The 19th^{em} century
(Cell theory (microscopy), evolutionary theories, embryology, genetics and microbiology)

I. Definition

In the 19ème century, science developed at an even faster pace than in previous centuries. Progress in science and technology (electricity, microbial medicine, industrial chemistry, etc.) gave credence to a positivist (Claude Bernard, Auguste Comte) and evolutionist philosophy, in which science asserted itself against vain metaphysics.

It's also the birth of the humanities as a discipline in its own right.

II. Evolution of microscopy and cell theory

Cell theory is a central and principal scientific theory of cell biology. It refers to the theory that all living things are made up of cells.

It is the most recognized foundation of biology in general, describing the properties of cells. The three basic principles of the theory are :

- Every living organism is made up of one or more cells, the basic unit of organism structure. This definition excludes viruses from the world of living organisms (outside the living cell, a virus can neither reproduce nor grow).
- The cell is the basic unit of life. The cell is a living unit and the basic unit of life, i.e. a cell is an autonomous entity capable of performing a certain number of functions necessary and sufficient for life.
- Every cell comes from another cell, by biogenesis (cell division), the basic unit of reproduction.

The cell is the structural unit, the functional unit and the reproductive unit.

The concept of the cell is a convenient way for scientists to describe the smallest **living** part of an organism, or the smallest living structure.

II.1. People who contributed to this theory

Many people have contributed directly or indirectly to the construction of this cellular theory. Here are a few of them:

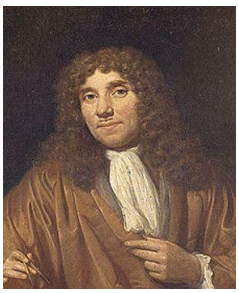
- **Marcello Malpighi (1628-1694)**

He was an Italian physician and naturalist of the 17ème century. He is considered the founder of microscopic anatomy or histology.

In 1671, Malpighi published a work entitled *Anatome plantarum* on the cellular anatomy of plants. He showed that the tissue
The cell is made up of vesicles of varying shape, which he called "utricles". By comparing the tissues of various plants, he saw that the utricles were fused together by a substance he called "cystoblastema".

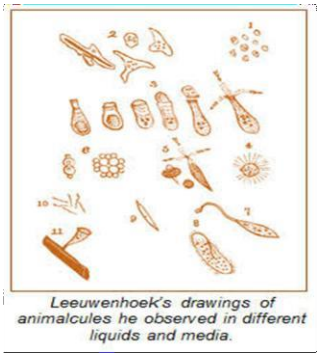
Malpighi proposed an analogy between bone and wood tissue. He surmised that all living things are based on an analogous basic structure.

- **Antoni Von Leeuwenhoek (1632 -1723)**



Dutch draper interested in science in the 17ème century. Precursor of cell biology and microbiology. He developed the technique of manufacturing microscope lenses of a quality unknown elsewhere in the scientific world of his time.

In the 1660s, he observed and drew for the first time numerous living cells, protozoa, microorganisms (bacteria) and even spermatozoa (around 1677), which he called "animalcules".



Leeuwenhoek's drawings of animalcules he observed in different liquids and media.

Leeuwenhoeck is the true inventor of the term "cell" and of the microscope, and provides a detailed description of the cell.

- **Robert Hooke (1635-1703)**

English multidisciplinary scientist (physics, mechanics, watchmaking, biology, paleontology and geology, astronomy, meteorology, architecture, etc.).

He is considered one of the greatest experimental scientists of the 17ème century, and a key figure in the scientific revolution of the modern era. He made a major contribution to biology. From 1660 onwards, he used a microscope of his own invention.

He is credited (1665) with the first description of a biological cell (small cavities) based on the observation of plants (cork fragment). He was the first to use the term "cell" in 1667.

However, neither Robert Hooke nor his contemporaries, such as the Italian physician and naturalist ***Marcello Malpighi***, understood the importance of the "cell" concept, and it wasn't until the 19e century that it came to the fore. It wasn't until 1839 that German physiologist, histologist and cytologist ***Theodor Schwann*** proposed his cell theory.

- **Theodor Schwann and Matthias Schleiden**

- ***Theodor Schwann (1810-1882)***

German physiologist, zoologist, histologist and cytologist.
Among his many scientific contributions, the following should be noted:

The very first statement of cell theory, or at least use of the word, i
1839.

"*There is a general principle for the production of all organic bodies, and that this principle is the formation of cells, as well as the conclusions that can be drawn from this proposition, can be understood under the term cell theory*."

The discovery of Schwann cells in the peripheral nervous system. The discovery of pepsin and its role in digestion.

The discovery of the role of yeast in alcoholic fermentation and the invention of the term "metabolism".

-Matthias Jakob Schleiden (1804-1881)

Professor of Botany at the University of Jena (Germany).

In 1837, he observed that, in plants, the nuclei of new cells are derived from the nuclei of old cells.

Sharing these observations with Schwann, he made the connection with his own observations on animals (notochord) and determined the importance of linking the two observations.

The resemblance between plant and animal cell nuclei was quickly confirmed by the two researchers. The result appears in the famous article entitled "Microscopic investigations into the similarity of structure and development of animal and plant cells".

The cellular theory was definitively established. History has thus associated ***M.J. Schleiden*** to ***T. Schwann***'s statement.

- **Rudolf Ludwig Karl Virchow (1821-1902)**

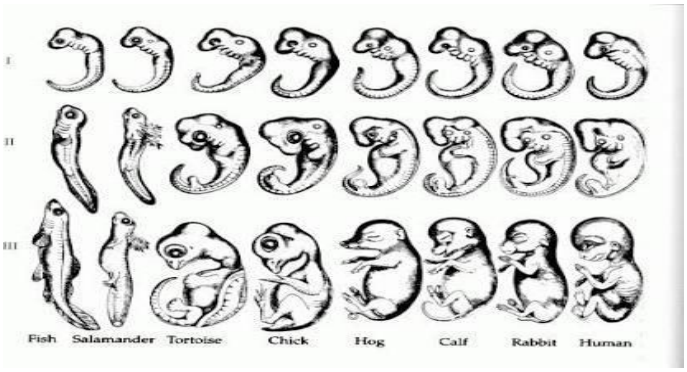
Pathologist and politician, considered one of the founders of modern pathological anatomy. He spent most of his career at Berlin's Charité Hospital. He promoted a strictly natural-science-oriented approach to medicine.

In 1855, he suggested that every cell comes from another cell, "*Omnis cellula e cellula*". This is the third axiom of cell theory.

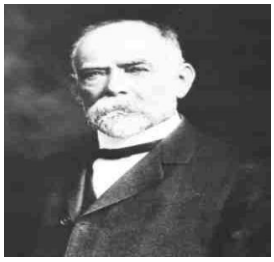
He is known for his theory of cellular pathology, according to which diseases have their origins in alterations in the body's cells. He was highly skeptical of microbiology, as it seemed to contradict his cellular pathology, since microbiology claimed to explain the causes of disease (due to pathogenic microorganisms). In 1858, the physician Louis Pasteur, by demonstrating that the theory of spontaneous generation was erroneous, followed suit.

III. Embryology and reproduction

It is a scientific discipline that encompasses the morphological description of the transformation of the fertilized egg into an organism. It became experimental in the XIX^{ème} century.



- **Carl Friedrich Wolff (1734 - 1794)**



German physician and physiologist, one of the founders of embryology.

In 1759, in his thesis entitled "*Theoria generationis*", Wolff studied the development of the chicken, reviving Aristotle's concept of epigenesis.

He introduces the germ layer theory, showing that the material from which the embryo is made is, at the start of development, in the form of leaf-like layers. He notes the progressive development of animal organs.

It was not until the beginning of the 19th^{ème} century that ***Von Baer*** really entered the field of modern embryology.

- **Karl Ernst Von Baer (1792-1876)**

German-Baltic biologist, professor of zoology and anatomy at Königsberg University (Germany). He was the father of embryology.

He studied mammalian embryology. His most important
The famous discovery in 1827 of the mammalian ovum, hitherto confused with the ovarian follicle, followed the 1824 discovery of the fertilizing role of spermatozoa by ***Prevost***

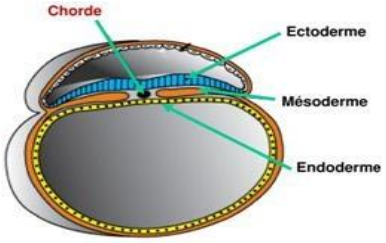
(1790-1850) and ***Dumas*** (1800-1884).

In 1828, he switched from descriptive to comparative embryology. He was at the origin of ***Von Baer***'s law, which specifies that embryonic characters common to several animal taxa appear earlier than the distinctive characters of these taxa.

- **Christian Heinrich Von Pander (1794-1865)**

He was a German-Baltic embryologist, zoologist and paleontologist. He imposed the embryonic leaflet hypothesis as the basic principle of embryology in 1817, which remains one of the foundations of modern embryology.

This hypothesis amounts to considering embryogenesis as the growth of three layers: the ectoderm, the mesoderm and the endoderm, referred to by Pander as the serous envelope, the liquid envelope and the mucous envelope.



To develop this hypothesis, he placed 2,000 chicken eggs in an incubator, extracted some at precise times and systematically described their contents.

An embryonic sheet is a group of cells produced during metazoan embryogenesis. During embryo formation, the cells are organized into cell sheets, which are distinguished from each other during gastrulation: the outer sheet is then called the ectoderm, and the inner sheet, the endoderm. In diploblastic or diblastic cells, there are only these two layers, separated by a hydrated extracellular matrix called the mesoglea.

In triploblastic metazoans, the intermediate leaflet forms a real tissue called mesoderm. The role of each of these layers is to form the organs of the future individual:

- The ectoderm produces the epidermis and the nervous system;
- The endoderm produces the digestive tract and its associated glands (pancreas);

- The mesoderm produces muscles, the skeleton and blood vessels.
- The mesectoderm - part of the muscles and skeleton of the head - comes from the ectoderm via the cells of the neural crest.

- **Robert Remak (1815 - 1865)**

He was a German embryologist, physiologist and neurologist. He obtained his medical degree in 1838 from the University of Berlin, specializing in neurology.

He explored the differentiation of the different germ layers of the embryo into tissues and organs. He became famous in embryology for reducing the four primitive embryonic layers described by ***Karl Ernst von Baer*** to just three: ectoderm, mesoderm and endoderm.

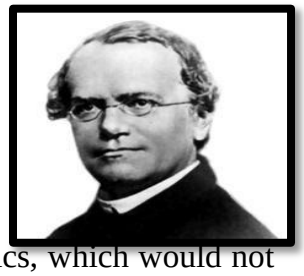
He discovered amyelin nerve fibers and nerve cells in the heart, still known as *Remak's ganglia*.

IV. Genetics

Genetics, from the Greek "genno" meaning "to give birth", is the science of heredity and genes. It is a sub-discipline of biology.

The term "genetics" was invented by English biologist ***William Bateson*** (1861-1926), who first used it in 1905. His official date of birth is **1865**, corresponding to the publication of **Mendel**'s work, but the value of this work was not recognized until **1900**.

- **Work by Gregor Mendel (1822-1884)**

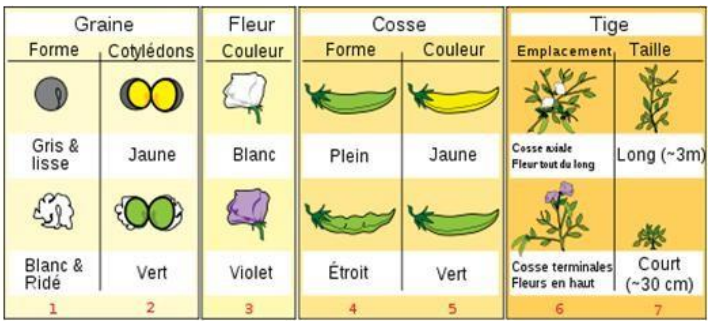


Mendel was an Austrian monk and Germanophile botanist who belonged to the Augustinian community of Brùnn.

He is known as the founding father of heredity and thus of the genetics. He carried out extensive experiments on heredity and genetics, which would not be known until 50 years later. He was the originator of what are now known as Mendel's Laws, defining how genes are passed from generation to generation.

In 1865, in the courtyard garden of his monastery, he decided to work on edible peas, which have seven phenotypes, each of which can be found in two different forms:

- Seed shape and color,
- Envelope color,
- Pod shape and color,
- Flower position and stem length.



He had the idea of first investigating what would happen if smooth-seeded peas were artificially fertilized with pollen from wrinkled-seeded peas and vice versa (cross-breeding). In 1866, he published an article entitled "Recherche sur les hybrides végétaux" (Research on plant hybrids), under the authority of the Brünn Natural Science Society, in which he set out the laws governing the transmission of certain hereditary traits.

Even today, these conclusions correspond to some of the fundamental laws of genetics:

- Characteristic disjunction: A character has two alleles, one paternal, the other maternal.
- Characteristic independence: Each pair of alleles is independent of the others (note that this doesn't work if they're on the same chromosome).

However, this research did not attract any interest from the scientific community a t the time.

- **Johann Friedrich Miescher (1844-1895)**

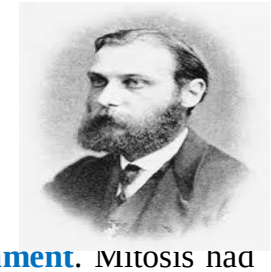
Swiss physician and biologist.

In 1869, he discovered a non-protein, non-lipid substance rich in phosphorus in the nucleus of cells, which he named "nuclein".

In 1872, he demonstrated the presence of nuclein in the spermatozoa of several species.

He hypothesizes that this substance plays a role in the transmission of heredity.

- **Walther Flemming (1843-1905)**



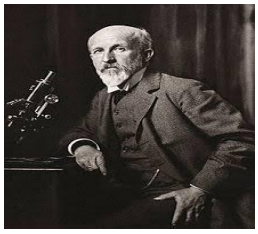
German biologist and one of the founders of cell biology.

He introduces the notion of "chromatin" (chroma = color) to designate the nuclear substance colored with an aniline-based dye.

In 1879, he first described mitosis, from the Greek **Mitos = filament**. Mitosis had already been described 40 years earlier by ***Carl Nageli***. However, he described it as an anomaly.

Flemming coined the terms **prophase**, **metaphase** and **anaphase** to describe cell division. He notes that when the cell divides, chromatin is transformed into filaments. His work was published in 1882.

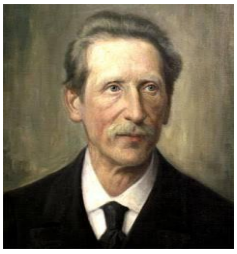
- **Oskar Hertwig (1859-1932)**



He's a German embryologist. He worked on reproduction in sea urchins.

In 1876, he published a paper showing that fertilization is the union of the nucleus of a male gamete with a female gamete.

- **Eduard Adolf Strasburger (1844-1912)**



German botanist. He devoted himself to the study o f plant embryology.

In 1880, they discovered that the fusion of the nucleus of the ovum and the spermatozoon is the essential element of fertilization.

- **Heinrich Wilhelm Gottfried Waldeyer Hartz (1836-1921)**

German anatomist.

He is known for his contribution to the neuronal theory o f nervous system organization. He proposed the names neuron. In

In 1888, he coined the term "chromosome" to designate the colored filaments o f cell division.

- **Theodor Boveri (1862-1915)**

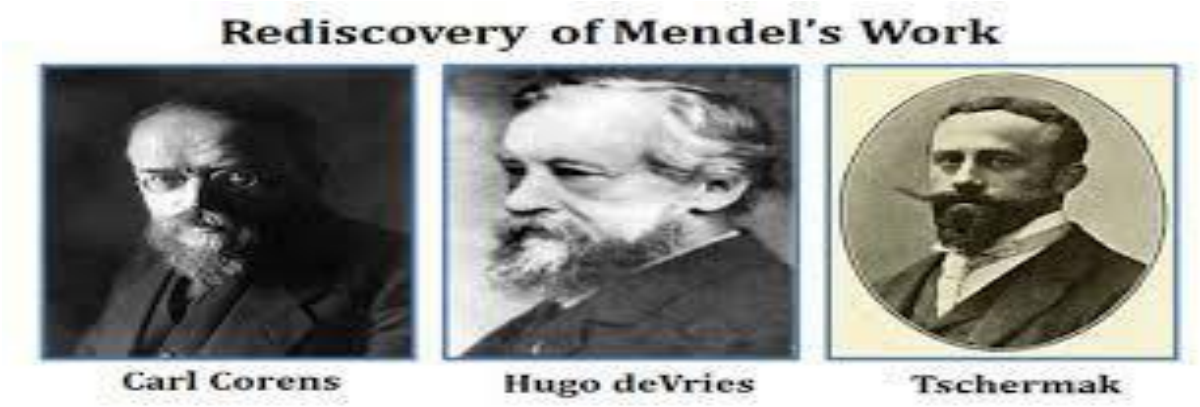
German biologist. His work is at the frontier of cytology, embryology and genetics.

In 1887, he authored the law of chromatic reduction (phase of the meiosis). In 1891, he demonstrated and affirmed that chromosomes are essential to life.

- **Rediscovery and extension of Mendel's work (1900-1910)**

Mendel sincerely believed that he had aroused great interest in his experiments, but he was mistaken. In the years that followed, no one thought of repeating his experiments, or at least commenting on them.

It wasn't until 1900, therefore, that the data in question were finally taken into consideration. Three names stand out this time: ***Carl Correns*** in Germany, ***Hugo De Vries*** in Holland and ***Erich Von Tschermak*** in Austria.



Separately, but at the same time, these three authors were surprised to discover that the fundamental laws of hybridization they themselves had been seeking had already been formulated, and that there was clearly nothing to add, nothing to take away from what Mendel had said thirty-five years earlier.

- **Walter Stanborough Sutton (1877-1916)**

He was an American physician and geneticist. His work focused on the study of meiosis in grasshoppers.

He first observed meiosis in 1902. He is best known for his contribution to chromosome theory (***Sutton and Boveri*** chromosome theory) in 1902.

In 1903, he proposed that chromosomes carry genetic information.

Chromosome theory of heredity: fundamental theory of genetics. It identifies chromosomes as the carriers of genetic information.

V. *History of microbiology and the discovery of the microbial world*

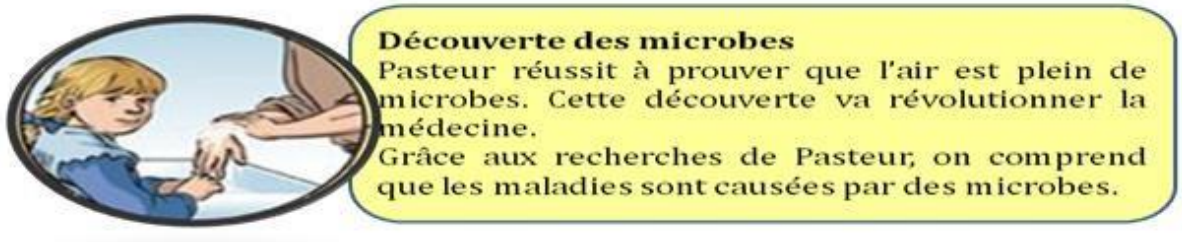
Microbiology is the study of very small living organisms that cannot be seen by the naked eye. This is why they are called microorganisms.

The very existence of the microbial world was unsuspected by man until the invention of the microscope by **Leeuwenhoek** towards the end of the 17ème century.

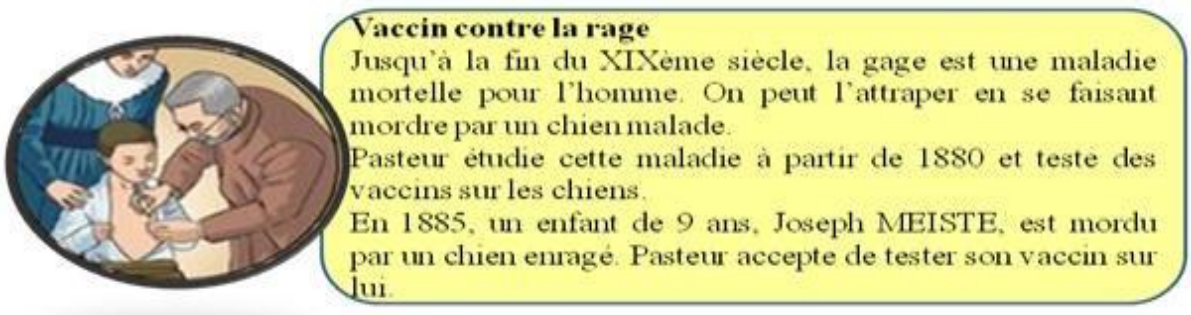
- **Louis Pasteur (1822-1895)**

Studies immunology and (new) microbiology.

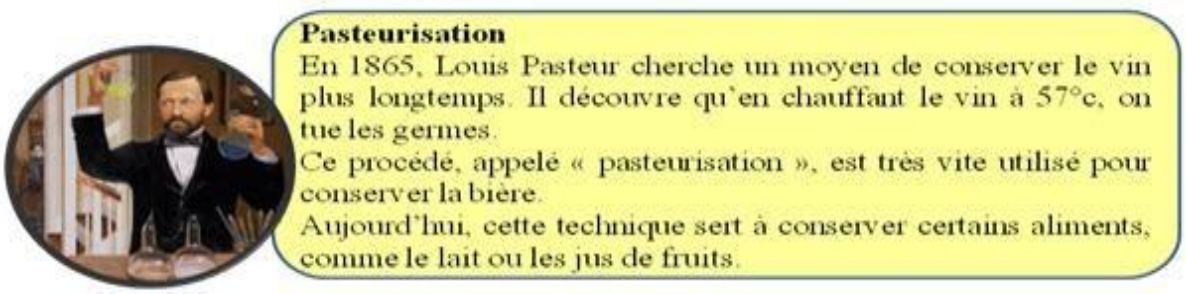
He observes the world of micro-organisms, and studies pathogens in particular.



He treated many diseases: anthrax, cholera, etc. In 1885, he carried out the first vaccination on a human (against rabies). This vaccination was to become systematic.



He demonstrated that spontaneous generation does not exist. He provided definitive proof that all fermentation processes are the result of microbial activity.



Pasteur prepared nutrient solutions in swan-neck flasks, without preventing the passage of unfiltered, untreated air, heated the broths and left them to stand. No microorganisms appeared.

Pasteurization is the process of heating food to 62.8°C for half an hour. Pasteur demonstrated that this was sufficient to eliminate harmful microorganisms.

The Institut Pasteur was founded in 1888. Pasteur's work led to the creation of a new discipline, **Microbiology**.

VI. Conclusion

The 19ème century was a century in which science and technical inventions exceeded all expectations. This led to a better standard of living for European and other populations around the world.