**Definition:** Monod, Jacques from *The Columbia Encyclopedia* (zhäk mōnô'), 1910–76, French biologist, educated at the Univ. of Paris (D.Sc., 1941). He was a leader of the French resistance in World War II. He shared the 1965 Nobel Prize in Physiology or Medicine with André Lwoff and François Jacob for discoveries concerning molecular genetic mechanisms inside body cells. His publications include *Chance and Necessity* (1971) and *Of Microbes and Life* (ed. with Ernest Borek, 1971).

**Summary Article:** Monod, Jacques Lucien from *Encyclopedia of Life Sciences*

**abstract**
(1910-1976) French molecular biologist who, with F. Jacob, introduced the 'operon model' of the regulation of cellular activity.

**keywords**
molecular biology

cellular regulation

Jacob

Lwoff

Wollman

Jacques Monod was born in Paris to a Huguenot family. His father, Lucien, was an artist and art historian and his mother, Charlotte Todd McGregor, was American. Both parents had an important influence on young Jacques’ education, pushing him toward science and music, though, with some hesitation, he finally chose to pursue a profession in biology.

After obtaining his degree from the Faculty of Science in Paris, Monod went to the Roscoff marine biology station, where he became acquainted with four scientists who shaped his conception of science and his scientific practice: Georges Teissier, who gave him a taste for quantitative description; André Lwoff, who introduced him to microbiology; Boris Ephrussi, whose field was physiological genetics; and Louis Rapkine, who taught him that only chemical and molecular descriptions could provide a complete interpretation of how living beings function. See also Lwoff, André Michel

In the autumn of 1931 Monod won a fellowship to study at the University of Strasbourg, in the laboratory of Edouard Chatton, the leading French protistologist of the time, where he became familiar with the techniques of microbiology. In 1932 Monod returned to Paris, spending two years in the Laboratory on the Evolution of Organized Beings, directed by Maurice Caullery, and in 1934 becoming an assistant in the zoology laboratory of the Sorbonne. In 1936 Monod spent a year at the California Institute of Technology, where the 'Drosophila group' directed by T. H. Morgan was working. Here he learned not only genetics but the new scientific style based on collective effort, ease of personal relations between scientists, and freedom of critical discussion. See also Microbiology, and Morgan, Thomas Hunt.

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Back in Paris, Monod returned to the Sorbonne to prepare a doctoral dissertation (defended in 1941) on bacterial growth.

Monod also continued his activity as an amateur musician. He formed a Bach choir, La Cantate, which he directed until 1948. It was there that he met Odette Bruhl, an archaeologist and orientalist. They married in 1938, and had twin sons, Olivier and Philippe, who both became scientists, the former a geologist and the latter a physicist.

During World War II, Monod joined a Resistance group after the German occupation of France. In 1943 he joined the French Communist Party and the Franc-Tireurs Partisans, organizing the general strike that led to the liberation of Paris. In 1945 he resigned from the Communist Party, being in disagreement with its policy.

In late 1945 Monod joined the Pasteur Institute as laboratory director in the department headed by André Lwoff. He spent the rest of his scientific career in this institution. In collaboration with Alice Audureau, Monod continued his research on bacterial growth and enzyme adaptation, in particular studying the enzyme that became the classic subject of his later research, β-galactosidase. See also Institut Pasteur and Satellite Institutes, and Enzymes: General Properties.

In 1947 Monod produced a general report on enzymatic adaptation, assessing the respective roles of the hereditary and environmental factors (the substratum) in enzyme synthesis. From 1948 on, a fundamental contribution to the implementation of Monod’s research programme on enzyme adaptation was made by the American immunologist Melvin Cohn, who spent five years in Paris.

The essential problem posed by the phenomenon of the induced biosynthesis of enzymes was to find out whether it consisted of the activation of a preexisting protein, a ‘precursor’, or whether, on the contrary, it involved the synthesis of a new protein. The linear kinetics (‘Monod’s plot’) established by experiment showed that the synthesis of the enzyme after addition of the inductor is a constant fraction of the rate of total protein synthesis. Furthermore, the study of the incorporation of the radioactive isotope sulfur-35 into the protein in the course of its induced synthesis confirmed that the formation of β-galactosidase corresponded to the total synthesis of the protein on the basis of its elements, without the formation of precursors or intermediaries. See also History of Enzyme Chemistry.

In 1953 Monod was assigned to create and direct the department of cellular biochemistry. The establishment of this department allowed Monod to develop a clear research programme, based on the idea that fundamental chemical organization would be revealed at the level of cellular constituents rather than at the level of tissue or differentiated organs. Monod possessed a powerful tool for this study: the investigation of bacterial growth. See also Escherichia Coli and the Development of Bacterial Genetics.

The new department had sufficient space to accept many students and visitors, primarily specialists in the physical and mathematical sciences.

Beginning in 1957, Monod and François Jacob established a close collaboration. At the time, the development of research on inductive systems required the methods of crossing bacteria and of zygotic induction developed by Jacob in collaboration with Elie Wollman in André Lwoff’s laboratory. This ‘great collaboration’ went beyond the solution to the problem of enzyme adaptation, uncovering the general mechanism of the regulation of protein synthesis and its genetic determination. The
collaboration produced three theoretical models that proved fundamental in the development of molecular biology: the operon, messenger RNA, and allosteric interactions. See also Jacob, François, Protein Synthesis, Messenger RNA in Prokaryotes, Enzyme Activity: Allosteric Regulation, and History of Molecular Biology

Together, Jacob and Monod conceived the famous Pa-Ja-Mo experiment, conducted in collaboration with Arthur Pardee, an American biochemist spending a sabbatical year in Paris. The conclusion to be drawn from this experiment was the existence of a double genetic determinism in protein synthesis. Two distinct genes intervened, one determining the structure of the synthesized molecule and the other controlling the expression of the first. Another conclusion was that different genes determining the structure of distinct proteins were subject to the same regulation system and this functional association was correlated with their genetic association. See also Bacterial Transcription Regulation

Jacob and Monod suggested that there was a single structure sensitive to the repressor and controlling the activity of an entire group of genes. This is the concept of operon, a unit of coordinated expression made up of an operator and the group of structural genes that it coordinates. See also Repression Mechanism, Escherichia Coli Lactose Operon, and Gene Expression Induction

The operon model opened the way to three research problems: (1) the nature of the repressor, (2) the mechanism of the repressor's chemical action and its relation to the target and the inductor, and (3) the molecular mechanisms of the transfer of genetic information for protein synthesis, the messenger.

Monod concentrated on the action mechanisms of the repressor and its chemical interactions with the target and the inductor and in 1961 Jacob and Monod generalized the concept of 'allosteric transition', a chemical interaction that allows complete freedom in the choice of chemical mechanisms, escaping all chemical constraints and obeying only the physiological constraints imposed by the system's consistency and submitted to the action of natural selection. Monod therefore considered the concept of allosteric interaction 'the second secret of life', the first being the double helix and the genetic code.

At the end of 1958, Monod was appointed Professor of Biochemistry at the Faculty of Science of the University of Paris. Later, in 1967, Monod was elected to the Collège de France, as the chair of molecular biology. His inaugural lecture in November 1967 was a solemn occasion for raising the philosophical implications of modern biology. See also Philosophy of Molecular Biology

By interpreting the essential properties of organisms in terms of molecular structures, molecular biology had wrought a new definition of life, one that Monod summarized in three basic characteristics of biological objects: teleonomy, the existence of an 'internal programme'; independent morphogenesis; and reproductive invariance. Particularly in his best-selling book Chance and Necessity (1970), Monod expounded his idea that modern biology stood in contradiction to any anthropomorphic interpretation of the universe or of life. The old ethical values no longer applied, and new ones had to be discerned. In a world in which science had demonstrated that human existence itself was contingent, acquisition of knowledge had to become the supreme value (the 'ethics of knowledge').

In 1965 Jacob and Monod were awarded the Nobel Prize in Physiology or Medicine for their research, together with André Lwoff. Monod then used his fame to demand university reform and to fight for the advancement of French science. During May 1968 Monod supported the student movement against the academic establishment.

Monod was an ardent defender of human rights. In the early 1950s he publicly protested about the
repression of intellectuals in the USA; in the 1960s he aided intellectuals and Jews in Hungary and the
Soviet Union and he came out against the French Secret Army Organization. He supported the
activities of the French family planning movement, fighting for the legalization of abortion, and in 1974
signed a plea in favour of beneficent euthanasia. The value and dignity of the individual was his
fundamental ethical guideline. See also Politics in Biology, Population and Family Planning Programmes:
Human Needs and Human Numbers, and Bioethics - Overview

In the 1960s Monod and his colleagues proposed thoroughgoing changes in the management of the
Pasteur Institute and in 1971 Monod became the general director of the Institute. He assumed the post
with a fully developed plan and with clear ideas - perhaps even dreams - of what an institution of
biomedical research should be like. Monod improved the financial situation, reorganized research,
eliminating or recasting many departments and creating others. Authoritarian and inflexible, he made
decisions firmly and courageously. This created some difficult relations with many colleagues and
Monod's years as head of the Pasteur Institute were difficult for personal reasons as well. In 1972 his
wife died after a long illness. His administrative tasks made it impossible for him to continue his
scientific activity, and he was compelled to resign from his position at the Collège de France. See also
France - Life Science Organizations

In 1975 he sketched out a policy of scientific development for the Institute, centred on what he
considered his fundamental vocation: the advance of the biological sciences in the service of
humankind. But Monod had no time to implement this project. In October 1975 an incurable disease was
diagnosed. He died in Cannes on 31 May 1976.

Further Reading

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