Biology and Geology

Secondary

4

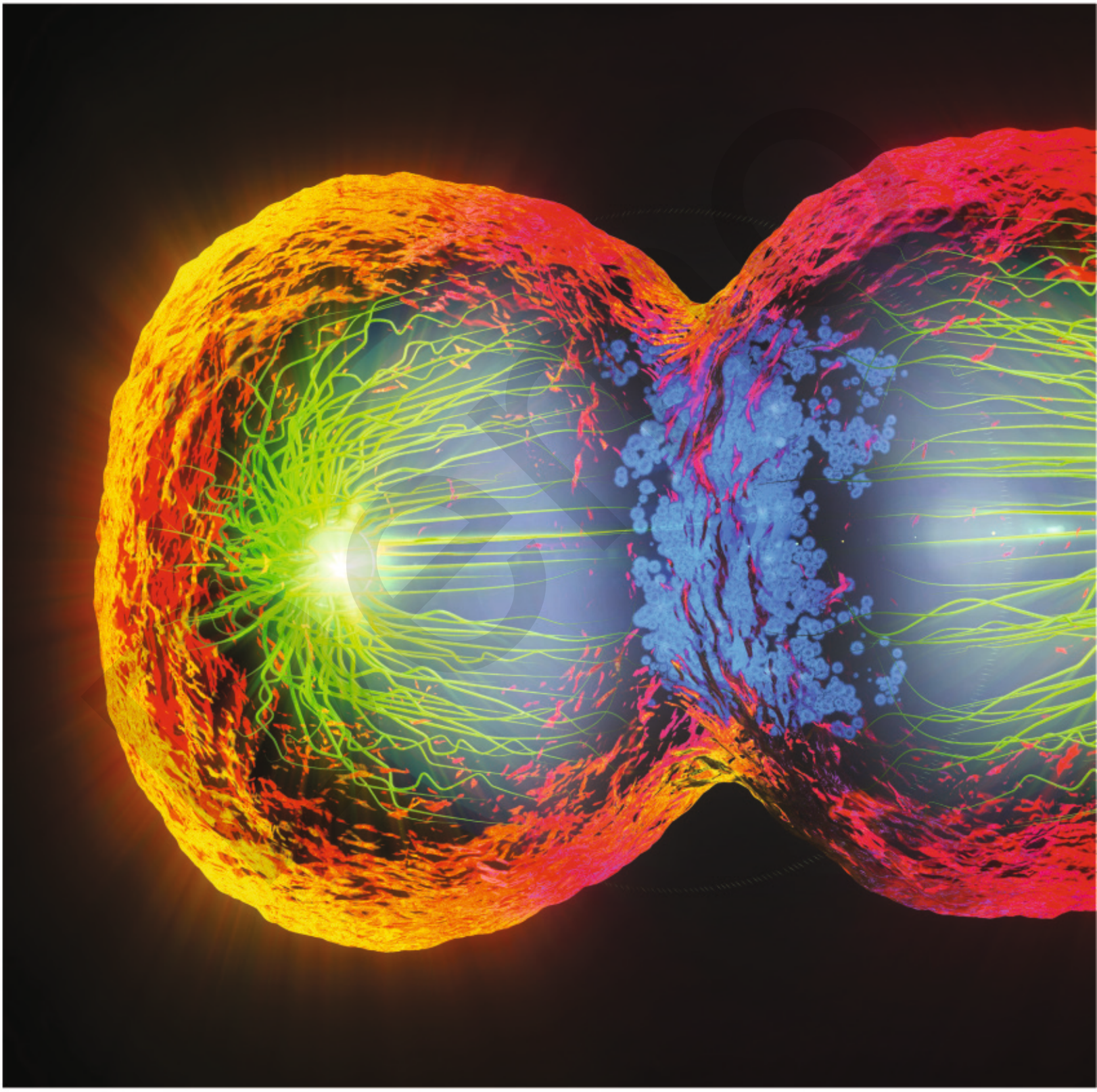
AEON

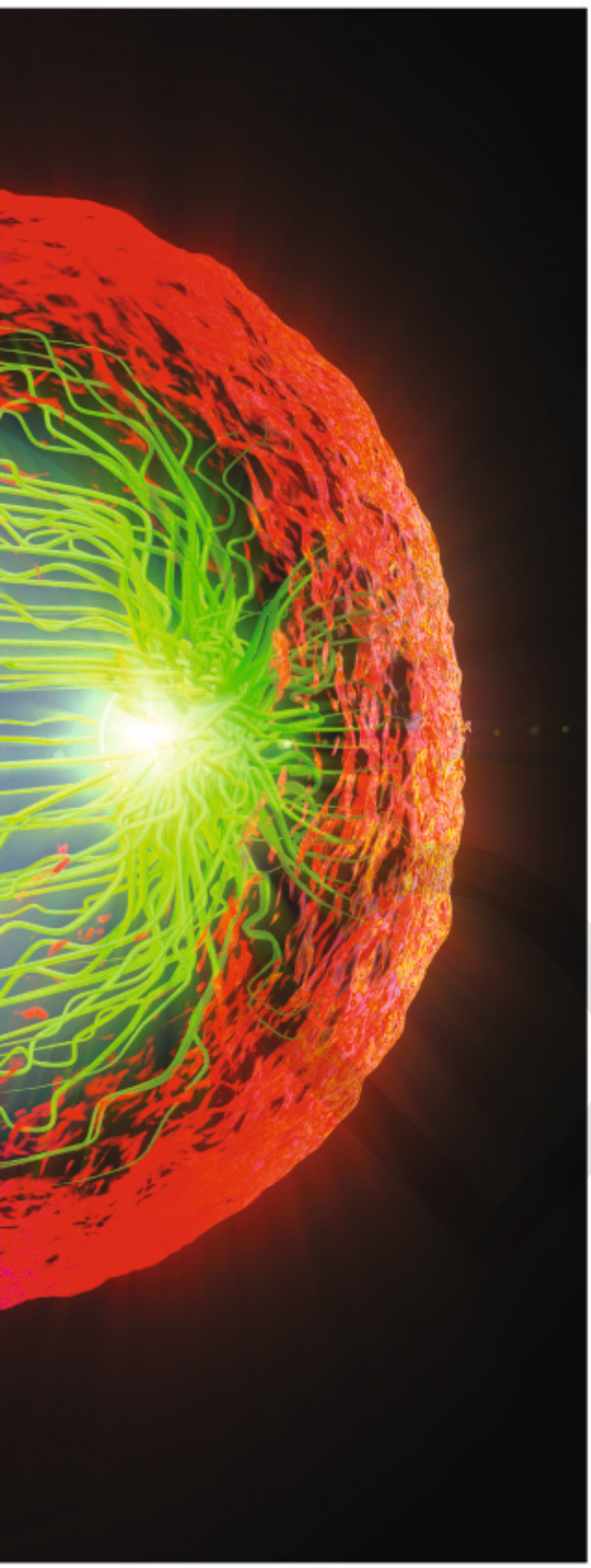
Basic knowledge

Key skills / Activities / Learning situations			
1 Linguistic skills and communication (LSC).		Learning situations	
2 Multilingual skills (MS).		Group work	
3 Mathematical skills and basic technology skills (STEM).		Pair work	
4 Digital skills (DS).		Sustainability and environment	
5 Personal and social skills, and learning to learn (PSSLL).			
6 Civic skills (CS).			
7 Entrepreneurial skills (ES).			
8 Cultural awareness and expression (CAE).			

UNIT 1

The cell, the unit of life





In this unit you will learn how to...

- Discover the basic ideas in cell theory.
- Understand what cells are like and how they carry out their vital functions.
- Understand the differences between prokaryotic and eukaryotic cells.
- Understand what chromosomes are and their importance in biological inheritance.
- Distinguish animal from plant cells.
- Identify the types of cell division: mitosis and meiosis and discover their biological significance.

Life, as we know it on Earth, is organized around cells. They are the smallest part of living organisms, and can perform all vital functions and divide to create new cells.

The problem of the origin of cells is the problem of the origin of life.

Although scientists do not know how the first cell appeared on Earth, they agree that it was the result of a physical-chemical phenomenon.

The fact that a physical-chemical process was involved raises two interesting possibilities:

a) The creation of life. A cell can be 'manufactured' in a laboratory (synthetic biology).

b) Extraterrestrial life. It is a possible that somewhere else in the universe had the necessary conditions similar to those that existed on Earth to create life (astrobiology).

Answer the following questions

- What is the smallest part of a living creature that can be alive?
- Can living organisms be created from inert matter?
- What are vital functions?
- What is the main difference between prokaryotic and eukaryotic cells?
- And between animal and plant cells?
- Do you know the names of any cell organelles?
- What is the process of cell division called?

1 Cell Theory

Anton van Leeuwenhoek and his primitive microscope.

The first cells were observed by Leeuwenhoek in the 17th century, using a primitive microscope he himself had made. Over time, microscopes evolved, enabling scientists to observe all kinds of cells. With all the information available by the mid-19th century, three scientists, Schleiden, Schwann, and Virchow, developed **cell theory.** The postulates of this theory are given below:

- All living organisms are formed from cells. If they have a single cell, they are called **unicellular** organisms; if they have many, they are known as **multicellular** organisms.
- The cell is the smallest part of living organisms with life, in other words, capable of performing all vital functions.
- All cells come from pre-existing cells.

This theory has undergone various changes over time.

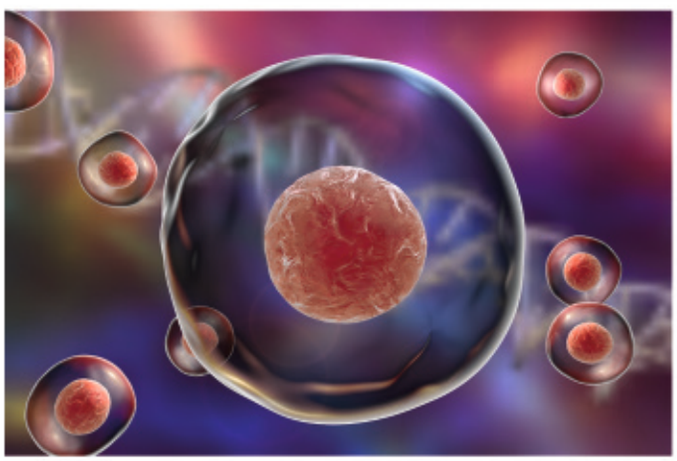
2 Cell structure

Although cells can be quite different from one another, they all have a common basic structure and are all able to carry out vital functions.

2.1. Basic parts of a cell

Membrane. A thin layer separating the cell from the outside environment. It allows nutrients to enter and waste matter to exit.

Cytoplasm. The jelly-like, watery material in which various molecules that take part in vital processes are dissolved. It may contain specific structures called cell organelles.



Genetic material. It consists of molecules containing information on how to perform cell activities.

Research

Look for information on the Internet on the theory of spontaneous generation. Compare it with cell theory.

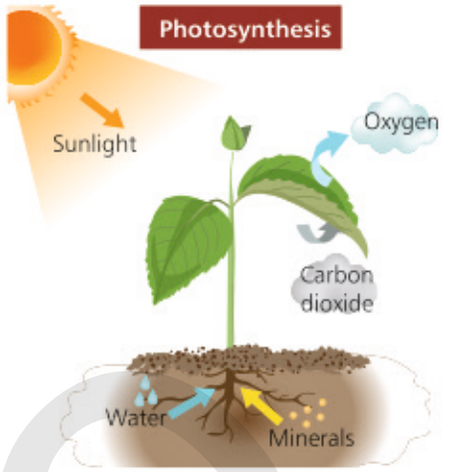
2.2. Cell functions

As we saw in the previous section, cells are able to perform the three vital functions: nutrition, interaction, and reproduction

- **Nutrition** consists of taking in molecules from the external environment, which we call **nutrients,** to cover two needs:
  - The **growth and renewal** of cell components.
  - **Energy production** for vital activities.

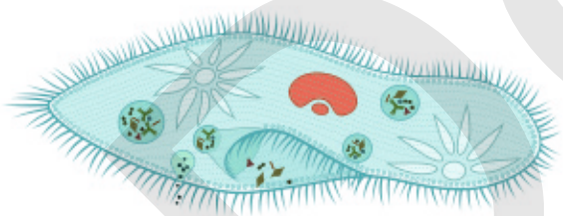
  The set of chemical transformations that occurs during nutrition is called **metabolism.** There are two types of nutrition:
  - **Autotrophic:** a cell synthesizes its organic molecules from inorganic molecules that it takes from its surroundings.
  - **Heterotrophic:** a cell does not synthesize its own organic molecules. Instead, it transforms the organic molecules it takes from its surroundings into its own organic molecules.

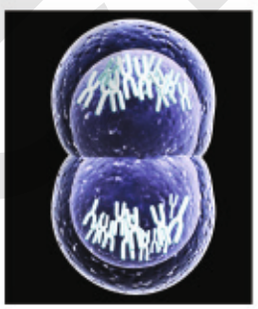
  At the end of nutrition, toxic or useless molecules for the cell are formed, which must be eliminated. This process is called **excretion.**
- **Interaction** is the ability of cells to capture changes in the surrounding environment **(stimuli)** and respond appropriately **(response).** This is how cells survive.
- **Reproduction** is the capacity of cells to form new cells from themselves. In unicellular organisms, new individuals are formed whereas in multicellular organisms, new cells are formed from the same organism **(growth).**



Autotrophic nutrition.


Heterotrophic nutrition.


Paramecium.


Cell in anaphase I of meiosis.

3 Cell types

3.1. Cell shape and size

Cell **size** varies greatly, from one to tens of microns. Bacteria measure one or two microns, and human eggs 100 microns.

There are also several cell **shapes,** depending on the function a cell performs. They can be elongated (sperm), stellate (neurons), discoidal (red blood cells), or prismatic (intestinal cells).

In depth

A micron (μ) is a unit of length equivalent to the millionth part of a meter. $1\mu = 10^{-6}$ m

It is used to express the size of cells.

Cell shapes: sperm, neurons, red blood cells, and intestinal cells.

3.2. Cell types by complexity

There are two main types of cells:

- **Prokaryotic:** these are smaller and simpler. Their genetic material is not protected. In other words, they do not have a differentiated nucleus and hardly any organelles. They are older.
- **Eukaryotic:** these are larger and more complex. Their genetic material is protected by a membranous envelope. In other words, they have a distinct nucleus and various organelles. They are more modern.

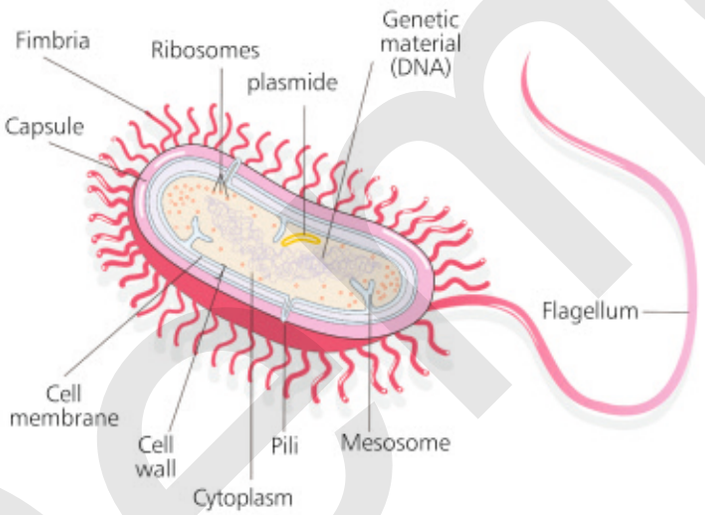
4 The prokaryotic cell

Cell membrane. A thin, flexible layer surrounding the cell. It is made up of lipids and proteins. It regulates the exchange of substances with the exterior.

Cell wall. A thick, rigid layer outside the membrane. It protects the cell and consists of complex sugars.

Cytoplasm. It is found inside the cell where vital reactions take place.

Genetic Material. It is made up of a circular DNA molecule. It contains genetic information.



Ribosomes. Small abundant granules used to make proteins.

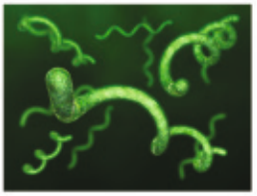
Capsule. Jelly-like outer layer with bacteria, which protects them from our immune system.

Fimbriae. Short, numerous filaments used to attach them to surfaces.

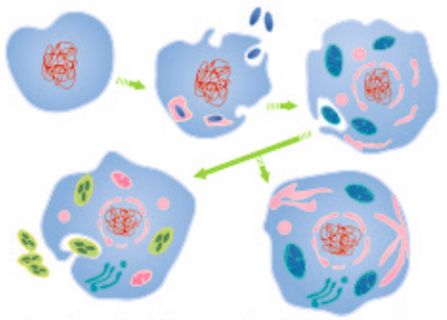
Flagellae. Long, fine filaments allowing cells to move. They only exist in certain bacteria.

This type of cell is characteristic of organisms in kingdom **Monera:** bacteria.

- **Archaebacteria:** these are the oldest, simplest bacteria. They live in extreme environments.
- **Cyanobacteria:** a group of eubacteria that carry out photosynthesis.
- **Eubacteria:** they are the most modern bacteria and have adapted to all environments. Depending on their shape, they can be:

			
Coconuts-spherical.	**Bacilli**-elongated.	**Vibrios**-shaped like a comma.	**Spirilla**-spiral.

5 The Eukaryotic cell



Eukaryotic cells: plants and Protista organisms

Eukaryotic cells: animal, fungi, and Protista organisms

As we have already seen, eukaryotic cells have a well-defined nucleus, and are more complex, because they have different cell organelles. They came into existence approximately two billion years ago (whereas prokaryotes developed 3.8 billion years ago). According to Lynn Margulis, they resulted from a process of endosymbiosis:

- The primitive eukaryotic cell was anaerobic and lived in an atmosphere where oxygen became a permanent fixture.
- Some aerobic bacteria captured by this cell settled inside it through symbiosis. This was the origin of mitochondria and animal cells.
- Later, the capture of photosynthetic bacteria marked the beginning of chloroplasts and plant cells.

5.1. Plasma membrane

This is a thin layer surrounding the entire cell, separating it from the outside. It is composed of lipids (phospholipids and cholesterol) and different types of proteins. It is extremely flexible and selectively permeable since it controls the substances that enter and exit the cell.

5.2. Cytoplasm

This is the part of the cell located between the plasma membrane and the nucleus. It is made up of a jelly-like substance, consisting of water with different dissolved substances (carbohydrates, lipids, proteins, salts, etc.), called **cytosol.** In the cytosol there are structures called **cell organelles** that, depending on their nature, can be membranous or non-membranous.

Women in Science

Lynn Margulis (1938-2011)

Outstanding American biologist. One of the leading figures in the field of biological evolution, she proposed the theory of endosymbiosis to explain the origin of eukaryotic cells.

Practice and learn

1. A scientist has discovered an unuual species of organism unlike any other existing ones in the Depths of a hidden cave. According to cell theory, what would it be made of?
2. What is the main difference between the spontaneous generation hypothesis and cell theory?
3. Divide the following cells into two groups, according to their type of nutrition: intestinal cell, leaf cell, root cell, stem cell, cyanobacteria and red blood cell.

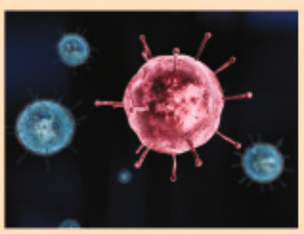
Autotrophic nutrition	Heterotrophic nutrition
...	...

4. What are the oldest bacteria? And what are the most recent ones?
5. Distinguish between the concepts of *cytoplasm* and *cytosol.*

Research

Viruses are small particles comprising nucleic acid surrounded by a protein coat. They are not considered cells because they do not have a cellular structure and do not perform vital functions except reproduction when they infect a cell. They are therefore obligate parasites and always cause disease. They come in a variety of shapes (such as helical and polyhedral) and can remain inactive for long periods.

- Why do you think viruses are considered 'cell forms'?
- Why can they be considered living organisms? And why not?

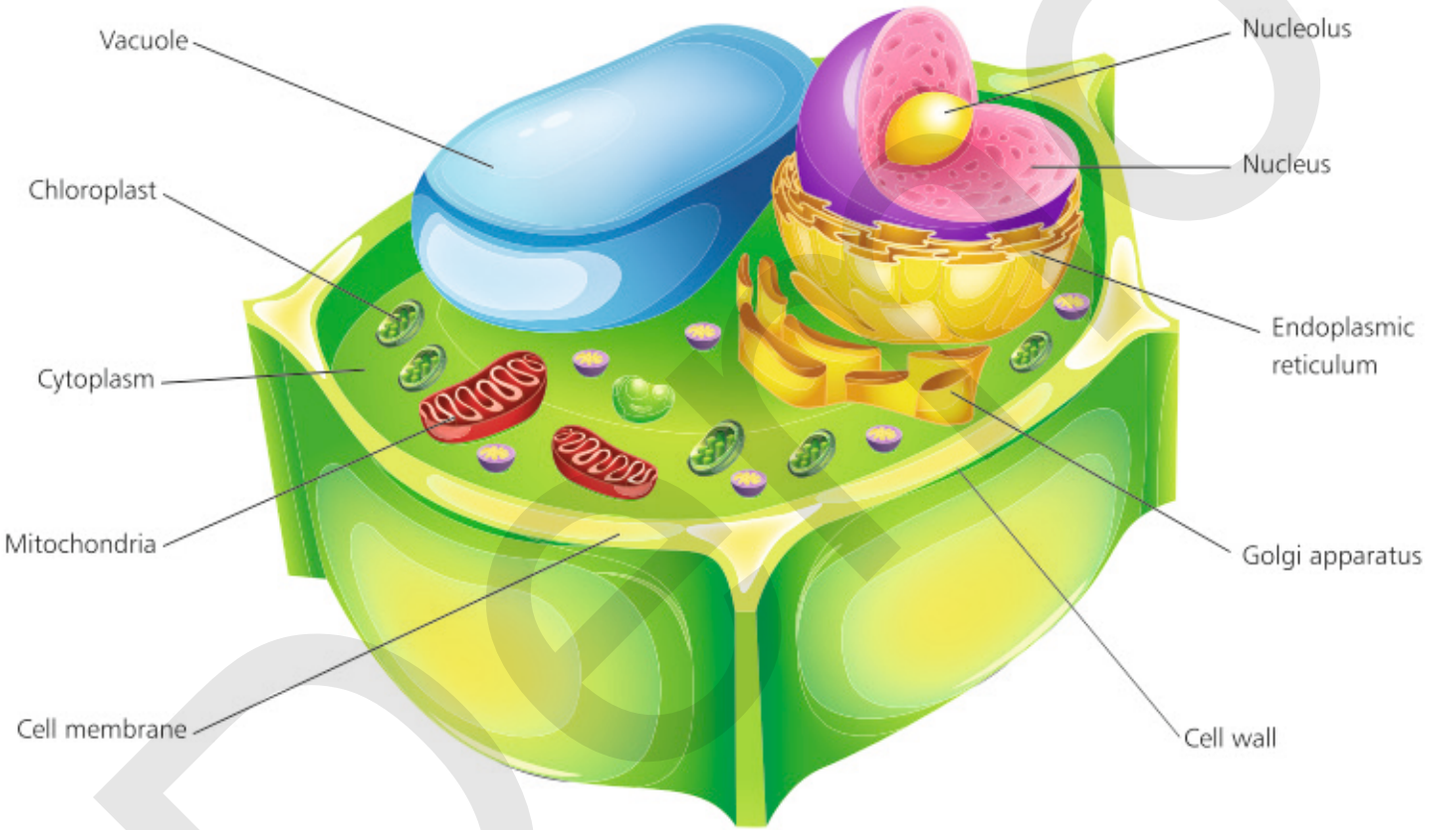


Membranous Organelles

Endoplasmic reticulum. A set of branched, interconnected membranous ducts. They are divided into two types:

- **Rough,** with attached ribosomes. They transport proteins synthesized in ribosomes to other places.
- **Smooth,** without attached ribosomes. They synthesize and transport lipids to other parts.

Golgi apparatus. A set of stacked, membranous vesicles. Through them, it receives substances from the reticulum and modifies them. They subsequently exist inside other vesicles to perform different functions.



Vacuole. A membranous vesicle storing various substances.

Mitochondria. A smooth external membrane with a rough internal one called a crista that perform cellular respiration.

Lysosome. A membranous vesicle containing digestive enzymes responsible for cell digestion.

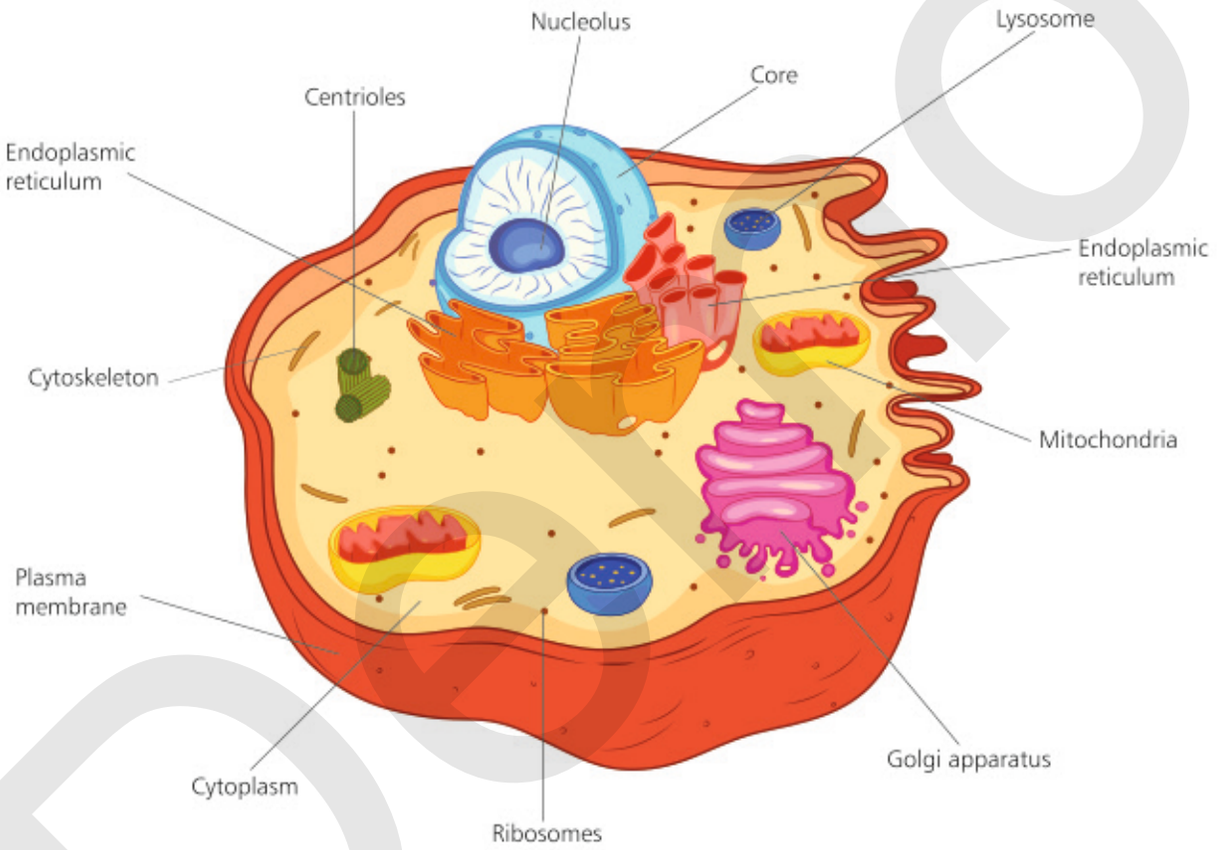
Chloroplast. A smooth external membrane and an internal one (thylakoid) that forms stacks (grana). It contains **chlorophyll** to perform photosynthesis.

Nonmembranous organelles

Ribosomes. Particles made up of RNA and proteins. They can be attached to the reticulum or free in the cytoplasm. They are the site of protein synthesis.

Cytoskeleton. Network of protein filaments running throughout the cytoplasm. Depending on their thickness, they can be:

- **Microfilaments,** composed of actin. They are involved in muscle contraction and the division of the cytoplasm.
- **Microtubules,** composed of tubulin. These are thicker and form the mitotic spindle in cell division. They are part of the centrioles, cilia, and flagella.



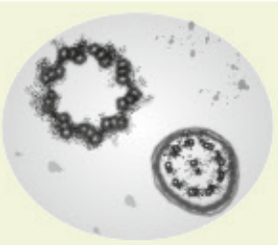
Cilia and flagella. Elongated extensions whose main function is movement. Cilia are short and numerous, whereas flagella are long and few in number. Their function is the locomotion of the cell. They comprise nine pairs of microtubules arranged in a circle with a central pair of microtubules.

Centrosome. Structure consisting of two centrioles connected to the microtubules of the cytoskeleton, which they control. **Centrioles** are made up of nine trios of circularly arranged microtubules.

Practice and learn

6. Draw a table with organelles or eukaryotic cells and the main function they perform.

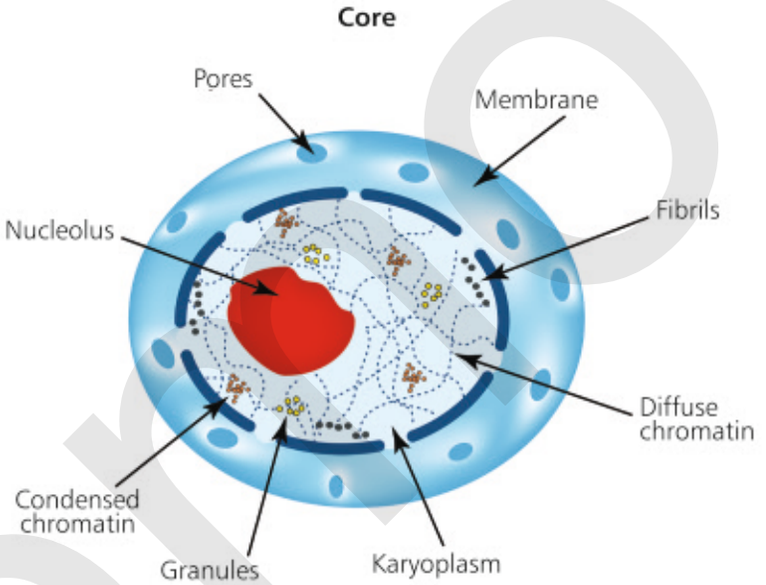
7. Below are cross sections of a cilium and a centriole. Which is which?



5.3. The nucleus

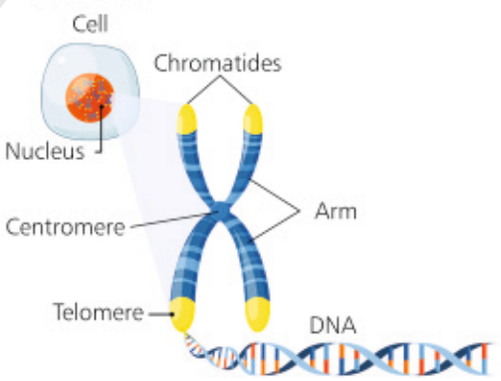
Located inside the cell, the nucleus is separated from the cytoplasm by a **nuclear envelope** (consisting of two membranes) with **pores** allowing molecules to move in or out. It contains a liquid called **nucleoplasm,** made up of:

- The **nucleolus,** composed of ribosomal RNA and proteins, used to store ribosomes.
- **Chromatin,** consisting of a set of filaments composed of DNA and proteins. DNA stores the cell's genetic information.

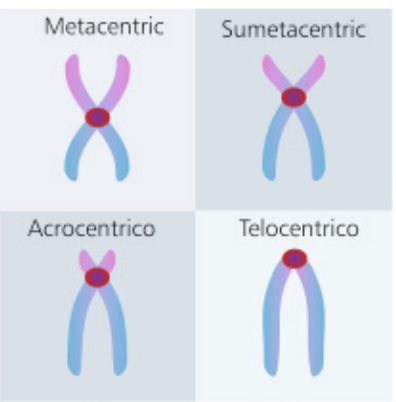


When the cell is going to divide, the chromatin filaments duplicate and condense, forming structures called **chromosomes,** with the following parts:

- **Chromatids:** each of the two identical strands of chromatin containing the chromosome. Also called daughter chromosomes.
- **Centromere:** the place where the two chromatids in a chromosome are joined.
- **Telomeres:** regions at the ends of chromosomes
- **Arms:** each of the two chromosomal regions separated by the centromere.



Chromosome.

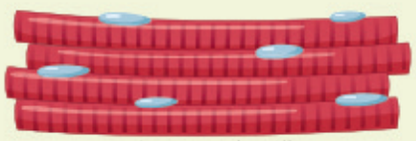


Types of chromosomes by shape.

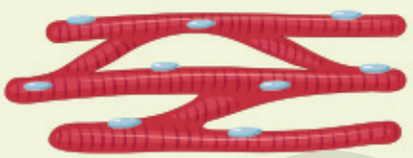
In depth

Some cells are plurinucleate, such as muscle cells.

Smooth muscle cells



Striate muscle cells



Heart muscle cells

In depth

A **gene** is a segment of a chromosome (DNA) with the information required to develop a character of an individual or cell. Although all cells have all the genes, they only use a few. This is why some cells differ from others in the same individual.

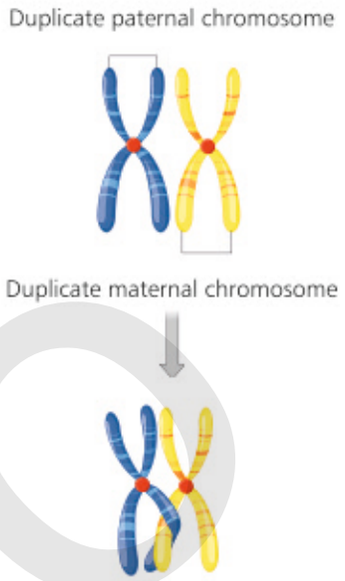
5.4. Chromosomes and karyotype

The set of chromosomes of a cell or individual is called a **karyotype.** The number, shape, and size of chromosomes are characteristic of each species. Depending on this, cells can be **somatic** (all non-reproductive cells, such as those in the brain, stomach, or tongue) or sexual (sperm and eggs). Human somatic cells have twenty-three pairs of chromosomes, and therefore their karyotype is **diploid (2n),** whereas human sex cells have twenty-three chromosomes, and therefore their karyotype is **haploid (n).** In other words, in somatic cells there are two sets of chromosomes: one inherited from the father and one inherited from the mother. The chromosomes of one series are homologous with respect to those of the other series. A chromosome from one series and its counterpart from the other series carry genetic information for the same characters.

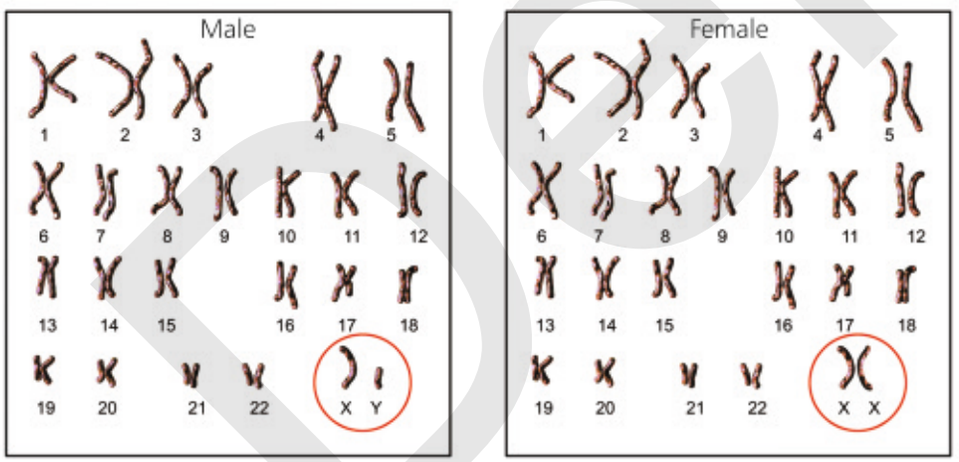
In the human species, the diploid karyotype contains twenty-three pairs of chromosomes, which can be classified as:

- **Autosomes:** chromosomes that carry information for the different characters of the individual, except sex. There are twenty-two pairs.
- **Sex Chromosomes:** chromosomes that carry information for the sex of the individual. They are a pair. They can be one of two types: **X** or **Y** **XX** indicates a female karyotype and **XY** a male karyotype.

Homologous chromosomes

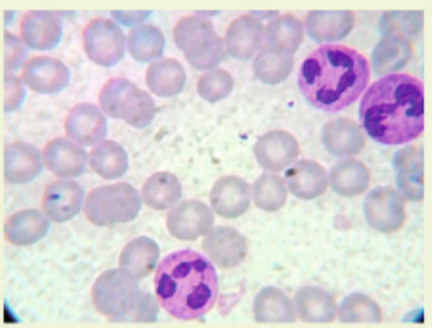


Human karyotype



In depth

Although female mammals have two X chromosomes, one of them remains inactive throughout their lives, forming the nucleus of a dark, dense body called a Barr body.



Practice and learn

8. What is the main difference between the composition of chromatin and nucleolus?
9. Define and distinguish the concepts of *chromatin, chromosome,* and *chromatid.*
10. Which of the following human cells: hepatocytes, sperm cells, enterocytes, neurons, ova, white blood cells, and red blood cells are haploid and which are diploid? Justify your answer.
11. What are homologous chromosomes? How do each of them originate?

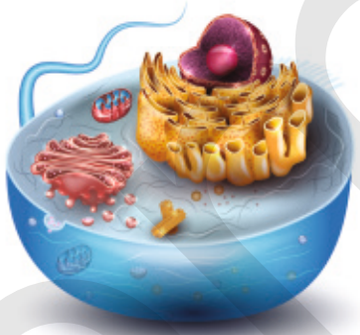
5.5. Types of Eukaryotic cells

There are two types of eukaryotic cells: the animal eukaryotic cell and the plant eukaryotic cell, which form part of animals and plants respectively. Both types of cells share most of the organelles we have already seen, but differ as regards those shown in the following table:

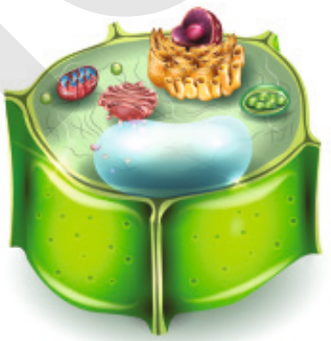
Organelles	Animal cells	Plant cells
Chloroplasts	no	yes
Cell wall	no	yes
Centrioles and their derivatives	yes	no

The **cell wall** is a thick, rigid layer covering and protecting the plant cell. Located outside the plasma membrane, it consists of cellulose fibrils.

Animal cell



Plant cell



6 Cell cycle and cell division

6.1. Cell cycle

Research

Find out what a Euglena cell is on the Internet and whether it is a plant or an animal cell. Justify your answer.

As we saw earlier, according to cell theory, cells originate from other pre-existing cells through a process called **cell division.** This is required to create new cells responsible for the **growth** of multicellular organisms and **repairing** damaged cells. In unicellular organisms, cell division produces new unicellular individuals. This means that it is a **reproductive mechanism.**

The newly formed cells cannot divide again until they have grown sufficiently. Two processes alternate throughout a cell's life: **cell division** and **cell growth.** The **cell cycle** is the set of events that take place in a cell's life from the time it originates until it divides again.

The cell cycle has two major stages with different durations:

- **Interphase** (very long).
- **Cell division** (very short).

Interphase

This stage occupies most of a cell's life. It is a stage with **great growth** during which many biomolecules are **synthesized** that increase a cell's size. It can be subdivided into stages:

- **G_1:** intense **protein synthesis** occurs. The size and number of cell organelles increase, meaning that the **cell volume increases.** If the cell is not going to divide anymore, the cycle stops here (G_0), as it does in muscle cells and neurons. If it is going to divide again, it continues to the next stage.
- **S: duplication** (synthesis) of all the **DNA** that was in the nucleus and **duplication of the centrosome** if the cell is an animal cell.
- **G_2: protein synthesis** and the formation of new organelles occur, and the cell prepares for cell division.

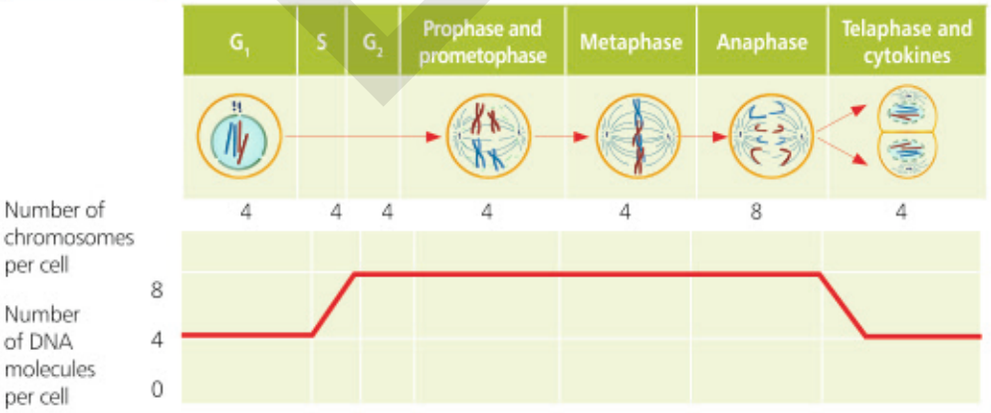
Cell cycle stages: interphase (G_1, S and G_2) and cell division (M).

Cell division

Once interphase is over, the cell has grown sufficiently and its nucleus contains all the duplicated genetic material, which will be shared between the two daughter cells that will be formed at the end of cell division. This can be subdivided into stages:

- **Mitosis,** the division of the nucleus with an exact distribution of the genetic material between the two daughter nuclei.
- **Cytokinesis,** the division of the cytoplasm with a distribution of cell organelles between the two daughter cells.

	Interphase			
	G_1	S	G_2	M
Approximate duration	Four hours	Ten hours	Four hours	Two hours
Cell activity	Protein and nucleic acid synthesis Normal cell activity	Gradual DNA replication	Cytoskeleton protein synthesis	Division of genetic material



Research

Identify the three differences between the concepts of cell division and cell growth.

In depth

The length of the cell cycle varies greatly. In epithelial cells, it lasts twelve hours. In liver cells, it lasts one or two years, and in neurons it lasts a lifetime.

In depth

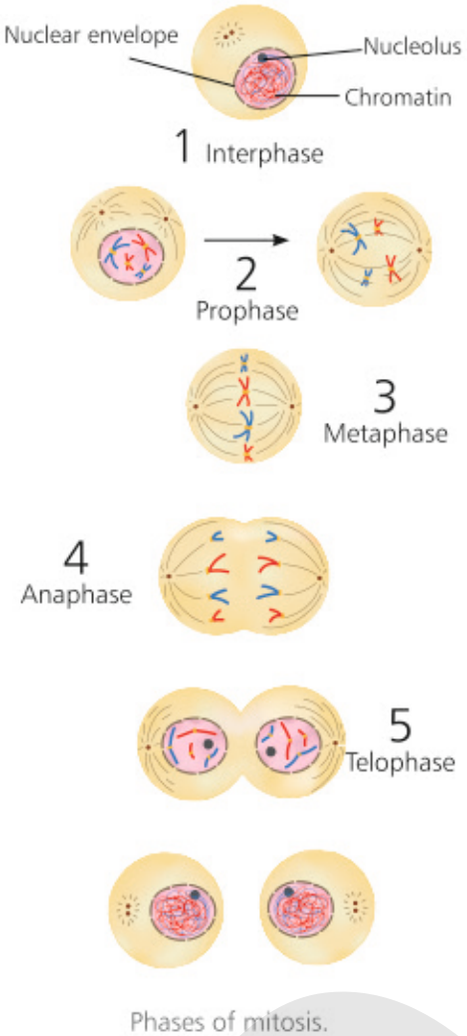
When cells divide uncontrollably, a mass of tumor cells forms, marking the onset of cancer.

6.2. Mitosis

This is a continuous process that can be divided into phases

- **Prophase.** A very long stage in which a series of simultaneous changes takes place:
  - The **nuclear envelope** disintegrates.
  - The **nucleolus** disappears.
  - The DNA strands (chromatin) condense and form **chromosomes.**
  - The **centrosome** (two centrioles) duplicates, and each of the centrosomes migrates to an opposite pole. A set of microtubules called the **mitotic spindle** is formed between them, which will be responsible for directing the movements of the chromosomes.
- **Metaphase.** At this stage, the chromosomes, which have just formed and are scattered throughout the cytoplasm, **attach** to a mitotic spindle filament at the centromere. The set of all chromosomes is arranged in the equatorial zone of the cell.
- **Anaphase.** The filaments of the mitotic spindle that had an attached chromosome contract and break in half. **Breakage of the chromosomes** occurs in its two chromatids (daughter chromosomes), which are **separated** and dragged to opposite poles.
- **Telophase.** The two groups of chromatids meet at opposite poles, triggering a series of changes:
  - The chromatids gradually decondense and become **chromatin.**
  - The **nucleolus** is reconstructed.
  - The **nuclear envelope** reforms.
  - The **mitotic spindle** disappears.

  By the end of telophase, **two** daughter **nuclei** with the **same genetic information** have been formed.

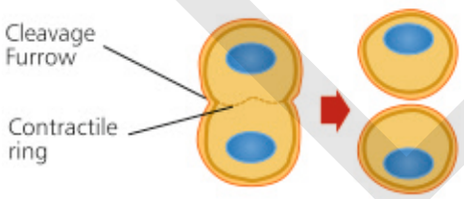


Phases of mitosis.

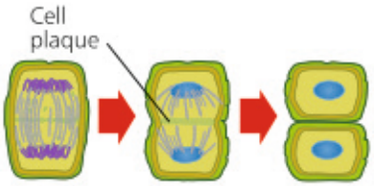
6.3. Cytokinesis

Cytokinesis occurs differently in animal and plant cells.

- **Cytokinesis in animal cells:**
  - The contractile ring at the base of the cell gradually **shrinks.**
  - Eventually the cytoplasm divides, producing two daughter cells of the same size.
- **Cytokinesis in plant cells:**
  - The cellulose wall is rigid and cannot be squeezed.
  - A series of vesicles originates that fuse in the equatorial plane
  - A **middle lamella** is formed, producing the cell wall that will separate the two daughter cells.



Snimal cytokinesis.



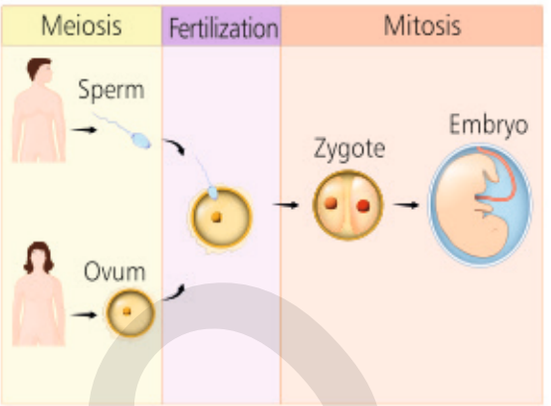
Plant cytokinesis.

6.4. Miosis

In **sexually reproducing** organisms, a process of fusion of the ovum and spermatozoon takes place, called **fertilization.** A new cell called a **zygote** is formed, with the chromosomes of both gametes. All the cells of the new individual will be formed from the zygote through successive mitoses. Since the chromosomes of the ovum and the spermatozoon combine in the zygote, this cell can only have half the characteristic chromosomes of the species. In other words, it must be haploid. **Meiosis** is a special cell division mechanism in which four haploid (n) cells are formed from a diploid (2n) **parent cell,** with half the chromosomes characteristic of the species yet genetically different.

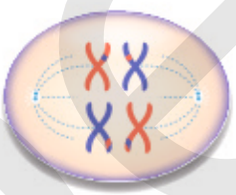
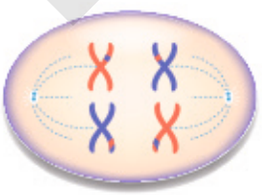
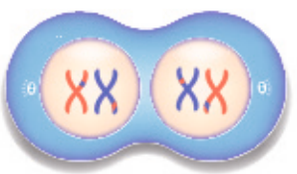
This process occurs in the reproductive organs and comprises **two cell divisions,** which in turn can be subdivided into **four stages** each, called **prophase, metaphase, anaphase,** and **telophase.**

Sexual reproduction



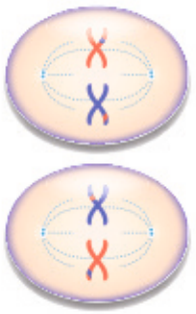
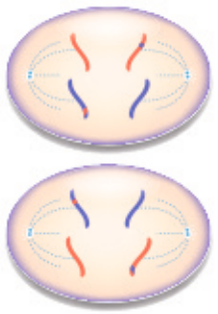
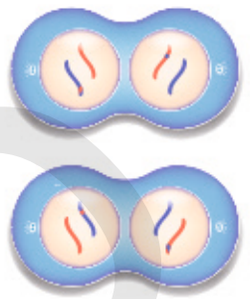
First meiotic division (meiosis I)

Before this division, during interphase, the cell **duplicated all the chromatin filaments** in the nucleus. Each filament and its copy are attached by a point called the **centromere.** These two chromatin filaments will produce chromosomes during meiosis.

			
PROPHASE I	**METAPHASE I**	**ANAPHASE I**	**TELOPHASE I**
Chromosomes are each formed by two identical chromatids. The nuclear envelope and nucleolus disappear. The centrosome duplicates and the mitotic spindle is formed. Each chromosome pairs with its homologue and **bivalents** are formed. Bivalents can exchange small chromosome fragments **(recombination).**	Centrosomes lie at opposite poles joined by mitotic spindle filaments. **Bivalents are located** in **the equatorial zone** and each one joins a filament of the mitotic spindle. In some chromatids, recombination takes place	Shortening of the mitotic spindle filaments occurs, **separating the two homologous chromosomes** of each bivalent. Each one is drawn to an opposite pole. Each chromosome has two chromatids.	A series of homologous chromosomes attach to each pole of the cell. The nuclear envelope and nucleolus disappear. Two daughter nuclei have been formed and cytokinesis takes place. **In the end** there are two cells, each with a haploid number of chromosomes.

Second meiotic division (meiosis II)

Unlike the previous case, during this second division, the chromatin filaments do not duplicate. Each of the two cells that have formed at the end of the previous stage undergoes the second meiotic division, which is essentially the same as mitosis.

			
PROPHASE II	**METAPHASE II**	**ANAPHASE II**	**TELOPHASE II**
Chromosomes are formed, with each one consisting of two chromatids (which are usually different). The nuclear envelope and nucleolus disappear. The centrosome duplicates and the mitotic spindle is formed.	Centrosomes are located at opposite poles, joined by mitotic spindle filaments. The **chromosomes are located in the equatorial zone** and each one is attached to a filament of the mitotic spindle.	Shortening of the mitotic spindle filaments occurs, **separating the two homologous chromosomes** of each bivalent, and each one is drawn to an opposite pole.	A haploid series of chromatids meets at each pole of the cell. The nuclear envelope and nucleolus reappear. Two daughter nuclei have formed, and cytokinesis takes place. **In the end there are four cells,** each with a haploid number of chromatids and **genetically different.**

Research

Although mitosis is a process that is highly controlled by the parent cell, various error can occur with major consequences for the daughter cells. Use the Internet to investigate the most frequent errors that occur and their consequences.

Practice and learn

12. Can gametes (sex cells) have an even number of chromosomes? Justify your answer.
13. Can somatic cells have an odd number of chromosomes? Justify your answer.
14. If a cell has a diploid chromosome number $2n = 24$, what chromosome number will the resulting cells have at the end of mitosis? And at the end of meiosis?
15. Draw a cell in prophase I of meiosis whose chromosome number is $2n = 6$.
16. Draw a pair of homologous chromosomes (with different colors) between which three recombinations have occurred.
17. Match the following processes with the stage when they occur:

    Processes: 1-disappearance of the nucleolus, 2-separation of homologous chromosomes, 3-separation of identical chromatids and 4-separation of different chromatids.

    Stage: a-mitotic anaphase, b-anaphase II, c-anaphase I and d-prophase I.

6.5. Differences between mitosis and meiosis

As we have seen, cells can divide by two different mechanisms: mitosis and meiosis. The main differences between the two are summarized below.

	Mitosis	Meiosis
Cells that can divide	All	Gamete stem cells
Number of cells obtained	Two	Four
Chromosome number of parent cell	2n	2n
number of chromosomes of the daughter cells	2n	n
Purpose	Growth and renewal of individuals	Continuity of the species over time
Number of cell divisions	One	Two
Variabilidad genética	No	Yes
Cell types obtained	Somatic	Sexual

6.6. Biological significance of mitosis and meiosis

Mitosis and meiosis are two cell division mechanisms with different meanings:

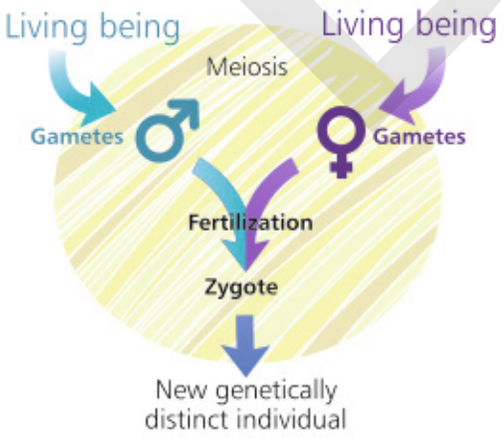
- **Mitosis** is intended to preserve the genetic information of cells and is the basis of **asexual reproduction.** It serves as a mechanism for the **growth and repair** of damaged tissues in multicellular organisms and as a **reproductive mechanism** in unicellular organisms.

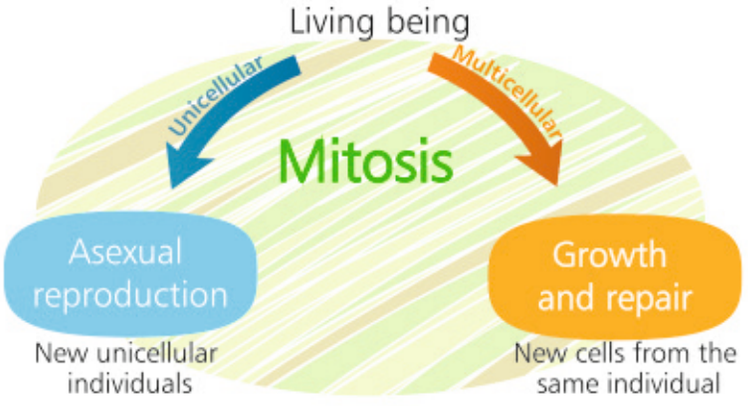
  When there are errors in this mechanism, problems such as **cancer** occur.

- The purpose of **meiosis** is the formation of cells specializing in reproduction **(gametes or spores)** and it is the basis of **sexual reproduction.** Since gametes are genetically different, the new individuals formed will also be different. This facilitates **adaptation** to the environment of the species and therefore, the **evolution** of life on Earth.

Research

Look for information about the different types of individuals in a beehive and their differences. Write a short report about this.





Read and understand

Microbes use sex to become more powerful

Microbes have sex too. This has been proved by researchers from the University of Bristol trying to see what trypanosomes were getting up to inside the tsetse fly. These unicellular parasites live inside the flies, which transport them from one place to another. The flies transmit sleeping sickness by biting their human hosts.

Researchers dyed microbes to identify each individual. After the microbes had mated, two different colours of cells were produced.

Scientists used fluorescent markers to try to understand what was going on with the gyrations of the microbes before they eventually merged into a single hybrid cell. After distinguishing the performers in the dance by dying them different colours, they were able to track their movements until they ended up forming a cell consisting of the two colours of the paired trypanosomes. 'Not only do the older insects have intricate courtships, you also need a very powerful microscope to see this,' said Wendy Gibson, author of the article published in the journal *Current Biology*.

Sex is important for microbes because of the opportunities it provides to exchange genes between different strains and achieve more powerful combinations. In the case of the trypanosomes responsible for sleeping sickness, the courtship ritual they perform inside flies enables them to acquire even more harmful combinations of genes in a single strain. According to the authors of the study, results suggest that sex between these microbes is not optional or unusual, but probably happens every time two of them meet inside a fly.

Trypanosomes belong to an unusual group of protozoa that includes other parasites of interest to medicine, such as those that cause leishmaniasis or trichomoniasis. Until not long ago, it was believed that these microbes could only reproduce by splitting themselves in two, but recent studies show that they also use sex to exchange genes. Articles like the one published in *Current Biology* will help to understand the strategies of these microbes to improve their genetic arsenal and become resistant to the drugs designed to control them.

Daniel Mediavilla
El País, 06/01/2014

Questions:

1. What kind of living thing is a trypanosome?
2. What is formed after two of these parasites fuse?
3. How important is sex to these microbes?
4. What disease do these microbes cause?
5. What diseases are caused by other parasites in the same group as trypanosomes?
6. How often do these microbes have sex?
7. Who published this article and in what journal?

Observing cells in the apical meristem of an onion (*Allium cepa*)

Objective:

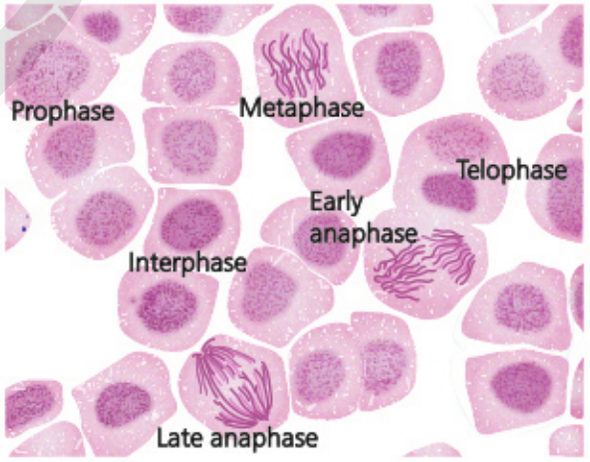
- To acquire the basic skills for observing and staining microscopic preparations.
- To observe cells at various stages of mitosis.

Materials:

- Microscope
- Tweezers
- Dropper
- Filter paper
- Orcein A
- Slides
- Needle with safety sleeve
- Lighter
- Watch glass
- Orcein B
- Coverslip
- Staining jar
- Scissors
- Beaker
- Toothpicks

Procedure:

1. Fill the beaker with water. Place toothpicks in the sides of the onion and set it on the beaker so that the bottom is in contact with the water (Figure 1). After a few days, the onion will have sprouted rootlets about three or four centimetres long.
2. Snip 2-3 mm from the ends of some of the rootlets with scissors and place them on a watch glass into which you have poured 2-3 ml of orcein A (to soften the cell walls).
3. Gently heat the watch glass, holding it with the tongs, over a lighter flame for about eight minutes, avoiding boiling, until it starts to give off steam.
4. Using tweezers, take one of the rootlets and place it on a slide. Add a drop of orcein B (to colour the chromosomes) with the dropper and let it act for one minute.
5. Place the coverslip very carefully on the rootlet. With the handle of a sleeved needle, hit the coverslip a couple of times, but without breaking it, to stretch out the rootlet as much as possible.
6. Place some strips of filter paper on the preparation. Place your thumb on the filter paper in the area of the coverslip and apply pressure to stop the coverslip from slipping.
7. Look under the microscope. At high magnifications, you will be able to see images like this.

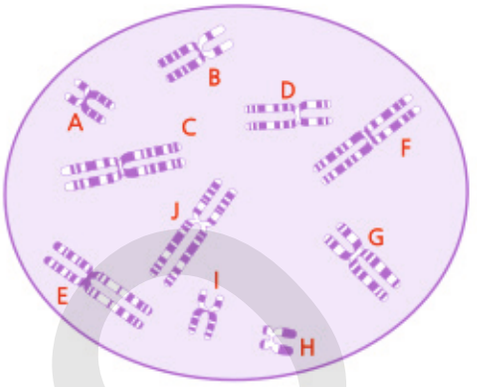


The science corner

Analysing a karyotype

This is a picture of cell division. We dyed the chromosomes and then we photographed them through the microscope, during the metaphase stage. Look at it carefully and answer the following questions:

1. What is the diploid number (2n) of this species?
2. What is the haploid number (n) of this species?
3. What are the pairs of homologues? (They are dyed the same way)
4. How many autosomes are there, and which ones are they?
5. How many sex chromosomes are there, and which ones are they?
6. Classify the chromosomes by shape.



Final activities

1. Classify the following organisms by type of nutrition: *yeast, wheat, wolf, paramecium, mushroom, whale, cyanobacteria, rose bush, amoeba* and *Clostridium.*
2. Match each of the following cell structures with the function they perform.

Cell structure
1. Vacuoles
2. Chloroplasts
3. Golgi apparatus
4. Smooth endoplasmic reticule
5. Ribosomes
6. Mitochondria
7. Lysosomes

Function
a. Protein synthesis
b. Lipid synthesis
c. Energy production
d. Glucide synthesis
e. Cell digestion
f. Substance storage
g. Molecule modification

3. The types of eukaryotic cells differ from each other, among other things, because of the way their cells develop. Explain which organelles would be the most developed ones in the following cells, on the basis of their function: muscle cells, sperm, plant cells and white cells.
4. Copy the table into your notebook and write down four differences between procaryotic and eukaryotic cells.

Differences in	Procaryotic	Eukaryotic
Age	…	…
Size	…	…
Complexity	…	…
Nucleus	…	…

Final activities

5. Match each term in the left column with one of the terms in the right column.

1. Somatic cell	a. Haploid cell
2. M phase	b. Cell differentiation
3. S phase	c. Diploid cell
4. Anaphase chromosome	d. Cell division
5. Gamete	e. DNA duplication
6. G_0 phase	f. Two chromatids
7. Chromosome anaphase	g. One chromatid

6. How many filaments does a metaphysical chromosome contain? And a chromatid? And an arm?

7. If a mother cell is $2n = 6$, how many different types of gametes can it produce. assuming there is no crossing over between homologous chromosomes? What mathematical expression could be used? Use this expression to calculate how many types of gametes could be produced, in the same conditions, from a human cell.

8. Classify the following statements into three groups, depending on whether they refer to mitosis, meiosis, or both.

1. They are designed to produce gametes	a. Mitosis
2. Daughter cells are identical to the mother cell	
3. Daughter cells have half the chromosomes or the mother cell	
4. At the end, four daughter cells are produced	b. Meiosis
5. At the end, two daughter cells are produced	
6. It is associated with sexual reproduction	
7. The mother cell is diploid	
8. It is associated with asexual reproduction	
9. The ADN is duplicated before the process	c. Both
10. The process includes a single cell division	
11. The process includes two consecutive cell divisions	

9. The graph below shows the variation in the concentration of cell DNA throughout the cell cycle. Look at it closely and fill in the table in your notebook with the names of the cell cycle processes that have taken place.

Interval	Process
From 0 to 1 hour	…
From 1 to 2 hours	…
From 2 to 3 hours	…
At 3 hours	…
From 3 to 4 hours	…
From 4 to 5 hours	…
de 5 a 6 h	…
At 6 hours	…
At 6 and a half hours	…
A 6:30 hours	…