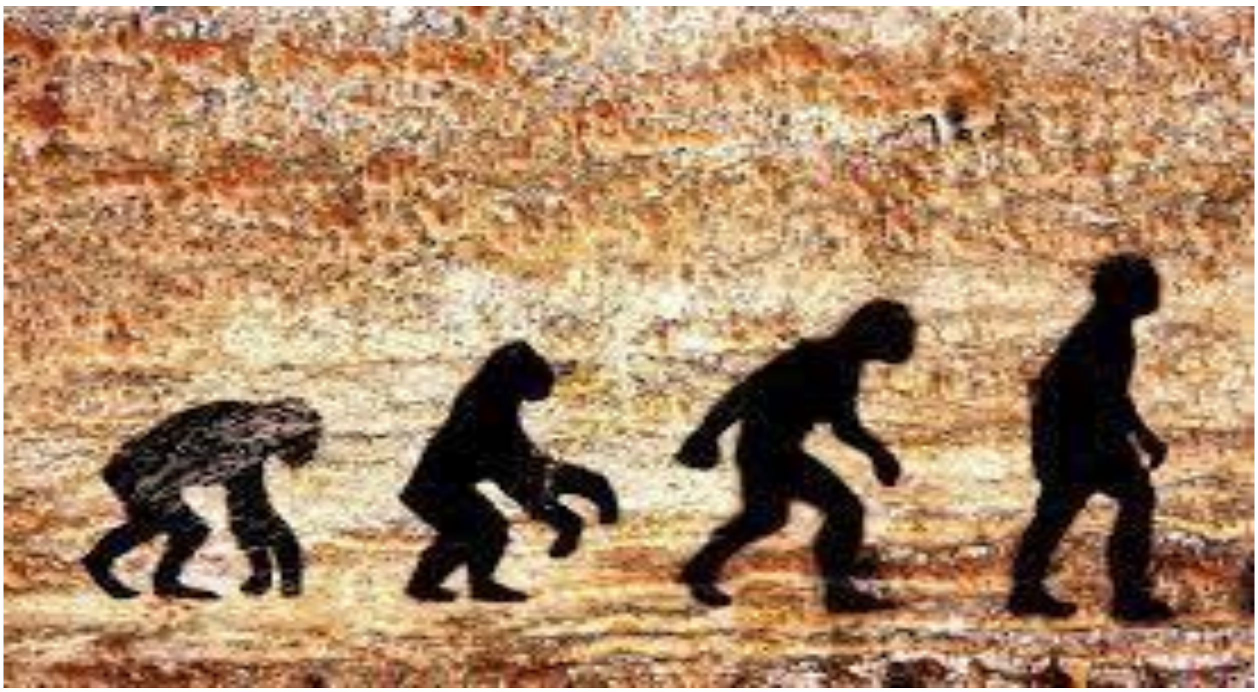
Abdelhafid Boussouf University Center of Mila
Institute of nature and life sciences
Common Core Natural and Life Sciences

Educational Handout

UNIVERSAL HISTORY OF THE BIOLOGICAL SCIENCES



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Abdelhafid Boussouf University Center of Mila
Institute of nature and life sciences
Common Core Natural and Life Sciences (1st year)
Semester : 1st Semester
UE : Transversal Teaching Unit
Course title : UNIVERSAL HISTORY OF THE BIOLOGICAL SCIENCES

Content of the course :

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INTRODUCTION

The aim of the Universal History of Biological Sciences course is to understand and acquire the basic notions of life in prehistoric times ; to find out what made it possible to go from prehistoric times to the Middle Ages; to better understand the progressive development of science in all its fields; and to learn about the early scientists who helped revolutionize science.

This course is intended for first-year students in the Common Core Department, Semester I. It focuses on the history of biology, and the question of life across eras and civilizations. It should highlight the role of technical progress in the evolution of biology.

CHAPTER I : GENERAL

1. Definition of science :

Before embarking on a history of science, it makes sense to define what we mean by science. The word itself comes from the Latin scientia, whose root is scire, meaning "to know".

Science can be described as a complex, self-organizing, and evolving network of scholars, projects, papers, and ideas. This representation has unveiled patterns characterizing the emergence of new scientific fields through the study of collaboration networks and the path of impactful discoveries through the study of citation networks.

2. What is biology ?

The word biology is derived from the greek words /bios/ meaning /life/ and /logos/ meaning /study/ and is defined as the science of life and living organisms. An organism is a living entity consisting of one cell e.g. bacteria, or several cells e.g. animals, plants and fungi.

Aspects of biological science range from the study of molecular mechanisms in cells, to the classification and behaviour of organisms, how species evolve and interaction between ecosystems.

Biology often overlaps with other sciences ; for example, biochemistry and toxicology with biology, chemistry, and medicine; biophysics with biology and physics; stratigraphy with biology and geography; astrobiology with biology and astronomy. Social sciences such as geography, philosophy, psychology and sociology can also interact with biology, for example, in administration of biological resources, developmental biology, biogeography, evolutionary psychology and ethics.

3. History of science :

The history of science focuses on the study of scientific knowledge. It undertakes to understand both the historical development and nature of scientific thinking and fundamental scientific concepts. The history of biology traces the study of the living world from ancient to modern times.

4. Knowledge :

It's the action of understanding and knowing the properties and characteristics of something: knowledge of nature.

5. Intuition :

Direct, immediate knowledge of the truth, without recourse to reasoning or experience.

6. The technology :

It's a humanitarian effort to transform knowledge and theories into practical work to improve living standards and the human environment.

7. Some Biology disciplines :

Biology is the science of living organisms. It covers part of the natural sciences and the natural history of living beings.

Life takes so many forms and on so many different scales that biology covers a very broad spectrum, from the molecular level, through the cell, then the organism, right up to the population and ecosystem level. These different levels show that the field of life is highly hierarchical, and as biology progresses, it specializes in multiple fields, all more or less related to each other.

7.1 Biochemistry :

It is a branch of the natural sciences and is concerned with the study of the chemical composition of cell parts in various living organisms, whether they are simple organisms such as (bacteria, fungi and algae) or complex organisms such as humans, animals and plants. Biochemistry is sometimes described as the science of life chemistry, due to the link between biochemistry and life. Scientists in this field have focused on researching chemical reactions within living organisms of all kinds by studying the cellular components of these organisms in terms of the chemical structures of these components, their locations and their vital functions. As well as studying the various biological reactions that occur within these living cells in terms of construction and composition, or in terms of demolition and energy production. Which greatly helps in understanding the tissues, organs and functions of living organisms.

7.1.1 Liebig, Justus, baron von (1803-1873) :

German analytical chemist who collaborated with Wöhler in organic chemistry investigations. With Wöhler, he discovered the benzoyl radical Eric Weisstein's World of Chemistry (C7H5O) in the 1830s, providing seeming support for Berzelius's radical theory. He measured the composition of silver fulminate to be 77.53% silver oxide and 22.47% cyanic acid, which was the same ratio as Wöhler had found for cyanic acid. At first, Liebig thought Wöhler was mistaken, but was eventually forced to agree that the compounds had the same chemical formula. Also with Wöhler, he wrote an article under the pseudonym S. C. H. Windler ("Schwindler" means swindler in German) which made fun of Laurent's substitution reactions. The article related how chlorine had been made to substitute for other compounds, producing substances entirely composed of chlorine atoms, but maintaining their original chemical properties.

Liebig promoted chemistry as the central science, trying to underscore its direct benefit to man in the form of pharmaceuticals. He developed a technique for determining the carbon and hydrogen contained in a sample from the carbon dioxide and water given off when a compound was burned. He also attempted to derive physiological phenomena from physical and chemical laws. In Agricultural Chemistry (1842), he presented organic chemistry in its application to physiology and pathology. He was influenced by Helmholtz in attempting to demonstrate that body heat and muscular action could be derived from the oxidation of foodstuffs. He also sought to establish an elemental balance between ingesta, excreta, and respiratory gases.

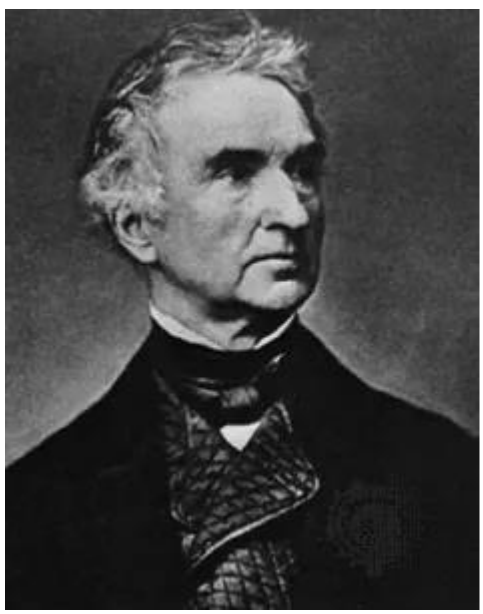


Photo 01 : Leibig, Justus von

By F. Hanfstaengl, 1868.

7.1.2 Calvin, Melvin (1911-1997) :

American biochemist who first described the photosynthetic process, now known as the Calvin Cycle. Calvin determined the process by tracking radioactive carbon dioxide through its transformation into carbohydrates. He allowed carbon-14 to be absorbed by plants, then mashed up the cells and separated the contents using paper chromatography. He discovered intermediate reaction products of photosynthesis and worked out the reaction scheme. He also discovered that photosynthesis proceeds in the absence of light. Calvin later confirmed which primary elements had formed the atmosphere from which primitive life developed. He received the Nobel Prize in Chemistry in 1961.

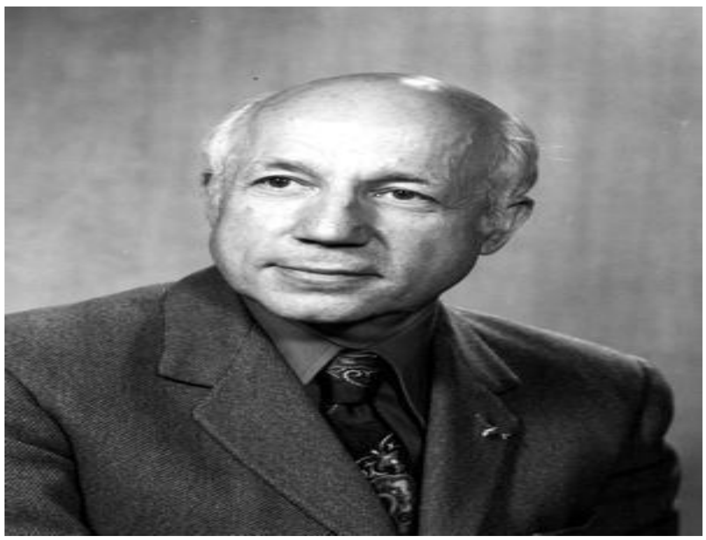


Photo 02: Melvin Calvin.

(National Academy of Science, via http://peer.tamu.edu/)

7.2 Microbiology :

(From Greek micro = small, bios = life)

Microbiology is the science dealing with study of very small organisms that can not be seen with naked eye these organisms are called microorganisms and require a microscope to be seen. This includes fungi and parasite (eukaryote), and bacteria (prokaryote), and viruses. Size is one of major criteria in differentiating microorganisms. The basic unit of measurement is the micrometer (μ = 10-3mm). The sizes of bacteria are (0.5- 15 μ).

The science of microbiology was developed with inclosing of other science development basically the progressing of the different science such as medicine cytology ,cell physiology ,genetic ,enzymology ,biochemistry ,ecology , etc. Microbiology includes the study of many types of cells, it is concerned with viruses, protozoa, bacteria, fungi, as infectious agents with emphasis on their structures and products and that allow them to cause disease. The field of microbiology includes the Following:

- **Microbial physiology :** The study of microbial growth, microbial metabolism and microbial cell structure.
- **Microbial genetics :** The study of the genetic information in microorganisms.
- **Cellular microbiology :** Study of cell biology.
- **Medical microbiology :** The study of microbial pathogenesis, epidemiology, and immunology.
- **Veterinary microbiology :** The study of the role of microbes in animal medicine.
- **Environmental microbiology :** The study the function and diversity of microbes in their natural environments.
- **Industrial microbiology :** include industrial fermentation, waste- Water treatment. And brewing.
- **Food microbiology :** The study of microorganisms causing fermentation , food spoilage and foodborne illness .

Other fields. Existence of microorganisms was hypothesized for many centuries before their actual discovery.

7.2.1 Van Leeuwenhoek, Antonie (1632-1723) :

Considered as the father of bacteriology, was an indefatigable scientist, inventor and tradesman from Delft, Netherlands who lived at the turn of the 16th and 17th centuries. He is commonly known as the "Father of Microbiology"; that title is well deserved, but diminishes his importance in other disciplines. His original thoughts and dedicated actions advanced so many fields that he is considered to be one of the greatest scientists of all time.

By refining the glass buttons that were then used by drapers to magnify their view of cloth, Leeuwenhoek created the first true (single lens) microscopes and was the first person to observe and describe single-celled organisms (microorganisms) that he termed "animcules". He was also the first to record microscopic observations of muscle fibers, bacteria, spermatozoa and blood flow in capillaries (small blood vessels), and to advance techniques in the micro-dissection of tissues. This work helped lay the foundations of Medicine, Surgery, and Cell biology, besides Microbiology.

Photo 03: Van Leeuwenhoek, Antonie.

Source : https://en.wikipedia.org/wiki/Antonie_van_Leeuwenhoek (US Public Domain image).

7.2.2 Pasteur, Louis (1822 – 1895) :

Louis Pasteur, a qualified chemist, was behind the most important scientific revolutions of the 19th century in the fields of biology, agriculture, medicine and hygiene. Beginning his research on crystallography, he soon embarked on a journey filled with discoveries which led him to develop the rabies vaccine.

Louis Pasteur's life was filled with revolutionary discoveries and also marked by a number of events that likely fueled his desire to understand the diseases of his time. A tireless and dedicated scientist, he traveled extensively throughout France to prove his theories and solve agricultural and industrial problems caused by infectious diseases.

Photo 04 : L. Pasteur.

By Nadar, 1895

7.3 Zoology :

Zoology is the branch of biology concerned with the study animals and animal kingdom. It is also known as animal biology. The study of zoology includes the interaction of animal kingdom in their ecosystems such as classification, habits, structure, embryology, distribution, evolution, and extinct species.

Zoology is the division of biology that deals with the animal kingdom. It is the scientific study related to the entire species of the animal kingdom.

The study of zoology includes animals physiology, their behaviour, and their interaction with other species in their environment. It is a huge course that includes the distribution of every animal species on earth including extinct animals. Apart from the animal kingdom and ecosystem, zoology also explores the new areas of research.

An ancient Greek philosopher, Aristotle, was a first-person to broadly classify the living things in the 4th century BC. Firstly he divided living things into animals and plants and then continued with his further classifications. Later the words like biology, botany, and zoology came into existence.

Later, Aristotle divided animals into two classes : one with red-blood and another without such as insects and crustaceans. Then, he further classified creatures into those who were able to walk, flow and swim.

The classification by Aristotle was followed until the 16th century, during the Age of enlightenment, scientists finally began to research closely. Now, zoology has become much more complex, where the living things are divided into five kingdoms, in which animal kingdom themselves divided into several smaller categories of Phylum, Class, Order, Family, Genus and, finally, Species.

7.3.1 Aristotle (384 - 322 BC) :

Aristotle is a towering figure in ancient Greek philosophy, who made important contributions to logic, criticism, rhetoric, physics, biology, psychology, mathematics, metaphysics, ethics, and politics. He was a student of Plato for twenty years but is famous for rejecting Plato's theory of forms. He was more empirically minded than both Plato and Plato's teacher, Socrates.

A prolific writer, lecturer, and polymath, Aristotle radically transformed most of the topics he investigated. In his lifetime, he wrote dialogues and as many as 200 treatises, of which only 31 survive. These works are in the form of lecture notes and draft manuscripts never intended for general readership. Nevertheless, they are the earliest complete philosophical treatises we still possess.

As the father of western logic, Aristotle was the first to develop a formal system for reasoning. He observed that the deductive validity of any argument can be determined by its structure rather than its content, for example, in the syllogism: All men are mortal; Socrates is a man; therefore, Socrates is mortal. Even if the content of the argument were changed from being about Socrates to being about someone else, because of its structure, as long as the premises are true, then the conclusion must also be true. Aristotelian logic dominated until the rise of modern propositional logic and predicate logic 2000 years later.

The emphasis on good reasoning serves as the backdrop for Aristotle's other investigations. In his natural philosophy, Aristotle combines logic with observation to make general, causal claims. For example, in his biology, Aristotle uses the concept of species to make empirical claims about the functions and behavior of individual animals. However, as revealed in his psychological works, Aristotle is no reductive materialist. Instead, he thinks of the body as the matter, and the psyche as the form of each living animal.

Though his natural scientific work is firmly based on observation, Aristotle also recognizes the possibility of knowledge that is not empirical. In his metaphysics, he claims that there must be a separate and unchanging being that is the source of all other beings. In his ethics, he holds that it is only by becoming excellent that one could achieve eudaimonia, a sort of happiness or blessedness that constitutes the best kind of human life.

Aristotle was the founder of the Lyceum, a school based in Athens, Greece; and he was the first of the Peripatetics, his followers from the Lyceum. Aristotle's works, exerted tremendous influence on ancient and medieval thought and continue to inspire philosophers to this day.

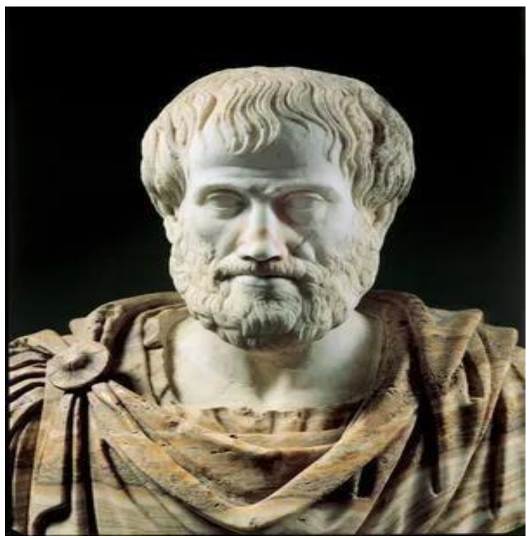


Photo 05: Aristotle.

Marble portrait bust, Roman copy (2nd century bce) of a Greek original (c. 325 bce); in the Museo Nazionale Romano, Rome, Italy.

7.3.2 Cuvier, Georges (1769-1832) :

Georges Cuvier was a French scientist from the 18th century. Cuvier was responsible for the theory of catastrophism and a new way of organizing life based on comparative anatomy.

Born in Germany in1769, Cuvier attended a strict military academy called Karlsschule in Germany from age 15 to 19. After graduating, he practiced as a tutor until age 26, when the Museum of Natural History in Paris requested that he join their staff. It was at the Museum of Natural History that Cuvier stayed and practiced comparative anatomy.

Cuvier's work in comparative anatomy broke the paradigm in biology, that life evolved in a continuous lineage from simplest organism to man. Dividing all living organisms into separate categories based on anatomical observation was ground breaking for his time.

However, Cuvier didn't accept evolution (although his work in the Paris Basin would eventually support the theory from Charles Darwin). Cuvier believed that the anatomy of all living species is so specific and crucial to its functioning that animals could not survive a significant change in their anatomy.

Cuvier was also a paleontologist and worked in the Paris Basin looking at fossil successions. Cuvier recognized breaks in the fossil succession, followed by an abrupt flourishing of life. Cuvier recognized these gaps as mass extinction events and attributed them to brief catastrophic events in earth's history.

This theory along with neptunism described the earth system as possessing volatile forces that come in and out of existence to shape the earth's landscape. These theories are in direct opposition with the theories of plutonism and catastrophism that would eventually take favor amongst the scientific community during the beginning of the 19th century.

Photo 06 : Portrait of Georges Cuvier

By James Thomson.

7.4 Botany :

Branch of biology that deals with the study of plants, including their structure, properties, and biochemical processes. Also included are plant classification and the study of plant diseases and of interactions with the environment. The principles and findings of botany have provided the base for such applied sciences as agriculture, horticulture, and forestry.

7.4.1 Theophraste (372/69–288/85 av. J.-C.) :

A Greek philosopher who first studied with Plato and then became a disciple of Aristotle, is credited with founding botany. Only two of an estimated 200 botanical treatises written by him are known to science : originally written in Greek about 300 bce, they have survived in the form of Latin manuscripts, De causis plantarum and De historia plantarum. His basic concepts of morphology, classification, and the natural history of plants, accepted without question for many centuries, are now of interest primarily because of Theophrastus's independent and philosophical viewpoint.

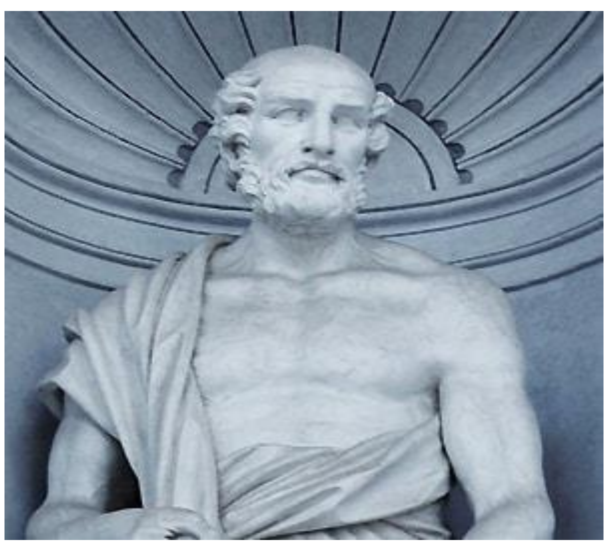


Photo 07: Roman bust of Theophrastus (c. 372-c. 288 BC).

Part of : Wellcome Trust Corporate Archive 1936.

7.4.2 Linné, Carl von (1707-1778) :

(born May 23, 1707, Råshult, Småland, Swed.—died Jan. 10, 1778, Uppsala), Swedish botanist and explorer. He studied botany at Uppsala university and explored Swedish Lapland before traveling to the Netherlands to complete his medical degree (1735). There he became the first to develop principles for defining genera and species of organisms and to create a uniform system for naming them, binomial nomenclature. Linnaeus's system was based mainly on flower parts, which tend to remain unchanged during evolution. Such a system was valuable in that it enabled students to place a plant rapidly in a named category. Linnaeus not only systematized the plant and animal kingdoms, but he also classified the mineral kingdom and wrote a study of the diseases known in his day. His manuscripts, herbarium, and collections are preserved by London's Linnaean Society. His works include Systema Naturae (1735), Fundamenta Botanica (1736), and Species Plantarum (1753).

Photo 08 : Carlous Linnaeus.

By Alexander Roslin, 1775.

7.5 Ecology :

Ecology is the science that studies the conditions of existence of living beings (animals and plants) in relation to the natural environment in which they live. It's the science of living beings' relationships with each other and with the outside world.

7.5.1 Humboldt, Alexander, Baron von (1769-1859) :

He was a scientific explorer and natural philosopher, who achieved fame following his return from South America in 1804. Already during his lifetime, biographies celebrating Humboldt began to appear , and upon his death in 1859, Humboldt was commemorated across the world—from Alexandria to New York City, from Paris and Moscow to Adelaide and Melbourne. An ocean current was named after him, as were numerous national parks, regions, and a penguin species. He has been described as the first ecologist , the "father of American environmentalism" , the inspiration behind the National Parks Movement in the United States and Great Britain, and a major influence on environmentalism in India .

Photo 09 : Alexander von Humboldt.

By Julius Schrader, 1859.

7.5.2 Ernst Heinrich (1834-1919) :

He was a German zoologist and evolutionist who was a strong proponent of Darwinism and who proposed new notions of the evolutionary descent of human beings. He declared that ontogeny (the embryology and development of the individual) briefly, and sometimes necessarily incompletely, recapitulated, or repeated, phylogeny (the developmental history of the species or race). Aineckel saw evolution as the basis for a unified explanation of all nature and the rationale of a philosophical approach that denied final causes and the teleology of the church. His Generelle Morphologie der Organismen (1866 ; "General Morphology of Organisms") presented many of his evolutionary ideas, but the scientific community was little interested. He set forth his ideas in popular writings, all of which were widely read though they were deplored by many of Haeckel's scientific colleagues.

Photo 10 : Ernst Heinrich.

[Http://en.wikipedia.org/wiki/Image:ErnstHaeckel.jpg source and rights].

7.6 Biophysics :

Biophysics attempts to explain, through physical laws, certain properties of living organisms and their physiology. Today, this science is closely linked to several biological disciplines, including biochemistry, genetics, molecular biology and microbiology. An extension of physics and physical chemistry, biophysics is concerned with biological problems, which it attempts to solve using techniques derived from the physical sciences.

7.6.1 Archimedes (287-212 BC) :

Was the most famous mathematician and inventor in ancient Greece. He is especially important for his discovery of the relation between the surface and volume of a sphere and its circumscribing cylinder. He is known for his formulation of a hydrostatic principle (known as Archimedes' principle) and a device for raising water, still used, known as the Archimedes screw.

There are nine extant treatises by Archimedes in Greek. The principal results in On the Sphere and Cylinder (in two books) are that the surface area of any sphere of radius r is four times that of its greatest circle (in modern notation, $S = 4\pi r^2$) and that the volume of a sphere is two-thirds that of the cylinder in which it is inscribed (leading immediately to the formula for the volume, $V = 4/3\pi r^3$). Archimedes was proud enough of the latter discovery to leave instructions for his tomb to be marked with a sphere inscribed in a cylinder. Marcus Tullius Cicero (106–43 bce) found the tomb, overgrown with vegetation, a century and a half after Archimedes' death.

Photo 11 : Archimedes.

By Giuseppe Nogari, 18th century.

CHAPTER II : PREHISTORY

Introduction :

Prehistory is the time before written records. It's the period of human history we know the least about, but it's also the longest by far.

The earliest known humans arrived in these lands around 900,000 years ago. Prehistory stretches from then until the Roman invasion in AD 43. Over this time, these lands underwent huge climactic, societal, political, technological and geological changes.

Prehistory is typically divided into several distinct periods based on archaeological and anthropological evidence, and it covers the time from the emergence of the earliest hominids to the invention of writing.

1. Prehistoric Periods :

1.1 The Paleolithic (Stone Age) :

Encompasses the entire period of early human history before the advent of metal use, spanning over two million years. It is traditionally divided into three distinct periods: Lower, Middle, and Upper Paleolithic, each marked by significant advancements in human tool use and lifestyle.

The Paleolithic Era, also known as the 'Old Stone' Age, derives its name from the earliest known stone tools crafted by our ancestors. This period marks a fundamental chapter in human history, characterized by the initial development of simple tools that laid the foundation for human progress. The discovery of these primitive tools, dating back to the Lower Paleolithic period, was a landmark achievement by the paleoanthropologist Louis Leakey in the 1960s. Unearthed in Tanzania's Olduvai Gorge, these tools symbolize the inception of the Stone Age and the beginnings of human ingenuity and adaptation.

Dating back 1.5 to 2 million years, early human tools consisted of choppers, scrapers, and hammerstones, primarily made from river rocks like quartz and obsidian. Mary Leakey categorized these into distinct industries, with the oldest being the Oldowan tools from Tanzania's Olduvai Gorge, indicating their wide use across Africa, Europe, and Asia. Even older tools, over three million years old, were discovered at Kenya's Lomekwi 3 site, suggesting early tool use by Australopithecus.

Photo 12 : Paleolithic art - a relief of mammoth.

Photo 13 : Paleolithic tools and bones found in Franchthi cave.

Paleolithic humans gradually gained environmental control, notably through mastering fire, evidenced by 300,000 to 400,000-year-old controlled fire use in Kenya 1.4 million years ago. A significant Upper Paleolithic development was the domestication of wolves into dogs around 30,000 years ago, signifying a profound human-animal bond.

Evidence of this includes over 30,000-year-old dog remains in Germany's Hohle Fels cave and Belgium's Goyet Caves, and a definitive 32,000-year-old canine burial in Predmosti, Czech Republic. This era also saw the rise of religious practices.

Early Paleolithic humans, including Homo erectus, led a nomadic lifestyle, moving in response to changing seasons and food sources. Living in small groups, they likely followed a cyclical migratory pattern, as suggested by their spread from Africa to Eurasia around two million years ago. Evidence of Homo erectus also includes the Meganthropus in Java, Indonesia, dated to 1.7 million years ago, and their presence in Western Europe around 1.2 million years ago, marking their widespread distribution across continents.

1.2 The Mesolithic or 'Middle Stone' Period :

The transition from the Paleolithic Age to the Mesolithic, or Middle Stone Age, is flexible. In Europe, it occurred around 15000 years ago, while around the Eastern Mediterranean and the Fertile Crescent, it came some 5000 years earlier.

In Africa, the Mesolithic era's onset varies from 24,000 years ago in modern-day Morocco to about 8,200 years ago in East Africa. In India, it spans between 12,000 and 8,000 years ago, and 10,000 to 16,000 years ago in the Far East. This era, linking the Paleolithic and Neolithic periods, saw significant hunter-gatherer societal developments, including advanced toolmaking. Known as the Epipalaeolithic in the Near East, the Mesolithic era is marked by a transition from crude Paleolithic laminar microliths to more efficient, geometric microliths, yielding smaller, less wasteful, and finely crafted tools.

The period also saw the emergence of early ceramics, with the earliest pottery dating back up to 9000 years in regions ranging from North Africa to Siberia. This development, predating agriculture, is still categorized as part of the Mesolithic despite its occasional appearance in earlier periods, as evidenced by a potentially 20,000-year-old ceramic bowl from China's Xianrendong Cave.

During the Mesolithic, human societies became less nomadic, thanks to improved hunting and fishing techniques and the abundance of food sources following the Ice Age. While still primarily hunter-gatherers, people began to utilize multiple familiar sites for living, suggesting a more settled lifestyle. This is illustrated by the Star Carr site in England, showing long-term, cyclical habitation and the earliest known carpentry work in the region.

Also, religious, artistic, and technological thought continued to expand in this era. Some 9000 years ago on the future site of Stonehenge – millennia before the great stone blocks were placed – Mesolithic humans had arranged rows of posts in what seems to be an astronomical alignment, and an apparent lunar calendar at Warren Field in Scotland dates from about the same time.

1.3 The Neolithic or 'New Stone' Period :

The start of the Neolithic, or New Stone Age, is denoted by a significant change in how humanity lived. Finally leaving behind the nomadic hunter-gatherer existence of earlier eras, humans began to raise their own food with the introduction of agriculture.

Around 10,000 B.C.E., the Neolithic era began in the Fertile Crescent with the cultivation of founder crops like flax, peas, barley, lentils, and einkorn and emmer wheat. This period saw the domestication of goats, sheep, cattle, and pigs. Agriculture's spread by 7000 B.C.E. reached Southeastern Europe, India, Pakistan, Azerbaijan, China, Southeast Asia, and later Northern Europe and the British Isles. Simultaneously, indigenous cultures in the

Western Hemisphere, starting around 9000 B.C.E. in Colombia and Ecuador, cultivated crops like squash, potatoes, and tomatoes.

This era also witnessed the evolution of Neolithic toolmaking from flaked to polished stone tools, introducing the adze for woodworking. Clothing became more sophisticated with the use of flax and wool. Notable megalithic structures like Stonehenge and Göbekli Tepe emerged, serving purposes from tombs to astronomical calendars and religious sites.

In a settled society, art and decoration become more common. A collection of pottery, sculpture (such as the acclaimed Thinker of Cernavoda, from 5000 B.C.E. in Romania), carvings, and murals from the Neolithic all demonstrate the increasing artistic demand (and sophistication) found in the New Stone Age.

Photo 14 : Pottery and tools from the Neolithic .

1.4 Acquiring knowledge in this era :

Man took these needs (food, clothing and protection) from natural sources (animals, plants and stones), where he learned the skills of hunting, protection, construction and hiding.

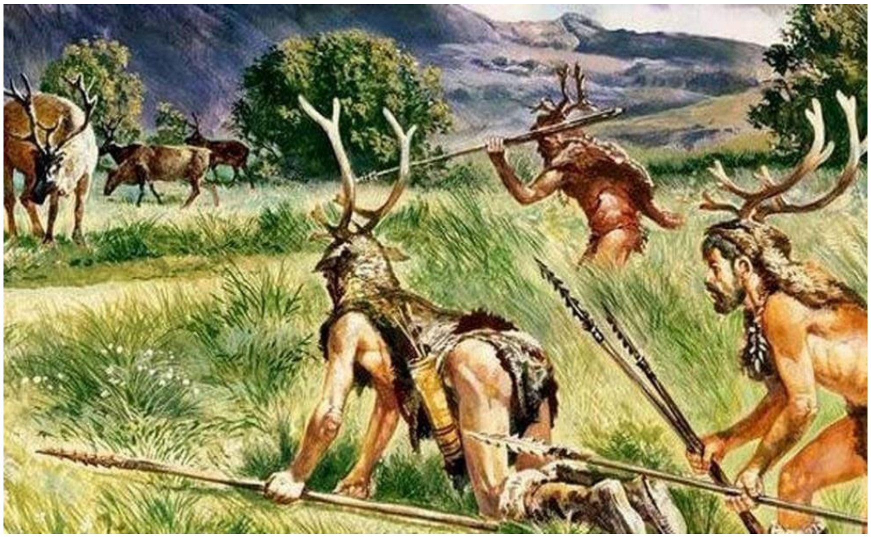


Photo 15 : Stone age hunter gatherers. Ancient Origins.

1.5 Food knowledge :

❖ **Depending on how you eat :**

1. the direct consumption stage,

2. the selection and diversification stage,

3. The blending and cooking stage.

❖ **Depending on power supply access mode :**

1. The hunting and harvesting stage,

2. The storage stage,

3. The farming stage,

4.The grazing stage.

1.6 Knowledge of raw materials :

a. Plant materials :

These were the first materials man used to make tools, because they were readily available and easy to transport and shape.

b. Animal materials :

Bone was used as a hunting and logging tool, while animal skins were used to make clothing and containers.

c. Stones :

It was easy for man to use stones as tools in his daily life because they were available everywhere and in deferent patterns, and they were also very easy to shape, which is why they were part of the raw materials.

d. Metals :

The use of metals came after a long period of use of stone. Because they are less widespread and require a change in appearance and composition, obtaining them requires knowledge of soil and rock composition.

1.7 knowledge of the defence sector :

a. clothing and footwear:

Man dressed to protect himself as he moved to regions whose environment differed from his own, and he added aesthetic purposes later.

As for footwear, it plays a protective role and makes walking safer.

b. Accommodation :

The man needed a home to protect him from the elements and aggression, as well as for his privacy.

The form of the habitat evolved from caves to roofed dwellings, and was then surrounded by blackberries.

Construction tools have evolved from plant elements to stone tools.

c. Defense:

The earth was full of wild animals, which is why man had to invent tools to fight them.

1.8 knowledge of toolmaking :

Man began with simple tools to provide food.

a. pottery tools :

The art of pottery developed at this time with the invention of agriculture, because of man's need for containers to preserve the harvest.

1.9 knowledge of the transport sector :

It began as a means of shopping, transporting crops or hunting to the place of consumption, then developed into a means of bringing people together.

The means of transport are known in 3 stages :

1. human energy, 2. animal energy, 3. hydraulic energy (boats).

CHAPTER III : ANTIQUITY

1. Mesopotamian and Babylonian science :

Ancient Babylon was an influential city that served as a center of Mesopotamian civilization for nearly two millennia, from roughly 2000 B.C. to 540 B.C. It was located near the Euphrates River, about 60 miles (100 kilometers) south of Baghdad in what is now Iraq.

Babylon had a significant impact on Mesopotamia. One of its early rulers, Hammurabi, created a harsh system of laws, while in later times, the Babylonian language was used across the Middle East as a way of communicating across borders. The law code, while not the oldest in the Middle East, is one of the most famous. The city is also famous for the construction of the Hanging Gardens of Babylon (if the ancient stories are true), a wonder of the ancient world that some people believe was built by the biblical king Nebuchadnezzar II.

The ancient scientists who lived in Babylon made important discoveries in mathematics, physics and astronomy. Among their many accomplishments, they developed trigonometry, used mathematical models to track Jupiter and developed methods of tracking time that are still used today. Ancient Babylonian records are still used by modern-day astronomers to study how Earth's rotation has changed.
It was Sumerian that first became a written language, around 3300 B.C. This writing was initially used for trade. In Mesopotamia, the writing medium was clay, which came in many forms, including tablets, cylinders and prismatic shapes.
The first traces of mathematics can be found on Babylonian clay tablets. The four basic operations were carried out using tables, and practical problem-solving was carried out using words detailing all the steps involved. Although these methods were impractical to use, they did have the merit of working, and made it possible to solve equations up to the

third degree. As in Egypt, there seems to have been no theorization of these algorithms. All that was given were empirically constituted examples, certainly repeated by pupils and scribes. As such, they are an empirical know-how, transmitted as such, and not a rational mathematical science. However, this algebra was not extended, and it was not until the work of Muslim mathematicians that this aspect of mathematics was developed.

Photo 16 : Babylonian Mthematical Tablet Depicting Their Functional Knowledge of the Pythagorean Theorem .

Again for the sake of trade, it was necessary to name animals and plants. But they didn't limit themselves to a simple enumeration, they classified them, and this went beyond the simply commercial domain. This is how certain animals and plants came to be classified into "kingdoms" (fish, crustaceans, snakes, birds and quadrupeds).

The Mesopotamians were familiar with many diseases and had remedies for all of them. Medical texts and manuals had even been written, but it would seem that the experience of the doctor was the most important. Remedies, based on plant drugs such as roots and minerals such as salt, went hand in hand with magic. In those days, for example, it was believed that certain plants had to be picked on certaines dates and administered a certain number of times (numbers such as 3, 7 and their multiples were highly prized). The recitation of incantations was also part of the remedy. The logical explanation for all this is that, in those days, illnesses were thought to be of divine origin. So, if you wanted to cure the sick, you had to appease the gods.

Geographical maps were 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, with Babylon at the center and distances represented by travel times rather than actual distances.

Archaeologically, little is known about the early history of Babylon. Ancient records suggest that more than 4,000 years ago, at a time when the city of Ur (in what is now southern Iraq) was the center of an empire, Babylon was a provincial administration center and was part of Ur's empire, wrote historian Gwendolyn Leick in her book "The Babylonians : An Introduction".

Babylon was built in an area that's "subject to very high temperatures and lies well beyond the reach of rain-fed agriculture," Seymour, a research associate at the Metropolitan Museum of Art in New York City, wrote in his book "Babylon : Legend, History and the Ancient City". He noted that an irrigation system that distributed water from the Euphrates was required to grow crops. "Once established, however, such a system could reap the benefit of rich alluvial soils and support extremely productive agriculture on the levees of canals," Seymour wrote.

Babylon's position on the Euphrates River, along with the canal systems that Babylon's rulers later constructed in the region, encouraged trade and travel, Stephanie Dalley, a retired teacher of Assyriology at the University of Oxford, wrote in her book "The City of Babylon : A History c. 2000 B.C. – A.D. 116". Prisoners captured in wars were sometimes forced to help build the canal network in the region, Dalley noted.

Leick noted that in 1894 B.C. after the Ur-based empire had collapsed, Babylon was conquered by a man named Samu-abum (also spelled Sumu-abum). He was an Amorite, a member of a Semitic-speaking people from the area around modern-day Syria. He turned Babylon into a petty kingdom made up of the city and a small amount of nearby territory. Babylon remained this way until, six kings later, a man named Hammurabi

(1792 B.C. to 1750 B.C.) ascended the throne. He had a major impact on the city's fortunes and transformed this once-small kingdom into a great empire.

Photo 17 : Babylonian Tablet of Astronomical Observations.

1.1 The empire of Hammurabi :

Hammurabi had to be patient before he could expand, Leick noted. Babylon was located between two large cities known as Larsa and Ashur, and Hammurabi had to be cautious. He used his time wisely. "At home he concentrated on improving the economic basis of his kingdom by building canals and strengthening fortifications," Leick wrote.

When the king of Ashur died around 1776 B.C., Hammurabi took advantage of the resulting power vacuum and expanded Babylon's territory by conquering Ashur. Following this, he conducted a series of campaigns against Larsa and defeated its ruler, Rim-Sin, who had ruled the large kingdom for nearly 60 years. "This victory signalled the annexation of all the old urban centers, such as Ur, Uruk, Isin and Larsa," Leick wrote. Further campaigns against Assyria and Mari further expanded Hammurabi's empire.

Archaeologists know little about what Babylon itself looked like during Hammurabi's reign. "The remains of Hammurabi's own city at Babylon are, unfortunately, almost inaccessible as the water table has risen too high to allow them to be explored," archaeology researcher Harriet Crawford wrote in a paper published in the book "The Babylonian World".

While archaeological remains in Babylon dating to this period are scarce, textual remains reveal more information. Leick noted that Hammurabi was so well respected that he became regarded as a deity. She wrote that parents gave their children names that meant "Hammurabi is my help" or "Hammurabi is my god."

Hammurabi himself discussed the nature of his divinity in his famous law code.

1.2 Mesopotamia :

Mesopotamia is located in the region now known as the Middle East, which includes parts of southwest Asia and lands around the eastern Mediterranean Sea. It is part of the Fertile Crescent, an area also known as "Cradle of Civilization" for the number of innovations that arose from the early societies in this region, which are among some of the earliest known human civilizations on earth.

The word "mesopotamia" is formed from the ancient words "meso," meaning between or in the middle of, and "potamos," meaning river. Situated in the fertile valleys between the Tigris and Euphrates rivers, the region is now home to modern-day Iraq, Kuwait, Turkey and Syria.

Humans first settled in Mesopotamia in the Paleolithic era. By 14,000 B.C., people in the region lived in small settlements with circular houses.

Five thousand years later, these houses formed farming communities following the domestication of animals and the development of agriculture, most notably irrigation techniques that took advantage of the proximity of the Tigris and Euphrates rivers.

Agricultural progress was the work of the dominant Ubaid culture, which had absorbed the Halaf culture before it.

These scattered agrarian communities started in the northern part of the ancient Mesopotamian region and spread south, continuing to grow for several thousand years until forming what modern humans would recognize as cities, which were considered the work of the Sumer people.

Uruk was the first of these cities, dating back to around 3200 B.C. It was a mud brick metropolis built on the riches brought from trade and conquest and featured public art, gigantic columns and temples. At its peak, it had a population of some 50,000 citizens.

Sumerians are also responsible for the earliest form of written language, cuneiform, with which they kept detailed clerical records.
By 3000 B.C., Mesopotamia was firmly under the control of the Sumerian people. Sumer contained several decentralized city-states—Eridu, Nippur, Lagash, Uruk, Kish and Ur.

The first king of a united Sumer is recorded as Etana of Kish. It's unknown whether Etana really existed, as he and many of the rulers listed in the Sumerian King List that was developed around 2100 B.C. are all featured in Sumerian mythology as well.

Etana was followed by Meskiaggasher, the king of the city-state Uruk. A warrior named Lugalbanda took control around 2750 B.C.
Mesopotamian religion was polytheistic, with followers worshipping several main gods and thousands of minor gods. The three main gods were Ea (Sumerian: Enki), the god of

wisdom and magic, Anu (Sumerian: An), the sky god, and Enlil (Ellil), the god of earth, storms and agriculture and the controller of fates. Ea is the creator and protector of humanity in both the Epic of Gilgamesh and the story of the Great Flood.

In the latter story, Ea made humans out of clay, but the God Enlil sought to destroy humanity by creating a flood. Ea had the humans build an ark and mankind was spared. If this story sounds familiar, it should; foundational Mesopotamian religious stories about the Garden of Eden, the Great Flood, and the Creation of the Tower of Babel found their way into the Bible, and the Mesopotamian religion influenced both Christianity and Islam.

Each Mesopotamian City had its own patron god or goddess, and most of what we know of them has been passed down through clay tablets describing Mesopotamian religious beliefs and practices. A painted terracotta plaque from 1775 B.C. gives an example of the sophistication of Babylonian art, portraying either the goddess Ishtar or her sister Ereshkigal, accompanied by night creatures.

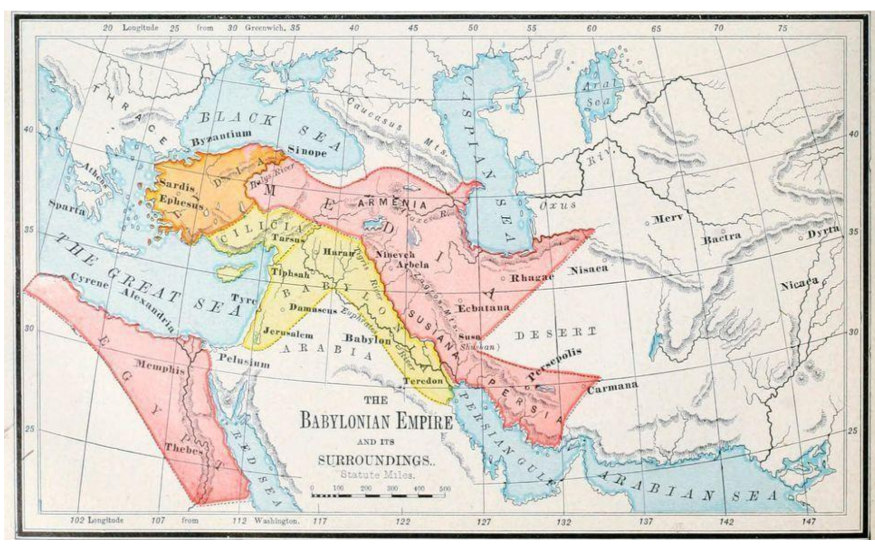


Photo 18 : A map of the Babylon Empire.

(Image credit: Niday Picture Library via Alamy Stock Photo).

2. Egyptian science :

Its existence and continuity span more than 3,000 years. Egyptian civilization is linked to a unique geographical location, the Nile Valley.
Egyptian engineering was impressively efficient : it took the Egyptians just thirty years to build each of the great pyramids.

Egyptian physicians had an in-depth knowledge of the inside of the human body. One of the earliest descriptions of the human body is given by the Egyptian papyrus of Ebers (1550 B C), which describes the human body as follows through which pipes run. These pipes carry different substances (blood, air, urine, food, etc.…). In this biology, it's the heart that speaks to the different parts of the body via the vessels.

They are skilled in cardiology, gynecology, eye, intestinal and urinary tract medicine. They perform successful operations. They were the most renowned physicians of their time, and were widely called upon, even from abroad. It's no coincidence that Greek physicians, like their mathematician and astronomer colleagues, trained in the House of Life in Alexandria's famous library.

The Egyptians were so expert at preserving the bodies of the dead that after thousands of years we know of the diseases they suffered such as arthritis, tuberculosis of the bone, gout, tooth decay, bladder stones, and gallstones; there is evidence, too, of the disease bilharziasis (schistosomiasis), caused by small, parasitic flatworms, which still exists in Egypt today. There seems to have been no syphilis or rickets.

Photo 19 : The Great Sphinx of Giza.

By Jorge LÃ¡scar published on 26 October 2016

Photo 20 : The Pyramids, Giza, Egypt.

By Shellapic76 published on 16 September 2016.

3. Chinese science :

Although modern science was born in Europe in the 17the century, many scientific inventions and discoveries were made in China and are now part of our everyday lives. Examples include blood circulation, attributed to William Harvey ; the first law of motion, rediscovered by Isaac Newton ; and movable type printing, reinvented by Johannes Gutenberg.

China's most important scientists include Shen Kuo (1031-1095) and Zhang Heng (78-139). The fruits of nearly thirty centuries of Chinese technological and scientific development were transmitted from the East to the West via the Islamic civilization. Since the 1960s, the work of Joseph Needham has enabled the West to gain a better understanding of China's history and scientific development.

4. Indian Sciences :

Humanity owes a debt to the Hindus for Arab-Indian numerals, including the zero, and for positional decimal writing, innovations that have now been universally adopted.

They mastered irrational numbers and the square roots of 2 and 3 with several decimal places. They also discovered what is known as the Pythagorean theorem. In chemistry, they did remarkable work in iron smelting. This enabled them to melt large objects such as the iron pillar of Delhi, which is over seven meters high and weighs more than six tons. In medicine, they discovered that certain illnesses were due to changes in the environment (seasonal changes, poor hygiene, etc.), but they did not attempt to classify diseases. The fundamental treatise of Hindu medicine is Ayurveda. Ayurveda explained that disease is caused by imbalance, and that to heal a patient, harmful elements must be replaced by harmonious ones.

Explanations of various surgical procedures are also included.

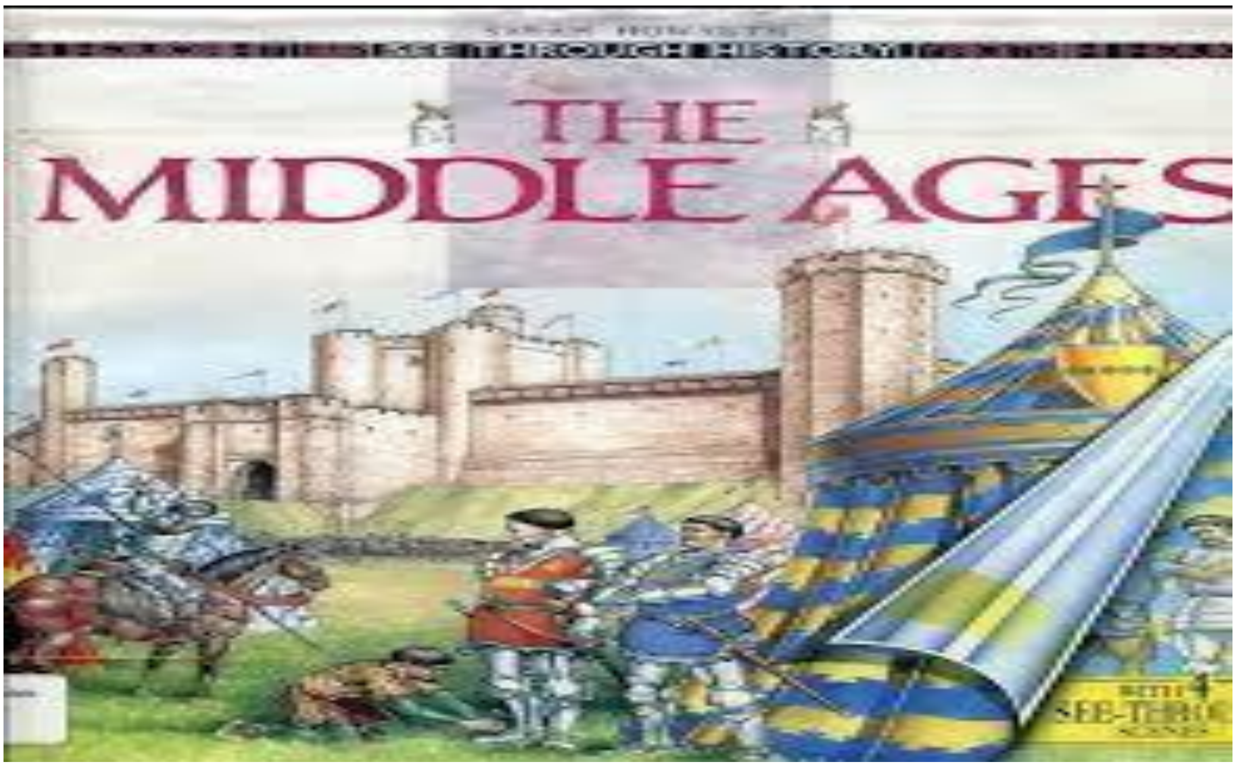
The ancient Indians coined the term àyour véda (= science of long life), which Filliozat suggests translating as "biology", since this term refers to all normal or pathological vital phenomena. The ancient Indians also had more or less empirical biological knowledge of various useful animal species.

5. Greek sciences :

The Greek sciences inherited Babylonian knowledge and, directly in Alexandria, Egyptian scientific knowledge. They were organized around the centers of exchange that were the great cities of the Greek colonies, which then surrounded the Mediterranean basin. The Greek sciences were closely linked to philosophical speculation : logic was born of the question of the coherence of discourse. There is no clear dividing line between science and philosophy. Most scientists are both scientists and philosophers, for the simple reason that science is not yet formalized. Like philosophy, it uses only natural language to express itself. It wasn't until Galileo several centuries later that science became formalized, and began to detach itself from philosophy.

The Greeks are considered the founders of mathematics, having invented its very essence : demonstration. Thales is sometimes considered the first philosopher to have the idea of reasoning about mathematical beings in themselves.

The best-known Greek scientists, in chronological order, include Thales, Pythagoras, Hippocrates, Aristotle, Theophrastus, Euclid and Archimed.


SEE THROUGH HISTORY
THE
MIDDLE AGES

CHAPTER IV : THE MIDDLE AGES

1. Arab sciences (in orient) :

In the Middle Ages, the Greek sciences were preserved, notably through the translation into Arabic of numerous books found in the Library of Alexandria. These sciences were then enriched and disseminated by Arab-Muslim civilization, which experienced a golden age (Al-Khawarizmi, Avicenna, Averroes). We owe him numerous works in astronomy, geography, optics, medicine and mathematics (mainly algebra, combinatorial analysis and trigonometry).

Tabel 1 : Brief chronolgy of Arab civiization

622/750	Conquest period. Umayyad Caliphate (Damascus).
750/936	Abbasid Caliphate (Baghdad). Calies Mansur, Harun al-Rashid, Al-Ma'mun. Development of arts and sciences.
936/1055	Domination of the Iranian Shi'ites (Buyid dynasty).
936/1171	Fatimid rule in Africa and Egypt (Cairo). Egypt reconquered by Saladin (1171).
756/XI century	Umayyad Caliphate of Cordoba. Apogee of Muslim Spain. Capture of Cordoba by the Christians (1236).
1055/v. 1258	Effective rule of the Turkish Saljuqs in the East (the Sultan reigns on behalf of the Caliph). Last caliph executed by the Mongols (1258).

13th - 14th centuries	Mongol domination in the East. Saljûqid vassal states.
14th century/1918	Formation of the Ottoman Empire (Turks): Balkans, Iraq, North Africa.

Character of Arabic science :

Firstly, Arab science is not just the science of the Arab peoples, but science in Arabic, which includes many Persian and even non-Muslim (Jewish) scholars. In fact, during the first century of ISLAM, the majority of scholars in Muslim territory were Christians. To a certain extent, the Islamic religion was more favorable to the development of scientific knowledge than the Christian religion at the same time. Not only was astronomical knowledge important in determining the precise start of the Ramadan and the direction of Mecca, but the Qur'an encourages the study of Nature : "Whoever walks in search of science ['ilm], God walks with him on the path to Paradise."

Tabel 2 : Main figures in Arab science

Geber Ibn-Hayyan (8th century)	A leading figure in Arab and Western alchemy.
Al-Khawarizmi (c.800/v.847)	A Persian mathematician, geographer, astrologer and astronomer, member of the Baghdad House of Wisdom.
Abu Kamil (9th century)	Disciple of Al-Khawarizmi.
Al-Battânî (9th century)	Astronomer and mathematician.
Al-Razi (V. 854/925-935)	doctor.

Abu al-Husayn al-Sufi (Late 10th century)	Astronomer.
Al-Bîrunî (late 10th century)	Astronomer, geographer, mathematician.
Ibn-Al-Haytham (965-1040)	The most famous physicist in the Arab world.
Ibn-Sina (980-1037)	doctor and philosopher.
Al-Khayyam (1048-1131)	doctor, astronomer and poet.
Al-Karagi (11th century)	Author of the sufficient book on the science of arithmetic.
Ibn Rushd (1126/1198)	Philosopher and commentator on Aristotle.
Al-Kashi (1429)	Mathematician .

Ibn-Sina (980-1037) :

Abu Ali Al-Hussein Ibn Abdullah Ibn Sina, known in the West as Avicenna, was one of the most eminent Muslim physicians and philosophers of his days whose influence on Islamic and European medicine persisted for centuries. He was named by his students and followers as "Al Shaikh Al Ra'ees" or the master wise man. The Europeans called him the "Prince of Physicians". As a thinker, he represented the culmination of Islamic renaissance, and was described as having the mind of Goethe and the genius of Leonardo da Vinci.

It is claimed that Ibn Sina had written about 450 works, of which 240 had survived.3 Some bibliographers list only 21 major and 24 minor works dealing with philosophy, medicine, astronomy, geometry, theology, philology and art. He wrote several books on philosophy, the most significant was "Kitab al Shifa" (The Book of Healing). It was a philosophical encyclopedia that brought Aristotelian and Platonian philosophical traditions together with Islamic theology in dividing the field of knowledge into theoretical knowledge (physics, metaphysics and mathematics) and practical knowledge (ethics, economics and politics). Another book on philosophy was “Kitab al-Isharat wa al tanbihat” (Book of Directives and Remarks).

Ibn Rushd (1126/1198) :

Ibn Rushd, whose Latin name was Averroes, was the most outstanding philosopher in the Islamic world working within the Peripatetic (Greek) tradition. He was particularly interested in the work of Aristotle and wrote a large number of commentaries of differing length on his works. Ibn Rushd was not only a philosopher but also a judge, legal thinker, physician, and politician, like so many of the other philosophers in the Islamic world. His work is marked by its commitment to what he took to be pure Aristotelianism and his relative antipathy to Neoplatonism. He defended the acceptability of philosophy in the Islamic world, arguing that it does not contradict religion but complements it. Ibn Rushd held that philosophy represents the system of demonstrative or rational argumentation, while religion presents the conclusions of philosophy to a wider audience in a form that enables the latter to understand how to act.
This thesis came to be characterized as the "double-truth" thesis, which held that philosophy and religion are both true despite contradicting each other. Nevertheless, Ibn Rushd did not hold such a thesis, whatever views were attributed to him outside of the Islamic world after his death. During his lifetime, Ibn Rushd suffered at the hands of rulers who were occasionally unsympathetic to philosophy, and after his death his style of philosophy soon fell out of fashion in the Arabic-speaking Islamic world. It is the commentaries that led to his continuing influence in Jewish and Christian Europe long after he was forgotten in the Islamic world.

2. Science of medieval Latin Europe (in the West) :

While throughout the earliest stages of the Medieval times Latin historical and literary texts, at least in Italy and Southern France, continued to be copied and, possibly, most of the vanished texts were actually lost during the chaotic times followingthe disruption of the Carolingian empire, yet, apart from that concerning medicine, there was little interest for technical and scientific literature. We have seen how during the late Roman times culture became increasingly bookish: the authoritative text, whether sacred or not, was the foundation of knowledge and its correct interpretation, be it logical, mystical or even some sort of esoteric 'gnosis' was 'the Truth'; in the meantime there vanished almost all interest in natural sciences, with their apparently purely theoretical contents.

The barbarian invasions were undoubtedly often quite destructive, even if we must remember that not in a few instances the barbarians came as peaceful settlers to fill the space vacated by the dwindling Roman populations. For instance, while the raids of the Huns or the invasion of the Longobards, were tremendously destructive, the earliest settlement of the Franks was comparatively peaceful. On the other side probably no one cared about the pensioning of the last Western emperor, Romulus Augustulus: formally, in fact, the empire had been unified under the Eastern Emperor, Odovacar was ruling Italy and the few remaining districts of the Western Empire asking of the Heruli and Patricius of the Romans in the name of the Eastern emperor, just as, for instance, the Frank Clovis was ruling Northern France as King of the Franks and Patricius of the Romanized Gauls. This formal arrangement had been usual for about a century, since the first Foedi had been more or less peacefully settled 86 in the empire and was punctiliously observed for over a century : such gold coinage as was struck by the Foedi had the types, name and titles of the Eastern Emperor, while copper was struck indifferently either in the name of Rome or in the name of the German ruler!

Still the Roman administrative framework, schools included, was extremely strong and the breed of professors very vital as, in Italy at least, the Gothic wars, the Longobard invasion, those of the Franks and the post-Carolingian chaos were not sufficient to completely extinguish either of them. Sporadically at least, it appears that schools were functioning also in England and Southern France.

Throughout the early middle ages we hear of a curious debate: the strictly orthodox, we would call them 'the fundamentalists', who clamour for the substitution of classical models in the schools, philosophers included, by Christian texts, and the conservative masters who, undeterred, went on exercising their pupils on Virgil and a few other favourite pagan authors.

In Italy lay schools of laws and medicine continued to operate in Pavia through the Longobard rule and most probably in Rome and Ravenna. Medical texts were copied or imported, and some still survive : e.g. the Dioscorides longobardorum, preserved at Montecassino, and which includes some original drawings added to the original series, or the two Byzantine superb codices: the Dioscorides vindoboniensis, an incredibly well illustrated copy prepared around 512 for an Anicia Juliana, who, judging by the name, must have been a relative of Boethius, and the somewhat later and almost as beautiful Dioscorides neapolitanus. But, as we said, the century beginning around 650 was one of increasing chaos and poverty almost all over Europe and was the real beginning of the so called 'Dark Ages'. Thus the Church begun to worry about schools and the Rispacense Council of 798 recommended the creation of school at all bishop's sees. Shortly afterwards and following this example, Charlemagne, as part of his program of restoration and recovery, repeatedly recommended, especially by the 'Capitular of Thionville' (805), the opening at all monasteries of scholae exteriores where lay people could study. Charles also resurrected the Schola palatina and charged of it Alcuin of York, who recruited most of his masters from Rome. Alcuin also started a systematic search and copying of surviving Roman texts, an activity which flourished through the times of the Carolingian dinasty. Indeed almost all the earliest Latin manuscripts surviving date from Carolingian times and derive from copies of the 5th-6th century.

Shortly after the death of Charles, his son Lothar I granted permission, by the Capitular of Olona, for establishing high schools for lay people in Pavia, Ivrea, Cremona, Florence, Fermo, Verona, Vicenza and Cividale, though we do not know if any action was actually taken.

Though the Carolingian attempts achieved little because of the rapid crumbling of the empire into a new period of chaos, yet its organisation set a pattern, which they had largely inherited from the late Roman empire, and was to evolve into the full fledged feudal systen on one side, but was also influential in shaping the future organisation of the universities.

At least in principle, the Carolingian system aimed to restore the organisation of the early Merovingian times. The significant difference was that the early Merovingians were ruling their Roman subjects formally as Patricii for the Byzantine emperor, the Carolingians held themselves to be the Western Roman Emperors, ruling of their own right on a, by now, unified people. At the top was the Emperor, who ruled by means of two parallel hierarchies: a comitatus of noble warriors (milites), freemen in their own right and mostly of barbarian origins, and a comitatus sacri palatii whose palatine counts were instead either slaves of the Emperor or, anyway, bound men, and who were generally recruited either among the Roman nobility or among the secular clergy (until about 700 in most countries mainly from the first, in Carolingian times almost exclusevly from the second). Usually the jurisdiction of the military counts overlapped with that of bishops and roughly corresponded with the ancient 'dioceses' (which were changing their name into 'counties'. However usually while the authority of the military counts was prevalent in peripherical areas of the empire, the authority of the palatine counts and of their subordinate officers (Missi dominici, curial notaries (Tabelliones) was prevalent within the central administration. Moreover, just because of their servile or semi servile condition, the palatines were considered as 'parts' of the Emperor himself who 'owned' them and, therefore, they could fully represent him and thus could inspect and control the military counts. Locally the central system was duplicated on a minor scale: the local military count acted through his vassals (military) and his tabelliones (civil servants).
At the same time the ecclesiastical authority, stemming directly from the Roman organization, was parallel to the civil one : the Pope was parallel to the Emperor, the Bishops to the counts, and the clergy was just equivalent to the vassals, that is to the lesser nobility and enjoyed the same privileges.
Thus were laid the premises for the parallel development of Medieval chivalry and of the scholastic system. In the early Medieval times and for several centuries schooling as was preliminary to legal and medical studies was centered in the monasteries. There we notice two different possibilities: some monasteries had both scholae interiores where the young oblates studied (an oblate was a child who had been given as an obol, that is donated, to

the monastery, usually at about ten years of age, but, though meant for growing up in the Church, usually took his final vows much later) and scholae exteriores open to lay students. However most monasteries were not big enough to support both types of schools and then the arrangements varied. Children could be entrusted to the monastery formally as 'oblates', but on the understanding that, when of age, would not take the vows, or they could attend the school as extramoeniales, that is as 'from out of the walls'. As throughout the early Middle Ages fiefs were not hereditary (in principle if not in practice) and marriage was not forbidden for the secular clergy and was fairly common at least in the lesser clergy (but we know of married cardinals and even a Pope, Adrian II 867-872, whose wife and doughter were kidnapped and murdered by the son of the bishop of Orte), there was a strong tendency to send to monastery's schools the cadets of both military and curial noble families, thus fostering their gradual merging.

The obligations of Christian religion and especially those of the Benedictine 'rule' made assistance to pilgrims and sick mandatory. Thus monasteries had to have physicians among the monks and where they were learning their trade also lay people could learn. So in the monasteries books were copied, but usually they were only either literary or medical ones. Thus we still have a number of 'herbals' or hortuli, often copies more or less complete and correct of Dioscorides and of Pseudo-Apuleius, but sometimes quite original, such as the little poem of Walfrid Strabo (808/9-849).

After the 11th century the Church begun to worry because of the excessive interest of several monks for medical practice ouside their monasteries (medicina exterior); thus the practice was gradually restricted until finally banished by the 4th Lateran Council (1215) and by the Decretals of Pope Honorius III (about 1220), and only clerics holding the minor orders and who had no other means of subsistence were exempted. However, by that time universities were already born and flourishing and the medical faculty was about to gain formal recognition.

Indeed the equation Vassals = Ecclesiastics and the many matters in which secular clergymen and curiales were indifferently mixed up was to prepare for the recognition of the equivalence of clergymen and university graduates.

This was first officially recognized by Emperor Frederick Redbeard with his decree Authentica habita of 1180 aimed to repay the Bolognese doctors for their support.


RENAISSANCE

CHAPTER V.THE RENAISSANCE (16TH AND 17TH CENTURIES)

The Renaissance in Europe (which began in Italy) was a period that ended with a veritable scientific revolution. Completely new theories emerged, calling into question the way man saw the world and his place in it.

In fact, what is commonly referred to as the Renaissance began much earlier in Italy and Avignon than in the rest of Europe (the word was only beginning to spread), and especially in France, which remained affected for a long time by the upheavals of the Hundred Years' War. As early as the 14the century (Trecento), Renaissance centers appeared in Venice, Siena, Florence and Rome, and even more so in the 15the century (Alsace, Burgundy, Portugal, etc.).

There are many reasons for this Renaissance, such as :

- The rediscovery in the XIIe century of ancient texts (Aristotle) preserved and enriched by the Arabs.
- The invention of paper (imported from China),
- The invention of the printing press (1453) (also imported and improved by Gutenberg) made it possible to distribute books in greater numbers and, above all, to publish books in vernacular languages instead of Latin, thus spreading culture,
- Progress in geography and cartography,
- Technical advances in navigation and positioning (compass),
- The contribution of Byzantine knowledge, following the decline and final collapse of the Byzantine Empire in 1453,
- Expansion of maritime exploration around the African continent (Portuguese), then to the New World,

The scientific and technical advances of the Renaissance, along with the revival of other fields (art), were one of the causes of the extraordinary period of exploration by

European navigators, first Portuguese and Italian, then Spanish and French, known as the Great Discoveries, which enabled Europe to secure world supremacy.

1. The birth of botany :

1.1 Otto Brunfels (c. 1488-1534) :

Named the father of botany, published his Herbarum vivae icones in 1530 and 1536. In this work, illustrated with excellent woodcuts, Brunfels describes all the plants he knows. He begins his descriptions with a list of names in different languages, followed by quotations from other ancients. He ends by giving his own assessment of the plant and its powers, the work having, like all botanical books of the time, a therapeutic vocation.

Photo 21 : Otto Brunfels

Löcher, in Cat. Schwäbisch Hall 2009.

Leonhart Fuchs (1501-1566) :

Published his important work historia stirpium in 1542, invwhich he described over 400 species. His superb illustrations were to be used many times thereafter. He describes each plant according to a predefined pattern : first, its shape, then its inhabitant, its seasonality (when the plant should be picked), its temperament and its powers. It should be noted that he describes decorative plants that have no therapeutic use.

Photo 22 : Portrait of Leonhart Fuchs

Part of : Wellcome Trust Corporate Archive 25 July 1945.

1.2 Andrea Cesalpino (1519-1603) :

He was an Italian physician, philosopher, and botanist who sought a philosophical and theoretical approach to plant classification based on unified and coherent principles rather than on alphabetical sequence or medicinal properties. He helped establish botany as an independent science.

He provides a comparative analysis of anatomical forms and definitions of his concepts. He investigated the difference between plants and animals: he drew comparisons between the organs of nutrition of plants (roots) and animals (stomach and intestines). Cesalpino's system was the first to be truly based on the comparative study of anatomical shapes.

Photo 23 : Portrait of Andrea Cesalpino

Part of : Wellcome Trust Corporate Archive August 1929.

1.3 Prospero Alpini (1553-1617) :

He was a physician and botanist who is credited with the introduction to Europe of coffee and bananas. While a medical adviser to Giorgio Emo, the Venetian consul in Cairo (1580–83), Alpini made an extensive study of Egyptian and Mediterranean flora. He is reputed to have been the first to fertilize date palms artificially.

Alpini was appointed professor of botany at the University of Padua (1593), where he cultivated several species of Oriental plants described in his De plantis Aegypti liber (1592 ; "Book of Egyptian Plants"). Included in this work were the first European botanical accounts of coffee, banana, and a genus of the ginger family (Zingiberaceae) that was later named Alpinia.

Photo 24 : Prospero Alpini

By R. Blokhuysen (19th century).

1.4 Gaspard Bauhin (1560-1624) :

He was a Swiss physician, anatomist, and botanist who introduced a scientific binomial system of classification to both anatomy and botany.

With his Prodromus and Pinax therati botanici, made the first attempt at a critical compilation of botanical knowledge. He grouped plants according to their affinities.

Photo 25 : Portrait of Gaspard (Caspar) Bauhin

Part of : Wellcome Trust Corporate Archive 25 July 1945.

2. The first zoologists :

2.1 Guillaume Rondelet (1507-1566) :

He was a French naturalist and physician who contributed substantially to zoology by his descriptions of marine animals, primarily of the Mediterranean Sea.

Rondelet's book, Libri de Piscibus Marinis (1554–55 ; "Book of Marine Fish"), contains detailed descriptions of nearly 250 kinds of marine animals with nearly the same number of illustrations. He included, in addition to fishes, whales, marine invertebrates, and seals, regarding them all as fishes. As professor of anatomy at the University of Montpellier and physician to a cardinal, Rondelet also wrote extensively on fever, diagnosis, and the preparation of medicinal drugs.

Photo 26 : Guillaume Rondelet

By C. Ammon, 1652.

2.2 Pierre Belon (1517-1564) :

A French naturalist whose discussion of dolphin embryos and systematic comparisons of the skeletons of birds and humans mark the beginnings of modern embryology and comparative anatomy.

Although based on the taxonomy of Aristotle, Belon's L'histoire naturelle des éstranges poissons marins (1551 ; "Natural History of Unusual Marine Fishes"), much of which is devoted to a discussion of the dolphin, and L'histoire de la nature des oyseaux (1555 ; "Natural History of Birds"), illustrating, classifying, and describing about 200 species, include original observations and concepts that made a deep impression on contemporary and later science. Belon was murdered by unknown assailants in the Bois de Boulogne.

Photo 27 : Portrait of Pierre Belon

Part of : Wellcome Trust Corporate Archive 25 July 1945.

3. The encyclopaedists :

3.1 Conard Gessner (1516-1565) :

Was a Swiss physician and naturalist best known for his systematic compilations of information on animals and plants.

In an early work, a medical tract on the virtues of milk, Libellus de lacte et operibus lactariis (1545), he included a letter to a friend in which he extolled mountains as one of the greatest wonders of nature. This reference and a later account of his scaling of Mt. Pilatus (1555) provide one of the first records of mountain climbing.

In 1545 Gesner published his Bibliotheca universalis, the first bibliography of its kind, listing about 1,800 authors alphabetically with the titles of their works, annotations, evaluations, and comments on the nature and merit of each entry. This monumental reference was followed in 1548 by the encyclopaedic work Pandectarum sive Partitionum universalium Conradi Gesneri…libri xxi, in which Gesner attempted to survey the recorded knowledge of the world under 21 headings. The first 19 books were published in 1548 ; the last, devoted to theological thought, was published in 1549, while the 20th, on medicine, was never completed.

Gesner's next monumental achievement was a compendium of recorded knowledge concerning animal life, the Historiae animalium, in which he sought to distinguish observed facts from myths and popular errors. The first volume (1551), a generously illustrated work of 1,100 folio pages, was concerned with viviparous quadrupeds (fourfooted animals that bear living young). Later volumes devoted to oviparous quadrupeds (those that hatch the young from eggs), birds, and fishes and other aquatic animals followed in 1554, 1555, and 1556 ; the partially completed fifth volume, on serpents, was published posthumously in 1587.

Photo 28 : Portrait of Conard Gessner

Galerie des naturalistes de J. Pizzetta, Ed. Hennuyer, 1893.

3.2 Ulisse Aldrovandi (1522-1605) :

Was a Renaissance naturalist and physician noted for his systematic and accurate observations of animals, plants, and minerals.

Pope Gregory XIII gave Aldrovandi financial assistance in publishing his numerous works on natural history, which included detailed observations of the day-to-day changes occurring in the incubation of the chicken embryo. Only four volumes, with detailed copperplate engravings, appeared during his lifetime; the remainder were prepared by his students from only a portion of his manuscripts. He also wrote Le antichità della città di Roma (1556), an account of various statues in Rome. His museum of biological specimens, classified according to his own system and left to the city of Bologna at his death, contributed to the later development of animal taxonomy.

Photo 29 : Portrait of Ulisse Aldrovandi

Part of : Wellcome Trust Corporate Archive 25 July 1945.

4. The birth of scientific anatomy :

4.1 Leonardo da Vinci (1452-1519) :

An Italian painter, draftsman, sculptor, architect, and engineer whose skill and intelligence, perhaps more than that of any other figure, epitomized the Renaissance humanist ideal. His Last Supper (1495–98) and Mona Lisa (c. 1503–19) are among the most widely popular and influential paintings of the Renaissance. His notebooks reveal a spirit of scientific inquiry and a mechanical inventiveness that were centuries ahead of their time.

Practiced cadaver dissection and produced numerous anatomical sketches.

Photo 30 : Portrait of Leonardo da Vinci

Drawn by : André Dutertre.

4.2 André Vésale (1514-1564) :

A Renaissance physician who revolutionized the study of biology and the practice of medicine by his careful description of the anatomy of the human body. Basing his observations on dissections he made himself, he wrote and illustrated the first comprehensive textbook of anatomy.

His De humani corporis fabrica is a compendium of descriptive anatomy that revolutionized the anatomical knowledge of his time.

Photo 31 : Portrait of André Vésale

By Charles Onghena 1841.

4.3 Bartolomeo Eustachi (1510-1574) :

An Italian anatomist and physician.

Eustachi's first works were Ossium examen and De motu capitis, both written in 1561. In 1562 and 1563 Eustachi produced a remarkable series of treatises on the kidney, the auditory organ, the venous system, and the teeth. These were published, together with the two earlier defences of Galen, in Opuscula anatomica (1564).

In Opuscula anatomica, Eustachi, basing his work on the dissection of foetuses and newborn children, was also the first to make a study of the teeth in considerable detail. His treatise contains an early description of the first and second dentitions as well as the tooth's basic composition of enamel and dentin, in some respects preceded by the account of Falloppio. He further attempted an explanation of the problem, not yet completely solved, of the sensitivity of the tooth's hard structure.

Photo 32 : Portrait of Bartolmeo Eustachi

Self-portrait, drawing by Leonardo da Vinci

4.4 Gabriele Falloppio (1523-1562) :

Was the most illustrious of 16th-century Italian anatomists, who contributed greatly to early knowledge of the ear and of the reproductive organs.

Fallopius discovered the tubes that connect the ovaries to the uterus (now known as fallopian tubes) and several major nerves of the head and face. He described the semicircular canals of the inner ear (responsible for maintaining body equilibrium) and named the vagina, placenta, clitoris, palate, and cochlea (the snail-shaped organ of hearing in the inner ear). A friend and supporter of Vesalius, he joined him in a vigorous assault on the principles of the classic Greek anatomist Galen, which resulted in a shift of attitude essential to the development of Renaissance medicine.

Photo 33 : Portrait of Gabriele Falloppio

Part of : Wellcome Trust Corporate Archive 1931.


MODERN AGE

VI. THE MODRN PERIOD

1. 17th century :

In Antiquity and right up to the 18th century, science was inseparable from philosophy (indeed, science was called natural philosophy) and tightly controlled by religion. With the emergence of astronomy and modern physics, religion's control over science gradually diminished, making science an autonomous and independent field. The transition from medieval science to the Renaissance is often confused with the Copernican revolution, iofn reality, the Copernican revolution is more akin to the transition between the Renaissance and the Enlightenment, since it took some time for the discovery of heliocentrism to be shared and accepted. From a scientific point of view, it was astronomy that triggered the changes of this era. After Copernicus, who lived before the Thirty Years' War, other astronomers took up astronomical observations again: Tycho Brahe, then Kepler, who did considerable work on observing the planets of the solar system, and formulated the three laws of planetary motion (Kepler's laws).

However, Kepler still lacked the instrument, the telescope, which, invented in Holland in 1608 for use as a simple telescope, and perfected by Galileo in 1609 for use in astronomy, enabled him to make observations that once again confirmed that the geocentric theory was refutable. Galileo's contribution was also very important in the sciences (kinematics, astronomical observations, etc.).

René Descartes (1596-1650) :

Was a French mathematician, scientist, and philosopher. Because he was one of the first to abandon Scholastic Aristotelianism, because he formulated the first modern version of mind-body dualism, from which stems the mind-body problem, and because he promoted the development of a new science grounded in observation and experiment, he is generally regarded as the founder of modern philosophy. Applying an original system of methodical doubt, he dismissed apparent knowledge derived from authority, the senses, and reason and erected new epistemic foundations on the basis of the intuition that, when he is thinking, he exists; this he expressed in the dictum “I think, therefore I am” (best known in its Latin formulation, “Cogito, ergo sum,” though originally written in French, “Je pense, donc je suis”). He developed a metaphysical dualism that distinguishes radically between mind, the essence of which is thinking, and matter, the essence of which is extension in three dimensions. Descartes’s metaphysics is rationalist, based on the postulation of innate ideas of mind, matter, and God, but his physics and physiology, based on sensory experience, are mechanistic and empiricist.

Photo 34 : Portrait of René Descartes

By Frans Hals 1649.

Blaise Pascal (1623- 1662) :

Was a French mathematician, physicist, religious philosopher, and master of prose. He laid the foundation for the modern theory of probabilities, formulated what came to be known as Pascal’s principle of pressure, and propagated a religious doctrine that taught the experience of God through the heart rather than through reason. The establishment of his principle of intuitionism had an impact on such later philosophers as Jean-Jacques Rousseau and Henri Bergson and also on the Existentialists.

Photo 35 : Portrait of Blaise Pascal

By F.J. De quevauvilller , 1823 .

Robert Boyle (1627- 1691) :

Was an Anglo-Irish natural philosopher and theological writer, a preeminent figure of 17th-century intellectual culture. He was best known as a natural philosopher, particularly in the field of chemistry, but his scientific work covered many areas including hydrostatics, physics, medicine, earth sciences, natural history, and alchemy. His prolific output also included Christian devotional and ethical essays and theological tracts on biblical language, the limits of reason, and the role of the natural philosopher as a Christian. He sponsored many religious missions as well as the translation of the Scriptures into several languages. In 1660 he helped found the Royal Society of London.

Photo 36 : Portrait of Robert Boyle

Part of : Wellcome Trust Corporate Archive 1931.

1.1 The first scientific journals :

The appearance of the first scientific journals led to better dissemination of knowledge and more constructive criticism between scientists, and above all to the seminal work in botany and zoology by J. Ray and F. Willughby.

John Ray (1627-1705) and Francis Willughby (1635-1672) played key roles in both botany and zoology during this period. In botany, Ray published a catalogus plantarum circa Cantabrigiam nascentium (Cambridge, 1660), or Catalogue of plants in the vicinity of Cambridge. The work was highly innovative compared to other British botanical publications. It set new standards that were to be followed by many botanists in Europe.

In 1670, Ray published a similar work on British flora in London : Catalogus plantarum Angliae.

In 1682, Ray collected various essays on botany in Methodus plantarum nova. From 1686 to 1704, he published a vast work on European flora, in which he described 18,000 species: Historia plantarum.

In zoology, Ray was the first to propose a classification of animals based on anatomical rather than behavioral or environmental criteria. His classification, particularly of birds, was the most advanced until Linné's work.

Willughby's untimely death prevented him from completing several works, which Ray later expanded and published under Willughby's sole name. These include Ornithologia (London, 1676) and De historia piscium (Oxford, 1686). Ray's most important works include Synopsis animalium quadrupedum et serpentini generis (London, 1693).

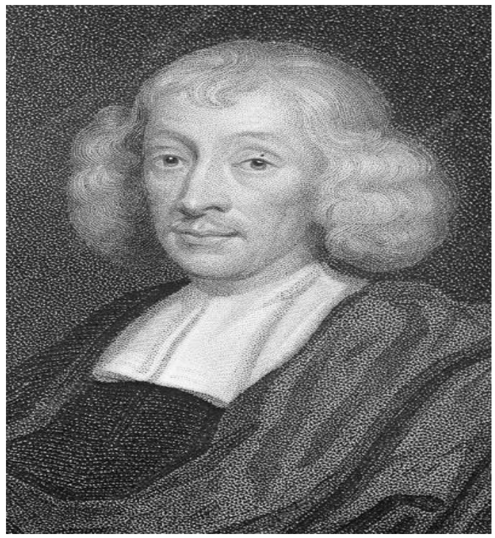


Photo 37 : Portrait of Jhon Ray

By George Bernard.

Photo 38 : Portrait of Francis Willughby

By Tim Birkhead.

1.2 Advances in biology and the use of the microscope :

It should be noted that biology did not become a truly autonomous discipline within natural history until the 19th century, with the development of modern microscopes. The second half of the 18th century saw the publication of a number of highly innovative works, some of which were made possible by the invention of the microscope. The invention is probably dated 1590 and is sometimes attributed to Zacharias Janssen. The invention of the microscope at the end of the 16th century, perfected in the 17th century, enabled us to study living beings in much greater depth.

William Harvey (1578-1657) :

An English physician who was the first to recognize the full circulation of the blood in the human body and to provide experiments and arguments to support this idea.
Discovered blood circulation in 1628. Harvey had studied heart movements not only in cold- blooded people, whose hearts beat more slowly.

Photo 39 : Portrait of William Harvez

Part of : Wellcome Trust Corporate Archive 1940.

Francesco Redi and spontaneous generation. (1626- 1697) :

Since Antiquity, we've seen that certain invertebrates (insects, worms, etc.) and vertebrates (toads, frogs, eels, etc.) arose spontaneously from the environments in which they lived (spontaneous ludge, which was combated by the Italian naturalist Redi. He was also one of the founders of parasitology, with his work on animal parasites (1684) describing some fifty species of Helminthes, Acarinae and Insects.

Photo 40 : Portrait of Francesco Redi

Part of : Wellcome Trust Corporate Archive 1938.

1.3 Microscopic biologists:

The most famous microscopists of the 17th century were :

Marcello Malpighi (1628-1694) :

-The father of microscopic anatomy.

-Whose name is now attached to dozens of structures in the human body and in insects. Publishes botanical works in his book entitled Anatome plantarum on the cellular anatomy of plants and studies plant embryology.

Photo 41 : Portrait of Marcello Malpighi

Part of : Wellcome Trust Corporate Archive 1948.

Antoni van Leeuwenhoek (1632-1723) :

-Dutch biologist.

-He built hundreds of microscopes, and thanks to them made fundamental biological observations : discovery of Protozoa and bacteria, study in 1677 of spermatozoa, observation of various microscopic animals (Sponges, Nematodes, etc.…).

-He also described the blood cells of various vertebrates and invertebrates.

-He also studied various animal tissues under the microscope.

- Along with Malpighi, he is considered one of the founders of Histology.

Photo 42 : Portrait of Antonie van leeunhoek

By Jan Verkolje 1930.

Robert Hooke (1635-1703) :

English microscopist. In his Micrographia (1665), he described and illustrated various living objects seen through a microscope.

Jan Swammerdam (1637-1680) :

2nd Dutch microscopist. He was a pioneer of fine anatomical study techniques, in particular the injection of dyes into human or animal organs. His dissections of Insects were astonishing for their time, and made him one of the creatures of Invertebrate anatomy. He was also a physiologist and embryologist.

2. 18th century :

In the 18th century, the life and earth sciences also underwent major development following voyages to Africa and the Pacific :

Georges Louis Leclerc, comte de Buffon (1707-1788) :

A French naturalist, remembered for his comprehensive work on natural history, Histoire naturelle, générale et particulière (begun in 1749). He was created a count in 1773. In 1739, at the age of 32, he was appointed keeper of the Jardin du Roi (the royal botanical garden, now the Jardin des Plantes) and of the museum that formed part of it through the patronage of the minister of marine, J.-F.-P. de Maurepas, who realized the importance of science and was anxious to use Buffon's knowledge of timber for the shipbuilding projects of the French government. Maurepas also charged Buffon to undertake a catalog of the royal collections in natural history, which the ambitious Buffon transformed into an undertaking to produce an account of the whole of nature. This became his great work, Histoire naturelle, générale et particulière (1749–1804), which was the first modern attempt to systematically present all existing knowledge in the fields of natural history, geology, and anthropology in a single publication.

Buffon's Histoire naturelle was translated into various languages and widely read throughout Europe. The first edition is still highly prized by collectors for the beauty of its illustrations.

Photo 43 : Portrait of Georges Louis Leclerc, Comte de Buffon

By E. Giroux, 1855.

Jean-Baptiste Lamarck (1744-1829) :

Was a pioneering French biologist who is best known for his idea that acquired characters are inheritable, an idea known as Lamarckism, which is controverted by modern genetics and evolutionary theory.

Between 1783 and 1792 Lamarck published three large botanical volumes for the Encyclopédie méthodique ("Methodical Encyclopaedia"), a massive publishing enterprise begun by French publisher Charles-Joseph Panckoucke in the late 18th century. Lamarck also published botanical papers in the Mémoires of the Academy of Sciences. **In 1792** he cofounded and coedited a short-lived journal of natural history, the Journal d'histoire naturelle.

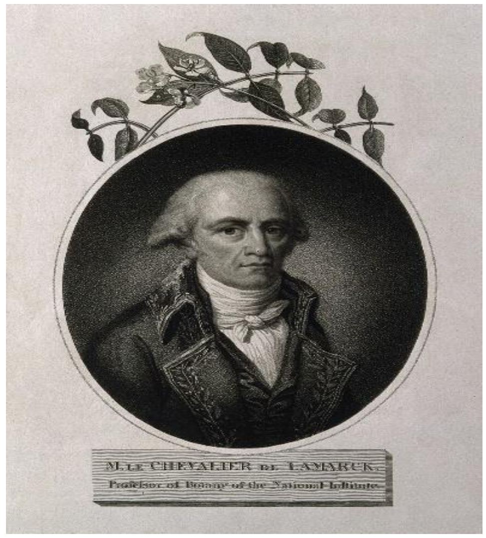


Photo 44 : Portrait of Jean Batiste Lamarck

By J. Hopwood, 1805.

2.1 Advances in biology :

This was the "Age of Enlightenment", when independent-minded philosophers and scientists reacted against the excesses of theology, in an attempt to make rationalism, the marvellous and superstition triumph. As far as we're concerned, it was the period when biology began to become an experimental science, particularly in the second half of the century, which in many ways heralded the discoveries of the 19th century. At the beginning of the 18th century, Joseph Guichard Duvernay (1648-1730) published several important memoirs for the Académie des Sciences in Paris on the circulatory and respiratory systems of cold-blooded vertebrates such as frogs, snakes and others. In 1720, Michael Bernhard Valentini (1657-1729) published a study comparing the anatomy of different vertebrates.

In 1734, Jacob Theodor Klein (1685-1759) published Naturalis Dispositio Echinodermatum, a pioneering work on sea urchins.

2.2 Botany :

Sébastien Vaillant (1669-1722) :

-French botanist.

-Publishes the Botanicon Parisiene (or Alphabetical enumeration of plants growing around Paris), after a long period working on plant reproduction.

-This book is one of the first to describe the flora of the around Paris.

Photo 45 : Portrait of Sébastien Vaillant

By Claude Aubriet.

Johann Wolfgang von Goethe (1749-1832) :

-Famous German writer and scientist.

-published, in 1790, an essay on plant metamorphoses, Versuch die Metamorphose der Pflanzen zu erklaren.

-He also outlines a theory of evolution in plants and links morphology with phylogeny. This makes him one of the first (and perhaps the first) to use the term metamorphosis in botany.

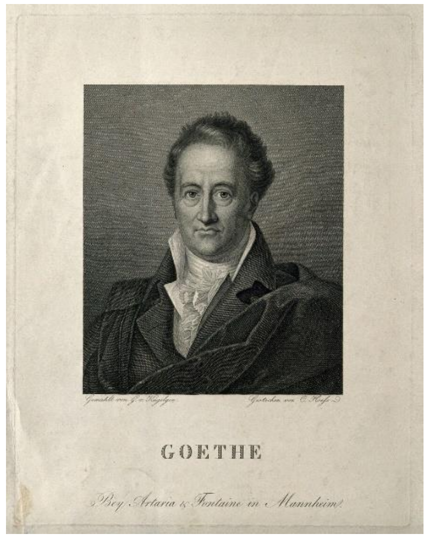


Photo 46 : Portrait of Johann Wolfgang von Goethe

By C. Hess after F. G. von Kügelgen, 1810.

2.3 Buffon :

Was a French naturalist, remembered for his comprehensive work on natural history, Histoire naturelle, générale et particulière (begun in 1749). He was created a count in 1773. **In 1735** he published a translation of Stephen Hales's Vegetable Staticks, in the preface of which he developed his conception of scientific method. Maintaining an interest in mathematics, he published a translation of Sir Isaac Newton's Fluxions in 1740. In his preface to this work he discussed the history of the differences between Newton and Gottfried Wilhelm Leibniz over the discovery of the infinitesimal calculus. He also made researches on the properties of timbers and their improvement in his forests in Burgundy. He was also intendant of the King's Garden between 1739 and 1788.

2.4 Linné (1707-1778) :

A Swedish naturalist and explorer who was the first to frame principles for defining natural genera and species of organisms and to create a uniform system for naming them (binomial nomenclature).

Swedish naturalist Carl Von Linné played an essential role, notably with his descriptions of tens of thousands of spaces and the introduction of binominal nomenclature. His plant classification was based on the work of Rudolf Jakob Camerarius (1665-1721) on plant sexuality.

CHAPTER VII : THEORY OF EVOLUTION 19TH CENTURY

1. Introduction to Evolution :

All species of living organisms, from bacteria to baboons to blueberries, evolved at some point from a different species. Although it may seem that living things today stay much the same, that is not the case—evolution is an ongoing process.

The theory of evolution is the unifying theory of biology, meaning it is the framework within which biologists ask questions about the living world. Its power is that it provides direction for predictions about living things that are borne out in experiment after experiment. The Ukrainian-born American geneticist Theodosius Dobzhansky famously wrote that "nothing makes sense in biology except in the light of evolution." He meant that the tenet that all life has evolved and diversified from a common ancestor is the foundation from which we approach all questions in biology.

2. Natural Selection :

Charles Darwin is best known for his discovery of natural selection. In the mid-nineteenth century, the actual mechanism for evolution was independently conceived of and described by two naturalists: Charles Darwin and Alfred Russel Wallace.

Darwin observed that beak shape varies amog finch species. He postulated that the beak of an ancestral species had adapted over time to equip the finches to acquire different food sources.

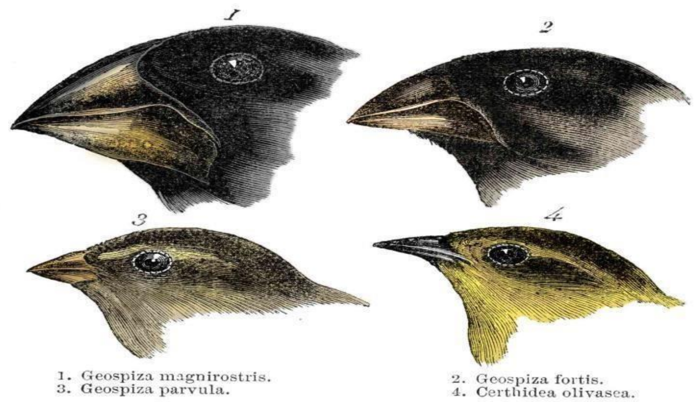


Photo 47 : The changes in bird beaks.

Importantly, each naturalist spent time exploring the natural world on expeditions to the tropics. From 1831 to 1836, Darwin traveled around the world on H.M.S. Beagle, including stops in South America, Australia, and the southern tip of Africa. Wallace traveled to Brazil to collect insects in the Amazon rainforest from 1848 to 1852 and to the Malay Archipelago from 1854 to 1862.

Darwin's journey, like Wallace's later journeys to the Malay Archipelago, included stops at several island chains, the last being the Galápagos Islands west of Ecuador. On these islands, Darwin observed species of organisms on different islands that were clearly similar, yet had distinct differences. For example, the ground finches inhabiting the Galápagos Islands comprised several species with a unique beak shape .

The species on the islands had a graded series of beak sizes and shapes with very small differences between the most similar. He observed that these finches closely resembled another finch species on the mainland of South America. Darwin imagined that the island species might be species modified from one of the original mainland species. Upon further study, he realized that the varied beaks of each finch helped the birds acquire a specific type of food. For example, seed-eating finches had stronger, thicker beaks for breaking seeds, and insect-eating finches had spear-like beaks for stabbing their prey.

Wallace and Darwin both observed similar patterns in other organisms and they independently developed the same explanation for how and why such changes could take place. Darwin called this mechanism natural selection. Natural selection, also known as "survival of the fittest," is the more prolific reproduction of individuals with favorable traits that survive environmental change because of those traits ; this leads to evolutionary change.

For example, a population of giant tortoises found in the Galapagos Archipelago was observed by Darwin to have longer necks than those that lived on other islands with dry lowlands. These tortoises were "selected" because they could reach more leaves and access more food than those with short necks. In times of drought when fewer leaves would be available, those that could reach more leaves had a better chance to eat and survive than those that couldn't reach the food source. Consequently, long-necked tortoises would be more likely to be reproductively successful and pass the long-necked trait to their offspring. Over time, only long-necked tortoises would be present in the population.

Natural selection, Darwin argued, was an inevitable outcome of three principles that operated in nature. First, most characteristics of organisms are inherited, or passed from parent to offspring. Although no one, including Darwin and Wallace, knew how this happened at the time, it was a common understanding. Second, more offspring are produced than are able to survive, so resources for survival and reproduction are limited. The capacity for reproduction in all organisms outstrips the availability of resources to support their numbers. Thus, there is competition for those resources in each generation. Both Darwin and Wallace's understanding of this principle came from reading an essay by the economist Thomas Malthus who discussed this principle in relation to human populations. Third, offspring vary among each other in regard to their characteristics and those variations are inherited. Darwin and Wallace reasoned that offspring with inherited characteristics which allow them to best compete for limited resources will survive and have more offspring than those individuals with variations that are less able to compete. Because characteristics are inherited, these traits will be better represented in the next generation. This will lead to change in populations over generations in a process that

Darwin called descent with modification. Ultimately, natural selection leads to greater adaptation of the population to its local environment; it is the only mechanism known for adaptive evolution.

Papers by Darwin and Wallace (Photo 47) presenting the idea of natural selection were read together in 1858 before the Linnean Society in London. The following year Darwin's book, On the Origin of Species, was published. His book outlined in considerable detail his arguments for gradual changes and adaptive survival by natural selection.

(a) (b)

Photo 48 : Both (a) Charles Darwin and (b) Alfred Wallace

Demonstrations of evolution by natural selection are time consuming and difficult to obtain. One of the best examples has been demonstrated in the very birds that helped to inspire Darwin's theory: the Galápagos finches. Peter and Rosemary Grant and their colleagues have studied Galápagos finch populations every year since 1976 and have provided important demonstrations of natural selection. The Grants found changes from one generation to the next in the distribution of beak shapes with the medium ground finch on the Galápagos island of Daphne Major. The birds have inherited variation in the bill shape with some birds having wide deep bills and others having thinner bills. During a period in which rainfall was higher than normal because of an El Niño, the large hard seeds that large-billed birds ate were reduced in number; however, there was an abundance of the small soft seeds which the small-billed birds ate. Therefore, survival and reproduction were much better in the following years for the small-billed birds.

In the years following this El Niño, the Grants measured beak sizes in the population and found that the average bill size was smaller.

Since bill size is an inherited trait, parents with smaller bills had more offspring and the size of bills had evolved to be smaller. As conditions improved in 1987 and larger seeds became more available, the trend toward smaller average bill size ceased.

3. Theory of Evolution :

Natural selection can only take place if there is variation, or differences, among individuals in a population. Importantly, these differences must have some genetic basis ; otherwise, the selection will not lead to change in the next generation. This is critical because variation among individuals can be caused by non-genetic reasons such as an individual being taller because of better nutrition rather than different genes.

Genetic diversity in a population comes from two main mechanisms: mutation and sexual reproduction. Mutation, a change in DNA, is the ultimate source of new alleles, or new genetic variation in any population. The genetic changes caused by mutation can have one of three outcomes on the phenotype. A mutation affects the phenotype of the organism in a way that gives it reduced fitness—lower likelihood of survival or fewer offspring. A mutation may produce a phenotype with a beneficial effect on fitness. And, many mutations will also have no effect on the fitness of the phenotype; these are called neutral mutations. Mutations mayn also have a whole range of effect sizes on the fitness of the organism that expresses them in their phenotype, from a small effect to a great effect. Sexual reproduction also leads to genetic diversity: when two parents reproduce, unique combinations of alleles assemble to produce the unique genotypes and thus phenotypes in each of the offspring.

A heritable trait that helps the survival and reproduction of an organism in its present environment is called an adaptation.

Scientists describe groups of organisms becoming adapted to their environment when a change in the range of genetic variation occurs over time that increases or maintains the "fit" of the population to its environment. The webbed feet of platypuses are an adaptation for swimming. The snow leopards' thick fur is an adaptation for living in the cold. The cheetahs' fast speed is an adaptation for catching prey.

Whether or not a trait is favorable depends on the environmental conditions at the time. The same traits are not always selected because environmental conditions can change. For example, consider a species of plant that grew in a moist climate and did not need to conserve water. Large leaves were selected because they allowed the plant to obtain more energy from the sun. Large leaves require more water to maintain than small leaves, and the moist environment provided favorable conditions to support large leaves. After thousands of years, the climate changed, and the area no longer had excess water. The direction of natural selection shifted so that plants with small leaves were selected because those populations were able to conserve water to survive the new environmental conditions.

The evolution of species has resulted in enormous variation in form and function. Sometimes, evolution gives rise to groups of organisms that become tremendously different from each other. When two species evolve in diverse directions from a common point, it is called divergent evolution. Such divergent evolution can be seen in the forms of the reproductive organs of flowering plants which share the same basic anatomies ; however, they can look very different as a result of selection in different physical environments and adaptation to different kinds of pollinators (Photo 49).

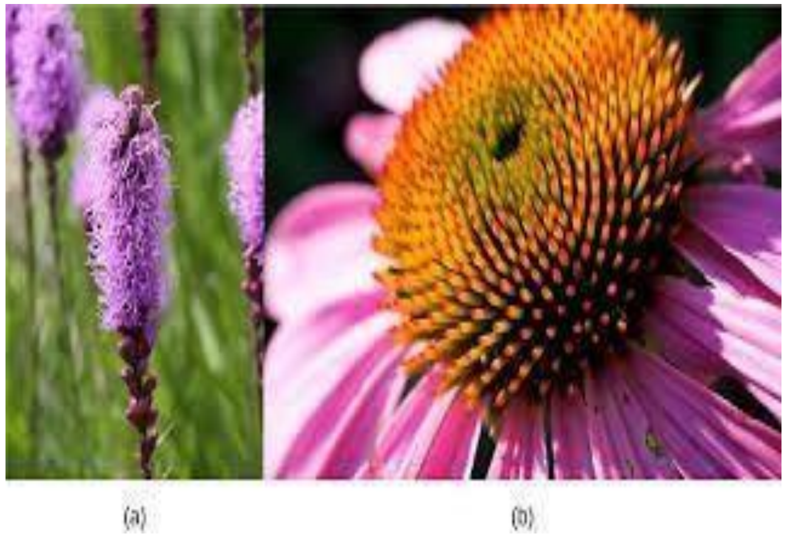


Photo 49 : Flowering plants evolved from a common ancestor.

Notice that the (a) dense blazing star (Liatrus spicata) and the (b) purple coneflower (Echinacea purpurea) vary in appearance, yet both share a similar basic morphology. (credit a: modification of work by Drew Avery; credit b: modification of work by Cory Zanker).

In other cases, similar phenotypes evolve independently in distantly related species. For example, flight has evolved in both bats and insects, and they both have structures we refer to as wings, which are adaptations to flight. However, the wings of bats and insects have evolved from very different original structures. This phenomenon is called convergent evolution, where similar traits evolve independently in species that do not share a recent common ancestry. The two species came to the same function, flying, but did so separately from each other.

These physical changes occur over enormous spans of time and help explain how evolution occurs. Natural selection acts on individual organisms, which in turn can shape an entire species. Although natural selection may work in a single generation on an individual, it can take thousands or even millions of years for the genotype of an entire species to evolve. It is over these large time spans that life on earth has changed and continues to change.

CHAPTER : VIII

I.HISTORY OF CYTOLOGY

1. Definition:

Cytology, is the study of cells as fundamental units of living things. The earliest phase of cytology began with the English scientist Robert Hooke's microscopic investigations of cork in 1665. He observed dead cork cells and introduced the term "cell" to describe them. In the 19th century two Germans, the botanist Matthias Schleiden (in 1838) and the biologist Theodor Schwann (in 1839), were among the first to clearly state that cells are the fundamental particles of both plants and animals. This pronouncement—the cell theory—was amply confirmed and elaborated by a series of discoveries and interpretations.

In 1892 the German embryologist and anatomist Oscar Hertwig suggested that organismic processes are reflections of cellular processes; he thus established cytology as a separate branch of biology. Research into the activities of chromosomes led to the founding of cytogenetics, in 1902–04, when the American geneticist Walter Sutton and the German zoologist Theodor Boveri demonstrated the connection between cell division and heredity. Modern cytologists have adapted many methods of physics and chemistry to investigate cellular events. See also cell.

Boveri, Theodor, (1862-1915) :

A German cytologist whose work with roundworm eggs proved that chromosomes are separate, continuous entities within the nucleus of a cell.

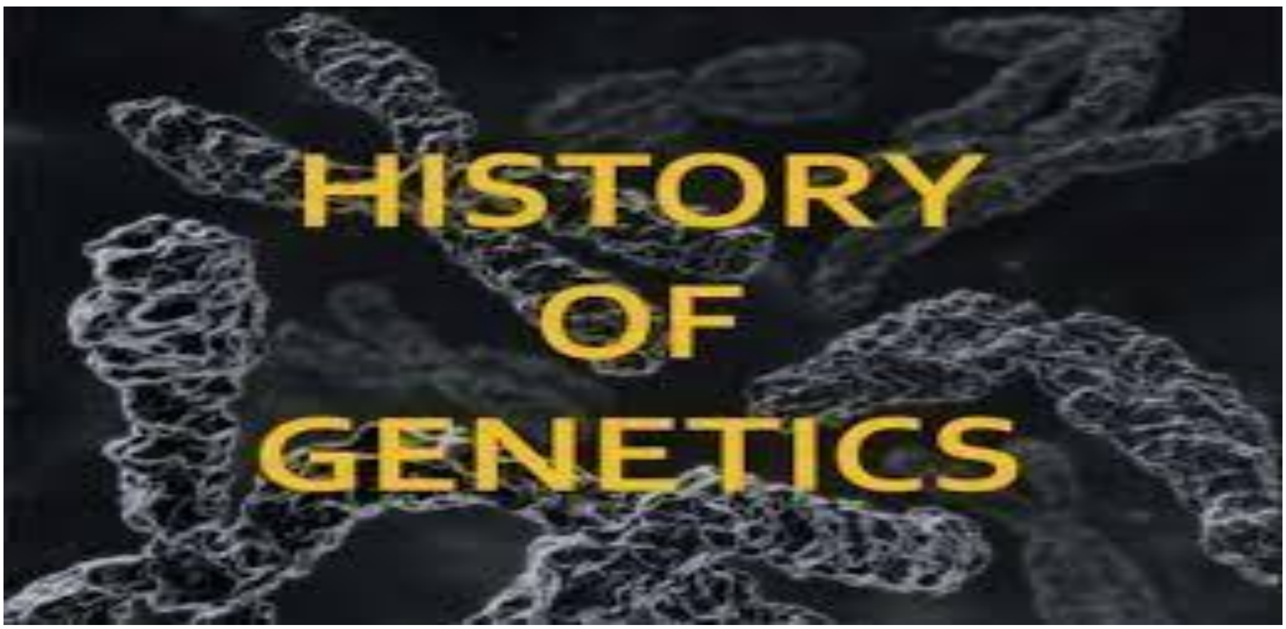
Boveri received an M.D. degree (1885) from the University of Munich and from 1885 until 1893 was engaged in cytological research at the Zoological Institute in Munich. In 1885 he began a series of studies on chromosomes. His first major report (1887) described the development of an unfertilized egg, including the formation of polar bodies (small cells that result from the division of an unfertilized egg). Later he described finger-shaped lobes that appeared in the nuclei of eggs of the roundworm Ascaris during early cleavage stages. These structures, he decided, were chromosomes, previously believed to be part of the nucleus and present only during nuclear division. Boveri's third report proved the theory—introduced by Belgian cytologist Edouard van Beneden—that the ovum and sperm cell contribute equal numbers of chromosomes to the new cell created during fertilization.

Later, Boveri introduced the term centrosome and demonstrated that this structure is the division centre for a dividing egg cell. He also proved that a single chromosome is responsible for particular hereditary traits and demonstrated the importance of cytoplasm by showing that chromosomes are influenced by the cytoplasm surrounding the nucleus. In 1893 he was appointed professor at the University of Würzburg.

Zernike, Frits (1888-1966) :

Was a Dutch physicist, winner of the Nobel Prize for Physics in 1953 for his invention of the phase-contrast microscope, an instrument that permits the study of internal cell structure without the need to stain and thus kill the cells.

Zernike obtained a doctorate from the University of Amsterdam in 1915. He became an assistant at the State University of Groningen in 1913 and served as a full professor there from 1920 to 1958. His earliest work in optics was concerned with astronomical telescopes. While studying the flaws that occur in some diffraction gratings because of the imperfect spacing of engraved lines, he discovered the phase-contrast principle. He noted that he could distinguish the light rays that passed through different transparent materials. He built a microscope using that principle in 1938. In 1952 Zernike was awarded the Rumford Medal of the Royal Society of London.


HISTORY
OF
GENETICS

II.HISTORY OF GENETICS

1. Definition:

Genetics is the study of genes. Our genes carry information that gets passed from one generation to the next.

For example, genes are why one child has blonde hair like their mother, while their sibling has brown hair like their father. Genes also determine why some illnesses run in families and whether babies will be male or female.

2. Gregor Mendel and the beginnings of genetics :

Around 1865, the Czech monk Gregor Mendel (1822-1884) began artificially pollinating white pea flowers with pollen from red-flowered peas, and observing the color of the peas insubsequent generations, he thus laid the foundations of a new science, **genetics.**

3. The double helix structure of DNA :

In 1953, the most revolutionary biological publication since Charles Darwin's Origin of Species appeared in the English journal Nature. This short publication presents the double-helix model for the structure of deoxyribonucleic acid, or DNA, and outlines in a few lines the genetic consequences of this structure. It was the work of two young researchers, the Englishman Francis Crick and the American James Watson, and earned them the Nobel Prize for Physiology or Medicine in 1962.

This discovery was of the utmost importance, not only because DNA is the molecule that transmits hereditary information from generation to generation, but also because its structure enables us to understand the mechanism of this transmission. DNA is a helical molecule with two strands, linked together by hydrogen bonds at the bases adenine (A), guanine (G), cytosine (C) and thymine (T). In this structure, adenine is always associated with thymine, and guanine with cytosine. When DNA replicates, the two strands separate and each reconstitutes a complete two-stranded helix in which the information is faithfully reproduced. In this way, the hereditary information that governs the properties of the cell and the organism is transmitted to daughter cells each time a cell divides.

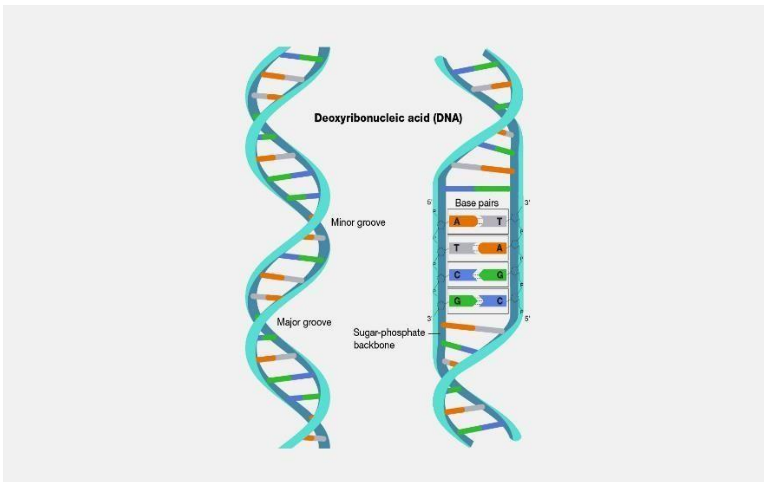


Figure 50 : Structure of DNA

3.1.1 Francis Harry Compton Crick (1916-2004) :

A British biophysicist, who, with James Watson and Maurice Wilkins, received the 1962 Nobel Prize for Physiology or Medicine for their determination of the molecular structure of deoxyribonucleic acid (DNA), the chemical substance ultimately responsible for hereditary control of life functions. This accomplishment became a cornerstone of genetics and was widely regarded as one of the most important discoveries of 20th-century biology.

In 1951, when the American biologist James Watson arrived at the laboratory, it was known that the mysterious nucleic acids, especially DNA, played a central role in the hereditary determination of the structure and function of each cell. Watson convinced Crick that knowledge of DNA's three-dimensional structure would make its hereditary role apparent. Using the X-ray diffraction studies of DNA done by Wilkins and X-ray diffraction pictures produced by Rosalind Franklin, Watson and Crick were able to construct a molecular model consistent with the known physical and chemical properties of DNA. The model consisted of two intertwined helical (spiral) strands of sugarphosphate, bridged horizontally by flat organic bases. Watson and Crick theorized that if the strands were separated, each would serve as a template (pattern) for the formation, from small molecules in the cell, of a new sister strand identical to its former partner. This copying process explained replication of the gene and, eventually, the chromosome, known to occur in dividing cells. Their model also indicated that the sequence of bases along the DNA molecule spells some kind of code "read" by a cellular mechanism that translates it into the specific proteins responsible for a cell's particular structure and function.

3.1.2 James Dewey Watson (b. 1928) :

Is an American geneticist and biophysicist who played a crucial role in the discovery of the molecular structure of deoxyribonucleic acid (DNA), the substance that is the basis of heredity. For this accomplishment he was awarded the 1962 Nobel Prize for Physiology or Medicine with Francis Crick and Maurice Wilkins.

This discovery helped to determine the structure of deoxyribonucleic acid, or DNA. In 1968, Watson became director of the Laboratory of Quantitative Biology at Cold Spring Harbor, New York. He is the author of The Double Helix (1968), which tells the story of the discovery of the structure of DNA. From 1988 to 1992, at the National Institutes of Heath, Watson directed the ambitious Human Genome Project, whose aim was to map the entire human DNA sequence and identify every single gene.


a
b
c

III.HISTORY OF EMBRYOLOGY

1. Definition:

A scientific discipline which studies the development of living beings from conception to birth. The origins of embryology can be traced back to antiquity, when numerous philosophers were interested in the evolution of the embryo. Their technical resources were limited, limited to observing the eggs of various animals, especially hens. Speculation and hypothesis took the place of technique. The most varied and erroneous doctrines were put forward in an attempt to explain the formation of beings.

Aristotle (322-384 B.C.) :

Wrote the first known treatise on embryology. embryology, as well as the first classification of animals into oviparous oviparous, viviparous and ovoviviparous species.

In the 17th and 18th centuries, the theory in vogue to explain embryonic development was that of preformationism, according to which the theory, the developing animal was always present in the egg, but so small and transparent. small and transparent. When it begins to develop, the miniature animal only grows, its tissues becoming denser and more visible.

Malpighi (1628- 1694) :

Was an Italian physician and biologist who, in developing experimental methods to study living things, founded the science of microscopic anatomy. After Malpighi's researches, microscopic anatomy became a prerequisite for advances in the fields of physiology, embryology, and practical medicine.

Malpighi probably concluded that the embryo is preformed in the egg after fertilization. He also made extensive comparative studies in 1675–79 of the microscopic anatomy of several different plants and saw an analogy between plant and animal organization.

In Arab-Muslim civilization, it was widely believed that the embryo forms in stages, starting with the meeting of 2 gametes, one female and the other male, according to the Koran in the 6th century.

Western scientists didn't take this into consideration, because for them, these were religious beliefs and not scientific theories. They didn't have an answer until the 17th century, when the theory of epigenesis appeared, stipulating that the embryo develops in increasingly complex ways in direct relation to its environment, and that cells divide to form organs. Among the scientists who supported this theory were Wolff (1769), Spallanzani (1775), Prévost (1824) and Von Baer (1827).

-In 1672, De Graaf discovered follicles in the ovaries, still known as De Graaf follicles.

-In 1674, Leeuwenhoek observed the human spermatozoon under a simple microscope. -In 1827, Karl Ernst Von Baer observed vertebrate embryos and formulated Baer's law of embryology, which stipulates that the general characteristics of embryos visible early in their development will gradually be replaced by increasingly specific characteristics. The embryos of a fish and a mammal, for example, will be similar in their early stages, then gradually differentiate as they develop their own specific characteristics.

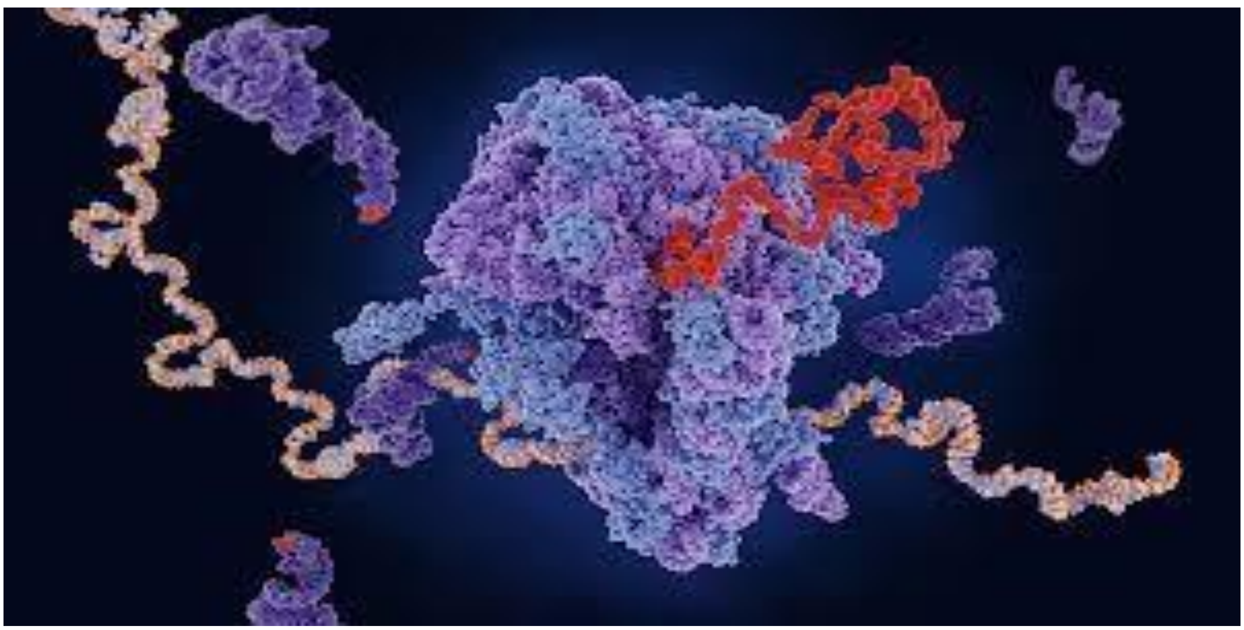
-In 1875, Hertwig discovered fertilization.

Descriptive embryology became experimental in 1880 with the work of Roux and Driesch.

-In 1880, Roux burned one of the frog blastomeres at stage 2. The remaining frog blastomere developed into what appeared to be a half-embryo.

-In 1891 Hans Driesch repeated Roux's experiment, but dissociated 2 blastomeres from sea urchins rather than frogs. Each of the isolated blastomeres developed into a complete larva. Driesch proposed the theory of regulatory development, noting that each sea urchin blastomere could regulate its own development.

-In 1924, Hans Spemann and Hilde Mangold demonstrated the organizer, a region of the amphibian embryo capable of inducing the surrounding cells to form dorsal structures (S.N.)



IV.HISTORY OF MOLECULAR BIOLOGY

1. Definition :

A discipline that studies the structure, synthesis and degradation of macromolecules (very large molecules) in living cells, as well as their metabolic regulation (the control of their synthesis or degradation in their cells) and expression.

Macromolecules include nucleic acids, DNA (deoxyribonucleic acid) and RNA (ribonucleic acid), proteins (including enzymes), carbohydrates, carbohydrate-protein complexes and lipids.

The term was first used by Oswald T.Avery in the late '40s and was associated from the outset with the study of nucleic acids.

In 1901, Tsvet discovered chromatography.

In 1901 Hopkins discovered the amino acid tryptophan, and **in 1906** he discovered vitamins, the first being vitamin B.

Some of the equipment used in biochemistry and molecular biology:

Centrifuge, electrophoresis, magnometer, PH meter….

CHAPTER : IX

I. HISTORY OF CLONING

1. Definition:

A clone is a group of cells or individuals derived from a single unit. The members of a clone are in principle (barring mutations) genetically identical. In the laboratory, cloning is a technique for reproducing genes, cells or organisms from a single cell.

Generally speaking, cloning makes it possible to obtain genetically identical living beings withoutsexual reproduction, but by asexual reproduction.

2.Some research into cloning:

In 1880, Weismann gave the theory of genetic loss (loss of genetic material (genes) as cells differentiate and specialize).
In 1888, Roux confirmed this theory with his experiment on frog blastomeres.

In 1891, Hans Driesch found the opposite to be true with his experiment on sea urchin blastomeres, as he discovered that each urchin blastomere could regulate its development to give a complete larva.

In 1935, for the first time, Hans Spermann mentions the possibility of transplanting cell nuclei into oocytes (nuclear transfer). He considered experiments with frogs.

In 1939, artificial parthenogenesis was initiated in the rabbit, and the work of Pinkns and Shapiroled to the birth of 3 female rabbits by parthenogenesis.

In 1962, frogs were cloned by nucleus transfer from adult cells; British biologists J.B.Gurdon announced the cloning of a frog from a differentiated intestinal cell.

In 1984, a sheep was cloned by separating cells from an embryo (Steen Willadsen).

In 1996, the birth of Dolly, a sheep cloned from a mammary gland cell. Jan Wilmnt and his team at the Roslin Institute in Scotland witness the birth of Dolly the sheep, the first mammal obtained by transferring the nucleus of an adult cell. Dolly was euthanized in 2003 for lung problems.

After the birth of Dolly the sheep, attempts at human cloning began but were unsuccessful. Human cloning trials still exist, but under religious and social control.

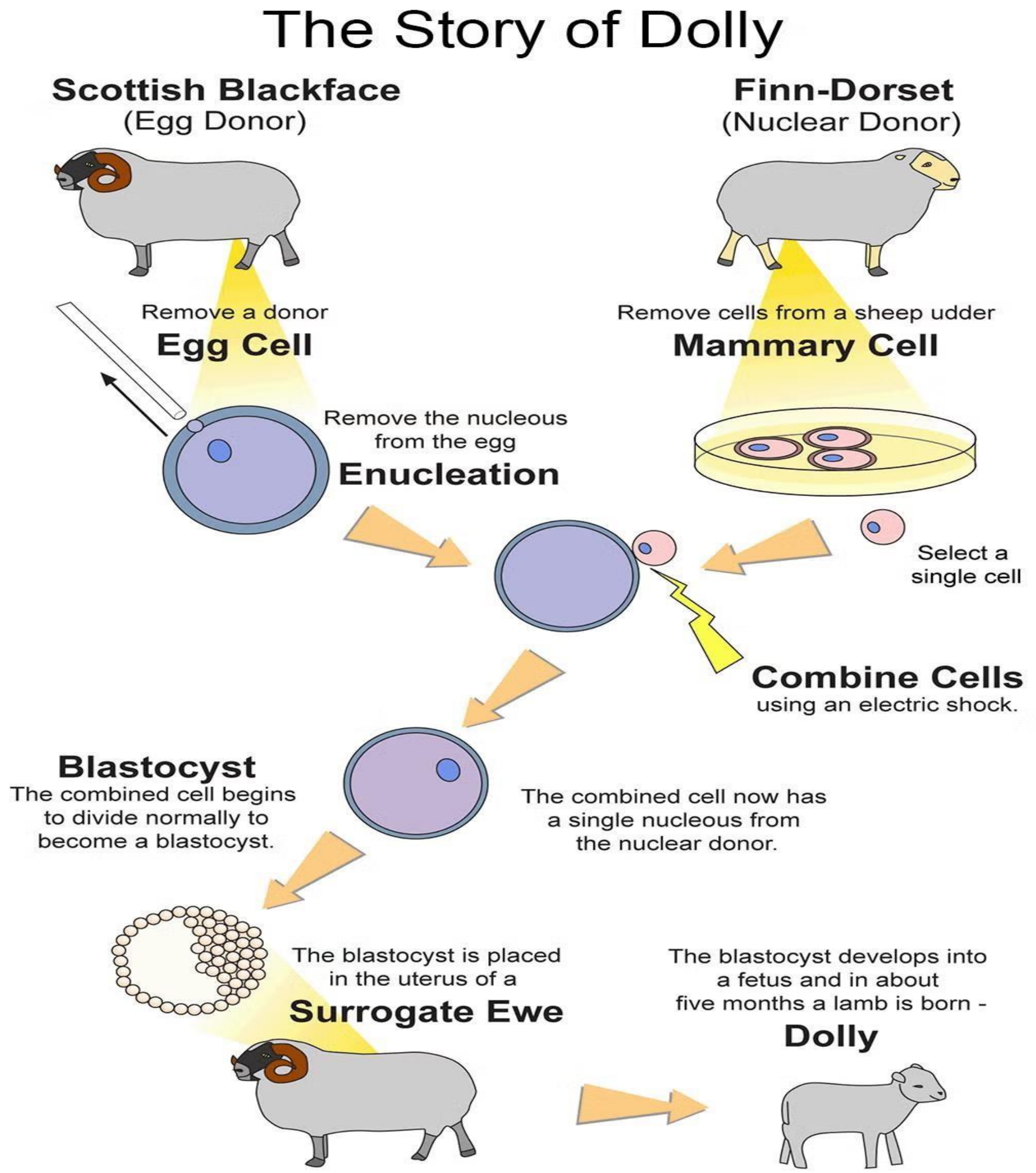


Figure 51 : Steps for making Dolly the sheep

II.HISTORY OF GENE THERAPY

1. Definition:

A therapeutic method using genes and the information they carry to treat a genetic disease or modify cellular behavior.

2. Example of disease:

Cancer, which is becoming one of the main targets of gene therapy, type I diabetes.

Types of therapy: there are 2 types:

2.1 Germ-line gene therapy:

this treatment involves modifying genes inside germ cells (sperm or eggs). (Currently banned for humans, but used for animals).

2.2 somatic gene therapy:

replaces the defective gene in somatic cells and affects only the person treated.

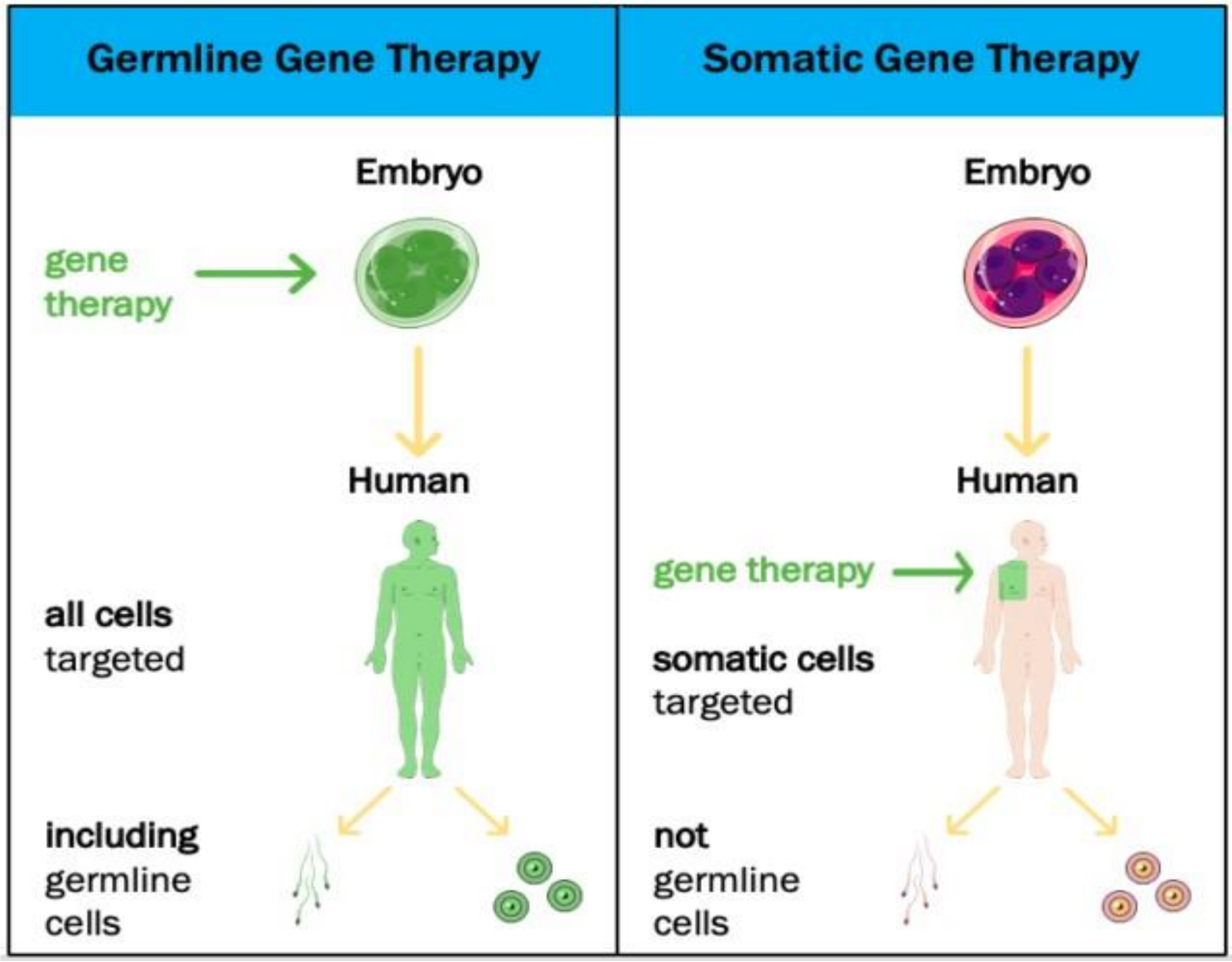


Figure 52 : Germline Vs. Somatic Therapy

Created by Sonya Frazier.

3. Successful experiments:

The first gene therapy experiment was carried out on the little girl Ashanti, who was born with a genetic defect (she does not produce the enzyme Adenosinedeaminase), her deficiency causing the death of blood cells (T lymphocytes) which play a very important role in immunity.

In 1990, they injected Achanti, and the result was positive.

REFERENCES

1. Christophe Ronsin, 2005- Histoire de la biologie moléculaire. Ed. De Boeck, 106p.
2. Denis Buican, 2008- Darwin dans l'histoire de la pensée biologique. Ed. Ellipses, 232p.
3. Encyclopædia Britannica.
4. James Hardy, February 19, 2024, Paleolithic, Mesolithic, Neolithic Periods, and More.
5. Jean Théodoridès, 2000- Histoire de la biologie. Ed. Puf, 127p.
6. Leaman, Oliver, 1997- Averroes and his Philosophy. Richmond, U.K.: Curzon.
7. Nasr, Seyyed, and Leaman, Oliver, 1996- History of Islamic Philosophy. London : Routledge.
8. Paul Strathern and Robinson, 2005- London, A Brief History of Medicine , p. 129.
9. Some handouts of the course.