recognising the limits of human chromosome programmes."[23] Interestingly, the document quoted Jacob's book to set up the state of the question: "The problem of the common core of biology and human science was posed: is the logic of the living (la logique du vivant) the same as that of the thinking, or, in other words, are there general laws of life of which the psychological (psychisme) would be the higher level?"[24] Corneille Castoriadis commented that the object of psychoanalysis, the unconscious, could not be understood along the lines of Jacob's epistemology; Jacob replied that epistemological questions are more fruitful if posed a posteriori after the discovery and not before it.[25] Jacob's reply aimed to avoid aborting the initiative. The contrast between the two approaches ultimately mirrored a broader contrast between the scientist and the philosopher or psychoanalyst. Other humanist scholars tried to engage with Jacob's intellectual tools. Le Roy Ladurie compared the demographic equilibrium between 1400 and 1730 to a quasi-homeostatic system and called cybernetics the social and demographic stability.[26] Interestingly, in a following meeting held at the Massachusetts Institute of Technology, there was a certain debate about the status of the new discipline. The preliminary document (unsigned) extended Jacob's view of making molecular biology a new discipline: "When molecular biology was born twenty years ago, it was neither physical, nor chemical, nor biological.

23. Project CIEBAF (Comité International d'Études Bio-Anthropologiques et d'anthropologie fondamentale), Colloque de Royaumont, February 6–7, 1971, Luria papers, box 39, ser i, Fondation Royaumont no. 1 (FR1), APS. The committee initially included Corneille Castoriadis, Claude Gregory, John Hunt, François Jacob, Claude Lefort, Jacques Monod, Edgar Morin, and Jonas Salk. See Institut Royaumont du bio-anthropologie et d'anthropologie fondamentale, Development historique, FR1, APS.

24. Project CIEBAF, February 6–7, 1971, Luria Papers, box 39 ser i, FR1, APS.

25. Project CIEBAF, FR1, APS.

26. Project CIEBAF, FR1, APS.

But at the same time, it was all of these things, and went beyond them. An attempt should be made to create a similar methodological push for the human sciences."[27] As noted earlier, this was how molecular biology was born at the Institut Pasteur, when Jacob and Monod, who had previously worked separately, combined their research into a common experimental project.

Nevertheless, the report summarizing the debate that was sent to participants some 7 months after the meeting was slightly different. This report had the same title and was written in English and signed by Massimo Piattelli Palmarini and Edgar Morin. The above-quoted passage was omitted, and the new discipline was characterized in terms of Morin's idea of the transdisciplinary. The report stated that "a transdisciplinary theory uses existing specialised knowledge, but ultimately restructures it in a totally unprecedent conceptual framework."[28] From a conceptual point of view, Morin's view differed slightly from that of Jacob. It switched from the notion of "scientific object" to that of "conceptual framework," but molecular biology was no longer taken as a model. The report instead mentioned Marxism, psychoanalysis, and cybernetics as examples of transdisciplinary theories.[29]

Marco Tamborini (2022b) has described how France's notion of form and biotechnics circulated and was elaborated throughout the twentieth and twentieth-first centuries among architects and engineers, who worked on understanding natural patterns to solve problems in building. In the 1970s, the Royaumont Center for a Science of Man carried out three research programs: "Genetics and Anthropology," "Animal Communication and Human Communication," and "Reason and Un-reason." However, despite Jacob's auspices, sociologists, anthropologists, and biologists did not find either a common language or a way of translating the perspective of bioanthropology into a coherent discipline. The Royaumont meetings gave rise to a great cultural foundation, but the relations between molecular biology and anthropology did not follow the historical pattern of creation of new objects that Jacob had described in his *Logic of Life*. Some 25 years later, the "Sokal Hoax" shocked the community of French scholars, making explicit how difficult the dialogue between the two cultures had become. Nonetheless, Jacob's perspective allowed him to talk to humanist intellectuals. Thanks to the success of *The Logic of Life*, Jacob became an influential intellectual. He proposed a discipline that was difficult to explain to a broader audience as a model for a possible integration of biological and human sciences.

27. Colloque de Cambridge (Massachusetts Institute of Technology [MIT]), "Méthodes et objets d'études pour une future bio-anthropologie," June 4–5, 1971, Luria Papers, box 39 ser i, FR1, APS.

28. Cambridge Symposium (MIT), "Methods and objects of study for a future bio-anthropology," June 4–5, 1971, Luria Papers, box 39 ser i, FR2, APS.

29. Cambridge Symposium, June 4–5, 1971, FR2, aps.

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