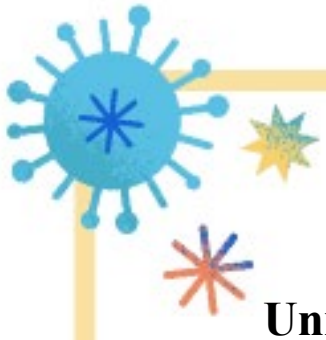

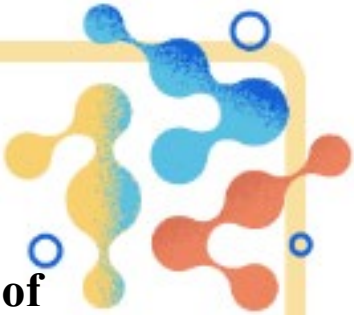

University of M'sila Faculty of Science Common Foundation Natural and Life Sciences

MODERN TIMES

Subject:
17th ,18th ,19th ,20th ,and 21th centuries

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GENERAL INTRODUCTION

In the evolving landscape of **Modern Times**, the **17th** century witnessed a transformative shift in science, distancing itself from philosophy and religious control. Pioneering figures like Galileo, Descartes, Pascal, and Newton laid the groundwork for autonomous scientific exploration.

The **18th** century, marked by the Age of Enlightenment, propelled scientific knowledge forward. Newton's gravitational insights gained prominence, analytical mechanics flourished, and experimental physics, especially in electricity, thrived. Buffon, Linnaeus, Cuvier, and Lamarck contributed significantly to life and earth sciences. The century culminated in Diderot and d'Alembert's Encyclopedia and the birth of the metric system.

The **19th** century saw a rapid acceleration of scientific development. Mathematics advanced with Cauchy and Riemann, while Young and Fresnel transformed Newton's optics. Maxwell unified electricity and magnetism, Mendeleïev classified elements, and Darwin revolutionized biology with evolution through natural selection. The cell theory, emphasizing cellular structure, biogenesis, and continuity, became foundational.

The **20th** century experienced an unprecedented scientific surge fueled by technological precision, global collaboration, and computational advancements. Physics progressed with atomic discoveries and Einstein's Special Relativity, while astronomy expanded through new observation tools and cosmological theories. Philosophers like Karl Popper and Thomas Kuhn influenced the philosophy of science. Biology witnessed extraordinary breakthroughs, including the discovery of DNA's double helix structure, paving the way for gene therapy and cloning. Interdisciplinary connections deepened, with mathematics emerging as a common language across scientific disciplines.

As we step into the **21st** century, digital sciences dominate, promising further interdisciplinary progress and transformative technologies, showcasing the continual evolution of our understanding of the universe. We will detail all of this in this chapter.

V. 1 Sciences in the 17th century:

Since Antiquity and until the 18th century, science has been inseparable from philosophy (in fact, science was called natural philosophy) and closely controlled by religions. The control of religion over the sciences will gradually diminish with the appearance of astronomy and physics modern, making science an autonomous and independent field; and from the scientific point of view which triggered the change at that time:

- Witness the refoundation of algebra accomplished by **Viète (1591).** After **Copernicus,** then other astronomers took over astronomical observations : **Tycho Brahe,** then **Kepler,** who carried out a considerable work on the observation of the planets of the solar system, and stated the three laws on the movement of the planets (laws of Kepler). **Galileo** 's contribution (in 1609) was also very important in science (kinematics, observations astronomical, etc).
- **Rene Descartes** first made a career as a scientist (work in analysis, geometry, optics). Learning of the outcome of Galileo 's trial (November 1633), he gave up publishing a *treatise on the world and light* (1634), and embarked on the philosophical career that we know *(discourse on method,* 1637), *(meditations on the first philosophy,* 1641). seeking to define a method for acquiring a fair and exact science.
- **Blaise Pascal** made discoveries in mathematics (probabilities), and in fluid mechanics (experiments on the atmosphere). **Huygens** develops a wave theory of light, which for having suffered a century of eclipse is no less brilliant. **Torricelli** discover the barometer.
- The most important scientist of this time is **Isaac Newton.** With **Leibniz** he invented differential and integral calculus . With his Optics, he makes a very significant contribution to this science, and above all he bases mechanics on mathematical bases, and thus establishes in a numerical way the validity of the considerations of **Copernicus** and **Galileo.** His book " *Philosophye Naturalis Principia Mathematica "* marked the evolution of physical design, was considered the unsurpassable model of scientific theory until the beginning of the 20th century. The prestige of **Newton** will have largely exceeded the borders of science, since he influenced many philosophers: **Voltaire, David Hume, Claude Henri** de Rouvroy de Saint-Simon, among others.
- **Francis Bacon** is considered, with the Irish physicist and chemist **Robert Boyle,** as the founder of the experimental method. Also, **Robert Boyle** is considered the founder of natural philosophy. Although empirical, the experimental method is extremely important for validating theories, it constitutes one of the foundations of the modern scientific method.

V.2 Sciences in the 18th Century: Age of Enlightenment.

As far as the sciences are concerned, the 18th century saw the growth of knowledge in a very significant way. The fields resulting from the 17th century and the Scientific Revolution continue their momentum, while new fields are explored, such as electricity. It was not until the 18th century that **Newton** 's work on gravitational interaction began to be truly disseminated. At the same time, **Voltaire,** true propagandist of **Newton,** gets involved in the debate and publishes two essays on **Newton :** *Epistle on Newton* (1736), and *Elements of the philosophy of Newton* (1738).

- Analytical mechanics developed throughout the century with **Varignon, D'Alembert, Maupertuis, Lagrange** and a few others, thus continuing the work of **Jacques Bernoulli** on mathematical analysis (continued by his brother **Jean Bernoulli,** and **Euler),** which he himself had based on the formalization of **Leibniz** differential and integral calculus. In addition to gravitation, scientists are interested in systems with connections, then apply the formalism to continuous media, which will allow **D'Alembert** in 1747 to determine the equation of vibrating strings, and to **Euler** in 1755 to establish the general equations of hydrodynamics, after **Daniel Bernoulli** *(Hydrodynamica,* 1738) and **Jean Bernoulli** made important contributions.
- Alongside the advance of analytical mechanics, the 18th century saw the development of experimental physics in a very significant way, especially from the 1730s, it was **Nollet** who established himself as the pope of this physics, and is also very involved in public courses. In this it is quite similar to a **Musschenbroek** in Holland, or **Desaguliers** in England. This experimental physics is thus interested in electricity. **Gray** in England understands the role of what **Desaguliers** will call after him conductors and insulators. At the end of the century, the important work of **Coulomb** make it possible to give a measure of the electric force while those of **Volta** make it possible to create the first voltaic piles.
- The theories of heat developed thanks to research on air springs initiated at the end of the 17th century, by **Boyle** in England, and **Mariotte,** a little later in France. Thus, **William Amontons** did important work on thermometers in the very first years of the century, quickly eclipsed by those of **Fahrenheit** and **Réaumur.** In 1741, **Anders Celsius** defines as ends of the temperature scale, the boiling of water (degree 100), and the freezing of water (degree 0). As for the theories of heat themselves, the difference between temperature and heat has not yet been conceptualized. **Boerhaave** at the beginning of the century, then **Black,** and finally **Lavoisier** at the end of the century, all adopted a material conception of heat. **Lavoisier** calls this fluid "caloric", the non-existence of which will be demonstrated in the 19th century.
- Life and earth sciences are experiencing a great development following trips to Africa and the Pacific , we must mention:

- ✓ **Georges-Louis, Count of Buffon** (1707-1788); is a French naturalist, mathematician, biologist, cosmologist, philosopher and writer, he participated in the spirit of the Enlightenment and contributed to *the Encyclopedia,* in particular by taking charge of the natural sciences. His theories have influenced two generations of naturalists, in particular **Jean-Baptiste de Lamarck** and **Charles Darwin.** Hailed by his contemporaries, **Buffon** was called " Pliny of Montbard ", in reference to the famous Roman naturalist of I st century, author of a monumental " *Natural History* ".

- ✓ **Carl Von Linnaeus** (1707-1778); **Carl von Linné,** is a Swedish naturalist who founded the foundations of the modern system of binomial nomenclature. Considering, according to **Edward Coke's** formula " *Nomina si nescis, perit cognitio rerum* " (knowledge of things perishes through ignorance of the name), that scientific knowledge requires naming things, he systematically listed, named and classified most of the known living species in his time, based on his own observations as well as those of his network of correspondents. The nomenclature he then established, and the hierarchy of classifications into class, genus, order, species and variety, imposed itself in the 19th century as the standard nomenclature.

- ✓ **George Cuvier** (1769-1832); is a French anatomist , promoter of comparative anatomy and paleontology in the 19th century.

- ✓ **Jean-Baptiste Lamarck** (1744-1829); is a French naturalist. At the beginning of the 19th century, he carried out the classification of invertebrates, which include about 80% of animals. He is one of those who for the first time used the term biology to designate the science that studies living beings.Thus one of the first naturalists to have understood the "theoretical necessity" of the evolution of living beings. He is also the first to propose a materialist and mechanistic theory of living beings from which he develops a theory of their evolution. His transformist theory is based on two principles:

1. the growing complexity of the organization of living beings under the effect of the internal dynamics specific to their metabolism ;
2. their diversification, or specialization, in species, following an adaptation to their environment of their behavior or their organs.

- The 18th century is also a century of inventorying knowledge. *The Encyclopedia or Reasoned Dictionary of Sciences, Arts and Crafts,* major work by **Denis Diderot** and **Jean Le Rond d'Alembert** published between 1751 and 1772, was the first major encyclopedia after the great encyclopedias of the Middle Ages. The Encyclopedia notably included a well-structured and referenced set of articles on astronomy, which made it possible to disseminate **Copernicus**

heliocentric model in society, as well as **Newton** 's theory of " universal gravitation " which made it possible to explain the movement of the planets around the solar system according to elliptical trajectories. The end of the century saw the creation of the metric system, at the instigation of **Laplace** notably.

V. 3 Sciences in the 19th century: (Cell theory)

In the 19th century, science developed at an even faster pace:

- Mathematics is refined thanks to the work of many scholars including **Cauchy, Galois, Gauss, and Riemann** are probably the most famous. Geometry is revolutionized by the appearance first of projective geometry, then of non- Euclidean geometries.
- **Newton** 's perspective undergoes a radical revision with the work **of Young** and those of **Fresnel :** we pass from the corpuscular conception of **Newton** to a revision of the undulatory conception of **Huygens.**
- electricity and magnetism are unified within electromagnetism by **James Maxwell** following the work of many physicists and mathematicians such as **Ampère, Faraday** or even **Gauss ;**
- Chemistry takes off, and the century sees the discovery of almost all the chemical elements, and their classification by **Mendeleïev,** and the creation of organic chemistry by many scientists including **Wöhler** and **Kekule** are perhaps the most illustrious.
- The end of the century sees the discovery of hitherto unknown physical phenomena (radio waves - X -rays - radioactivity) by a whole series of great scientists among whom one will find in particular **Hertz, Roentgen** as well as **Peter** and **Marie Curie.**
- Medicine which had been stagnant for a long time is progressing with in particular the discovery of vaccines by **Jenner** and **Pastor.** We abandon the theory of spontaneous generation. Biology is becoming a science in its own right thanks to **Jean-Baptiste Lamarck,** who invented the word and the thing in 1802, proposing a theory of living beings from which then follows a **theory of evolution.**
- **The theory of evolution:** difficulties reappear between science and religion with the publication by **Charles Darwin** (1809-1882); is an English naturalist whose work on the evolution of living species revolutionized biology with his work " *On the origin of species* published in 1859".

Famous within the scientific community of his time for his field work and his research in geology, he formulated the hypothesis that all living species evolved over time from a single or a few common ancestors. through a process known as " natural selection ". Darwin saw **the theory of evolution** during his lifetime accepted by the scientific community and the general public, while his theory of natural selection had to wait until the 1930s to be generally accepted as the essential explanation for the process of evolution. In the 21st century, it is indeed the basis of **the modern theory of evolution.** In modified form, **Darwin** 's scientific discovery remains the foundation of biology, as it logically and unifiedly explains the diversity of life.

- **The cell theory** is the central and main theory of cell biology and the most recognized foundation of

biology in general. The 3 basic principles of the theory are:

- ✓ All living organisms are made up of one or more cells.
- ✓ The cell is elementary of life.
- ✓ Every cell comes from another cell, by biogenesis.

- **In 1660 : Antoni van Leeuwenhoek** observed for the first time living cells, bacteria.
- **In 1675: Antoni Van Leeuwenhoeck** (1632-1723) is the real inventor of the terminology "cell" and the **microscope** which made a detailed description of cell.
- **It was in 1838** with **Matthias Jakob Schleiden** and **Theodor Schwann** that the notion of cells takes on its full scope: "the cell is the structural and functional unit of plants and animals" Their observations of living material will lead them to state that "all organisms are made of small units: cells" . This is the second axiom of *cell theory.*
- **In 1858, Rudolf Virchow,** a German doctor, suggests that every cell comes from another cell. This is the third axiom of cell theory.
- **In 1861, Louis Pasteur,** by demonstrating that the theory of spontaneous generation is erroneous, goes in this direction and it is thereafter by being interested in anthrax and rabies that he will finalize the vaccination, of which he is often attributed the discovery, by failing to cite the research of his predecessors (Bert, Toussin, etc.);

- Biology then saw the development of physiology, in particular thanks to **Claude Bernard.** The birth of genetics, following the work of **Gregor Mendel,** exhibited in 1865 and published in 1866, but whose importance would not be recognized until the very beginning of the 20th century.

V.4 Sciences in the 20th century : (Gene therapy and cloning)

Just like the 19th century, the 20th century saw a significant acceleration in discoveries scientists. There are several reasons for this:

- ✓ improving the accuracy of instruments, in particular through the application of certain discoveries;
- ✓ the globalization of exchanges, thus leading to a pooling of scientific efforts.
- ✓ the rapid development of computing from the 1950s (in the United States), with a lag in Europe due to reconstruction (1960s).

Due to the lack of hindsight, it is difficult to see science in the 20th century in a historical way, but we can still note several theories and discoveries of importance:

- Physics has known great advances, especially with atomic physics discovering the structure of the atomic nucleus. Special Relativity by **Albert Einstein** makes it possible to lay the foundations of the physics of objects at very high speeds.
- Astronomy has known great advances: thanks in particular to new discoveries in fundamental physics, and to the revolution in observation instruments: radio telescopes built in the 1950s and 1960s have made it possible to broaden the spectrum of observable electromagnetic radiation , computing processing large amounts of data. This leads to new cosmological theories, with the expansion theory of the Universe currently being generally held in the scientific community. Astronautical developments have also contributed to sending veritable observation and experiment laboratories into space;
- The 20th century has known several philosophers. We can cite two philosophers of science who left their mark on this field:
  - ✓ the first is **Karl Popper**, who notably stated that for a theory to be scientific,
  - ✓ the second is Thomas Kuhn, who explained that the evolution of science is punctuated by long periods of calm (called normal science) , **Thomas Kuhn** notably took the example in his book " The structure of scientific revolutions ".
- The life and earth sciences have known, for several decades (in fact since the 19th century), an important development, due to the attention paid to natural phenomena, with in particular the role played by **René Dubos.**
- Everything related to biology has also seen spectacular progress. A better understanding **of the life cycle of cells, the role of genes** and other basic elements of life have allowed great advances and opened up completely new perspectives. The discovery of the double helix structure of **DNA** is the most famous

example of gene therapy and cloning.

• Biology uses chemistry and physics, while the latter uses astronomy to confirm or refute its theories, resulting in a better understanding of the Universe. And mathematics, a more or less separate scientific body, is becoming the common "language" of many branches of contemporary science.

The first decade of the 21st century is characterized by dazzling progress in the digital sciences. The fields of application are multiplying and will probably extend into all spheres of science and increasingly sophisticated technologies. Biological evolution is, moreover, only a particular case of universal evolution, because nothing is stable: nebulae, stars, continents and seas, climates, societies, customs, religions, everything is in perpetual transformation….

CONCLUSION

As a conclusion, From the 17th century's liberation from religious and philosophical constraints to the 18th century's Enlightenment, marked by the growth of Newtonian principles and the birth of the metric system, scientific progress surged. The 19th century witnessed an exponential acceleration in knowledge across mathematics, physics, chemistry, and biology, with luminaries like Darwin reshaping our understanding of life. The advent of the 20th century ushered in a scientific explosion: from atomic physics and relativity to revolutionary discoveries in genetics and DNA's structure. Philosophers like Popper and Kuhn reshaped how we perceive scientific theories and progress. The 21st century commenced with digital sciences dominating, promising further interdisciplinary breakthroughs and transformative technologies, reflecting the perpetual evolution in our comprehension of the universe. This journey outlines a relentless quest for knowledge, each century building on the foundations laid by its predecessors, propelling humanity towards deeper insights and boundless possibilities.

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