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Ministry of Higher Education and Scientific Research

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Tasdawit n Bgayet
Université de Béjaïa

Courses

Universal history of the biological sciences

Chapter V: Modern times

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Defining key *concepts*

- **Cell**: Basic unit of all living organisms.
- **DNA**: Genetic material carrying hereditary information.
- **Evolution**: The process by which species change over time, mainly through natural selection.
- **Genetics**: Study of heredity and genes, their transmission and expression.
- **Molecular biology**: Study of the structures and functions of biological molecules, such as proteins and nucleic acids.
- **Biotechnology**: Application of biology and genetics to the production of substances or the modification of organisms.

Introduction

The term **"modern times"** in the context of biology has no strict definition, but generally refers to the period from the **Scientific Revolution** (17th century) to the present day, marked by major advances in the understanding of biological mechanisms. This period saw the transition from theoretical biology to experimental approaches, with increasingly rapid development of knowledge and technologies.

In the 18th century, knowledge continues to grow, thanks to..:

- Teaching dissemination
- Increase in the number of students involved in scientific activities.
- Scientific revolution with a paradigm shift (world view, model, current of thought).
- Autonomy of research from the authorities (Catholic Church)
- Organization of scholars (academies; journals).
- Scientific classification

The XIX^{em} century was the epoch of theories such as **evolution, ... cellular, physiology, heredity and genetics**, a century in which scientific research made great advances and discoveries, particularly

in medicine, the field that benefited most from these advances. The work of biologists such as Pasteur and Koch enabled us to identify the origins of many previously unknown diseases, to prevent them and, thanks to advances in chemistry, to produce effective remedies and drug treatments.

Physics, in turn, has also contributed to the development of new technologies, such as medical imaging and radiotherapy, invented thanks to Röntgen's discovery of X-rays.

These discoveries opened the door to other discoveries: the electron microscope in 1930 was the key player in the development of genetics in the second half of the 20th century.

The 18th century Enlightenment

I. Definition

The Age of Enlightenment, a term used to designate the 18th[e] century, was a period that saw the birth of a great **philosophical**, **cultural** and **scientific** movement initiated by intellectuals in European countries.

The aim was to reform society and advance knowledge by encouraging science and intellectual exchange in opposition to superstition.

The 18[ème] century **saw** a significant **growth in knowledge**, with **a reinforcement of the place of science** in society through, for example, the spread of science education, an increase in the number of people involved in scientific activities, and a slightly greater degree of specialization than previously.

The fields that emerged from the 17[ème] century and the Scientific Revolution continue to develop, while **new fields are explored** (such as electricity). **The contribution to biology** is quite significant: for example, since Aristotle, the classification of living beings had not evolved.

II. Origin of the term "Light

The new ideas of the XVIII[e] century were driven by *philosophers* who grouped together under the name : the Enlightenment.

The Enlightenment defended ideas of freedom. They want to disseminate knowledge to the general public. This ideology was built by philosophers and their ideas:

The philosophes des Lumières were **French writers** of the 18th[e] century. They wanted to "enlighten" the world through reason and science. They criticized absolutism and the Church for relying on ignorance and failing to respect human rights.

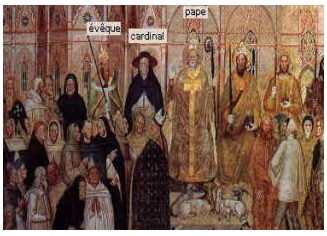
These philosophers admired the English model and English thinkers like ***John Locke*** (1632-1704). For Locke, it's important to understand that knowledge comes from reflection. He defended liberties and the idea that no government can exist without a contract with the people.

II.1. Ideas for lights

Enlightenment philosophy is based on the scientific method. From the 18[ème] century onwards, philosophers rejected all beliefs. According to them, any belief that could not be proven by scientific experiment had to be rejected.

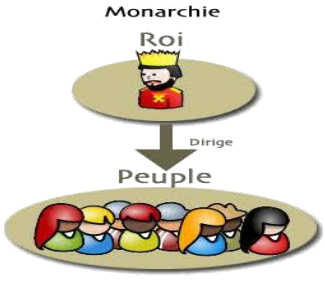
That's why they rejected **religion** and **monarchy**.

- ### Religion



In those days, religion (Christianity) dictated the way people thought and acted, and was closely linked to politics, with the clergy wielding a great deal of power. Philosophers rejected these religious dogmas.

- ### Monarchy



The king had absolute power. Europe was dominated by powerful monarchies. Philosophers believed that governments should respect fundamental rights and freedoms, such as the right to "express oneself".

II.2. The philosophers of the Enlightenment

- ***Montesquieu*** **(1689-1755)**

He's a French writer and philosopher. He criticizes French institutions:

- It proposes the separation of powers (legislative, executive and judicial).
- Powers must be separated and not combined in the hands of a single man (as in the case of absolute monarchy).

- ***François Marie Arouet***, known as **Voltaire (1694-1778)**

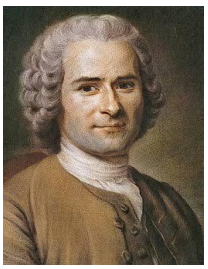
He was a French writer and philosopher. He's not against monarchy, but he wants the king to renounce his divine right (which comes from God).

He, too, wants tolerance. Most philosophers believe in God, but they want man to be able to choose his beliefs.

- ***John locke*** **(1632-1704)**

He's an Englishman. He is an advocate of religious tolerance, which means respecting others regardless of their religion. He asserts that people have natural rights: life, liberty and security. So the king doesn't have all powers over the people.

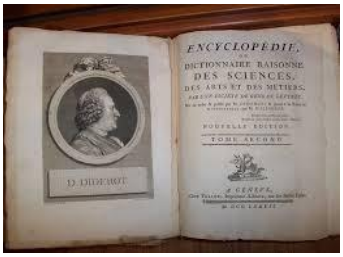
- ***Jean-Jacques Rousseau*** **(1712-1778)**



In his book "Du Contrat Social" (The Social Contract), he suggests that men are free and equal under the law.

II.3. Light diffusion

The "Age of Enlightenment" was a time of great debate and fruitful exchange of ideas. To overcome ignorance and improve society, knowledge had to be disseminated. There were several ways of doing this:



- **Diderot**'s *Encyclopédie* disseminated these new ideas and the scientific advances of the day, explaining them in the form of plates describing scientific processes.
- *Literature* (novels, essays, stories, theater, fables, etc.).
- *Libraries*.

- *Universities*, *Academies* (society of writers, artists, etc.).
- *Newspapers* and *magazines* spreading ideas (kings tried to censor ideas, but without success).
- *Cafés* (philosophers liked to meet in cafés to exchange ideas).
- The nobility and the bourgeoisie converse in *Salons*.
- *Travels* around Europe and the world (inspired by ideas found in different countries).

IV. The contribution of the Enlightenment to biology

The incessant philosophical questioning that characterized the eighteenth[e] century also led to a slow reconsideration of the methods and concepts of "natural history" in the natural and life sciences, culminating in experimental biology gradually replacing the descriptive and classificatory sciences cherished by the naturalists.

In classical times, they described the main morphological characteristics of all known animals and plants. The Enlightenment (1715-1815) invented the word biology, simultaneously in France by ***Jean-Baptiste Lamarck*** and in Germany by ***Treviranus*** in 1802.

Theoretical reflection deepened, but above all this was the advent of the experimental method. For **the life sciences,** it was above all progress :

- Methods for classifying living beings.
- Studies in animal and plant physiology.
- Research into the major issues surrounding the origin and generation of living beings.

• In Animal Physiology

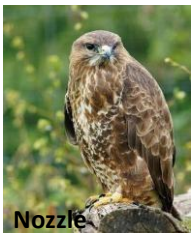
The mechanical model (a set of inert, passive cogs) remains, but the chemical model is gradually making it possible to explain the phenomena.

Physiologists started out as doctors (first half of the century), and it was only later that they freed themselves from medicine.

- **Lavoisier 1790**: memoir on animal respiration.
- **Haller 1747**: *Primae lineae physiologiae*

❖ For digestion:

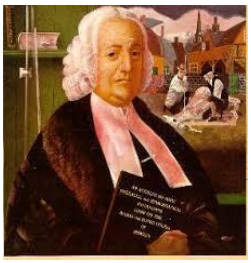
There are 2 schools of thought: those who reduce it to trituration and those who reduce it to the action of chemical juices.



Boerhaave, followed by ***Réaumur*** (1752), provided a synthesis: *digestion of birds* (work on buzzard regurgitation, which for the first time led to work that could be likened to *in vitro* digestion).

Spallanzani (1729-1792) took up ***Réaumur***'s work and generalized the notion of gastric juices regardless of diet.

❖ For circulatory function



The only major works in this field are those by ***Stephen Hales*** *Hemastatic* (1733), who highlighted the fundamental properties of blood circulation, such as the difference in tension between arteries and veins.

❖ For muscle contraction

In 1753, ***Haller*** demonstrated the contractile and sensitive properties of muscles and tendons, using experiments on decapitated animals. He thus distinguished the properties of muscles from those of nerves.

❖ For the nervous system

No great advances. ***Haller*** reasoned too much in terms of dissociating muscles and nerves, which "obscured" the debate. But little by little, the notion of reflex movement took hold.

Jean Astruc (1684-1766) built a mechanical model in which certain areas of the brain control certain movements.

Robert Wyatt **of Edinburgh** (1714-1766) built a model in which the unconscious soul is housed in the brain and controls certain movements.

But the first breakthroughs came with ***Barthez***, ***Galvani*** and ***Lavoisier***.

• Botany and plant biology

As mentioned since Aristotle, the classification of living beings had not evolved.

Carl Von Linné (1707-1778), Swedish botanist and great systematician, is the best-known figure in the history of biology, and was to dominate the century.

Classification was based on the arrangement of the plant's reproductive organs (stamens and pistil), the number of stamens and the way they were fused.

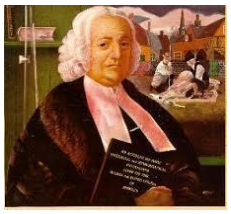
Linnaeus is also the inventor of a rigorous and simple Latin binominal nomenclature, still used today to designate species. This system enables all animal and plant species (and, later, minerals) to be accurately designated by a combination of two Latin names (the binomial), including :

- A genus name whose first letter is capitalized.
- A specific epithet (adjective or attribute). It is written entirely in lower case.

Anatomy and **physiology** made little progress.

In 1711**,** ***Geoffroy*** confirmed that flowers produce seeds when fertilized.

Needham observes pollen grains.



Hales (1727) carried out 140 experiments and demonstrated the action of the sun on the rise of sap.

Expeditions began to study distant flora.

• Zoology and animal biology

Buffon (1707-1788) began publication of his treatise "Histoire Naturelle" in 1749.

Daubenton, a physician, contributed to this treatise as an anatomist. He describes almost two hundred mammals using a comparative method.

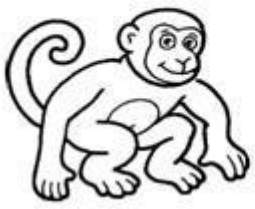
Geoffroy Saint-Hilaire, professor of zoology at the Muséum (1793), studied vertebrates in particular. He took part in ***Bonaparte'***s expedition to Egypt, where he collected observations on various animal species. In his work of the early 19ème century, he demonstrated the role of embryology in understanding the structure of living beings.

Cuvier, professor at the Muséum (1795), made numerous observations on animals. Most of his work took place at the beginning of the 19ème century. He attempted to establish a zoological classification (1800-1805).

He was able to reconstruct fossil vertebrates (1812-1813), proving the existence of extinct species. He is the founder of paleontology.

- ## The origin of species?

According to ***Linnaeus***, the primate group includes man and certain animal species. More precisely, it is divided into four genera: *Homo* (man), *Simia* (monkeys), *Lemur*, and *Vespertilio* (bats).

Linnaeus' classification was subsequently revised, and bats are no longer part of the group, but the word primate remains. Linné's classification led to a fixist vision of the living world: each species was an unchanging entity. Nature contained as many species as were originally created (1736).

This view prevailed for over a century, from which time onwards we became interested in the origin of species, and sought to explain variations within a species.

Georges-Louis Leclerc* De *Buffon (1707-1788) spoke of transformism, which describes the way animals evolve. Participant in the spirit of the Enlightenment, in parallel with the Encyclopédie. His theories influenced two generations of naturalists, in particular Jean-Baptiste de Lamarck and Charles Darwin.

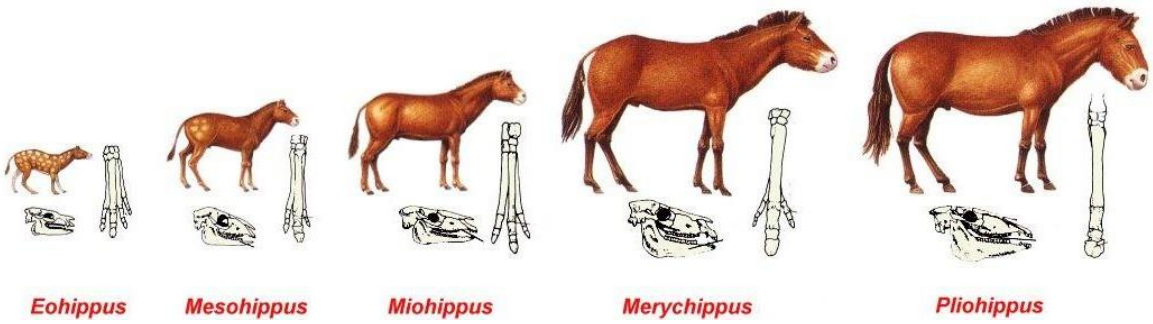
❖ Lamarck's transformism

Lamarck (1744-1829) believed that animals could "transform" over time. He was the first to explain the adaptation of species to their environment and the geological record. His theory is based on two principles: use and non-use, and the heredity of acquired traits. His two hypotheses :

- "In any animal which has not passed the term of its development, the more frequent and sustained use of any organ gradually strengthens that organ, develops it, enlarges it and gives it a power proportional to the duration of this use, whereas the constant lack of use of such an organ insensibly weakens it, deteriorates it, progressively diminishes its faculties and finally causes it to disappear."

- "All that nature has caused individuals to acquire or lose through the influence of the circumstances to which their race has long been exposed, and consequently through the influence of this predominant use of this organ or that of a constant lack of use of that part, she preserves by generation to the new individuals that come from it, provided that the changes acquired are common to both sexes or to those that produced this generation."

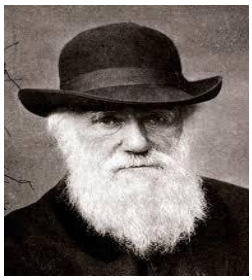
This is the thesis of the heredity of the acquired. It was to have a major influence.



- Heredity is acquired:

Diderot believes that the environment influences heredity, i.e. that the use or inactivation of an organ leads to its heredity or disappearance.

❖ Darwin's evolutionism



Charles Darwin (1809-1882) published "The Origin of Species" in 1859, in which he put forward a scientific explanation of evolution in the form of a simple mechanism based on the principle of natural selection, or the struggle for existence in nature: only the best adapted survive.

Evolution = Modified descent

- Natural selection corresponds to the unequal chances of reproduction between members of a population.
- These inequalities exist thanks to the variability of phenotypes between individuals.

Mechanisms of evolution :

- The survival of all the individuals in a generation is impossible.
- Organisms have differences that can be advantageous for survival.
- Advantageous differences accumulate over generations.
- The accumulation of advantageous differences leads to the appearance of new species.

He believes that all current species originated from the initial batch, and that some then degenerated: for example, the horse became a donkey.

Degeneration is not exactly identical to degeneration in that it is reversible: if the degenerated animal were placed in a favorable environment, it would, over several generations, regain its normal appearance.

Social Darwinism and Eugenics:

Darwin did not reject the theory of heredity of the acquired. He was at the origin of social Darwinism (the struggle between different species for survival). Over time, the theory

Darwin's original ideas have been refined with the results of experiments and observations carried out by biologists.

The scientific community has widely accepted the evolution of life as a fact, demonstrated by experience and observation on numerous occasions, including: the examination of fossils, which shows the evolution of life forms over time; comparative anatomy, which highlights the morphological similarities between animals that are nonetheless different.

❖ ***Denis Diderot*** (1713-1784)

He wrote part of the "Encyclopédie", a great scientific and philosophical inventory. He commented on :

- The origins of life: spontaneous generation is always present.
- Evolution: man is the most evolved animal, thanks to natural selection.

❖ Moreau de Maupertuis

He put forward the idea of the generalized evolution of nature; for him, every animal evolves by "leaps" of spontaneous generation.

❖ Baumann

He believes that evolution has followed the human path, animals, plants and minerals.

Note

It's worth noting that evolutionary theories made their debut in the 18ème century, extending into the 19ème century with Darwin.

IV. The contribution of the Enlightenment to medicine

Medical practice at the time (previously) was based on Hippocrates' twenty-century-old humoral theory. It can be summed up as follows:

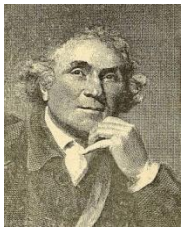
The human body is made up of four humors: blood, bile, pituitary, whi serous and mucous fluids, and melancholy or black bile.

Illness stemmed from an imbalance between the four natural humors.

The physician's art consisted in re-establishing the harmonious blend between them necessary for a state of health. Purges, bleeds and enemas were traditional treatments.


Things began to change in the 18ème and early 19ème centuries, with the introduction of the microscope, stethoscope and acoustic percussion to aid diagnosis.

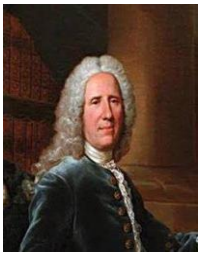
Corvisart, sought to provide clinical medicine with a scientific foundation based on pathological anatomy.



Bichat, known for his treatise on *General Anatomy*, in which he clarified the notion of tissue and contributed to advances in embryology.

Boerhaave, a Dutch physician whose work attracted students from all over Europe.

The new methods are meeting with a great deal of opposition and would not become widespread until the 19thème century. In the old days, barbers practised surgery without requiring students to have the same basic knowledge as medical students.



It was ***François Gigot de La Peyronnie*** (1678-1747), the king's first surgeon, supported by Louis XV, who, in successive stages, starting in 1731 with the creation of the **Royal Academy of Surgery**, succeeded in setting in motion the process that was to lead to surgeons becoming the most important medical professionals in the world.

ers.

The first ***cataract*** operation to remove the crystalline lens was carried out in 1745 by ***Jacques Daviel***.

The first appendectomy was performed by ***Claudius Amyand*** in 1735 (operation).

This was the period when books devoted exclusively to the subject of mental illness were published for the first time. The 18ème had opened people's eyes to the appalling plight of the insane, and they began to view the insane with compassion.

The most famous of these philanthropic doctors was ***Philippe Pinel*** in France. He abolished brutal therapeutic methods and laid the foundations for **psychotherapy**.

The same trend is occurring in Spain, Italy and Germany.

The second half of the 18e century saw the publication of numerous popular medical works. They reveal public **health** concerns. *The Dictionnaire portatif de santé* describes dozens of **occupational diseases** in great detail.

It suggests appropriate remedies, recommends diets and extends its recommendations to clothing and healthy living. In the Age of Enlightenment, the dictionnaire portatif de santé (portable health dictionary) was aprecursor of occupational medicine.

Important discoveries in **immunology** were made during the 18ème century:

Edouard Jenner invented vaccination (then called variolation): To immunize people against smallpox, he contaminated them with a virus similar to smallpox (smal pox), but harmless to humans.

v. Some of the Enlightenment technologies that changed the world

During the 18th[e] century, scientists and inventors renewed science and technology. They laid the foundations for the Industrial Revolution. The great inventions of the century were the following:

- In 1705, ***Jean Marius*** invented the folding umbrella.
- In 1707, the Bateau à Vapeur was created by (among others) ***Denis Papin***.
- ***Basile Bouchon*** invented the loom in 1725.
- The counterweight elevator was introduced by ***Renouard De Velayer*** in 1743.
- In 1747, ***Jean Antoine Nollet*** invented the electrometer to measure electrical charge.
- The rubber raincoat was created by ***François Fresneau*** in 1747.
- In 1752, ***Benjamin Franklin*** demonstrated that lightning is an electrical phenomenon, and invented the lightning rod to protect against it.
- ***Jean-Baptiste de La Chapelle*** creates the lifebelt in 1765
- In 1768, the hydrometer for measuring the density of a liquid was created by ***Antoine Baumé***.
- ***J. Macquer***, invented the rubber hose in 1768.
- In 1770, the automobile was created by ***Joseph Cugnot***, among others.
- In 1780***, Lavoisier*** created the calorimeter to measure heat quantities.
- 1783 the hot-air balloon is invented (***Joseph-Michel*** and ***Jacques-Etienne***).
- The parachute, in 1783 and by ***Louis-Sébastien Lenormand***.
- The tin can was created in 1795 by ***Nicolas Appert***.

vi. Conclusion

Replacement of ideas stemming from "Catastrophism" by ideas of linear evolution.

New classifications are emerging as a result of new criteria based on external morphology.

Several speculative ideas appear as precursors to future theories.

Numerous and diverse inventions that are still useful to us today have seen the light of day.

day.