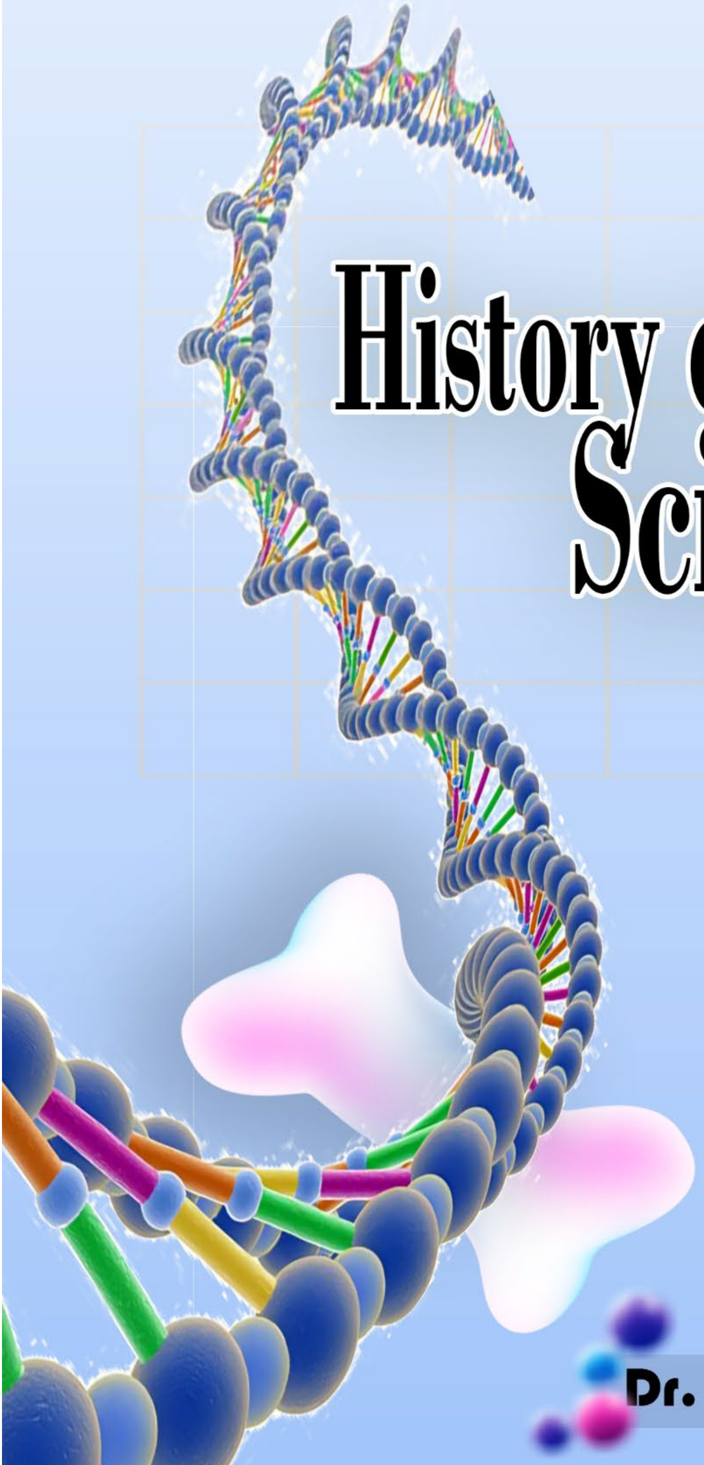
University of M'sila Faculty of Science
Common Foundation Natural
and Life Sciences

History of Biological Sciences



Dr. Benrezgua.E

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CH01:Prehistory and Antiquity

BENREZGUA-ELHADJ	UNIV-MSILA	elhadj.benrezgua@univ-msila.dz

INTRODUCTION

In the annals of human history, the chapters of prehistory and antiquity stand as the foundational canvases upon which the tapestry of our civilization was woven. Prehistory, veiled in the mists of time before the emergence of written records, challenges our understanding with artifacts unearthed from ancient soil. It spans from the dawn of humanity, marking our nomadic existence through the Paleolithic age, where survival meant mastering the art of hunting and gathering. The subsequent Neolithic period ushered in agriculture and sedentarization, setting the stage for the rise of organized societies.

Antiquity, the age of burgeoning civilizations, unfolds with the birth of written language around 3000 years BCE. This era saw the advent of structured societies along the banks of great rivers like the Nile, Euphrates, and Tigris, fostering the birth of early civilizations in Mesopotamia and Egypt. Iron, with its transformative power, replaced bronze, reshaping societies and economies. The ancient Mesopotamians, notably the Chaldeans, left behind a legacy of mathematics, astronomy, and medical knowledge inscribed on clay tablets. Meanwhile, in the Nile Valley, the Egyptians, deeply intertwined with their environment, crafted a civilization rich in astronomy, mathematics, and medicine, recording their wisdom on papyri.

In Greece, the cradle of democracy, profound thinkers like Socrates, Plato, and Aristotle pondered the mysteries of existence, laying the foundation for Western philosophy. The Hellenistic period, marked by the vast influence of Alexandria and its Museum, witnessed an intellectual flourishing. Knowledge became not just a possession but a pursuit, leading to remarkable discoveries and the compilation of vast libraries.

This chapter embarks on a journey through these epochs, exploring the remarkable achievements, the cultural intermingling, and the intellectual pursuits that shaped the prelude to our modern world. Delving into the remnants of ancient civilizations, we uncover the essence of our shared human heritage, marveling at the ingenuity and wisdom of those who came before us. Join us as we unravel the enigmas of prehistory and antiquity, uncovering the threads that bind us to our ancestors and illuminate the path of human progress with an interest in the evolutionary side of biological sciences.

I. PREHISTORY

It is conventional to start the story at the time of the invention of writing. Our knowledge of prehistory is therefore based exclusively on the analysis of art efacts discovered during archaeological excavations.

Prehistory is generally defined as the period between the appearance **of** humanity and the appearance of the first written documents. The classic definition of prehistory poses a certain number of problems, particularly with regard to the criteria used for **its beginning** and **its end,** but also for **dating .** of **its limits.** It is divided into different periods characterized by particular techniques: **The Neolithic** (the age of polished stone), **and the Paleolithic** (the age of cut stone) [1]:

I.1 The Paleolithic

This is the oldest period, characterized by the technique of carved stone and a nomadic way of life ignoring live stock or agriculture. Humans then lived by hunting and gathering. This epoch begins three e million years ago. Among the techniques developed during the Paleolithic period, let us point out the domestication of fire, the manufacture of clothing and containers from animal skins, the manufacture of hunting tools and canoes. The domestication of the dog probably dates from the Paleolithic era.

I.2 The Neolithic

The era is originally defined by the use of polished stone, but is above all characterized by the appearance of lives tock (domestication of goats and cattle) and agriculture, and therefore by sedentarization (at least seasonal) of the populations. The oldest traces of a Neolithic population are found in the Middle East and date to between 9,000 and 6,000 BCE. At that time were also developed the art of pottery, weaving, stone construction. The invention of the wheel dates back to this period.

I .3 Medicine in Prehistory

Medicine in prehistoric times was characterized by primitive yet intuitive practices aimed at healing and alleviating ailments. Early humans relied on natural remedies derived from plants, herbs, and minerals, displaying a deep understanding of their environment. Shamanistic rituals and spiritual beliefs often played a significant role in prehistoric medicine, emphasizing the connection between the physical and spiritual realms. Despite the absence of advanced medical knowledge, prehistoric communities developed rudimentary surgical techniques, such as trepanation, to treat head injuries[1].

Example of first surgical act:

Trepanation is the oldest form of surgery of which there is physical evidence. Examination of fossil skulls shows that operations of this type were carried out as early as the Neolithic; In ancient Greece; trepanation is described by [Hippocrates.]

Skull of a maiden trepanned with flint, Neolithic (3500 BC); the patient

I.4 Historical aspect

The chronology of prehistory began to be established in the 19th century, following the work of the great systematists of the previous century, **Carl von Linne,** and especially **Buffon,** who had largely pushed back the date of the origin of life on Earth.

In 1820, Christian Jürgensen Thomsen orders the collections of his museum according to the main materials used and creates a so-called “three ages” classification:

- **Stone Age**
- **Bronze Age**
- **Iron Age**

II. ANTIQUITY (appearance of civilization)

The word "civilization" derives from the Latin **civis** which means "citizen". It therefore implies a society, a group of populations in which each person has a specific role: the tasks are specialized and the relationships between individuals are governed by rules organized around a link of authority. In particular, there are laws and a judicial system (as arbitrary as it may be) which aims to settle disputes between individuals while avoiding personal score settling as much as possible. It is agreed that the first civilizations were born from the large-scale organization of agriculture, on the banks of the great rivers of the Middle East (Nile, Euphrates, Tigris, Indus) and China. The historical period as such begins with the invention of writing, around 3000 years before our era, in Mesopotamia and Egypt. Mesopotamia and Egypt were Bronze Age civilizations. These civilizations were shaken in the middle of the second millennium BC by the arrival of the Iron Age, whose historical significance was immense. Iron is more difficult to work than bronze, due to its higher melting temperature, requiring more sophisticated furnaces. Note that iron ore is much more abundant than copper ore, during the Bronze Age, the rarity of the metal made it a luxury item, the prerogative of nobles and warriors. The peasants had only stone tools making it difficult to farm outside narrow areas near rivers, where the land is easy to work, such as Egypt and Mesopotamia[2].

II.1 MESOPOTAMIAN AND BABYLONIAN PRE-SCIENCE

II.1.1 Mesopotamia in history

Mesopotamia is the “country between two rivers”: the Tigris and the Euphrates, a civilization developed there as ancient as on the banks of the Nile. The use of bricks rather than stones in the construction of large buildings meant that the Mesopotamian civilization did not leave such lasting traces as the Egyptian. From the middle of the 19th century, archaeologists discovered the ruins of several buried cities, such as Our, Babylon (Babel), Nineveh, which gradually revealed the extent of Mesopotamian civilization. The oldest civilization of Mesopotamia developed near the mouths of rivers, around -3000, in the region called Sumer.

It's Sumerian which becomes a written language for the first time, around 3300 BC. J.-C. This writing was used at the beginning for the trade. The invention of writing is a very important thing for the preservation and transmission of ideas. The writing medium in Mesopotamia was clay present in many forms, in tablets; Most of the technical knowledge of Mesopotamia seems date back to the time of the Sumerians, the third millennium BC. The city of Babylon (or Babel) becomes the most important center.

In the middle of the second millennium, peoples knowing the use of iron (the Hittites) invade Mesopotamia and thereafter, in the first millennium, the power moves north, in the area known under the name of Assyria. The Assyrians (El Achoriynes in Arabic), kept the language and writing of the Babylonians. Most of the written documents that we have on Mesopotamia come from excavations carried out in Assyria. Irrefutable archaeological evidence of the Deluge, a sort of prolonged flood that affected all of lower Mesopotamia around -3200, was uncovered in the 1920s. first millennium, a people settled in Syria, the Arameans, ended up imposing their language throughout the East.

In this language, the peoples inhabiting lower Mesopotamia called themselves Kaldou, which becomes Chaldeans in French. For this reason, lower Mesopotamia is often referred to as Chaldea and its inhabitants Chaldeans.

Chaldean knowledge has come down to us mainly in the form of terracotta tablets covered with socalled cuneiform (wedge-shaped) characters, because they were printed with a carved reed.

This script was used for more than 3000 years, starting from -3500. We have hundreds of thousands of such tablets, found during multiple archaeological digs[2].

II.1.2 Mathematics

It is on Babylonian clay tablets that we find the trace of the first mathematics:

- The four basic operations were done using tables and practical problem solving using words detailing all the steps.
- The strength of Chaldean mathematics lies in their positional numeral system, base 60 (sexagesimal).
- The division of the circle into 360 degrees, of the degree into 60 minutes and of the minute into 60 seconds (and similarly for the units of time) goes back to the Chaldeans, who transmitted it to the Greeks.
- The Chaldeans ignore the zero, which makes their notation ambiguous. They apply their number system to fractions.
- The Chaldeans can also be considered as the founders of algebra, However, this algebra will not be extended and we will have to wait for the work of Muslim mathematicians to develop this aspect of mathematics.
- **For trade,** it was necessary to name animals and plants. But they did not limit themselves to a simple enumeration, they classified them and this went beyond the mere market domain.
- This is how hundreds of animals and plants are classified into " kingdoms ".

II.1.3 Astronomy

Magic and astrology played an important social role in Mesopotamia. Therefore, the astronomical observations of the Chaldeans were numerous:

- The Chaldeans used a lunar calendar. Like the period of the Moon (29 d., 12h., 44 min., or 29.531 days).
- They concluded that the solar year is 365.20 days. This is remarkably close to reality (365.26 days).
- They could predict lunar eclipses and solar
- eclipse possibilities (i.e. they could tell when a solar eclipse was likely to occur.
- They are the authors of the Zodiac and of its division into twelve constellations.
- They observed the positions of the planets, without however developing a theory to explain them;
- geographical maps are also produced, such as that of the city of Nippur (which was even used by archaeologists exploring the remains of the city). A map of the world was even found, placing Babylon in the center and the distances represented by the duration of the journey and not by the actual distances.

II.1.4 Medicine

- The Mesopotamians knew several diseases and had remedies for each of them.
- Medical texts and manuals had even been written, but it would seem that the doctor's experience was the most important.
- Remedies, based on plant drugs such as roots but also minerals such as salt, rubbed shoulders with magic[2].

II.2 EGYPTIAN SCIENCE

II.2.1 Egypt in history

Egypt was host, along with Mesopotamia, to the first great civilization of antiquity. From the distant civilization of the Neolithic. Its existence and maintenance span more than 3,000 years.

Egyptian civilization is linked to a unique geographical location which is its entire foundation: the Nile Valley. This country is entirely dependent on its artery, the Nile, and its annual floods which fertilize the soil. It is the Nile which, by its flood, brings water and silt, that is to say, life. The kings who reigned over Egypt (pharaohs) were classified by ancient historians into thirty dynasties.

II.2.2 Character of Egyptian knowledge

Ancient Egypt was a centralized monarchical state. The scribes, a sort of accounting functionaries, were responsible for the inventory and the distribution of the harvests and it was in their hands that the transmissible knowledge of the Egyptians rested, in particular in mathematics.

Paradoxically, the most fertile era in technical inventions is *the Old Kingdom* **(the era of the great pyramids).** For example, the great pyramids of Cheops and Chephren have their faces oriented towards the four cardinal points in relation to the course of the Sun (equinox).

Egyptian **engineering** achieved impressive efficiency: the Egyptians took only thirty years to build each of the great pyramids. The number of workers needed, the volume of stones to bring, the transport from the quarries, the infrastructure necessary for the realization (ramps), the quantity of food to bring to the workers, everything is calculated. The precision of the stone-cutting technique, too, is truly impressive and it is still not understood how the 20,000 workers of the **pyramid of Chephren** have succeeded in making such huge blocks perfectly joined by mounting them where they are. The temples, obelisks and tombs are equally impressive[2]. The scribes calculated quickly and well, the workers worked quickly and well.

II.2.3 Mathematics[2]

- The Egyptians have a *juxta-positional* numeral system (analogous to Roman numerals); They have signs for the unit, the ten, the hundred, etc.
- The significance of the number 10 likely stems from our ten fingers, which have been used to count since prehistoric times.
- The Egyptians only know integers, unit fractions (of the form $1/n$, where n is an integer).
- All other fractions must be reduced to combinations of these.
- **Herodotus** attributes the invention of geometry to the Egyptians. In fact, their geometric
- knowledge is purely practical and empirical.

- They know how to calculate the area of a rectangle, a trapezium, a triangle.
- They know that the volume of a pyramid is 13 *Bh (B:* base, *h:* height).
- Note that the proof of this last formula requires reasoning based on the integral calculus, but we do not know how the Egyptians achieved it. They adopt the value $\pi \approx 3.1605$.
- In general, the Egyptians are stronger in geometry than in arithmetic.

II.2.4 Astronomy

- The Egyptians distinguish the planets from the stars.
- They have rudimentary instruments for measuring astronomical positions.
- The zodiac, which we have inherited, is none other than the calendar of the Egyptian seasons, established from the Mesopotamian zodiac.
- They have the best calendar of Antiquity: a year divided into 12 months of 30 days, plus 5 days.
- This calendar underestimates the length of the year by about 6 hours and leads to "floating solstices" (wandering year), that is to say a progressive shift in the seasons (a receding season every 360 years, approximately).
- It is the kings who will demand the development of a new calendar, with a leap year every four years to correct the situation.
- The Egyptians measured time using sundials during the day and *clepsydras* (water clocks) at night.

II.2.5 Medicine

knowledge of Egyptian medicine is based mainly on the discovery of numerous papyri where diagnoses and treatments are recorded.

- The legendary founder of Egyptian medicine is the physician-architect in the service of Pharaoh **Djoser,** who lived around (-2800/ - 2700).
- Egyptian medicine is hybrid: on the one hand it contains a strong dose of magic; incantations uttered by the doctor are supposed to bring healing by themselves
- The use of empirically discovered drugs also seems important.
- The Egyptian doctor is a craftsman, whose knowledge must be transmitted in a hereditary way: one is a doctor from father to son, as one is a scribe, or armourer, or shoemaker from father to son.
  It seems that Egyptian surgery was superior to medicine[3].
- Egyptian doctors have an in-depth knowledge of the inside of the human body. They identified and described a large number of diseases.
- They are competent in cardiological, gynecological, eye, intestinal and urinary tract medicine.

- They perform operations successfully knew how to sew up wounds; they made dental fillings with gold; they repaired fractures by replacing the bones and holding them together with wooden splints.
- They are the most famous of their time and are widely called upon, including from abroad. As with mathematics, they taught their knowledge orally and through a number of papyri. It is no coincidence that Greek physicians, like their mathematician or astronomer colleagues, came to train in the *House of Life* in the famous **library of Alexandria.**

II.3 GREEK SCIENCE

II.3.1. Extent of Greek civilization in history

Those who are called Greeks, but who call themselves Hellenes, are of Indo-Aryan origin and populated present-day Greece around the year (–2000).

During the archaic period (–750/–500) the mercantile economy developed and the bourgeoisie and at the same time the blossoming of science and philosophy.

At that time, several cities founded colonies around the Aegean Sea, in southern Italy (Great Greece), in Sicily. The city of Miletus alone founded 80 colonies, including Naucratis, on the Nile delta. Among the colonies of Phocaea is Massalia (Marseille), founded around -600. Greek civilization spread over almost the entire Mediterranean and the Black Sea.

The following period (–500/–338) is the so-called classical period. The democratic system is spreading. Ionia is conquered by the Persians and mainland Greece fights against them (Medic wars). Civil wars rage between various cities, in particular between Athens and Sparta, this period marks the pinnacle of classical Greek culture in literature and the arts. It is also the time of Socrates, Plato and Aristotle.

After -338, Greece came under Macedonian domination but its civilization spread throughout the East through the conquests of Alexander the Great. Greek kingdoms shared the East (Egypt of the Ptolemies, Syria of the Seleucids) and Greek cities flourished: Alexandria in Egypt, Antioch, Pergame, etc. The Greek language becomes the language of communication in the Mediterranean. This is the Hellenistic period, that of the apogee of ancient science.

II.3.2 Character of Greek science

Greek philosophy is characterized above all by a concern for intelligibility: we wanted to understand phenomena by inserting them into a system. It is also characterized by the use of logical reasoning), but in general very speculative.

The Greeks are above all excellent dialecticians, that is to say, they strive to convince their interlocutors. One of the main tasks of the great Greek philosophers will be the sanitation of logic and dialectics.

It remains that the Greeks are clearly distinguished from their Eastern predecessors by this taste for speculative philosophy and geometry. The Greeks did practically no scientific experiments in the sense we understand it today.

We will divide Greek science into three periods, corresponding to the eras: (1) archaic, (2) classical and (3) Hellenistic.

II.3.3 The Archaic Period (The Pre-Socratics)

II.3.3.1 The first Ionian philosophers

The first known Greek philosophers did not inhabit Greece proper, but the periphery of the Greek world, notably Ionia and southern Italy. The city of Miletus was the most important in Ionia and was the homeland of several philosophers of this period.

- The main characteristic of the Ionian philosophers is their ***materialism:*** they propose an explanation of natural phenomena without having recourse to the intervention of the gods, but only by the natural play of matter[3]. They are the inventors of the concept of ***Nature,*** in Greek ***physis,*** as distinct from the supernatural world.
- The first known philosopher is **Thales** of Miletus, one of the "seven sages" of ancient Greece, he drew the course of the sun from one solstice to another, and demonstrated that compared to the sun, the moon is the one hundred and twentieth part. It was he again who fixed the duration of the month at thirty days, and who wrote the first treatise on Nature. He suspected that water was the principle of things, that the world was animated and full of demons. It is said that he discovered the seasons of the year, and that he divided it into three hundred and sixty-five days, he measured the Pyramids by calculating the ratio between their shadows and that of our body.
- **Anaximander** from a younger generation than Thales, also from Miletus, was perhaps the pupil and **Anaximenes,** last representative of the school of Miletus

- **The Pythagoreans**

Little is known of PYTHAGORE, except that he was born in Samos in (-572) and that he emigrated to Crotona, in southern Italy. He founded, in Crotona, a politico-religious sect, whose disciples were subjected to strict discipline. The sect of Pythagoras exercised temporary control over Croton, but soon the inhabitants revolted against such a rigid order and forced the exile of Pythagoras to Metapontum, where he died around -500.

- A disciple of Pythagoras, PHILOLAOS (-470), left Italy for Greece where he founded a Pythagorean community. Philolaos left us a model of the Universe: The Earth is spherical. All the stars revolve around a central focal point.

- The Pythagorean doctrine involved a belief in the reincarnation of souls, it places mathematics at the heart of philosophy. The Pythagoreans knew the so-called “Pythagorean theorem”, apparently without proof, gradually adopted the requirement of a proof in the study of mathematics, integrated music into mathematics; The fact that the sounds produced by vibrating strings are in harmonious ratio when the lengths of these strings have integer ratios (at equal tension and density) was of capital importance to them. This fact tended to demonstrate that “numbers are the models of things”.

II.3.4 The classical period

- **Socrates**

Socrates has been called "the midwife of reason" because of his dialectical method which consists to guide his interlocutor towards a rational conclusion rather than presenting his ideas directly to him.

- **Plato and his school**

Plato Unlike Socrates, of whom he is the most important disciple, Plato is interested in the physical world and the means of knowing it, Plato is above all an idealist in the strong sense of the term: he distinguishes the sensible world (that of sensations) of the intelligible world (that of ideas). Note that in Greek, eidos can be translated both by idea and by form. However, he attaches great importance to the study of geometry and the stars.

- **Eudoxus of Cnidus**

Attached to the school of Plato, Eudoxe of Cnide (–406/–355), considered one of the greatest mathematicians of antiquity. Eudoxus' main contribution to mathematics is the introduction of the concept of 'magnitude'. Problems that could have been handled algebraically or arithmetically are now expressed in purely geometric language.

- **Aristotle**

Aristotle (–384/–322) was a disciple of Plato. He founded his own school in Athens which was called Lyceum, because of its location on a site dedicated to Apollo Lycian. Aristotle often gave his lessons while walking in the company of his students. After Aristotle's death, his school was led by Theophrastus (– 322/–287), then by Strato (–286/–270) and by Lycon (–270/–228).

According to Aristotle, we must distinguish sensitive knowledge (ie provided by our senses) from truly scientific knowledge, obtained by a series of definitions and demonstrations. In this sense, Aristotle is Platonic. However, unlike Plato, Aristotle admits that ideas are partially accessible through the senses.

Aristotle is the founder of natural history (biology) and devotes at least a quarter of his treatises to it.

II.3.5 Classical Greek Medicine

Temple medicine: During the classical period, two types of medicine were opposed in Greece: the medicine of the temples and that of the different schools of medicine. The first is a magical practice, flourishing in Greece at the very moment of the birth of philosophy and rational science.

It is possible that she was imported from Egypt, or at least strongly influenced by her. In addition, there were herbalists who prepared a host of traditional remedies.

Their practice is not only empirical, but tinged with magical beliefs. In particular, they believed that certain plants should be picked at particular times of the lunar cycle, by pronouncing certain formulas or incantations.

Medical Schools: Parallel to – and in opposition to temple medicine there were medical schools. **The school of Cnidus** attached great importance to observations (for example, auscultation of the lungs was practiced there), but was reticent about theory.

The school of Cos, on the contrary, insisted on the importance of theory and reasoning, the medicine of Cos is the first truly scientific medicine, although its theories seem very naive to us today. The most illustrious representative of the school of Cos is Hippocrates (-460/ *-377).* We can rightly consider Hippocrates as the father of scientific medicine, because of his caution, his distrust of magical practices.

II.3.6 The Hellenistic period

The Hellenistic period was cluttered with wars ended with the Roman conquest of the Greek world, with the mixing of ideas, cultures and religions that took place there, this cosmopolitan period is that of antiquity that most resembles our modern world. It was at this time, more precisely between (-300 and -150) that ancient science reached its peak[3].

- **Alexandria and the Museum**

Alexandria was not only the capital of the kingdom of Egypt, but the effective metropolis of the Greek world and of science until the fifth century of our era, that is to say for seven centuries.

- Ptolemy I is the founder of the Museum of Alexandria which was a cultural and scientific institute inspired by Aristotle's High School, but on a larger scale.
- The Museum had promenades, classrooms, cells (offices), an observatory, dissecting rooms, living quarters and even a zoological garden, it was flanked by a huge library, which numbered several hundred thousand volumes (in the form of papyrus rolls).

II.4 THE ROMANS

The decline of the ancient sciences undeniably occurs from the beginning of the Roman Empire. The strictly Roman contributions are more technological than scientific. It is however worth mentioning their architecture, The Romans, **excellent engineers,** left roads and buildings still usable after 2000 years, but their reluctance in the face of speculative philosophy did not allow any real development.

Among the Latin authors touching on science, let us quote:

1. **Titus Lucretius Carus, (-98/ -55)** is a poet attached to the Epicurean school. In a long poem entitled *De Natura Rerum* (Of Nature), he describes Epicurean physics and draws moral lessons from it.

He warns humans against needless fear of the gods, since the fate of the world is governed by material phenomena only.

2. **Marcus Vitruvius Pollio** is an engineer-architect of the first century BC. In his work, *De Architectura* (On Architecture), he explains not only the theoretical and aesthetic principles of architecture, but also the basics of physics and mechanics known at the time.
3. **the Elder Caius Plinus Secundus, (23/79)** is above all a naturalist, author of a vast encyclopedia (the first known) entitled *Natural History* in which he wants to bring together all the knowledge of his time.

II.5 CHINA

II.5.1 China in history

China has been hosting to an **organized civilization** from the earliest antiquity. Although it has not always been unified, it has nevertheless experienced less upheaval than the Mediterranean world and has enjoyed much greater ethnic and cultural stability.

II.5.2 Character of Chinese science

- The Chinese did not practice a speculative and deductive philosophy like the Greeks.
- Their science is both more practical and more observational.
- The Chinese term for **"science",** *kexue,* means **"classifying knowledge".**
- Ancient Chinese techniques were generally superior to those of Europeans until the 15th century.

- The greatest Chinese cultural and scientific thrust dates back to the Warring States period (–5th/– 3rd centuries) and curiously coincides with the period of greatest progress in Greek science.
- The next period, during which a bureaucratic empire takes hold, also marks a slowdown in progress. This slowdown is attributed to Confucian social doctrine, which tends to favor a stationary regime by suppressing individual selfishness and competition, which prevents the emergence of a merchant bourgeoisie, to the benefit of a caste of civil servants.
- However, it seems that the existence of a merchant bourgeoisie is very favorable to the rapid development of science and technology[3].

II.5.3 Chinese technical innovations

Some Chinese innovations that only found their way to the West later:

1. Printing, usually without movable type.
2. The compass.
3. The universal joint (known *as Cardan* in the West).
4. Mechanical clocks.
5. Gunpowder
6. magnetic compass
7. blood circulation

Among China's most important scientists are **Shen Kuo** (1031-1095) and **Zhang Heng** (78- 139)

II.5.4 Mathematics

The Chinese used, as early as the -14th century, a positional numeral system based on 10. Their language included monosyllabic words for all the numbers from 1 to 10, in addition to 100 and 1000. These words are still the same today today.

- Calculations were therefore relatively simple in China, compared to Greece, which explains
- their greater prowess in algebra, but also their weakness in geometry.
- The zero was not introduced until the 8th century.
- The abacus (or abacus) was invented between the 3rd and 6th centuries and made it possible to quickly perform complicated arithmetic calculations.

- Chinese geometry was much less developed than that of the Greeks.
- The Chinese however knew the Pythagorean theorem, an ingenious proof of which was given by **Tchao Kiun king** in the 2nd century.
- Their value of ÿ is remarkably precise: in the 3rd century, Lieou Houei obtains $\pi \approx 3, 14159$. Tsou
- Tchong Tche, a little later, obtains $3.1415926 < \pi < 3, 1415927$

II.5.5 Astronomy

- The Chinese have used a year of 365.14 days from the first centuries of their history.
- They compiled extensive star catalogs (a catalog from the Warring States period has 1464 stars) and
- meticulously observed novas and comets.
- These old observations are still useful to astrophysicists.
- The Chinese used an equatorial celestial coordinate system, as is customary in astronomy today.
- The ancient Chinese cosmology is naive. However, it is said that there is no celestial vault (the
- “extended night”) and that the stars float in the void.
- From the year 527, mention is made of marine fossils and the correct explanation is given: the formation of mountains at the bottom of the ocean.

II.5.6 Physics

Chinese physics is based on two principles (yin and yang) and on five elements (or agents): earth, fire, metal, water and wood. The two principles are in constant opposition and Nature always seeks to restore the balance. The following qualities are associated with the two principles[3]:

1. Yin: dark, cold, damp, feminine, odd.
2. Yang: clear, warm, dry, masculine, even.

As for the five elements, they also correspond to.

1. five flavors (sour, bitter, sweet, astringent, salty),
2. five places (north, east, south, west, center),
3. five colors (blue-green, red, yellow, white, black),

II.6 INDIA

India, a land steeped in history and ancient wisdom, boasts one of the world's oldest and most profound civilizations. Stretching back over 4,500 years, the Indian civilization has been a cradle of diverse cultures, languages, and traditions. From the great Indus Valley Civilization, one of the world's earliest urban centers, to the Vedic period's philosophical and scientific contributions, India's heritage is rich and multifaceted. Throughout millennia, it has been a melting pot of ideas, spirituality, and artistic expression, giving birth to major religions like Hinduism, Buddhism, Jainism, and Sikhism. India's contributions to mathematics, astronomy, literature, and medicine have left an indelible mark on human knowledge[3].

II.6.1 The Vedic Indians

In the middle of the second millennium BC, at the beginning of the Iron Age (-1500), Aryan-speaking peoples gradually invaded Iran and northern India.

- The invaders of India are said to be Vedic Aryans and their language is Sanskrit, still today the sacred language of India.
- These people elaborate sacred texts called Vedas (meaning “knowledge”), the main one being the Rig Veda (Veda of hymns).
- The Vedas contain by allusion certain conceptions of the material world, in particular on a certain normal order of the world. •
- During the first millennium BC, supplements to the Vedas, the Brâhmanas, were written.
- The Vedic world system is described in one of them. The immense influence of the Vedic religion is felt in all the “scientific” knowledge of the Indians.
- In fact, astronomical and mathematical knowledge is difficult to dissociate from religion for them.

II.6.2 Astronomy

- The Vedic Indians placed great importance on astronomy, due to their deep belief in cycling, ie the cyclical repetition of the world's race and events.
- Knowledge of the period of revolution of the stars was therefore important.
- The great length of certain cycles forced the Indians to develop a number system that could describe very large numbers.
- The Vedic calendar uses a year of 12 months of 30 days (360 days). A leap month of 25 or 26 days is added every five years. Each day is divided into 15 “hours” (or moments) of day and 15 moments of night.

- The number of these moments in a year is therefore 10,800, which is also the number of metric units in the Rig- Veda! A certain mystique of numbers seems to characterize Vedic philosophy.
- It seems that the Greeks influenced India very early in astronomy, through contacts during the conquests of Alexander and also later.
- However, the Indians made, for religious reasons, careful observations of the movement of the Moon and the Sun.
- The astronomer Aryabhata (born in 476), who perfected the system of epicycles borrowed from the Greeks and who believed in the rotation of the Earth, used the value $\pi = 3.1416$.
- In trigonometry, Aryabhata is also the inventor of the sine.
- Indian mathematics is subordinate to astronomy: there is no treatise on pure mathematics and mathematical knowledge is exposed in treatises on astronomy.
- On the other hand, no importance seems to be given to evidence, which is a major setback compared to the Greeks.
- In ancient times, the Indians used a semi-positional numeral system, with different symbols for 1-9, 10-90, 100-900, etc.
- It is generally accepted that the zero made its appearance in the 5th century, the numbers from 1 to 9 being older.
- Westerners say that the most lasting legacy that Indian science has left to humanity is undoubtedly the decimal numeral system of nine Arabic Indian digits plus zero.
- However, the oldest inscription still visible using this complete decimal system dates from the year 876, a date coinciding with the Muslim civilization.
- The decimal system with zero reached China to the east and spreads to the West in the 12th century.
- In chemistry, they carried out remarkable work in the fusion of iron

II.6.3 Medicine

They discovered that some illnesses were caused by changes in the environment (change of seasons, poor hygiene, etc.), but they did not try to classify the illnesses.

- The fundamental treatise of Hindu medicine is **Ayurveda**. The latter explained that diseases are due to an imbalance and that thus to cure a patient it is necessary to replace the harmful elements by those which are harmonious.
- Explanations of various surgical operations are also prese

Conclusion

In conclusion, the journey through the history of science, from prehistoric times to antiquity, reveals the remarkable evolution of human understanding and curiosity. During the prehistoric era, our ancestors' keen observations of the natural world laid the foundation for scientific inquiry. They made significant strides in understanding celestial patterns, animal behaviors, and plant properties, setting the stage for the systematic study of nature.

In antiquity, the torch of knowledge was carried forward by ancient civilizations such as Mesopotamia, Egypt, China, India, and Greece. These cultures made groundbreaking contributions to various scientific disciplines, including mathematics, astronomy, medicine, and philosophy. Thinkers like Pythagoras, Euclid, and Aristotle pioneered theories and concepts that shaped the course of scientific exploration for centuries to come.

As we reflect on prehistory and antiquity, we recognize the ingenuity and intellectual curiosity of our forebears. Their discoveries, theories, and methods form the bedrock upon which modern science stands. The lessons learned from these early pursuits continue to inspire contemporary scientists, reminding us of the enduring human spirit that seeks to unravel the mysteries of the universe. The chapters of prehistory and antiquity serve as a testament to the enduring human quest for knowledge, a quest that continues to drive scientific inquiry and discovery in the modern age.


CH02: MIDDLE AGES AND THE RENAISSANCE
TCSNV-MSILA-1st YEAR / 2023-2024

INTRODUCTION

The Middle Ages, spanning from the 5th to the 15th century, occupies a pivotal position in European history, signifying the transition from the decline of the Western Roman Empire to the advent of the Renaissance and the Great Discoveries. Positioned between Antiquity and modern times, this era is meticulously divided into the High Middle Ages (6th - 10th century), central Middle Ages (11th - 13th century), and late Middle Ages (14th – 15th century).

Commencing in 476 with the deposition of the last Western Roman emperor, the Middle Ages' conclusion is conventionally marked at the end of the 15th century, yet contextual variations exist, such as the fall of Constantinople in 1453, Christopher Columbus's inaugural voyage in 1492, or the start of the Protestant Reformation in 1517. Despite these symbolic dates, contemporary historiography posits the Renaissance, spanning from the 15th to the mid-16th century, as the true bridge from the Middle Ages to modern times.

The Western Middle Ages, extending from 476 to 1492, covers a span of one thousand and sixteen years, with the Renaissance acting as a transitional phase. Despite being often labeled as the Dark Age, this period witnessed the preservation and enrichment of Greek sciences through Arabic translations, particularly during the Arab-Muslim civilization's golden age.

The Middle Ages, marked by theological dominance and a relative stagnation of sciences, saw rare individuals making strides in biology, including figures like Averroes, Michael Scot, and Abu Muhammad Ibn al-Baitar. The Renaissance, occurring at the Middle Ages' closure, ushered in transformative innovations in navigation, cartography, and medicine, fostering a renewed interest in various scientific disciplines.

Advancements in the Renaissance, ranging from the invention of the printing press to astronomical discoveries and the evolution from alchemy to modern chemistry, signify a profound shift in the scientific landscape. The dissemination of knowledge improved, allowing for mass education and the formation of a scientific community, creating a bridge between distinct disciplines united by scientificity and mathematics.

As the Renaissance unfolded from 1450 to 1600, it marked a period of rebirth and transition, witnessing the popularization of innovations like the comp ass and sextant, developments in cartography, and the emergence of figures such as Christopher Columbus, Leonardo da Vinci, and Galileo. This era not only reshaped Europe's geographical and cultural identity but also laid the foundation for the autonomy of science and the development of its first theoretical systems. In this chapter, we will provide full detail on what was mentioned in the introduction, and our focus will be on the Middle Ages and the Renaissance eras.

III. THE MIDDLE AGES: (Western, and Eastern)

The **Middle Ages** is a period in the history of Europe, extending from the 5th century to the 15th century, which began with the decline of **the Western Roman Empire** and ended with **the Renaissance** and the Great Discoveries. Located between **Antiquity** and **modern times,** the period is subdivided between: **the High Middle Ages** (6th - 10th century), **the central Middle Ages** (11th - 13th century) and **the late Middle Ages** (14th – 15th century) [4].

The most commonly accepted date for the starting point of the Middle Ages is **the year 476,** when the last Western Roman emperor was deposed, and this was first proposed by **Bruni.** The end of the Middle Ages is generally placed at the end of the 15th century but depending on the context, the exact date may vary. We can for example cite the fall of Constantinople in 1453, the first voyage of **Christopher Columbus** in 1492 or the start of the Protestant Reformation in 1517. These symbolic dates alone do not mark a change of era and contemporary historiography considers that the Renaissance period from the beginning of the 15th century to the middle of the 16th century marks the transition from the Middle Ages to modern times. In the same way, there was no sudden passage from Antiquity to the Middle Ages but a fairly long process called Late Antiquity extending from the end of the 3rd century to the middle of the 7th century. A broader definition is given by **Jacques Le Goff,** defender of a Western ***"long* Middle Ages"** which would extend from the 4th century (the establishment of Christianity) to the 18th century (the industrial revolution in Great Britain and the French Revolution), contesting the idea that the Renaissance would have put an end to medieval culture.

The Western Middle Ages is therefore located between 476 and 1492 years after Jesus Christ. It extends over a period of one thousand and sixteen years. The Renaissance is a period of transition between the Middle Ages (≈476-1492) and modern times (≈1492-1789).

In the Middle Ages , the Greek sciences were preserved, in particular by the translation into Arabic of many books, present in the Library of Alexandria. These sciences are then enriched and disseminated by **the Arab-Muslim civilization** which then lives a golden age (AlKhwarizmi, Avicenna, Averroes). We owe him many works in astronomy, geography, optics, medicine, but also in mathematics (mainly algebra, combinatorial analysis and trigonometry).

The Eastern Middle Ages go back to Antiquity when the first civilization would have settled in Sumer in Mesopotamia. The establishment of the Sumerians dates back to the Uruk period, that is to the 4th millennium BC . For several millennia, the Middle East was one of the centers of cultural and scientific development among the most important in the world, contact with European, African and Asian civilizations led to the development of the exchange of goods, knowledge and multiple conflicts for the control of wealth, holy places, or communication channels. So, the Islamic civilization greatly improves knowledge and culture, for example the schools of medicine. The Arabs will import paper into the West, buying the technique from the Chinese and then importing it into Europe through their conquests[4].

The Middle Ages (The Dark-Age) is the time of the reign of theology (the inquisition), a very long period in which the sciences are blocked, in regression and have even become prohibited. Only a few rare people will be able to afford to do a little biology, and still very badly[4]:

- **Averroes (1126 to 1198)** is a cultured Spaniard who translates ancient texts into Arabic, and translations of the scholastic philosopher.
- **Michael Scot (1175-1236),** this will be the starting point of a renewed interest in the animal world.
- **Abu Muhammad Ibn al-Baitar (1190-1248)**: is an Arab physician and botanist who devoted several works to the pharmaceutical knowledge of his time. In particular, he described the properties of more than 1400 species of plants.
- **Vincent de Beauvais (1190-1267)** is the author of the *Speculum Naturale* or *Mirror of nature* in which he summarizes the knowledge of his contemporaries in natural history.
- **Frederick II of the Holy Empire (1194-1250)** wrote an illustrated manual of falconry and ornithology, “De Arte venandi cum avibus”, in which he described more than 900 species of birds. He records very precise observations on the behavior of birds, far ahead of his time. He does not hesitate to criticize Aristotle, whom he criticizes for having only a theoretical knowledge of birds.
- **Albert the Great (1200-1280)** is the author of a vast treatise, De *animalibus,* devoted not only to fauna, but also to flora and minerals. authored 21 books on anatomy.
- **Thomas de Cantimpre (1201-1272)**, whose *De Naturis Rerum* is a compilation of knowledge of the time in natural history.
- **Konrad von Megenberg (1309-1374)**, whose best-known work, “ *Das Buch der Natur”* was the first text on natural history written in the German language.
- The 12th century saw the rediscovery **of Aristotle** and his treatises devoted to animals, notably through the commentaries of the Arab philosopher, and in the 13th century, **Ibn al** Nafis, working in a hospital, wrote the "Complete Manual of the Art of Medicine ".

The following table represents the chronology and some Highlights from the time of (Antiquity – Middle Ages):

Name of the time	Approximate and symbolic dates	Some highlights of the time	Dynasties
Antiquity	-3500 – 476 (≈ 4000 years)	• Invention of writing (-3500) • Ancient Egypt (-3150 to -31) • Ancient Rome (-753, founding of Rome, to 476, fall of the Western Roman Empire) • Germanic Iron Age (400- 800) • Fall of the Western Roman Empire	**Ancient Egypt:** Monarchy (pharaohs) **Ancient Rome:** Monarchy (kings) (-753 to -509) Republic (consuls) (-509 to - 27) Empire (emperors) (-27 to 476)
High Middle Ages	476 – 987 (≈ 500 years)	• The Merovingians conquer Gaul (481-537) • Charles Martel stops the Muslim advance (732) • Troubled change of dynasty (753) • Viking Age (793-1066) • Creation of the Holy Roman Empire (962- 1806)	**Merovingians** (457-751) **Carolingians** (751-987)
Middle Ages Central or Classical Middle Ages	987 – 1328 (≈ 300 years)	• Troubled Dynasty Change (987) • Discovery of America by the Vikings • Writing of the Roman de Renart (12th -13th century • Catharism (12th century and 13th century) • "Curse" of the Capetians and change of dynasty (1316-1328)	**Direct Capetians** (987-1328)
Late Middle Ages Or Middle Ages late	1328 – 1498 (≈ 200 years)	• Great inventions and discoveries	**Valois direct** (13281498)

IV.THE RENAISSANCE

The Renaissance is a period that takes place at the end of the Middle Ages and at the beginning of modern times. In the course of the 15th century and in the 16th century, this period made it possible to launch many innovations that were popularized, such as the compass or the sextant ; cartography developed, as well as medicine, thanks in particular to the current of humanism. According to English historian **John Hale,** it was at this time that the word Europe entered common parlance and was endowed with a frame of reference solidly supported by maps and a set of images affirming its visual and cultural identity. Science as a discipline of knowledge thus acquired its autonomy and its first great theoretical systems [4].

The dissemination of knowledge improves: in the 12th century, ancient texts are rediscovered

(Aristotle) preserved and enriched by the Arabs, then the invention of paper is imported from China to finally culminate with the invention of the printing press (1453) (also imported and improved by **Gutenberg),** and the first printing of a book devoted to natural history dates back to at least 1475. It concerns an illustrated version of the *Buch der Natur* written by **Konrad von Megenberg** in the previous century. This made it possible to distribute more books (manuscript copies took time) and above all to publish books in vernacular languages instead of Latin, thus spreading culture.

Many advances are made in geography and cartography, **Pierre d'Ailly** and *the Imago mundi* from 1410; and map of **Fra Mauro** in 1457. These encourage technical progress around navigation (caravel) and positioning (compass, sextant, etc.). Maritime exploration extends around the African continent (Portuguese), then towards the new world. However, there was indeed a radical change in vision of the world, which focused more on the awareness by the greatest number of the roundness of the Earth (it had been rediscovered in cultivated circles since the 12th century), from the moment that navigators had crossed the Atlantic. In particular, the voyages of **Christopher Columbus** had a considerable impact[4].

IV.1 Astronomy

Directly permitted by the mathematics of the 21st century, astronomy is emancipated from astrology. Solving third-degree equations thus allows **Johannes Kepler** to calculate an earthrise on the Moon. The astronomical discoveries of **Nicolaus Copernicus,** by **Tycho Brahe** and **Galilee** especially, who, at the end of the 16th century, invented the telescope and drew up the first maps of the stars of the solar system, will have the most important repercussions on modern science. Europe passes thus with **Nicolas Copernicus**

from a geocentric image of the world to a modern heliocentric conception (the earth revolves around the sun), from a “closed world to an infinite world” in the words **of Alexandre Koyré.**

IV.2 Alchemy to chemistry

Esoteric science since Antiquity, alchemy gave birth, during the Renaissance, to modern chemistry, even if it was with **Lavoisier** especially, in the 17th century, that the divorce will be effective. By proposing a classification by properties of the elements, alchemy leads to an initially intuitive then experimental knowledge of matter. Many philosophers and scholars are thus at the origin of alchemists, such as **Francis Bacon** or **Pierre Gassendi,** and even, later, **Isaac Newton.** The atomist vision of alchemy will thus be confirmed by the first physicochemical laws, with **Nicolas Lemery** (1645 - 1715) who published the first treatise on chemistry.

IV.3 The emergence of modern physiology

The medical discoveries and advances made in the knowledge of anatomy, especially after the first translation of many ancient works **of Hippocrates and Galen** in the 15th and 16th centuries allowed advances in hygiene and the fight against mortality. **Andre Vesalius** thus lays the foundations of modern anatomy while the functioning of blood circulation is discovered by **Michel Servet** and the first artery ligatures are performed by **Ambroise Pare** and **Misha Balabushkin.**

IV.4 Dissemination of knowledge

The field of techniques progresses considerably, thanks to the invention of the printing press by **Gutenberg** in the 15th century, an invention that upsets the transmission of knowledge. The number of books published thus becomes exponential, mass education is possible, moreover scientists can debate through the reports of their experiments. Science thus becomes a community of scholars.

Finally, the Renaissance allows, for the scientific disciplines of matter, the creation of distinct disciplines and epistemologies but united by scientificity, itself permitted by mathematics, because, according to the expression of **Pascal Brioist :** "the mathematization of a practice leads to giving it the specific title of science”.

The following table represents some outstanding characters of the renaissance (15th - 16th century):

Era name	Approximate and symbolic dates	Some notable figures of the Renaissance
Rebirth ("Transition")	1450–1600 (≈ 150 years)	• **Christopher Columbus** (Italian navigator, 14511506) • **Leonardo da Vinci** (Italian polymath, 1452-1519) • **Nicolas Machiavelli** (Italian theorist, 1469-1527), • Nicolaus Copernicus (Polish physician and astronomer, 1473- 1543) • **Otto Brunfels** (German botanist, 1488-1534), • **Pierandrea Mattioli** (Italian physician and botanist , 1501- 1577); • **Leonhart Fuchs** (German physician and botanist , 1501-1566), • **Nostradamus** (French physician, apothecary and astrologer, 1503-1566) • **Andrea Cesalpino** (Italian philosopher, physician, naturalist and botanist , 15191603), • **Prospero Alpini** (Italian physician and botanist , 1553-1617), • **Gaspard Bauhin** (Swiss naturalist, 1560-1624); • **Galileo** (Italian physicist and astronomer, 15641642); • **William Shakespeare** (English poet, playwright and writer, 1564-1616);

Conclusion

The Middle Ages, spanning from the 5th to the 15th century, marked the transition from the decline of the Western Roman Empire to the Renaissance and the Great Discoveries. Divided into the High, Central, and Late Middle Ages, this period witnessed the preservation of Greek sciences in the West and significant cultural and scientific developments in the East. The Western Middle Ages, lasting from 476 to 1492, saw the dominance of theology, leading to a restriction and prohibition of sciences. Notable individuals like Averroes, Michael Scot, and Ibn al-Baitar made contributions despite these challenges.

The Renaissance, occurring in the 15th and 16th centuries, was a transformative period bridging the Middle Ages and modern times. It saw innovations in navigation, cartography, medicine, and the development of humanism. The dissemination of knowledge improved with the rediscovery of ancient texts, the invention of paper, and the printing press. Advances in astronomy, from a geocentric to a heliocentric model, marked a significant shift in worldview. Alchemy evolved into modern chemistry, and progress in anatomy and physiology contributed to advancements in medicine.

The Renaissance facilitated the creation of distinct scientific disciplines, united by scientificity and supported by mathematics. The era allowed for mass education through the printing press, fostering a community of scholars and laying the foundation for modern science.

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

MODERN TIMES

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

By BENREZGUA.E

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.

In the **19th** century, scientific development experienced a remarkable acceleration. Mathematics advanced through the contributions of Cauchy and Riemann, while Young and Fresnel revolutionized the understanding of optics. Maxwell's unification of electricity and magnetism, Mendeleïev's classification of elements, and Darwin's theory of evolution through natural selection reshaped biology. The formulation of cell theory emphasized the importance of cellular structure, biogenesis, and continuity, laying essential groundwork for modern biology.

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. MODERN TIMES

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**[5]**.
- **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 nonexistence 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. *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 [5]: (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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[4] Boyle, Robert. "The Sceptical Chymist." 1661.

[5] Kuhn, T. S. (1962). *The Structure of Scientific Revolutions.* University of Chicago Press. Kuhn's work addresses how scientific progress occurs through paradigm shifts.