Lesson N°07 : Nineteenth century

I. Cell theory [27]

❖ Cell theory is a universally recognized historical theory based on three principles or postulates. Several scientists contributed to the development of cell theory from the early seventeenth century to the mid-nineteenth century.

The invention and production of simple, compound microscopes, which enabled scientists to see the microscopic world clearly for the first time, contributed significantly to the development of cell theory.

The three postulates of cell theory are as follows

- ❖ All living organisms consist of at least one cell.
- ❖ The cell is the basic unit of life.
- ❖ All cells originate from pre-existing cells.

While a cell is the basic unit of life, and the smallest element considered independently alive in an organism, it is itself composed of smaller structures, called organelles. Thus, cells are not the smallest structures present in organisms.

The historical development of cell theory begins with **Robert Hooke**, who invented the term "cell" in 1665. Hooke was an English scientist and architect. He built his own rudimentary compound microscope (a microscope with three sequential lenses), with which he made several observations that he published in a book entitled "*Micrographia*". In his book, Hooke presents a microscopically observed drawing of a very thin section of a cork used to close the neck of a bottle. The material was filled with regular, delimited cavities that he named "cells", after the Latin word *cellula*, meaning small part.

The next step in the development of cell theory was the discovery of the fundamental living nature of cells. This was the work of **Antoni van Leeuwenhoek**, often referred to as the "**father of microbiology**". Antoni van Leeuwenhoek was a businessman, politician and microscope devotee. He learned to make his own glass lenses and built a simple microscope, essentially a single powerful magnifying lens, capable of magnifying objects to over 200 times their original size.

This microscope enabled him to make many important observations, notably on freshwater protozoa, which he called "animalcules". He also described bacteria for the first

time by observing the plaque on his own dental plaque. Imagine the shock at the time to discover that his own mouth was full of tiny organisms !

The next major advance in cell theory is attributed to **Matthias Schleiden**, whose work is often cited in collaboration with **Theodore Schwann**. In fact, Schleiden and his close friend Schwann are often referred to as the "**founders of cell theory**". Matthias Schleiden was a German botanist renowned for studying the structure of plants under the microscope. In a book published in 1838, he declared that "all plants are composed of cells and cellular products". He also noted the importance of the nucleus, which he believed to be essential for the production of new cells, and observed that new cells seemed to originate from the nucleus of ancient cells.

The last discovery in our chronology of cell theory, that all cells originate from pre-existing cells, is attributed to a German pathologist and politician named **Rudolf Virchow**.

II. **Embryology**

❖ Embryology is the science devoted to the study of embryonic development, i.e. the period of life between fertilization of the egg and birth or hatching. Describing and explaining embryo formation, and studying the mechanisms and causes of embryonic development [**28**].

The origins of embryology go back to Antiquity, when many physicians and philosophers were interested in the evolution of the embryo. Their technical resources were limited to observing the eggs of various animals, especially the chicken. Speculation and hypothesis replaced the inadequacy of techniques. The most varied and erroneous doctrines were put forward in an attempt to explain the formation of organisms [**29**].

Aristot wrote the **first known treatise on embryology**, as well as the first classification of animals into oviparous, viviparous and ovoviviparous species. But his fanciful hypotheses, steeped in finalism, were to prove detrimental to the development of science until the Middle Ages [**30**].

It wasn't until the mid-17th century that an important milestone in the history of embryology was reached: the publication in **1651** of **W**. **Harvey**'s Exercitationes de generatione animalium established the fundamental notion that "all living things come initially from an egg". Studying the development of a hen's egg germ, Harvey found that the

embryo formed gradually, part by part: this process was interpreted by the **theory of epigenesis** [**29**].

Another theory, that of preformation, temporarily supplanted the previous one, thanks to the use of the microscope which, in 1677, made it possible to observe spermatozoa. This discovery, together with that of follicles in mammalian ovaries made by **R**. **De Graaf**, was interpreted at the time as proof **that a being would be preformed**, **either in the egg**, **for ovists** (included **Malpighi**, Buffon, Malebranche and Bonnet), **or in the spermatozoon, for animalculists** (include A. Leeuwenhoek, **Hartsoeker**, Leibniz, Andry, Delenpatius) [**30**].

Imaginations are given free rein. It was at this point that Bonnet expressed his famous "nesting of germs" hypothesis. The ovary of Eve, mother of the human species, would have contained the germs of human beings, nested one inside the other, all the smaller the further back in time they are from the first woman. Each embryo is a being in miniature, and development is no more than an unfolding of forms. On the contrary, the egg is no more than a nutrient ground, and it is in the spermatozoon that the being is preformed [**31**].

III. **Immunology**

❖ Immunology is defined as the science of immunity. The word "immunity" comes from the Latin immunitas, meaning "exemption, dispensation, remission". In the 19th century (around 1865), the word was taken up in biology to designate the property possessed by an organism of being refractory to certain pathogenic agents. Immunology thus appeared as the study of the means by which an organism escapes the pathogenic effects of certain substances [**32**].

It wasn't until the 19th century, however, that immunization became "scientific", in the sense that it was carried out on a large scale and led to the eradication of several diseases. The three major figures of this era are [**32**] :

⇨ The Englishman **Edward Jenner** (1749-1823): the originator of "vaccination", in the sense of the inoculation of humans with cowpox virus ("vaccinia") to prevent human smallpox.

⇨ The German **Robert Koch** (1843-1910): it was he and his team who showed that infectious diseases are caused by micro-organisms, each of which is responsible for a particular pathology [**33**].

⇨ And France's **Louis Pasteur** (1822-1895): uses the term "vaccination", but generally to designate any inoculation of germs attenuated or inactivated by laboratory procedures that prevents the outbreak of a disease [**33**].

IV. **Genetics**

As a recognized scientific discipline, genetics itself only emerged at the beginning of the 20th century, its beginnings dating back to the 19th. **Grégor Mendel**'s aim was to elucidate the laws governing the origin and formation of plant hybrids. Working on pea varieties with clear and distinct phenotypic traits such as color and shape, he demonstrated that hereditary factors exist in pairs and behave independently, coming together or separating at the random of generations. Above all, Grégor Mendel accurately introduces the major concepts of **dominance** and **recessivity** [**34**].

Mendel's work therefore remained unknown until the early 1900s, at a time when agriculture needed to improve and adapt to the consequences of industrial development, urbanization and a growing population. It was necessary to be able to "manipulate" existing horticultural and agricultural varieties and create new, more productive ones, possibly more resistant to disease, wind and drought [**34**].

V. **Molecular biology**

It was a physicist, Erwin Shrödinger, who paved the way for biology after the Second World War. The result was the irruption of chemical and physical techniques into the life sciences, which transformed the field of biology ; molecular biology began with two major discoveries [**35**] :

- **Oswald Avery** showed in **1944** that genes are made up of DNA,
- **Francis Crick** and **James Watson** proposed the DNA double helix model in **1953**, based on X-ray diffraction data.

The foundations of modern biology are based on the ideas of [**35**] :

⇨ **Charles Darwin**, who in **1859** presented a new theory of the evolution of living species through natural selection: species continually adapt to the different environments they encounter, and therefore evolve [**26**].

⇨ **August Weismann**, who in **1885** formulated the "theory of the continuity of germ plasm", in which he distinguished between germ cells, which transmit life throughout generations, and somatic cells, which constitute "perishable" bodies [**35**].

⇨ And **Gregor Mendel**, who discovered the laws of heredity while working on garden peas. He introduced the concept of dominant and recessive traits, which were to form the basis of genetics in its infancy, but his work, published in **1866**, remained ignored until the dawn of the 20th century [**34**]. **Hugo de Vries** discovered mutations in **1900**.

Theories	savants	years	Involvement in development
Cellular	Robert Hooke	1635–1703	Robert Hooke was an English scientist famous for observing a slice of cork under a microscope and coining the term "**cell**".
	Antoni van Leeuwenhoek	1632–1723	Antoni van Leeuwenhoek was a Netherlands scientist famous for building simple microscopes with a single lens and high magnification, enabling him to observe a multitude of microscopic organisms.
	Matthias Schleiden	1804–1881	Matthias Schleiden was a German scientist best known for determining that all plants are made up of cells. Together with Theodor Schwann, he is considered the father of cell theory.
	Theodor Schwann	1810–1882	Theodor Schwann was a German scientist best known for determining that all living organisms are made up of cells. Together with Matthias Schleiden, he is considered the father of cell theory.
	Rudolf Virchow	1821–1902	Rudolf Virchow was a German scientist known for having determined that all new cells in an organism are produced from pre-existing cells.