



The Villablanca Connection



BIOLOGY AND GEOLOGY

1º ESO

Vol. 1

"NOSCE TE IPSUM"

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- My past, present and future students → I am not sure who learns and who teaches (and what)

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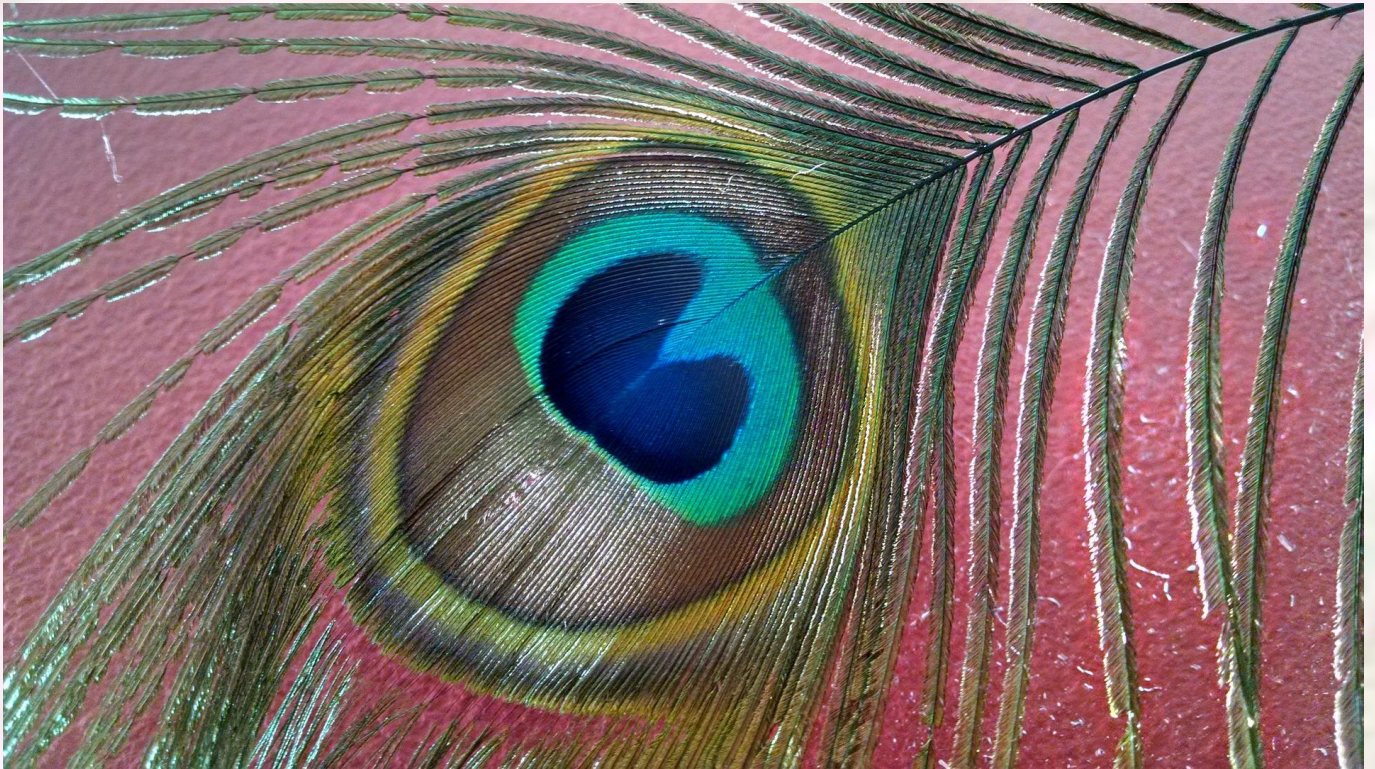
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The Villablanca Connection

UNIT 1:

LIFE ON EARTH



"Look deep into nature, and then you will understand everything better"
Albert Einstein

Unit 1: Life on Earth.
Biology and Geology 1º ESO
Villablanca Connection

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Unit 1: LIFE ON EARTH.

1. The living beings' problem.

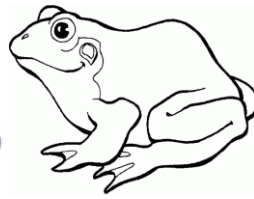
One of the most interesting Natural Sciences is called **Biology**.

Biology deals with life and all that we have learnt about the living beings. The persons that dedicate professionally to Biology are called biologists. Biologists study any aspect of life. They are interested in how an organ, as a human heart for instance, works; and also how a lion behaves to hunt a prey; and also what are the edible or the poisonous plants; and also what are the impacts if a forest is cleared and the trees are cut down...

Personally, as a biologist myself, I am very much interested in the differences between living and non-living beings. What do you think about this? Is it easy to distinguish between living and non-living beings? Let's try to classify the following beings into living beings and non-living beings:



Ameba



Frog



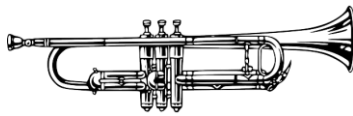
Lichen



Wasp nest



Sunflower seeds



Trumpet



Starfish



Microwave oven



Waterfall

Well, I am quite sure you did it right with the trumpet and the microwave oven (of course everybody *knows* they are non-living beings). But what about the waterfall? Yes, it is mostly water but is *water* alive? Is *water* a living being? Can we find *water* in living beings? Is the water only a place where some living beings live? Is it only a component of the living beings? The water of the waterfall moves, changes, reacts... Does it mean that waterfalls are in fact living beings? On the other hand, the sunflower seeds do not move, do not change and, under certain conditions, can remain equal to themselves for years to come... Are they *really* alive? And what do you think about the lichen or the ameba? Oh, my! What are they? They just look like the stains in my sport clothes! Are the biologists trying to tell us that they are truly alive?

You can have a break now with all those raveling thoughts. The question was a tricky one from the beginning. The fact is that the more you learn about biology the more difficult is to answer what life is. It is not that easy to distinguish between living and non-living things. How does it feel? It is probably one of your first days at the high school and you have just discovered that your Natural Science class is going to dedicate most of the school year to something that even the experienced biologists assume they do not fully understand: life. Isn't it crazy? Welcome to the real world. Can you see now why I entitled this very first point "The living beings' problem"?

2. Vital functions

Let's have a look into the 1º ESO typical pupil's mind: "So you are trying to tell me that science is complex, so what? Aren't you going to teach me something or what? I already knew all this high school stuff was a great waste of time. If all I have to remember is that (stupid) biologists cannot define life and that they are unable to distinguish between living and non-living things this is going to be easier than what I expected".

Hey, take it easy, kids. You do not need to feel that frustrated and, of course, you should not blame the biologists. They (we) are doing their (our) best. You will agree if you pay attention to the following.

In your primary school years you have learnt that living things usually move, grow, breath, reproduce, respond to stimuli, etc... That's why you have found so easy to distinguish living and non-living things till now. Biologists have studied a lot of these different characteristics and they have defined what living beings can do into three great groups of functions that can, as a whole, help us in this "living beings' problem". They are called the **vital functions** and biologists agree that any living being in this planet has to perform the three of them to qualify as "living".

The vital functions are:

Nutrition function: It is the process by which the living beings exchange matter and energy with their environment. One important thing that living beings need is to get materials for the continuous building of their bodies. Sometimes this process makes them bigger (growth), but not necessarily. Somehow, living things decay if they do not replace continuously the materials they are made of.

There are two kinds of nutrition:

Autotrophic nutrition lets the plants and other living things to produce their own materials from very simple inorganic substances they can get easily from the air and the soil. Namely, just water, CO₂ and minerals. We call “autotrophs” to the living beings with this particular type of nutrition.

Heterotrophic nutrition implies that the materials have to be taken already made from other living beings that owned them previously. The so called “heterotrophs” obtain materials and energy eating organic matter they get from other living things.

Interaction function: It is the process by which the living beings exchange information with the environment. Living beings need to detect the changes in the environment in order to react in an adequate way so the survival is possible. The lion has to know if there is a prey available in the surroundings, the plants have to produce flowers or fruits in the convenient season of the year, the mosquitoes can detect the gases of our breathing from incredible distances so they are directed exactly to the exposed part of our bodies where they'll find the blood required for the hatching of their spring.

Also, living beings can produce signals to spread messages of their interest. Everybody knows that the growl of the dog means “don't get so close to me” or that the beautiful colors of the peacock are a way to say to the females “come and let's be friends”. There are thousands of other examples.

Reproduction function: It is the process by which the living beings produce new living beings (descendants) that are similar to them and maintain their characteristics. There are two main kinds of reproduction:

In the **asexual reproduction** one living thing produces identical descendants.

In the **sexual reproduction** two individuals produce specialized sexual cells (=gametes) that become a new living thing when they fuse together. The descendants are similar but not identical to their parents.

If you have been able to keep your attention to this point you will probably have noticed that I began talking about “living beings” and suddenly I changed to “living things”. You don't have to worry about it. Both expressions are equivalent. We can use both of them referring to “something with life or something that lives”. There is also the word “organism” meaning exactly the same. As an exercise you can look for some sentences above with “living being” or “living thing” and rewrite them with “organism” instead.

Before going further, let's have a look to these activities:

Activity 1.

Write “autotroph” or “heterotroph” according their type of nutrition:

Sharks		Whales	
Frogs		Algae	
Pines		Butterflies	
Mushrooms		Roses	
Horses		Cows	
Ferns		Humans	

Activity 2.

Choose the vital function related with these situations. If you choose “interaction” write also the stimulus, the response and, in the case of animals, the sensory organ.

Situation	Vital function	Stimulus	Response	Sensory organ
A maple tree absorbing CO ₂				
A cheetah chasing a fox				
A plant closing its flowers at the sunset				
Mould growing on an orange				
A marine alga absorbing water				
A frog laying eggs				
A couple of deer copulating				
A driver stopping at a traffic light				
The light in the rear of a light worm				
A human with perfume in a party				

Activity 3.

Animals have a particular way to move. Match in your notebook.

a) Salmons	1) Jump
b) Falcons	2) Slither
c) Caterpillars	3) Walk
d) Kangaroos	4) Run
e) Horses	5) Hop
f) Snakes	6) Fly
g) Frogs	7) Crawl
h) Humans	8) Swim

Activity 4.

Write in your notebook the definition of each of the vital functions and get sure you understand and remember them.

Activity 5.

¿Have you heard of the Ebola virus? ¿Are virus living things? Try to find out in the Internet.

3. Chemical composition of the living beings. Organic and inorganic matter.

As you have heard before, organisms are formed by cells –we will talk about them later- but even the cells are made of a handful of chemical substances. In the chemistry laboratory scientists can analyze what are these chemical substances and, surprisingly, they have found out that all of the living beings –it doesn't matter how different they look- are composed of the same six different compounds (=biomolecules). Two of them are very common in rocks and soils of the Earth surface, but the other four are only to be found in organisms. These are the **biomolecules** or immediate principles present in terrestrial living things:

1. **Water**. It is the most abundant biomolecule in the body of the living beings.
2. **Mineral salts**. A small amount is essential to be alive.
3. **Glucids** or carbohydrates. Cells need them to produce or store energy.
4. **Lipids**. Like oils or fats, they play important roles in the living things.
5. **Proteins**. The building blocks of life and the chemical operators in the cell factory.
6. **Nucleic acids**. Like the famous **DNA**. They are needed to preserve inheritance.

Guess which two are also present in non-living things and which four are only present in organisms... Yes, you are right: water and mineral salts are known as **inorganic immediate principles** (=inorganic biomolecules) because they are everywhere in rocks, soils and oceans. On the other hand, glucids, lipids, proteins and nucleic acids are known as **organic immediate principles** (=organic biomolecules) because only can be found in organisms or remains of organisms.

Please, note that this terminology is a little bit confusing (not my fault, I promise). How come that the water, which is the most abundant biomolecule in the organisms, is in fact considered inorganic? Do not worry about the reason now, just be careful when you memorize this classification of biomolecules.

Anyway, you will have noticed that “organic” and “organism” are related somehow and that “inorganic” sounds like the opposite to “organic”. Let's make our minds clear about these words. When we analyze in the lab non-living beings we always find small and simple chemical substances (=inorganic molecules) made of 2, 3 or maybe... 10 atoms (did you know that molecules are made of atoms joined by chemical bonds?). It is the case of water (3 atoms, only two different) or the mineral salts (one of the most common, the sodium chloride, has two different atoms: sodium and chlorine). But, on the other hand, if we analyze living beings we find water and mineral salts, of course, but also there are huge complex molecules made of tens, hundreds and even thousands of atoms where three or more can be different (=organic molecules). These molecules are so complex because carbon atoms form linear and circular chains where other carbon chains can be inserted like the branches in a tree.

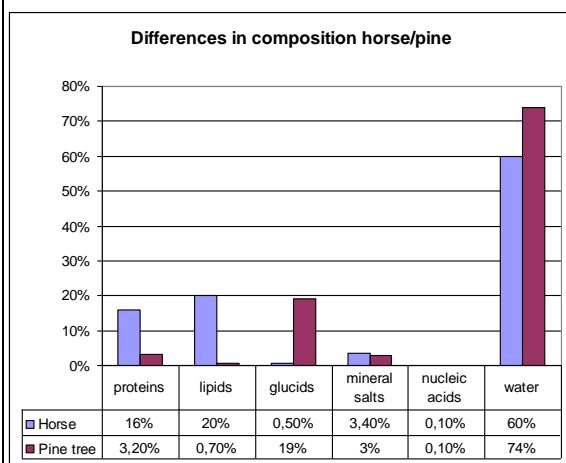
As we have already learnt, living things exchange materials with the environment (nutrition). That means that there has to be a way to produce organic materials from the inorganic ones and vice versa. Plants and other organisms with **autotrophic nutrition** take from the air and the soil inorganic nutrients (small and simple molecules) and combine them to produce organic materials (very big, complex molecules with chains of carbon atoms). You already know that it is possible thanks to a process called **photosynthesis** that requires energy in the form of sunlight. And both autotrophic and heterotrophic organisms are continuously using these organic materials as a fuel to perform the vital functions, cutting up the complex molecules into simple ones to get the energy of their chemical bonds. As a result organic matter is becoming inorganic matter and we call this process **respiration**. Too much information for you? Let's try to summarize this organic-inorganic issue in a simple useful chart.

Type of matter	In non-living things	In living things	Molecules	Carbon atoms	Autotrophic nutrition	Heterotrophic nutrition	Photosynthesis	Respiration
Inorganic matter	present	present (water and minerals)	small and simple	absent or not forming chains	takes	produces	takes	produces
Organic matter	absent	present	big and complex	present and forming chains	produces	takes	produces	takes

It is time for the following activities:

Activity 6.

In this graph the differences in composition between a horse and a pine tree are shown:



a) How are they alike?

b) How are they different?

Activity 7.

Classify these things as organic or inorganic matter:

1. The fin of a fish		14. A plastic cap		27. A can of sardines	
2. Bottled water		15. The fire		28. The shell of an egg	
3. Red paint		16. A wool sweater		29. Olive oil	
4. The sound of a bell		17. The cork of a bottle		30. A pair of leather shoes	
5. Cut grass		18. A brick in a wall		31. The ghost of a castle	
6. An elephant's tooth		19. A cotton handkerchief		32. The flour of a cake	
7. The stones of a river		20. A seed		33. The images in the TV	
8. A golden ring		21. A wooden fork		34. Your favorite song	
9. Orange juice		22. The skin of a snake		35. The hair of a tiger	
10. A sugar cube		23. The glass of a window		36. The echo of a voice	
11. A cat's skull		24. A silver tray		37. The screen of your cell-phone	
12. An olive's pit		25. The salt in a salad		38. The rubber of a tyre	
13. The air we breath		26. A mussel shell		39. The sheets of a book	

Activity 8.

Complete the sentences with organic/inorganic and autotrophic/heterotrophic:

- a) The shark feeds on fish that is _____ matter. That's why the shark has _____ nutrition.
- b) The oak feeds on CO₂ that is _____ matter. That's why the oak has _____ nutrition.
- c) The deer feeds on grass that is _____ matter. That's why the deer has _____ nutrition.
- d) The bacteria in our intestine feed on the leftovers of our food that are _____ matter. That's why these bacteria have _____ nutrition.
- e) The olive tree feeds on water that is _____ matter. That's why the olive tree has _____ nutrition.
- f) The mushrooms feed on dead leaves that are _____ matter. That's why the mushrooms have _____ nutrition.
- g) The Iberian lynx feeds on rabbits that are _____ matter. That's why the Iberian lynx has _____ nutrition.
- h) The yeast feeds on sugar that is _____ matter. That's why the yeast has _____ nutrition.
- i) The moss feeds on CO₂ and water that are _____ matter. That's why the moss has _____ nutrition.
- j) The whale feeds on krill that is _____ matter. That's why the whale has _____ nutrition.
- k) The mosquito feeds on blood that is _____ matter. That's why the mosquito has _____ nutrition.
- l) The bacteria of the yogurt feed on milk that is _____ matter. That's why these bacteria have _____ nutrition.
- m) Algae feed on CO₂ that is _____ matter. That's why the algae have _____ nutrition.
- n) A mould feeds on orange skin that is _____ matter. That's why the mould has _____ nutrition.
- ñ) The panda bear feeds on bamboo that is _____ matter. That's why the panda bear has _____ nutrition.

Activity 9.

Classify the 15 living beings of the previous activity according their type o nutrition.

Autotrophs	
Heterotrophs	

Activity 10.

Certain types of mould grow and feed on food leftovers.

- a) Would you say the nutrition of these moulds is autotrophic or heterotrophic?
- b) Explain why.

Activity 11.

Remember the differences between sexual and asexual reproduction and decide what type of reproduction is present in these cases:

- a) A bacterium divides and produces two identical bacteria.
- b) A female bird is laying eggs in the nest.

Activity 12.

Make a chart in your notebook with the classification of the biomolecules or immediate principles.

4. The Earth: a home for life.

Before discussing more amazing common characteristics of the living beings we need to dedicate this last part of the unit to the conditions of our planet that make life possible.

The fact is that after quite a few years of exploration of the universe we have failed in finding living beings out of our planet. Well, the universe is so big and our technological means so limited that most of the scientists agree that it is only a matter of time that we succeed in our search of living and even intelligent beings. But in science a fact is a fact. And the reason why it is the Earth the only known planet with life is worth an explanation.

Living beings in the Earth (the only ones that we know, I insist) need to survive:

- Liquid water
- Oxygen
- Carbon dioxide (CO₂)
- Light
- Mineral salts
- Not too high and not too low temperature

All these requirements for life as we know it are fulfilled in the Earth thanks to two important circumstances:

- The presence of the atmosphere
- The distance from the Earth to the Sun is in the habitable zone.

If the Earth was 1 % nearer to the Sun all the water in the planet would be in a vapor state. If the Earth was 1 % farther to the Sun all the water in the planet would be in a solid state. Due that we are in the habitable zone the mean temperature in the Earth surface is 15° C, a comfortable temperature to perform the vital functions.

On the other hand, the atmosphere protects life from the harmful radiations of the Sun. As you already know, without the **ozone layer** life would be impossible on the terrestrial ecosystems. Scientists have discovered that this ozone was originated, from 2000 to 700 million of years ago, using the oxygen produced by ancient cyanobacteria. From the beginning of life on Earth, living beings and their environment are in permanent interaction. Changes in the environment have consequences in life and changes in life have consequences in the environment. This delicate balance is unique, as far as we know, in the universe; and makes the Earth the only precious planet where a **biosphere** exists. The biosphere is the zone of the Earth where living beings exist and where the interaction between life and environment brings the ideal conditions for the continuity of life.

But although we are talking in general about the living beings, you know very well that not all of them require the same conditions of water, light, soil or food. We call **habitat** to the place where a particular living being lives because it is in that specific place where adequate conditions are found to its survival.

The conditions that we find in a particular place are called **environmental factors**. Environmental factors are classified into:

- **Biotic factors**: are determined by the presence of other organisms like the competition for food or the collaboration in feeding the offspring, for instance.

- **Abiotic factors**: they depend on chemical or physical circumstances like the amount of light, the concentration of oxygen or the speed of the wind, for instance.

On the Earth we can find two major types of environment: aquatic and terrestrial environments.

In the **aquatic environment** water is abundant and temperature fluctuations are small because the water regulates very well the exchanges of heat. But light cannot reach depths beyond 150 m because it is absorbed by the water. That means that photosynthesis is only possible in this so called **photic zone** and the available oxygen dissolved in the water is always scarce.

In the **terrestrial environment** organisms have to find a way to get water and to deal with oscillations of temperature during the day and the different seasons.

Activity 13.

Have you ever seen a pill bug? It is a small terrestrial crustacean that curls up in a ball when threatened. In this experiment 25 pill bugs were randomly situated in this box with half the bottom covered with a wet cloth. After two hours they were placed as is shown in the picture.



- What are the conditions in each of the numbered zones?
- What conditions do the pill bugs prefer?
- What do you think is the habitat of these pill bugs?

Activity 14.

- What are the differences between the photic and the aphotic zones?
- Can animals live in the aphotic zone? And plants?
- How are the leaves of the plants that live in the desert? Why?
- What is the habitat of the zebra, the lion and the giraffe?

Activity 15.

A group of ecologists have studied the conditions of the water in a river from its place of birth to the sea.

zone	flow	temperature	oxygen
High upper course	very fast	less than 10°C	12 mg/L
Low upper course	fast	less than 15°C	9 mg/L
Middle course	slow	15°C	6 mg/L
Lower course	very slow	20°C	5 mg/L

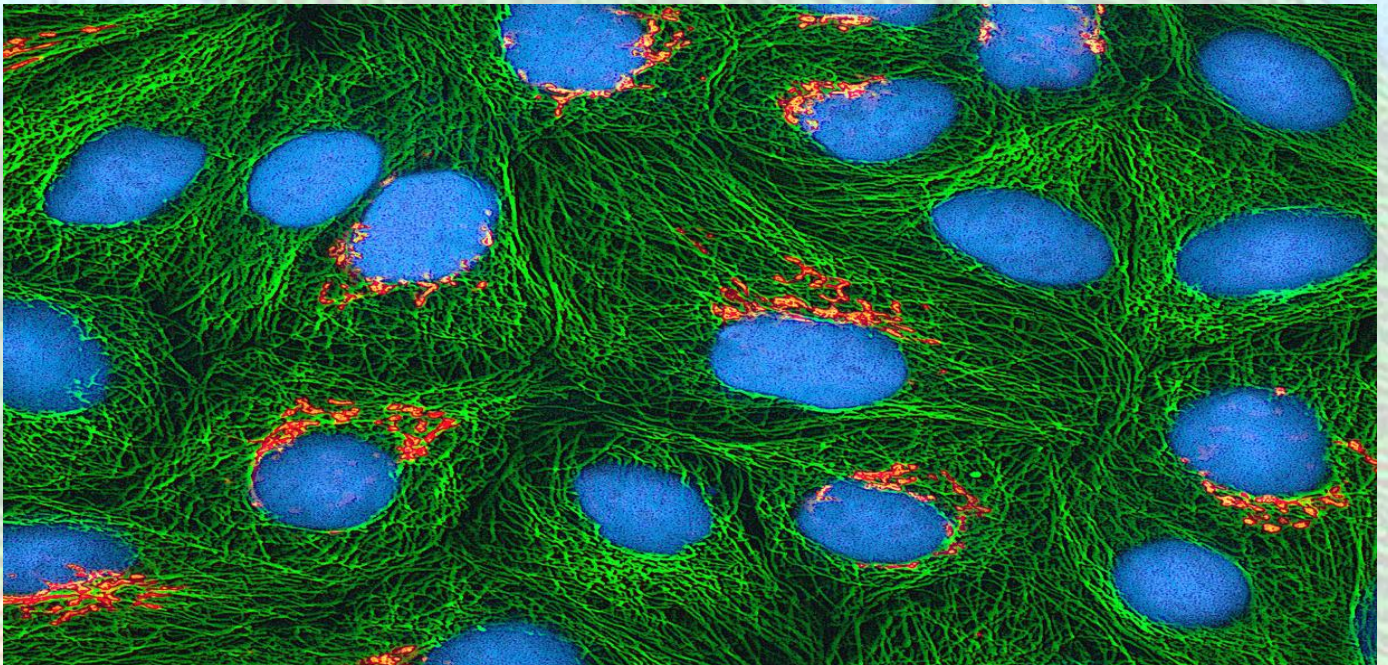
- The trout needs 9 mg/L of oxygen to survive. In which zones of the river can it live?
- Describe the changes in temperature and amount of oxygen as we get closer to the sea
- What is the relationship between temperature and oxygen dissolved in the water?



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UNIT 2:

CELLS



“Every living thing is made of cells, and everything a living thing does it is done by the cells that make it up.”
L.L. Larison Cudmore.

Unit 2: Cells.
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Unit 2: CELLS.

1. What are cells?

There is another very important characteristic of the living beings we can find in the Earth: They are all formed by one or more cells. Somehow, life on this planet depends on the existence of these little life units. So it is possible to define "living being" as an organism that is formed by one or more cells. From this point of view we classify the organisms as **unicellular** and **multicellular** organisms.

There exists a whole division in biology to study cells specifically. It is called **cytology**. Cytologists study both the structure and the functioning (=physiology) of the cell and it is amazing how so different living beings have cells so similar.

There are three characteristics that are always present in the structure of any cell:

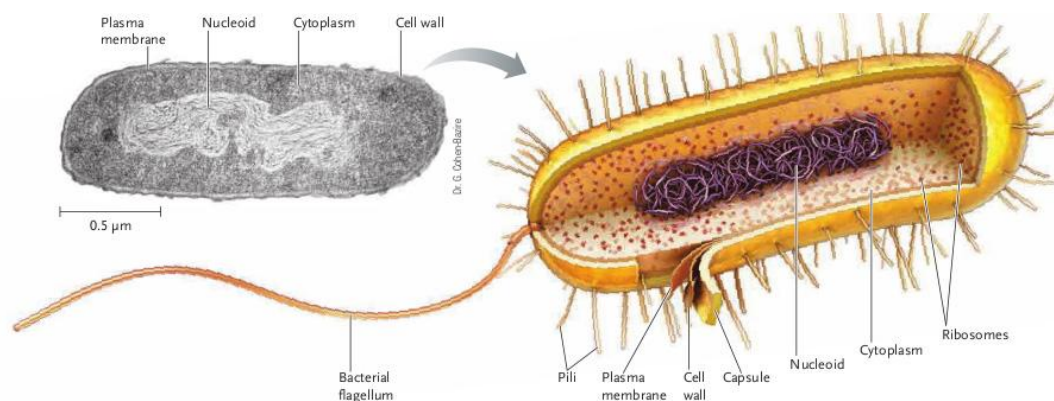
- The **plasmatic membrane** (=plasma membrane), that is a very thin and elastic external cover that delimitates the cell from the outside.
- The **cytoplasm**, which is a gelatinous substance inside of the cells where some **organelles** can be found.
- The **DNA**, which can be directly disperse in the cytoplasm or enclosed in a big organelle called nucleus. The function of this DNA or **genetic material** is directing all the functions of the cell and controlling its activities.

Cytologists have found out that every living thing in the planet is formed by very few cell types. In fact there are only two main kinds of cells in the biosphere: the **prokaryotic** and the **eukaryotic** cells, depending mostly if the DNA is directly in the cytoplasm or if it is enclosed into the nucleus.

2. Prokaryotic cells.

- The DNA is placed directly in the cytoplasm (=they do not have a nucleus).
- They are the smallest and simplest cells.
- They are supposed similar to the first living things that appeared on the Earth about 3800 million years ago.
- They never form multicellular organisms.
- They are everywhere. In fact they form the most successful living beings of the planet, but they are difficult to see as they are microscopic organisms.
- They do not have organelles, with the exception of the **ribosomes** as this is where proteins are biosynthesized (= "produced by biological means").
- They can perform either autotrophic or heterotrophic nutrition.
- Externally to the plasmatic membrane there is always another cover called **cell wall** and, in some cases, there is even a third one called **capsule**.
- Some have one or more flagella to move.
- All the organisms with prokaryotic cells group together in the Monera kingdom and their most important representatives are the bacteria and the cyanobacteria.

This is the aspect of prokaryotic cells when using a potent microscopy:

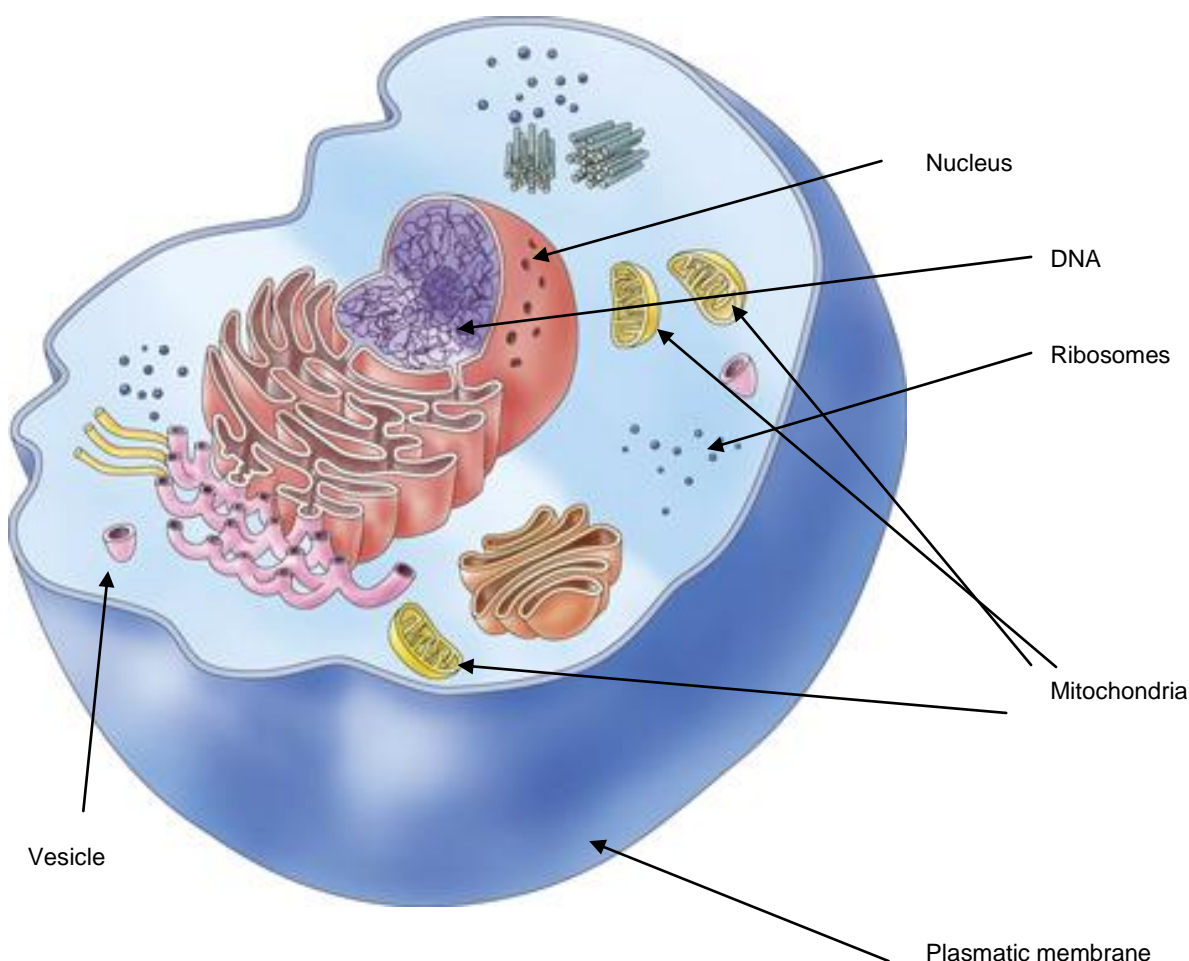


You can find a lot of drawings and pictures if you look up "bacteria" in the internet.

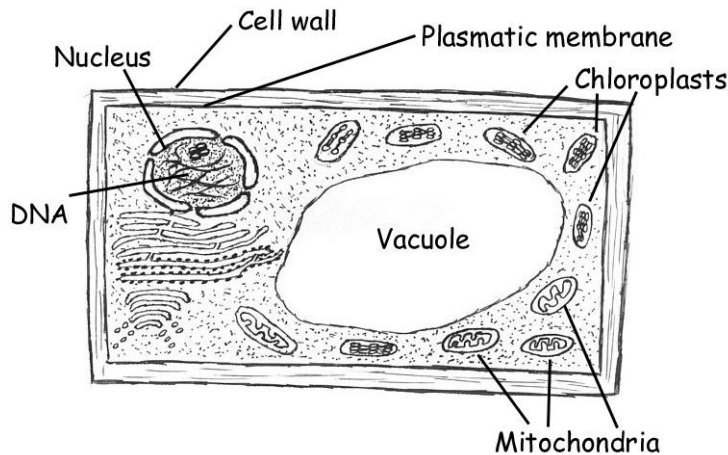
3. Eukaryotic cells.

- The DNA of these cells is always inside a big organelle called **nucleus**.
- They are bigger and more complex than prokaryotic cells.
- They appeared more recently in evolution. There are eukaryotic cells since about 2000 million of years. They evolved from ancient prokaryotic cells.
- We can find unicellular living beings with this kind of cell but, more amazing, all multicellular organisms are formed by this type of cells.
- All of them have **ribosomes** and many other more complex organelles in the cytoplasm. For instance, they all have **mitochondria**, the organelles where the energy required for the cell is produced.
- Some eukaryotic cells have heterotrophic nutrition but there are others with autotrophic nutrition thanks to the existence of specialized organelles called **chloroplasts**.
- There are two major types of eukaryotic cells: the animal-like eukaryotic cells and the plant-like eukaryotic cells.

3.1. Animal-like eukaryotic cells.



3.1. Plant-like eukaryotic cells.



You can look up in the Internet other pictures and drawings of eukaryotic cells.

Activity 16.

Write in your notebook the differences between prokaryotic and eukaryotic cells focusing specially in:

- which one appeared first
- size and complexity
- position of the DNA
- organelles present
- living beings that have them

Activity 17.

What kind of nutrition do we find in animal-like eukaryotic cell and plant-like eukaryotic cell? How do you know?

Activity 18.

Write the words "present" and "absent" to fill this table:

	Plasmatic membrane	Cellular wall	Nucleus	Vacuoles	Mitochondria	Chloroplasts
Prokaryotic cell						
Eukaryotic animal-like cell						
Eukaryotic plant-like cell						

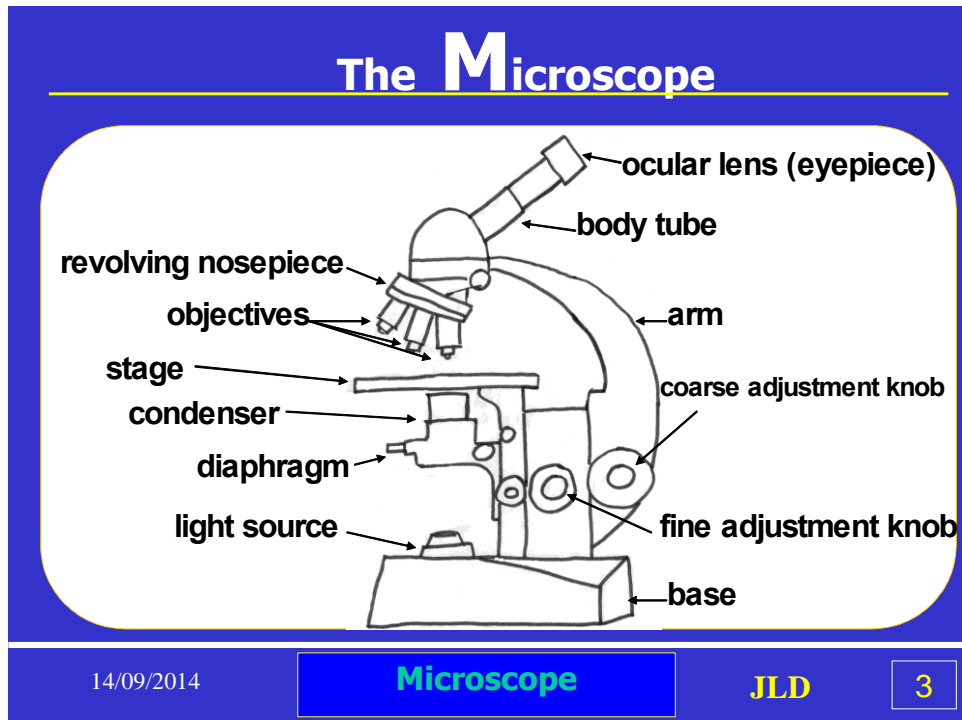
Activity 19.

Write in your notebook which type of cell can we find in:

- a mosquito
- a horse
- an oak tree
- an onion
- the bacteria that human use to produce yogurt
- the cyanobacteria that filled the atmosphere with oxygen 2000 million years ago
- the virus of the influenza (this is a tricky question)
- the muscles of your body

4. The microscope.

Cells are always very small. Their size is measured in “**micrometers**” (=0,000 001 m or 0,001 mm). This is the reason why we cannot see the amazing microscopic world surrounding us. The tool that scientists use to detect and study the microscopic organisms is the microscope. There are many types of microscopes. The optic microscopes that we can find in our school laboratory are enough to see most of the eukaryotes microorganisms or the cells of the plants and the animals. The size of these cells is about 4 to 100 micrometers. But bacteria and cyanobacteria are smaller (some of them less than 1 μm) and to see them we may have to use an electron microscope that allows a magnification of up to 1 000 000 times.



This is a drawing of the optic microscope that you can find in a school laboratory. See how many different parts and components form this precise device. The slide is placed on the stage and while you look through the ocular lens you have to focus the image with the coarse and fine adjustment knobs. To be an expert in using the microscope is something that takes a lot of practice and dedication.



This is the picture of the optic microscope of a school laboratory. You can look up for pictures and drawings of electron microscopes in the Internet.

5. The cell theory.

Biologists call “the cell theory” to the fact that all living organisms are made of, at least, one cell. Scientific theories are very useful because they allow us to make predictions. In this particular case the cell theory allows us to state that if a new living being is discovered anywhere in this planet it will be made of one or more cells. For more than a hundred years scientists have been looking for organisms without cells but we have not found out one yet.

As cells are so small, they were not discovered until very powerful lenses were available to build a microscope. The first person who described unicellular organisms in a book was a Dutchman called **Leeuwenhoek** who used a magnifying glass to look into a drop of water. He could not believe what he saw there. He wrote about “animacules” (=“tiny animals” in Latin) moving and swimming and feeding... like a town in miniature.

Then, it took some time before an Englishman called **Robert Hooke** invented the word “cell” after looking at the aspect of a thin layer of cork with a microscope that he devised.

In the nineteenth century **Schleiden**, **Schwann** and **Virchow** established that both animals and plants were made by millions of cells which were able to perform the three vital functions. They saw that in multicellular organisms the cells group together to perform similar functions forming **tissues**.

On the other hand, Biologists do not consider that viruses are living beings. They are not made of cells and they do not perform the three vital functions, although they can reproduce when they infect a living cell of an organism.

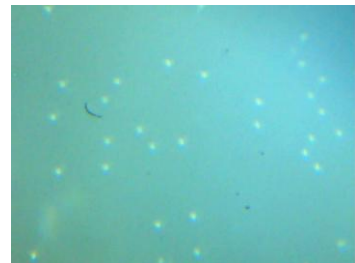
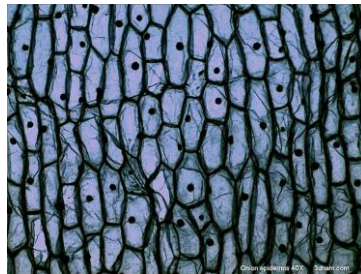
Activity 20.

Answer the following questions:

- Which types of microscopes are used to study the smallest of the unicellular living beings?
- Who was the man who invented the word “cell”?
- What is a micrometer ($=\mu\text{m}$)?
- How can we focus the image in a microscope?
- If you were able to discover a living being without cells you would win the Nobel price, why?
- What is the name of the organelle that produces the energy in a eukaryotic cell?
- Where is the chlorophyll in a plant-like eukaryotic cell?
- What is the difference between a unicellular organism and a multicellular one?
- What are the ribosomes and where do we find them?
- What is a tissue?

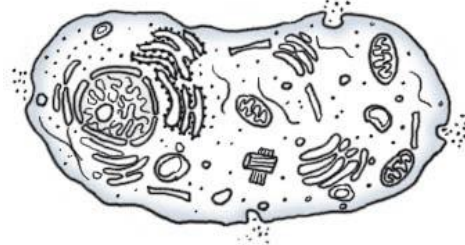
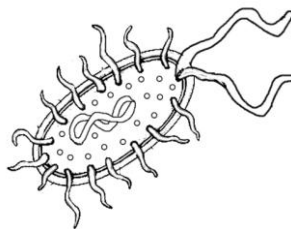
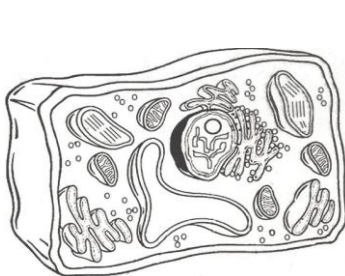
Activity 21.

Classify these cells:



Activity 22.

Copy in your notebook, write the names of the different structures and color them.



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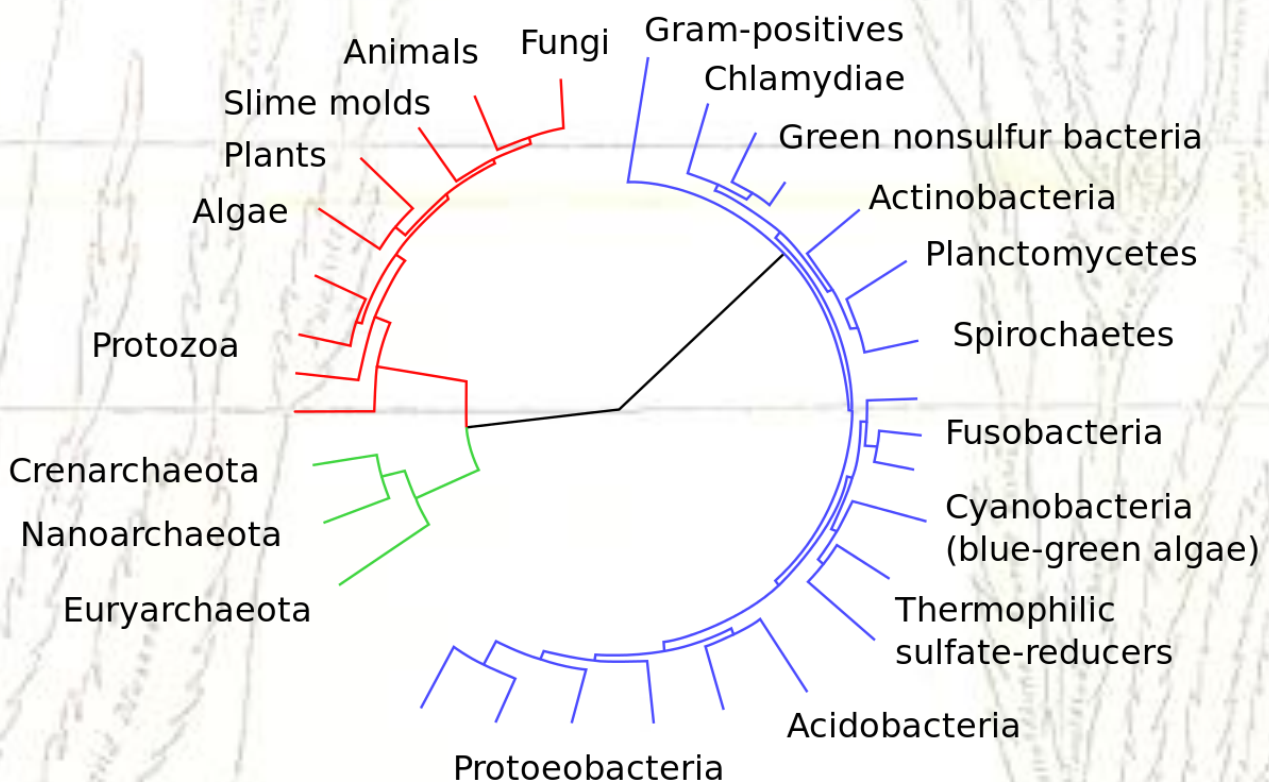
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The Villablanca Connection

UNIT 3:

CLASSIFICATION OF THE LIVING BEINGS



“Both biological and cultural diversity are now severely threatened and working for their preservation is a critical task.”

Murray Gell-Mann

Unit 3: Classification of the living beings.
Biology and Geology 1º ESO
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Unit 3: CLASSIFICATION OF THE LIVING BEINGS.

1. What do we do when we 'classify' something?

Sometimes the variety of the things that surround us is so big that it is very difficult to study them. So, one of the best ways to begin to increase the knowledge we have about them is trying to organize the elements into groups. **Classifying** is the process by which we group together the elements taking into account the characteristics they have in common. And the result of this process is a classification. Depending on the particular characteristics that we choose we may have different classifications. We say that the **final classification depends on the criterion**. (The plural of this word is 'criteria').

Activity 23.

Have a look to the followings elements we use very often at the school or at the office.



- Classify these elements into two groups and write down which have been the criterion that you have used.
- Classify these elements into three groups and write down the criteria that you have used.
- Try to classify them now into four or five groups and write down the criteria.
- In which group would you include a cutter?

2. Biological classification.

We call **biological diversity**, or just **biodiversity**, to the huge amount of different life forms that live or have lived on the Earth. Scientists estimate that there could be between 10 and 100 millions of different species of organisms living today on the Earth and uncountable other species that became extinct during the history of the planet. Most of these species remain unknown nowadays.

Fortunately, living beings are related one another and they are descendant of the same ancestors. This makes easier the work of classifying this astonishing amount of organisms. Biological classification takes into account these relationships between species and individuals as the most important criterion to group the different organisms.

2.1. Unicellular and multicellular organisms.

We already know that most of the organisms in this planet are **unicellular** (=single-celled organisms). They perform the three vital functions with just one cell and they are microscopic living beings. Despite of this small size their shape and ways of living are incredibly different. Some of them are autotrophs and perform photosynthesis; others are predators or parasites with heterotrophic nutrition.

In some cases when the unicellular organisms divide into two, four, eight or more cells, these daughter cells do not separate and remain living together. The result may look like a multicellular organism but it is not a *real* multicellular living being. If we separate them each individual cell will be able to live by their own. We call **colonies** to these groups of unicellular organisms that live together though each of them could live without the others.

Real **multicellular organisms** have many cells that depend on one another; they are bigger and we are used to see them (in fact we *are* one of them). They can have billions of cells and, although every single cell performs the vital functions, some kind of coordination appears to make the organism work as a whole. Sometimes different groups of cells in the organism specialize in different aspects of the functioning of this organism. We call a **tissue** to these groups of cells specialized in one function. Different tissues form an **organ** and different organs form a **system**. So, for instance, in our digestive **system** we have different **organs** like the stomach where we can find different **tissues**, like the muscular tissue, that moves the food inside, or the secretor tissue, that produces the gastric juice, etc.

2.2 Different levels of organization of the living beings.

If we put together what we know about unicellular and multicellular organisms and the possibility of cells forming tissues, tissues forming organs and organ forming systems, we can observe five levels of organization in the living beings that will be very useful later as criteria of classification of the biodiversity. We can summarize those levels as follows:

- Level 1: Unicellular organisms and colonies. We find here bacteria, cyanobacteria and protozoa.
- Level 2: Multicellular organisms without tissues. The simplest multicellular organisms like fungi, algae and sponges.
- Level 3: Multicellular organisms with tissues but without organs. It's the case of cnidarians and moss.
- Level 4: Multicellular organisms with organs but without systems. As in platyhelminthes worms and plants.
- Level 5: Multicellular with systems. Like arthropods, molluscs, annelids, equinoderms and all the vertebrates.

From level 1 to level 5 the complexity of the living beings increases.

2.3. Taxonomy.

The part of the biology that deals with the groups in which the living beings can be classified is called **taxonomy**. The system used by the scientists to make these groups is **hierarchical** (=hierarchic). This means that every organism belongs to a series of groups that are progressively more general or inclusive, that is, that superior groups contain the inferior groups just like the “matrioshka” or Russian dolls.



In the same way that the bigger dolls contain the smaller dolls the hierarchical classification of the living beings is made of progressively less general or inclusive groups until we get to the individual that we are classifying.

We use the expression “**taxonomic rank**” or just **taxon** to refer to one of the groups in which living beings are classified. when we refer to several of them we use the word “**taxa**”.

Well, the 7 main taxa that scientists use to classify the living beings are, from more general to more particular or inclusive:

- Kingdom
- Phylum (plural Phyla) (sometimes, as happens with the plants, the word “Division” is preferred)
- Class
- Order
- Family
- Genus
- Species

(“King Phillip Comes Over For Good Spaghetti” or “El Rey es un Filósofo de mucha Clase que Ordena para su Familia Géneros de buena Especie” if you prefer it in Spanish.)

Let's see how it works with an example. Have you ever heard of the panda bear? This is how the panda bear is classified by taxonomists:

- Kingdom: Animalia (this taxon includes all the living beings that are considered animals)
- Phylum: Chordata (all the animals whose nervous system is in a dorsal position)
- Class: Mammalia (all the animals with mammary glands)
- Order: Carnivora (all the mammals with mouth evolved to eat meat)
- Family: Ursidae (all the carnivore mammals with short tail, stout body, big head and small ears)
- Genus: Ailuropoda (it means “feet similar to the ones of the red panda”)
- Species: A. melanoleuca (it means “with black and white colors”)

Besides the 7 main taxa there can be intermediate groups of living beings among them. In that case the prefixes “super” and “sub” are commonly used. When these intermediate or secondary taxa are needed the hierarchical nature of the classification has to be respected. So, between, for example, the Order and the Family we have the sub-Order and the super-Family. In the example of the classification of the panda bear it is common to include the subphylum Vertebrata that comprises all the animals with a backbone.

2.4. The species. How are they named.

Have you noticed how the names of the taxa are Latin names? Centuries ago the only language that was used by scientists of different countries was Latin. In the 18th century the most famous scientist that had devoted his life to the classification of living beings was a Swedish called Carl Nilsson Linæus but he has passed to the history of science with his Latinized name: **Carolus Linnaeus** (or, in Spanish, Linneo). Linnaeus is considered the father of

the taxonomy and he described and studied a great amount of different organisms. The base of his system of classification is the species.

The species is a group of living beings with similar characteristics that can interbreed and produce a fertile offspring. That means that the offspring can also reproduce again.

Linnaeus adopted a **binomial system** to name each species. The name of each living being is formed by two Latin words. The first one is also the name of the Genus in which that living being is classified. The second one is the specific name that distinguishes that living being from the others in its Genus. Both words form the **scientific name** of the species. There are very strict rules to write the scientific names of the different species:

- Scientific names of the species are **always written in italics**, if we are using a word processor, or underlined if we are writing by hand. For instance, *Tyrannosaurus rex* and not "Tyrannosaurus rex".
- The first letter, and only the first letter, of the Genus has to be written in capital letters. The specific name has to be written always in lower-case letters. For instance, *Panthera leo* and never *PANTHERA LEO* or *Panthera Leo* or *panthera leo* or *panthera-Leo*.
- After the scientific name, using brackets, it is usually added the abbreviation of the name of the scientist who discovered or described the species for the first time. For instance, *Populus alba* (L.)

Activity 24.

- Define the term "classification criteria".
- Would two living beings from the same Class have more or less characteristics in common than two living beings from the same Family?
- Which taxon groups together more living beings the Phylum or the Order?
- Write down the names of the 7 main taxa, beginning with the inferior one.
- Which is the correct order from more general to more particular of these taxa: super-Class, Class, Phylum, sub-Phylum?

Activity 25.

Choose the correct scientific name of the human being:

- HOMO sapiens
- homo SAPIENS
- Homo sapiens (L.)
- Homo sapiens* (L.)

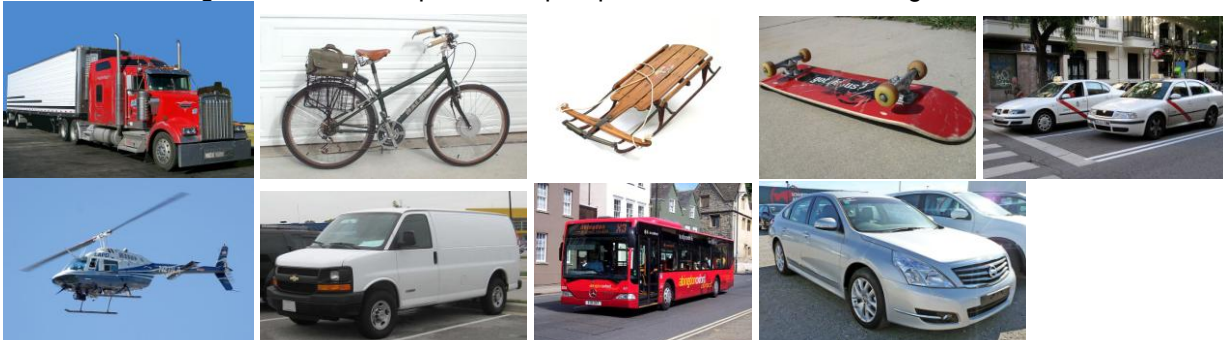
Activity 26.

Look up in a guide or in the Internet the scientific names of the following living beings:

- One of the bacteria that is used to produce yogurt
- the cat
- the lion
- the tiger
- the rose
- the polar bear
- the oak
- the daffodil
- the African elephant
- the Asian elephant
- One poisonous mushroom

3. Dichotomous keys

Scientists always try to make things easier for the students while they are still in training. This is why they design guides or keys that let other inexperienced people to learn how to distinguish between sometimes very similar living beings. Dichotomous keys are very effective tools to learn about living beings because they are very easy to use. All we have to do is to answer to questions with just two alternatives. The answer to the first question leads us to a second question and then to a third question and so on until we find the name of the species we are looking for. Let's have a look to this example. Imagine that in our neighbourhood we can find very different types of vehicles. How could we organize them to help a non-expert person to determinate if a given vehicle is one of these?



We could organize these elements in a dichotomous key like this:

1. a) Vehicles with wheels → Go to number 3.
1. b) Vehicles without wheels → Go to number 2.
2. a) Vehicles that fly → Helicopter.
2. b) Vehicles used in the snow → Sled.
3. a) Vehicles with two wheels → Bicycle.
3. b) Vehicles with more than two wheels → Go to number 4.
4. a) Vehicles with a steering-wheel → Go to number 5.
4. b) Vehicles without a steering wheel → Skateboard.
5. a) Vehicles normally used to transport people → Go to number 6.
5. b) Vehicles normally used to transport goods → Go to number 7.
6. a) Vehicles that can transport more than 5 passengers → Bus.
6. b) Vehicles that can transport less than 5 passengers → Go to number 8.
7. a) Very heavy vehicles with more than 4 wheels and articulated structure → Truck.
7. b) Not so heavy vehicles with usually 4 wheels → Van.
8. a) Public transportation vehicles → Taxi.
8. b) Vehicle for private use → Private car.

Can you see how a dichotomous key works?

Activity 27.

Try to make a different dichotomous key to organize the nine types of vehicles.

4. The 5 kingdoms.

All the living beings in this planet can be grouped in five kingdoms (remember: the more general or inclusive of the taxa).

- **Monera kingdom.** We find here all the unicellular organisms with prokaryotic cells that live independent or, only in certain cases, can form colonies. Bacteria and cyanobacteria belong to this kingdom.
- **Protista kingdom** (some biologists prefer "protocista kingdom"). The organisms in this kingdom are in some cases unicellular and multicellular in others, but all of them are eukaryotic and never develop real tissues if they are multicellular. Protozoa and algae belong to this kingdom.
- **Fungi kingdom.** Unicellular or, more often, multicellular eukaryotic organisms without real tissues and with heterotrophic nutrition. Most of them are decomposers. Yeasts, moulds and mushrooms belong to this kingdom.
- **Plant Kingdom.** Groups multicellular eukaryotic autotroph organisms. They have real tissues and sometimes they have organs. Examples: ferns, cactuses, oaks, mosses...
- **Animal kingdom.** Multicellular eukaryotic heterotroph organisms. They have real tissues and most of them organs and systems. Examples: rabbits, flies, sardines, ostriches, kangaroos...

Let's try to summarize this information in a simple chart:

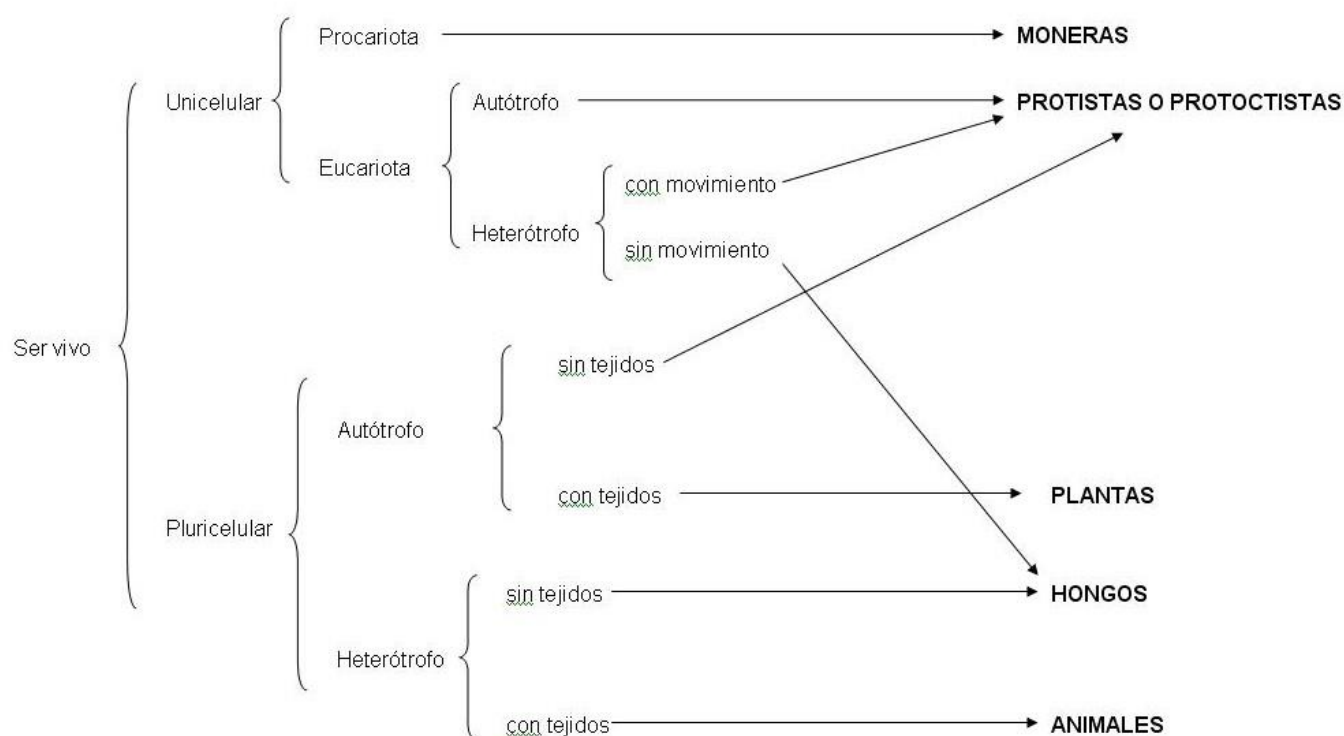
Kingdom	Number of cells	Type of cell	Type of nutrition
Monera	unicellular	prokaryotic	autotrophic/heterotrophic
Protista	unicellular/multicellular	eukaryotic	autotrophic/heterotrophic
Fungi	unicellular/multicellular	eukaryotic	heterotrophic
Plant	multicellular	eukaryotic	autotrophic
Animal	multicellular	eukaryotic	heterotrophic

And here you have a dichotomous key to find out to which kingdom a living being belongs:

1. a) Unicellular organisms → Go to number 2.
1. b) Multicellular organisms → Go to number 4.
2. a) With prokaryotic cells → Monera kingdom.
2. b) With eukaryotic cells → Go to number 3.
3. a) Autotrophic organisms or heterotrophic with cilia or flagella → Protista kingdom.
3. b) Heterotrophic decomposer organisms → Fungi kingdom.
4. a) Heterotrophic without tissues → Fungi kingdom.
4. b) Heterotrophic with tissues or autotrophic → Go to number 5.
5. a) Autotrophic with tissues → Plant kingdom.
5. b) Heterotrophic with tissues → Animal kingdom.

A different way to represent dichotomous keys is using curly brackets like here (in Spanish):

CLAVE SIMPLIFICADA DE REINOS PARA 1º ESO

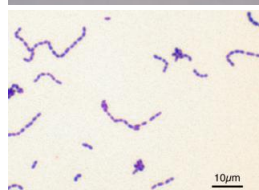


Activity 28.

Which Kingdom do these living beings belong to?

*Fucus vesiculosus**Pinnularia sp.*

Yellow jacket wasp

*Rosa sp.*

Bacteria



Moss



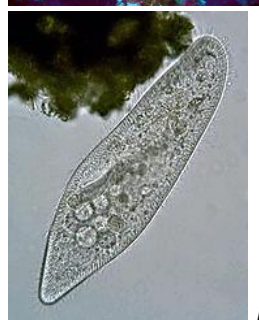
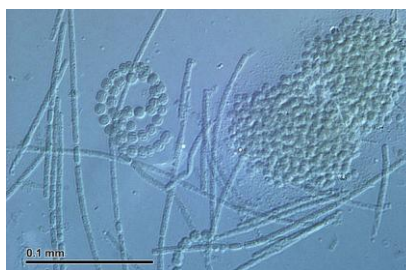
Mould on an orange



Lizard



Marine Sponge

*Morchella sp.**Paramecium sp.*

Cyanobacteria



lettuce



Starfish

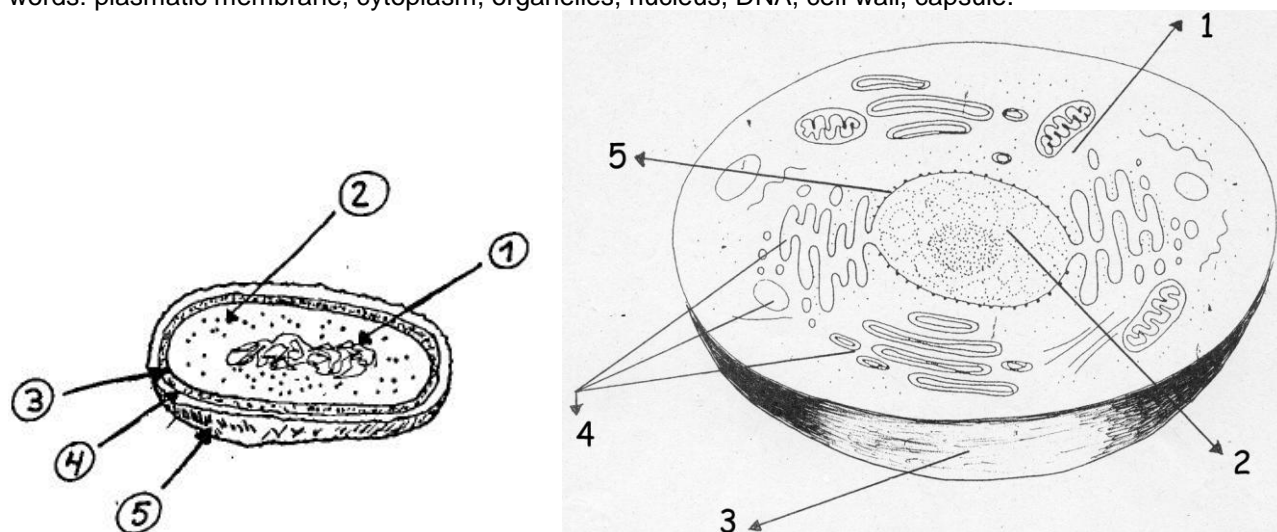
Activity 29.

Fill this table with “yes” or “no” and write the Kingdom of these living beings.

	Autotrophic nutrition	Heterotrophic nutrition	It performs photosynthesis is	It does not perform photosynthesis is	Unicellular	Multicellular	Prokaryotic cells	Eukaryotic cells	With tissues	Without tissues	Kingdom
spider											
oak											
mushroom											
bacteria of the yogurt											
medusae											
unicellular algae											
yeast											
lettuce											
ameba											
frog											
intestinal bacteria											
paramecium											
coral											
multicellular algae											
bacteria of the meningitis											
sponge											
moss											

Activity 30.

Distinguish between the prokaryotic and eukaryotic cells and match the numbers in the drawings with the following words: plasmatic membrane, cytoplasm, organelles, nucleus, DNA, cell wall, capsule.



Activity 31.

Write in this table “eukaryotic cell”, “prokaryotic cell”, “both types of cell” or “neither of the types of cell”

a) they appeared first in evolution	
b) their DNA is enclosed in an envelope	
c) they are the bigger cells	
d) they have DNA	
e) they form multicellular organisms	
f) they have organelles	
g) they have plasmatic membrane	
h) they are microscopic	
i) they have many different organelles	
j) they perform nutrition, interaction and reproduction	

Activity 32.

In this table write how prokaryotic and eukaryotic cells are alike and how they are different.

They are alike in	They are different in

Activity 33.

- Name the vital functions
- Distinguish between the nutrition of plants and the nutrition of animals.
- Explain the difference between sexual and asexual reproduction. Name one example of each one.
- Write the name of the organic and inorganic principles that form the living beings
- Write an example of stimulus and describe the reaction of the living being.
- What is the difference between a colony and a multicellular organism?
- Reorder these taxa from the most general to the most particular: Family, Species, Genus, Class, Kingdom, Order and Phylum.
- Which of these scientific names are correct?
1. *Pinus halepensis* 2. *PINUS halepensis* 3. *Pinus Halepensis* 4. *Pinus halepensis*
- Where do we find a “revolving nosepiece”?

Activity 34.

What is a dichotomous key? What are they used for?

Activity 35.

Fill the table with the words “system”, “cell”, “tissue” or “organ” according the following definitions:

a) Part of the body with a specific function whose structure is made of different tissues.	
b) The unit of life. Living beings have at least one of these.	
c) Several organs cooperating in a general activity in an organism.	
d) A group of cells coordinated to perform the same function	

Activity 36.

Write down the characteristics of the organisms in the Monera Kingdom.

Activity 37.

What do we mean when we say that the Earth is in the “habitable zone”?

Activity 38.

Describe the main characteristics of the aquatic and terrestrial environments.

Activity 39.

What is the “habitat”?

Activity 40.

What is “biodiversity”?

Activity 41.

A male lion and a female tiger can be crossed in captivity and the result is a hybrid animal called “liger”. Ligers are said to be the largest cats of the world. As they are descendant of two different species their fertility is reduced and seldom reproduce. Write down the definition of “species”.

Activity 42.

Look at the organisms and answer the following questions:

- How many species of plants are in the picture? How many species of animals?
- Which ones belong to the same genus?
- Which ones belong to the same family?
- Which ones belong to the same class?
- Which ones belong to the same Phylum?



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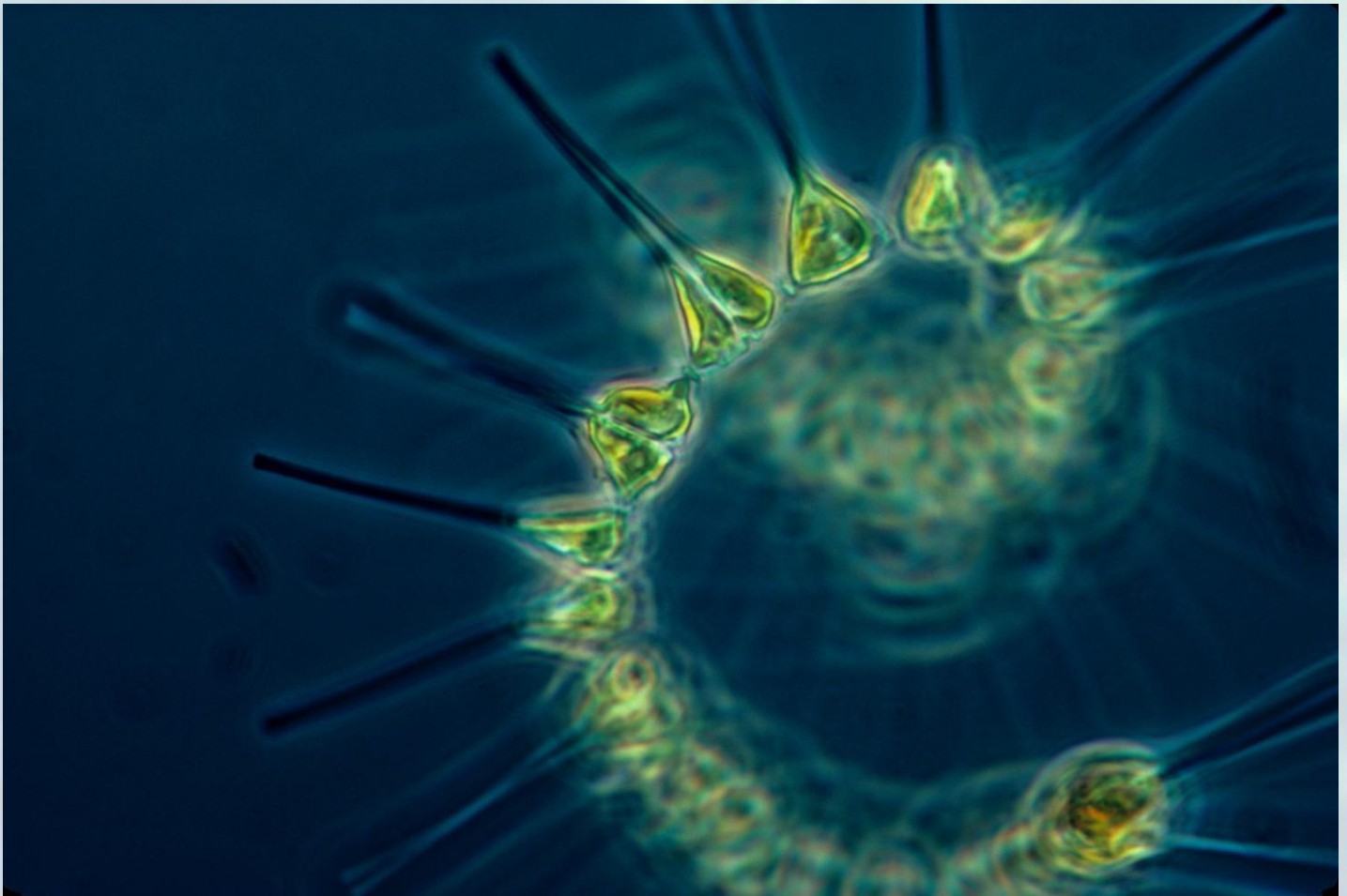
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The Villablanca Connection

UNIT 4:

UNICELLULAR LIVING BEINGS



“We forget that microorganisms rule the world. Now we're looking and finding things we didn't know were there.”

Tara O'Toole

Unit 4: Unicellular living beings.
Biology and Geology 1º ESO
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Unit 4: UNICELLULAR LIVING BEINGS.

1. Introduction.

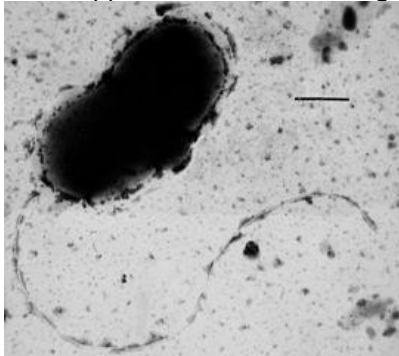
As we studied in the previous unit there are many different types of unicellular organisms. In fact the unicellular organisms that we can find on the Earth belong to three different kingdoms. All the living beings classified into the Monera kingdom are prokaryotic unicellular organisms but there are also many unicellular living things into the Protista (or Protoctista) and the Fungi kingdoms. There are a lot of differences between them and we are going to learn some of them in this unit.

To make things a little bit more complicated you have to remember that “unicellular” and “microscopic” are not synonyms because although all unicellular organisms are microscopic not all the microscopic organisms are unicellular. There are a lot of multicellular organisms that can only be seen using a microscope. So, make your mind clear and remember that in this unit we are going to study the unicellular organisms of the Monera, Protista and Fungi kingdoms.

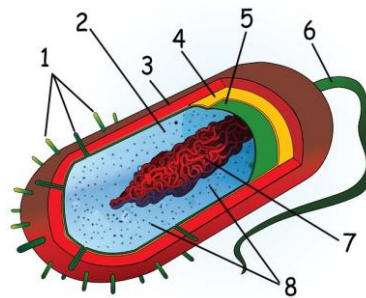
The part of the biology that studies microorganisms is called microbiology.

2. The Monera kingdom.

By now it is quite sure that you know that all the organisms in this kingdom are prokaryotes. They are the only ones with a prokaryotic cell so you already have an accurate idea of how they are. Of course, you also know that the only representatives of this kingdom are the bacteria and the cyanobacteria. Just in case, let us have another look to the appearance of these living beings:



Desulfovibrio vulgaris



Structure of a bacterium

The bar represents
0,5 μm



Cyanobacteria forming a colony.

2.1. Vital functions of bacteria and cyanobacteria.

2.1.1. Nutrition.

Cyanobacteria are autotrophs. They perform photosynthesis and produce the organic matter that they use in growing and obtaining the energy they need. They are only found in environments where there is light enough for this autotrophic nutrition. Although most of them live in aquatic environments, some of them find enough water in damp soils or the bark of some plants. There are also some species of cyanobacteria living inside of the body of certain fungi with which they establish a close interspecific relationship called symbiosis. These fungus-cyanobacteria organisms are known as lichens.

On the other hand, some **bacteria** are autotrophs but most of them are heterotrophs because they have to obtain organic matter from other organisms. They can do that feeding in different ways:

- **Saprophytes.** These bacteria live on decomposing organic remains like dead leaves or dead animals. They turn the organic matter into inorganic matter that can be used again by the plants. They are very important decomposer members of the ecosystems.
- **Parasites.** These bacteria feed on other organisms harming them and causing infectious diseases.
- **Symbionts.** They form very close associations with other species of living beings producing a mutual benefit. It is the case of the bacteria that live inside our intestine feeding on what we eat and producing some vitamins and ecological protection to us. There are also symbiotic bacteria living inside some plants helping them to obtain the nitrogen they need and feeding on the sugar that the plant produces.

2.1.2. Interaction.

Cyanobacteria cannot move. They usually float in the water or live attached to a surface. They detect the conditions of the environment and grow and reproduce, when the conditions are favorable, or form resistance structures when the conditions become adverse.

Some bacteria do not move, but others swim by means of the flagella or slide over surfaces. They detect many different stimuli and respond in the appropriate way that guarantees their survival. Bacteria have colonized almost every environment in this planet so they are found everywhere: floating in the air, living inside other organisms, swimming in the oceans and the rivers, etc. There are even bacteria living in the boiling waters of the geysers and the dark inners of the rocks.

2.1.3. Reproduction.

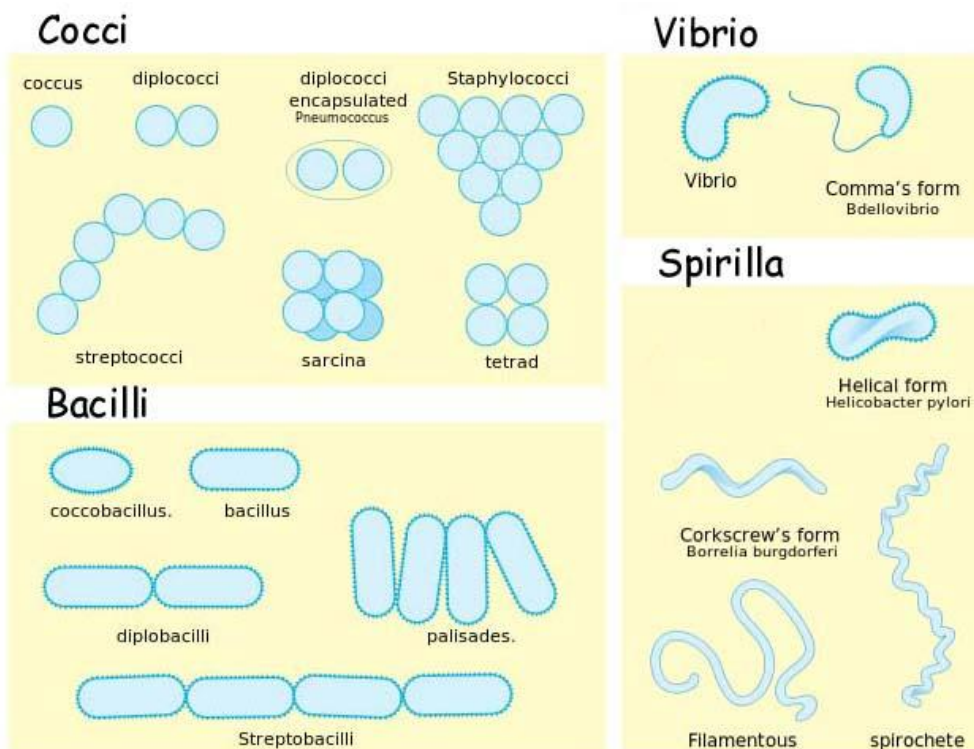
Bacteria and cyanobacteria reproduce asexually by means of **binary fission**. That means that a single cell divides its body into two daughter cells. Sometimes the daughter cells separate and sometimes they remain together. When this happens and successive cells divisions take place there can be formed groups of many millions of individuals called **colonies**. When these colonies are big enough they can be seen even without a microscope.

2.2 Classification of bacteria according their shape

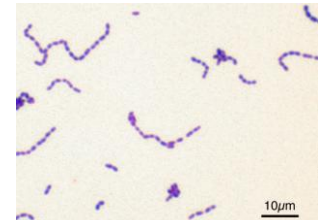
There are four basic forms of the bacteria:

- **Coccus** (pl. cocci) → They have a spherical shape.
- **Bacillus** (pl. bacilli) → They look like little rods or like the pills we usually take when we are ill.
- **Vibrio** (pl. vibrio) → They are slightly bent and remind the aspect of a comma.
- **Spirillum** (pl. spirilla) → They are spiral-shaped, sometimes remembering a corkscrew or a twisted filament.

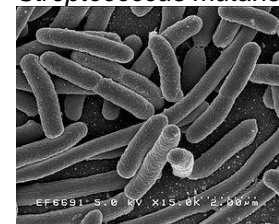
These basic forms may combine one another so you had better have a look to this drawing to understand the classification:



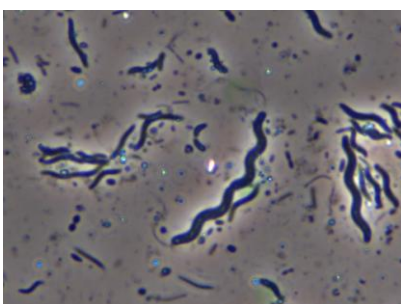
Here you have some real bacteria in order that you can see how they adjust to the classification:



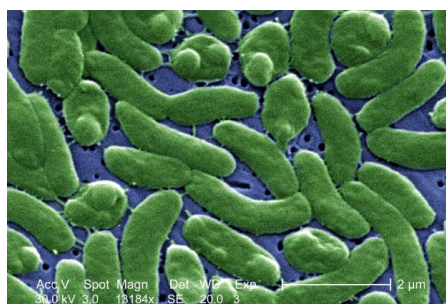
Streptococcus mutans



Escherichia coli



Spirillum sp.



Vibrio vulnificus

3. Microorganisms of the Protista kingdom.

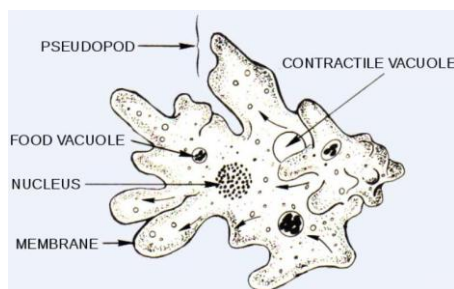
The Protista kingdom groups together very different kinds of eukaryotic living beings but, basically, there are two big types: the protozoa and the algae. Protozoa are always unicellular, but in the algae group we can find both unicellular and multicellular representatives. We will save the multicellular algae for the next unit and now we will focus only in the unicellular ones, but let us consider protozoa in the first place.

3.1. Protozoa.

Protozoa are unicellular eukaryotic organisms. They do not have usually a cellulose cellular wall, and the plasmatic membrane can remain uncovered, but in some cases they can produce a hard cover made of quartz or limestone. They are mostly heterotrophs, but some species have chloroplasts and can perform photosynthesis so they have autotrophic nutrition. Most of them live on aquatic environments like freshwater ponds, rivers and also in the oceans. Some of them can live in the ground, if it is humid, and there are some species that live inside other living beings either as parasites or symbionts.

Protozoa are classified into four main groups:

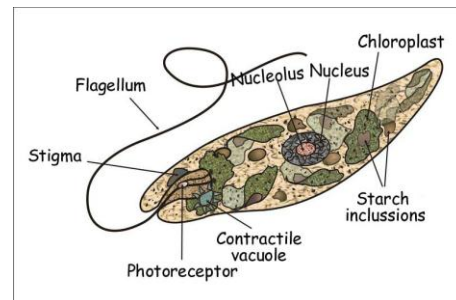
- **Amoeboids** → They can move by stretching out parts of their body called pseudopodia (=pseudopods). They can also engulf particles of food using the pseudopods in a process called phagocytosis. They are very common in freshwater like ponds and swimming-pools. Example: *Entamoeba histolytica*.
- **Flagellated** → They can move using one or more flagella. Most are heterotrophs (like *Peranema sp.*) but some are autotrophs (like *Euglena sp.*)
- **Ciliated** → Their body is covered with cilia that are used like oars to row through the water. They are very abundant in freshwater and there are also some species that can live inside other living beings in symbiosis with them. One of the more common is *Paramecium sp.* and a real beautiful one is *Stentor sp.* Some can live attached to a substrate and use the cilia to impulse the bacteria and other particles of food inside of their body like *Vorticella sp.*
- **Sporozoans** → They are parasites and can enter inside the cells of their host where they often reproduce. An example is *Plasmodium sp.* that causes the malaria in humans, one of the illnesses that kill more human beings in the world.



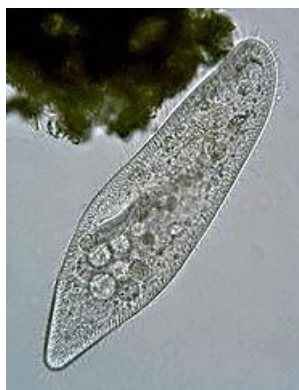
Amoeba sp.



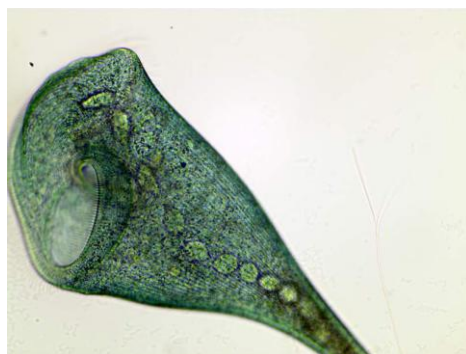
Paranema sp.



Euglena sp.



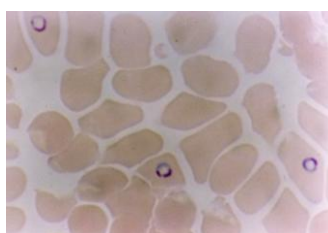
Paramecium caudatum



Stentor coeruleus



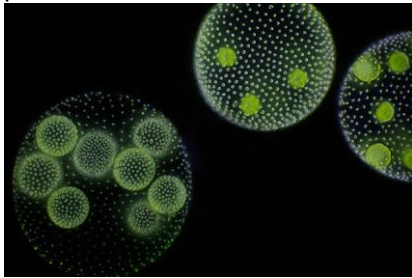
Vorticella sp.



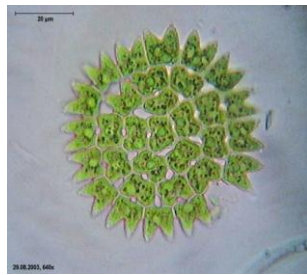
Plasmodium falciparum inside of human red blood cells.

3.2 Unicellular algae

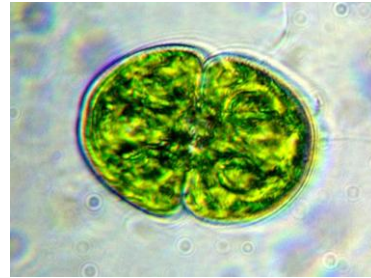
Although the more known species of algae are multicellular there are many unicellular species. Algae are eukaryotic organisms with a cellulose cell wall and they seldom move because they do not have cilia, flagella or other locomotive mechanisms. Many unicellular algae form colonies and are believed to be the ancestors of the plants.



Volvox sp.



Pediastrum sp.



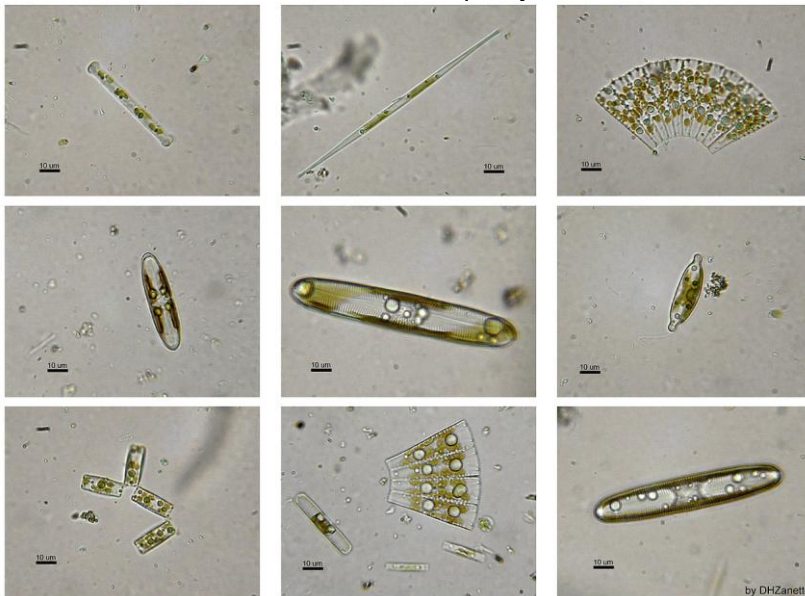
Cosmarium sp.

Unicellular algae are an important component of the phytoplankton and they are in the base of the food chains in all freshwater and oceanic ecosystems. They also play an important role as essential contributors to the amount of oxygen present in the atmosphere thanks to the photosynthetic process.

There are many different types of unicellular algae. One of the most representative group is the group of the diatoms.

Diatoms are unicellular or colonial algae with a cell wall impregnated by silicon forming a frustule made of two valves that fit together like a shoebox and its lid.

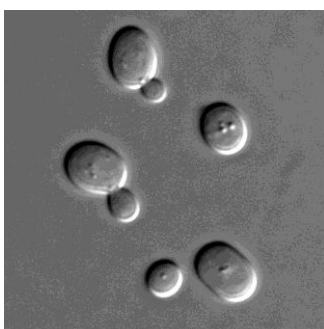
Diatoms are a widespread group and can be found in the oceans, in freshwater, in soils and on damp surfaces and are sometime used in studies of water quality.



Different types of diatoms

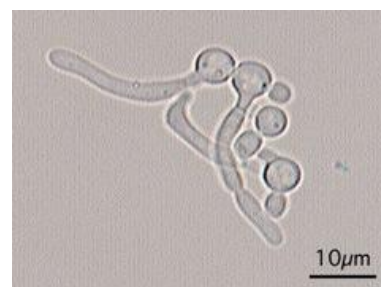
4. Microorganisms of the Fungi kingdom.

Fungi are eukaryotic heterotrophic organisms with a cell wall that is **not** made of cellulose. Yeast are unicellular fungi with a lot of interest to us because some are beneficial (*Saccharomyces cerevisiae*) and others are harmful (like *Candida sp.*).



Saccharomyces cerevisiae.

The buds can be observed very well.



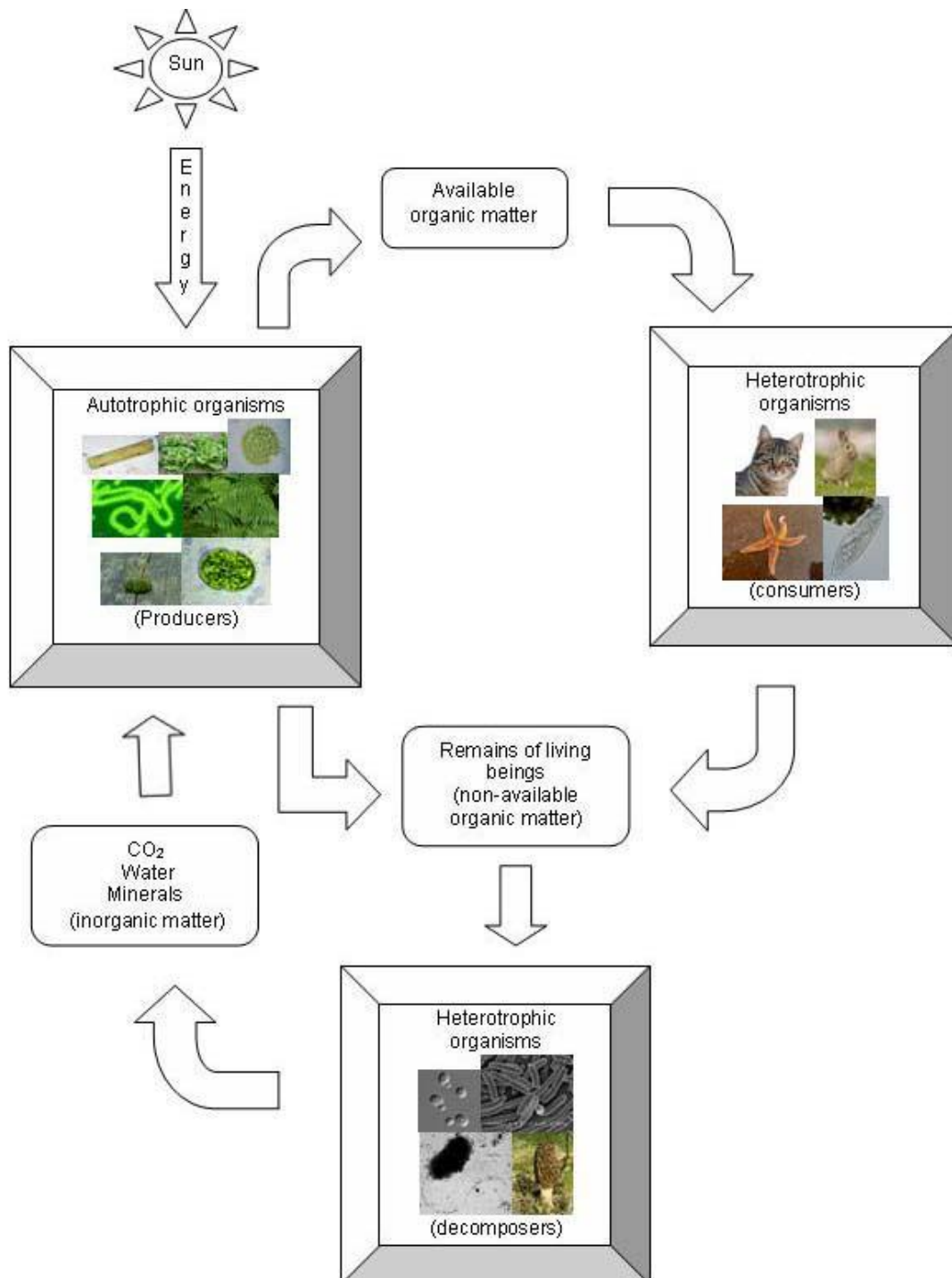
Candida albicans

Saccharomyces cerevisiae is a very useful yeast that is used both in industrial and artisan processes. It is the responsible of the production of wine, beer and bread. It reproduces by “budding” producing a “bud” that will become a small daughter cell.

On the other hand, *Candida sp.* produces several infections in humans especially in the mouth and the reproductive organs.

5. Microorganisms and biosphere.

Most of the living beings in this planet are in fact unicellular and microscopic organisms. Their importance in the systems that support life cannot be exaggerated. Unicellular algae, some protozoa and many bacteria can perform **photosynthesis** and provide the ecosystems with organic materials and energy. They are also the main responsible for the oxygen of the atmosphere and the oceans. Many others bacteria, unicellular fungi and protozoa are **decomposers** and recycle the matter in the ecosystems breaking down the remains of the living beings into inorganic substances that are this way available again for autotrophic organisms.



6. Microorganisms and People.

Most of the species of microorganisms are completely **harmless** to humans. They live surrounding us without bothering us, totally unnoticed. They are **innocuous** microorganisms.

A very important group of microorganisms is very useful to humans. Some of them help us with our digestive processes or the proper functioning of our immune system, like the bacteria in our intestine. Some of them are used to produce food like bread, cheese, yogurt or wine and have a great economic importance. They are **beneficial** microorganisms.

And there is also a small group of microorganisms that cause infectious diseases to the human beings. They are **pathogenic** microorganisms.

SOME ILLNESSES CAUSED BY MICROORGANISMS			
ILLNESS	NAME OF THE MICROORGANISM	TYPE OF THE MICROORGANISM	SOME SYMPTOMS
botulism	<i>Clostridium botulinum</i>	bacterium	double vision, weakness
salmonellosis	<i>Salmonella enterica</i>	bacterium	diarrhoea, vomits, fever
malaria	<i>Plasmodium sp.</i>	protozoon	fever, weakness
criptococcosis	<i>Cryptococcus neoformans</i>	fungus	pulmonary damage

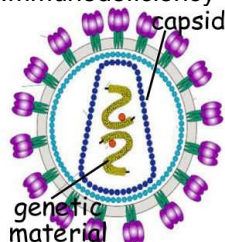
SOME BENEFITS OF THE MICROORGANISMS			
PRODUCT	NAME OF THE MICROORGANISM	TYPE OF THE MICROORGANISM	INDUSTRY
penicillin	<i>Penicillium chrysogenum</i>	fungus	Pharmaceutical industry
beer	<i>Saccharomyces cerevisiae</i>	fungus	food industry
vinegar	<i>Acetobacter sp.</i>	bacterium	food industry
lipase	<i>Pseudomonas sp.</i>	bacterium	chemical industry
biodiesel	<i>Chlorella sp.</i>	alga	energy industry
activated mud	<i>Euplotes sp.</i>	protozoon	wastewater treatment

7. A word for viruses.

Yes, they are not considered living things, and that is the reason why they are not classified into any kingdom. But we cannot ignore them because they are closely related to the vital processes as they need to enter a living cell in order to reproduce. In doing so, they sometimes kill the cell that they have used to reproduce and that can be a problem for the living being that has been infected.

We believe there are millions of different viruses; most of them have not been studied yet. There are viruses that infect plants, there are viruses that infect animals and there are even viruses that infect bacteria. Viruses are usually very specific in the type of cells that they can infect, so we can say that most of viruses are harmless to the human beings. But some of them produce very dangerous diseases and virologists and doctors are doing their best to preserve human health researching for new vaccines and treatments.

Viruses are not made by cells and they are really small: there is room for thousands of them in a single bacterium. So they can be observed only with an electron microscope. This is the typical structure of the HIV (=Human Immunodeficiency Virus, the virus that produces AIDS):



Viruses do not perform the nutrition or interaction functions and they only can reproduce inside a host cell. The newly produced viruses leave the cell (sometimes killing it) and infect new host cells. A virus outside of a cell is called a *virion* and it is considered a non-living particle.

Nowadays some researchers are taking advantage of the capacity of the viruses to enter in certain types of cells and are studying the way in which we could use them to transport useful substances, like medicines, inside of the cells that need them. Humans are also using certain viruses to produce vaccines and to stimulate the immune system. In that sense we can say that some viruses are beneficial to us.

Activity 43.

How do we call the microorganisms whose cell has not a nucleus?

Activity 44.

Complete the following sentences:

- a) Bacteria belong to the _____ kingdom.
- b) The cells of the protozoa are _____ cells.
- c) Inside the Protista kingdom we can find the algae and the _____.
- d) Microbiology is the part of the _____ that studies _____.

Activity 45.

Draw a bacterium and label its components.

Activity 46.

Escherichia coli and other bacteria live in our intestine helping us to digest food and providing us with some vitamins. In exchange they live protected and well nourished. Are these bacteria parasites, saprophytes or symbionts?

Activity 47.

Describe how bacteria reproduce by binary fission.

Activity 48.

Draw the different types of bacteria.

Activity 49.

How can protozoa move?

Activity 50.

Which of the following characteristics refer to protozoa?

- a) they are prokaryotes
- b) they can be multicellular
- c) most of them are heterotrophic
- d) they usually cannot move
- e) they can be pathogenic

Activity 51.

Which of the following characteristics apply to bacteria?

- a) they are present everywhere
- b) they can be multicellular
- c) they reproduce by binary fission
- d) some are autotrophs
- e) they have chloroplasts
- f) they are prokaryotes

Activity 52.

What would be the consequence in the cycle of the matter if decomposer organisms disappear?

Activity 53.

- a) What is the plankton?
- b) What is the phytoplankton?
- c) What is the zooplankton?

Activity 54.

What is the name of the microorganism that is used to produce wine? In which kingdom is it classified?

Activity 55.

Which organism can reproduce by budding?

Activity 56.

Name two different protozoa with cilia.

Activity 57.

The name of one of the microorganisms that is used in the production of yogurt is *Streptococcus thermophilus*. In which kingdom is it classified and what can you say about its shape?

Activity 58.

Remember the differences between the eukaryotic animal-like cell and the eukaryotic plant-like cell and fill this table:

	Eukaryotic animal cell	Eukaryotic plant cell
Type of nutrition		
Substances they need		

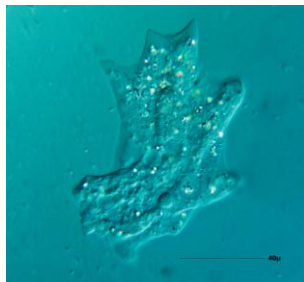
Activity 59.

Define the following terms:

- a) unicellular algae
- b) protist organism
- c) microorganism
- d) heterotrophic nutrition

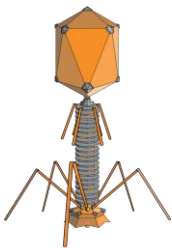
Activity 60.

Name the structures used by these microorganisms to move:



Activity 61.

The parasite in the picture attacks bacteria and reproduce into them producing so many descendants that the bacterial cells literally burst. What is the name of this parasite and in which kingdom is it classified?



Activity 62.

What is the meaning of "pathogenic"?

Activity 63.

Name four different products produced by microorganisms with industrial interest.

Activity 64.

Name four different illnesses produced by microorganisms.

Activity 65.

Match each term in A series with one term in B series.

A: Virus, Yeast, Paramecium, Linnaeus, DNA and Photosynthesis.

B: Protozoon, Binomial system, AIDS, chloroplasts, unicellular fungus and genetic material.



The Villablanca Connection

UNIT 5:

***ALGAE FUNGI AND
LICHENS***



**“A truly good book is something as wildly natural and primitive, mysterious and marvelous, ambrosial and fertile, as a fungus or a lichen.”
Henry David Thoreau.**

Unit 5: Algae, fungi and lichens.
Biology and Geology 1º ESO
Villablanca Connection

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"Rook Lane Chapel Frome1" by The original uploader was Nabokov at English Wikipedia - Transferred from en.wikipedia to Commons.. Licensed under CC BY-SA 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Rook_Lane_Chapel_Frome1.JPG#/media/File:Rook_Lane_Chapel_Frome1.JPG

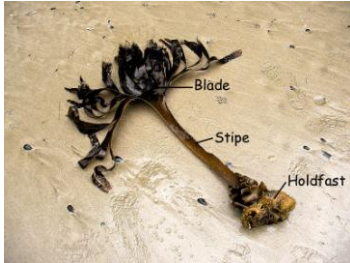
Unit 5: ALGAE, FUNGI AND LICHENS.

1. Algae.

Algae are classified into the **Protista** or **Protoctista** kingdom. Most of them are unicellular and we have studied them in the previous unit. But multicellular algae are very common aquatic living beings and I am sure you have seen them many times before. Most people think of them as some kind of aquatic vegetables and very often they consider them as aquatic plants. In fact, some algae have something like a root, a stem and even something like leaves, and all of them perform **photosynthesis**, so the differences between multicellular algae and aquatic plants are not obvious and we have to discover them by a very close look.

Algae are **eukaryotic** living beings. They can be unicellular (see Unit 4) or multicellular and their cells have a cellulose cell wall and chloroplasts with chlorophyll. They are **autotrophic** and can produce their own organic matter using the energy from the sunlight because they can perform photosynthesis (=“produce with light” in Greek). They live both in fresh water and salt water where they are the **producers** of the aquatic ecosystems providing organic matter to the herbivores.

The reason why biologists classify algae in a kingdom different than plants is that algae have not real tissues neither they have real organs. Their entire body is formed by a **thallus** (=multicellular non-moving body in which there is no organization of tissues or organs). However, the thallus can sometimes develop plant-like structures like false stems, false leaves and false roots.



Saccorhiza polyschides, a brown alga, showing the **holdfast** (=false roots), the **stipe** (=false stem) and the **blade** (=false divided leaf).

Algae have both sexual and asexual reproduction. They often can reproduce asexually by fragmentation of the thallus, but they can also produce gametes that can fuse together to form the zygote.

1.1. Classification of the multicellular algae.

Multicellular algae are classified according to the pigments that are present in their cells. All of them have **chlorophyll** in order to perform photosynthesis, but sometimes other pigments are also present and colors different than green can result. We distinguish three main groups of multicellular algae:

- **Brown algae:** Most of them live in salt water. Besides the chlorophyll there is another pigment in the chloroplasts called fucoxanthin that is responsible for the different shades of brown that we can find in the members of this group. Some algae of this group are very big like *Macrocystis* sp. that forms prominent underwater forests of kelp (the common name of this type of algae) or *Sargassum* sp., which creates unique habitats in the tropical waters of the Sargasso Sea, in the Atlantic Ocean.



Giant kelp (*Macrocystis pyrifera*).

Fucus vesiculosus. (See the gas-bladders).



Saccharina latissima on a beach.

- **Red algae:** Most of them live in salt water. They have phycoerythrin (a red substance) and other pigments in the chloroplasts besides the chlorophyll. They are often attached to the ocean floor or on animal shells. Most of the algae that can be found in coral reefs belong to this group and contribute to the construction of the reef secreting calcium carbonate.

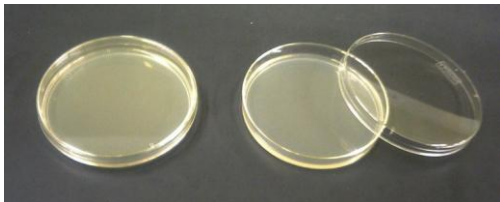
← *Palmaria palmata**Corallina officinalis* →*Mesophyllum sp.*

- **Green algae:** This is the most diverse group of algae. There are many species of green algae that live in fresh water and also there are many species that live in salt water. The green color is due to the presence of chlorophyll in the chloroplasts without any other pigments in quantity enough to superpose their color.

*Ulva lactuca.**Chara vulgaris.*

1.2. Algae and humans.

Some species of algae have been used as food for humans for thousand of years. China consumes more than 70 species, Japan 20 species; and algae are also eaten in Ireland, Wales, Korea, Chile, New Zealand, etc. And they are a good source for vitamins and bioelements. There is also a taste for algae nowadays in modern cuisine.



Microbiologists throughout the world use agar as a medium on which to grow bacteria and fungi. Agar is obtained from red algae.

Agar Plates (agar medium in 100mm Ø Petri-dish) for bacterial culture.

Stabilizing substances, pigments, additives, excipients and gelling agents obtained from the algae are also of interest for industrial purposes. Besides, dried algae have been used for centuries in agriculture as fertilizers and today there is a deep interest in a bio-fuel obtained from algae oils as a possible substitute of the fossil fuels.

Activity 66.

Why are not algae classified into the plant kingdom?

Activity 67.

If the algae are autotrophic organisms, why some of them are not green?

Activity 68.

In the picture of *Fucus vesiculosus* of the previous page we can see in the thallus of the alga a number of structures filled with gas. What are they for?

Activity 69.

Draw in your notebook an alga with holdfast, stipe and blade.

2. Fungi.

Fungi are sessile organisms, living in the soil, on the dead leaves or in the carcasses of dead animals or plants. They do not look like animals, but they are not plants either.

Fungi are eukaryotic heterotrophic organisms. Some can be unicellular (yeasts: see the previous unit) and many others are multicellular. Their cells have a cell wall, but it is made of **chitin** instead of cellulose, and they never form real tissues or organs. Fungi present so many differences with animals and plants that biologists classify them in their own kingdom: the fungi kingdom.



Fungi forming small mushrooms on the fallen leaves

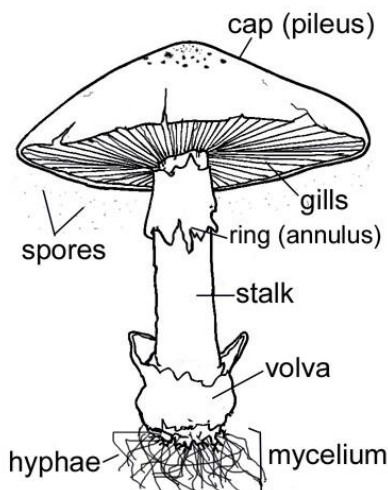
	Similarities and differences between animals, plants and fungi		
	Animals	Plants	Fungi
Type of cell	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	No	with cellulose	with chitin
Type of nutrition	Heterotrophic	Autotrophic	Heterotrophic
Chlorophyll	No	Yes	No
Tissues	Yes	Yes	No

Fungi are heterotrophic and they feed in different ways:

- **Saprotrophs:** They feed on the remains of dead organisms or discharged organic matter like dead leaves, excrements, etc. They secrete enzymes that decompose the animal or plant remains and absorb their nutrients. A lot of inorganic matter is then produced fertilizing the soil, because this inorganic matter is directly available for the plants. They are part of the decomposer organisms that recycle the matter in the ecosystems.
- **Parasites:** They feed on living organisms (animals or plants) producing a harm to them. Some of them can kill the plants that we use for our food, ruining the crops, and others can produce illnesses in humans.
- **Symbionts:** They establish a mutual positive relationship with other species (symbiosis) that provides them with their food. For instance some fungi form mycorrhizal symbiosis with the roots of the plants in the soil. The **mycorrhiza** is a structure surrounding the roots where an exchange of substances takes place between the fungus and the plant. Fungi provide the plant with minerals and water and the plants provide carbohydrates and other organic nutrients to the fungi. In other cases the fungi can establish a symbiosis with an animal. It is the case of the leafcutter ants. These ants cultivate the fungus inside their ants' nest providing it with cut leaves and the fungus produces food for the colony. Of course there are also fungi and algae living in symbiosis forming the lichens, but we will have a look to them later in this unit.

The body of the multicellular fungi is formed by a huge number of very fine filaments called **hyphae** that are usually underground and cannot be easily seen. The set of the hyphae is called the **mycelium** of the fungus, and sometimes looks like a spider web, but most of the times it is inconspicuous because of the small size of its hyphae. The visible part of many fungi is actually their reproductive organ and it is called the **mushroom** or carpophorus (= "fruit bearer" in Greek). The mushroom produces microscopic spores that float in the air until they eventually come down to the soil where, given the proper conditions, they can germinate producing the hyphae of a new fungus.

Parts of a mushroom

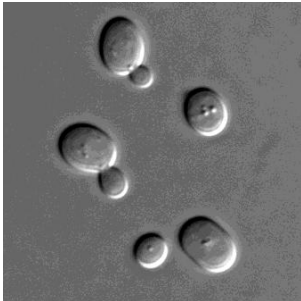


*A mushroom growing on a dead tree
(see the gills where spores are produced)*



Fungi are classified into three main groups:

- **Yeasts:** They are unicellular and we studied them in the previous unit (see Unit 4 to review how yeasts can be useful or dangerous for humans)
- **Moulds:** They never form conspicuous reproductive structures but they can be easily observed when food spoils.
- **Mushrooms:** They form big aerial reproductive structures to guarantee the adequate dispersion of the spores.



Saccharomyces cerevisiae
(a yeast)



Stilton cheese veined with *Penicillium roqueforti*



Amanita phalloides accounts for the majority of fatal mushroom poisonings worldwide.

2.1. Fungi and humans.

We have discussed earlier (see Unit 4) how yeast can be used to produce several kind of food. Multicellular fungi can also be used to produce food (like cheese) and many of them are considered by themselves a delicatessen both in modern and traditional cuisine.

Many fungi are a source for pharmacological substances like antibiotics (penicillin), immunosuppressants (cyclosporine) or cholesterol inhibitors (statin).

Many fungi species are poisonous to humans, with effects ranging from slight digestive problems or allergic reactions as well as hallucinations to severe organ failures and death.

In agriculture some species are used to control pests like insects, mites, weeds or other pathogenic fungi.

In industry some fungi are used to obtain industrial chemicals like citric acid.

3. Lichens.

Lichens are organisms that result from the symbiosis of a fungus and a cyanobacteria and/or an alga. The fungus and the alga establish a mutually beneficial relationship where the alga (or the cyanobacteria) obtains water, minerals and protection from the environment while the fungus obtains the products of the photosynthesis performed by the alga or the cyanobacteria.







Lichens can live in extreme environmental conditions where neither the fungus nor the alga would survive. They can grow on the bare rocks and are usually among the first organisms to appear on fresh rock exposed after an event such as a landslide or a volcanic eruption. They can also grow in walls, roofs and exposed surfaces where no other organisms can grow. We can find lichens in every ecosystem in this planet. They live in Antarctica and in the Sahara desert as well as in the rainforest or the alpine elevations. There are even lichens living inside certain rocks among the grains of its minerals.

Lichens are both resistant and sensitive. As an example of the former, in 2005 an experiment of the European Space Agency, designed by a Spanish researcher, took place in orbit and two different species of lichen were directly exposed to the vacuum of space with its widely fluctuating temperatures and cosmic radiation. Fifteen days later the lichens were brought back to earth and were found to be in full health with no discernible damage from their time in orbit.

On the other hand, lichens have been used as **bio-indicators** of the quality of the air because the different species of lichens have a different tolerance to the presence of pollutants in the air. Fruticose lichens are often more sensitive to pollutants than foliose or crustose lichens.

Lichens are often classified depending on the form and development of the thallus. There are five main types of lichens according to their growth:

- Fruticose
- Foliose
- Crustose
- Leprose
- Gelatinous

Common lichen growth forms*					
					
This lichen grows like a multiply branched tuft or leafless mini-shrub, so has a fruticose growth form.	This lichen has leaf-like structures, so is foliose .	This lichen grows like an orange crust coating the rock, so is crustose .	This lichen grows like a crust, and in a pattern that radiates outward from the center, so has a crustose placodioid growth form.	This lichen grows like powder dusted on the rock so is a leprose lichen.	This lichen is gelatinous , without internal structure for its parts.

* The images and texts of this table have been taking from <http://en.wikipedia.org/wiki/Lichen>

Activity 70.

Draw a mushroom in your notebook and write the names of its different parts.

Activity 71.

- Are the fungi autotrophs or heterotrophs?
- Explain the different types of nutrition in the fungi.

Activity 72.

Summarize in a table the differences between algae, plants and fungi.

Activity 73.

- Name a type of unicellular fungi.
- What is the mycelium?
- Explain one symbiosis in which a fungus gets a benefit.
- Name a pharmaceutical drug that human can obtain from fungi.

Activity 74.

What is agar used for? In what organisms can we find agar?

Activity 75.

Describe what type of organisms are lichens.

Activity 76.

There are no algae and no lichens in the bottom of deep seas. How can you explain this?

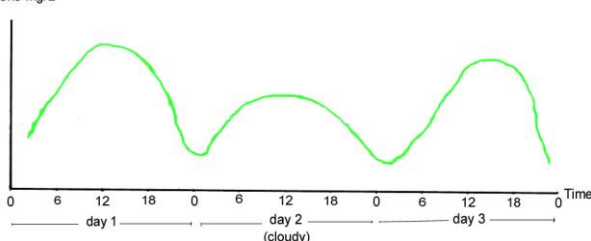
Activity 77.

Classify these sentences in true or false and correct the false ones.

- Lichens are unicellular organisms.
- Algae have heterotrophic nutrition.
- The spores of the fungus are produced in the gills of the cap of the mushroom.
- Fruticose lichens are more sensitive to the pollutants of the air.
- Red and brown algae have not chlorophyll.
- Lichens are composite organisms that result from the symbiosis of an alga and a cyanobacteria.

Activity 78.

Oxígeno mg/L



A group of students have been collecting data in a pond for 3 days. When they represent the results of their measures of the oxygen released by the algae of the pond they obtain this graph:

Explain the results for the three days.

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The Villablanca Connection

UNIT 6:

PLANTS



**"The clearest way into the Universe is through a forest wilderness."
John Muir.**

Unit 6: Plants.
Biology and Geology 1º ESO
Villablanca Connection

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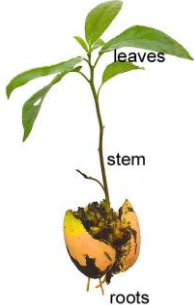


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Unit 6: PLANTS.

1. Introduction.

From an immediate point of view, plants are very conspicuous living beings green in color and very limited in their movements. In a more scientific approximation, we can say that they are **eukaryotic multicellular** organisms with **cellulose** in the cell wall and **chlorophyll** in the chloroplasts. They live usually attached to the ground, from where they obtain water and minerals, and they also take carbon dioxide from the air to produce their organic food thanks to the sunlight. So, they are **photosynthetic autotrophic** organisms.



All plants are classified into a kingdom of their own: the **plant kingdom**. Plants usually have real tissues and, in most of the cases, real organs. The organs that are commonly present in plants are the **root** (to extract water and minerals from the soil), the **stem** (to transport nutrients between the different parts of the plant) and the **leaves** (to get the CO₂ from the air and collect the sunlight to perform photosynthesis). In many cases we can also find **flowers** to produce the gametes responsible for the sexual reproduction.

Plants are classified in two main groups:

- **Plants without seeds.** They are very simple plants that reproduce through spores and have to live in wet environments. We are going to study two groups in this type of plants:
 - **Mosses**
 - **Ferns**
- **Plants with seeds (=Spermatophytes).** These plants have flowers and are more widely widespread. We consider two groups inside this type of plants:
 - **Gymnosperms.** Plants with unnoticeable flowers and bare seeds (=the seeds are not inside a fruit).
 - **Angiosperms.** Plants with conspicuous flowers and the seeds inside a fruit.

Activity 79.

What are the substances needed by the plants to grow?

Activity 80.

What are the organs that the plants use to take the CO₂?

Activity 81.

State whether these statements are true or false and correct the false ones:

- a) Mosses reproduce by seeds.
- b) Plants are heterotrophic organisms that produce their own food
- c) Plants are autotrophic organisms because they produce inorganic matter.
- d) Plants have chitin in their cell walls.
- e) Ferns are plants without seeds.
- f) The fruit of the gymnosperms is conspicuous and edible.

Activity 82.

Copy the drawing in your notebook and write the names of the main organs of the plants.



2. Plants without seeds.

400 million years ago there were no multicellular autotrophic organisms outside the water. To conquer the terrestrial environment the primeval plants had to find a way to:

1. **avoid dehydration,**
2. a way to **sustain their body,**
3. a way to **transport water and nutrients** to the different parts of their bodies and
4. a water **independent reproduction system.**

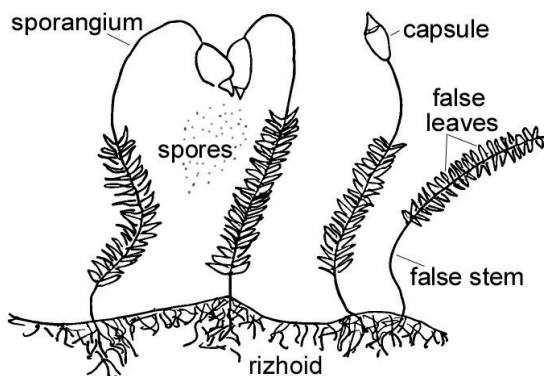
One of the first succeeding attempts was carried out by the primitive mosses.

2.1. Mosses.

Mosses are very little plants that avoid dehydration by living in wet and shady environments and by their small size (no more than some centimeters tall). They do not have real supporting structures and they can stand by growing very close one of another forming miniature forests.

Mosses do not have transport tissues (they are not really **vascular plants**) and absorb the water and the nutrients through their entire surface. Although they present structures that are similar to the roots, stem and leaves of the vascular plants they receive different names because these structures do not perform the same function than the real roots, stem and leaves.

When the conditions become favorable mosses grow a sporangium with a capsule where spores are produced and eventually released to reproduce themselves.



Parts of the external anatomy of the mosses



A group of mosses with sporangia

Mosses can colonize any environment that remains wet most of the time, but some species can dry up and survive for a long time so when the rain falls again they become green once more.

The mosses need a humid environment, so they grow preferably in the part of the rocks or the bark of the trees that is more exposed to the rain, which can be used to get directions inside a forest where orientation is difficult by other means.



Moss indicates the direction of the rain.

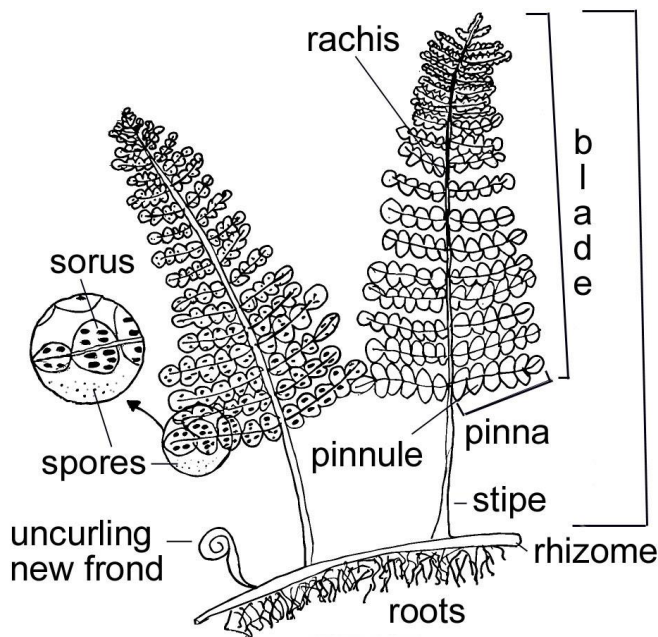


Sphagnum sp. can form "green blankets".

2.2. Ferns.

Ferns have real tissues and real organs. They are considered the first **vascular plants** that appeared on Earth. This means that ferns have specialized transport tissues to distribute the nutrients and the products of the photosynthesis. These **conductive vessels** make possible a more efficient distribution between more distant parts of the plant, and this means that ferns can be much bigger in size than mosses. In fact, before the appearance of more complex plants many million of years ago, the ferns formed extensive forests of huge trees. Their remains are nowadays the big coal deposits that can be found all over the world.

The ferns that we can find today are usually the size of a bush or an interior ornamental plant. They have **real roots**, **real stem** and **real leaves**, and they live in shady places under the cover of the trees in the forests. The stem, which is called **rhizome**, is most of the times horizontal and grows underground, so the only aerial part of the plant are the **fronds**, that is the name of the leaves of the ferns. In the lower surface of the fronds we can find the **sori** (it is plural for "**sorus**"), little brownish spots where the sporangia are. They reproduce through spores that germinate in shady wet soil to produce an underground heart-shaped structure known as **prothallus** that eventually will produce male and female gametes that, after the fertilization, will become a new fern.



External anatomy of a fern.



Prothallus of a fern



Ferns in the undergrowth of a pine forest in the Sierra de Guadarrama



Detail of sori in the underside of a frond.

Activity 83.

Make a drawing of a moss and label the different parts of its external anatomy.

Activity 84.

Why do we say that the "rhizoid" of a moss is not a real root?

Activity 85.

Define “sporangium”.

Activity 86.

Decide whether these statements are true or false and correct the false ones:

- a) Mosses and ferns are not plants.
- b) Lichens are not plants.
- c) Mosses and ferns have conductive vessels to distribute the nutrients to the different parts of their body.
- d) Spores need a wet place to germinate.
- e) Seeds are more resistant to desiccation than spores.
- f) Fronds are not real leaves.
- g) Mosses are usually bigger than ferns thanks to their transport tissues.
- h) The living being that can be seen growing on the bark of this tree is a real plant:



- i) Mosses are organisms that result from the symbiosis of a fungus and an alga.
- j) Although mosses are eukaryotic organisms they cannot perform photosynthesis.
- k) The cells of the ferns do not have chloroplasts and they have heterotrophic nutrition.
- l) The sporangia of the ferns are in the sori placed in the underside of their fronds.

Activity 87.

Why do mosses and ferns have to live in wet environments?

Activity 88.

What is the main difference between mosses and ferns?

Activity 89.

Draw a fern and label the different parts of its external anatomy.

Activity 90.

This drawing shows a moss called *Eustichium norvegicum*. What are the names of structures 1, 2 and 3?



Activity 91.

According to the text of this Unit, what are the four problems that primeval plants had to solve to conquer the terrestrial environment?

Activity 92.

Make a diagram to show the different groups into which plants are classified.

3. Spermatophytes: Plants with seeds.

Plants with seeds are organisms a little bit more **complex** than mosses or ferns. They possess more types of tissues and they use a totally different way to reproduce that implies a new organ: the **flower**. In the flower, the male and female structures produce the gametes that are required to **sexual reproduction** and, as a consequence of the development of the **zygote**, the seeds will guarantee that the new generation of plants germinates even in not so strict conditions of water availability.

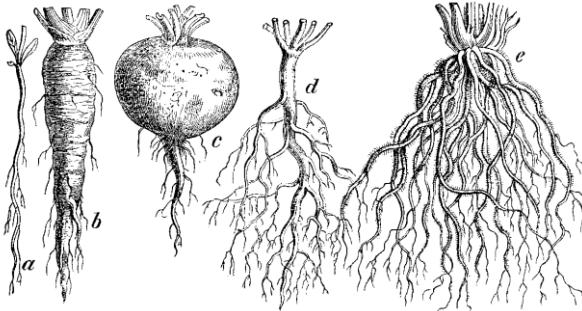
3.1. The basic plant structure: root, stem and leaves.

The root.

The root is the underground organ of the plants that is in charge of two important functions:

1. The root **anchors the plant to the ground**, avoiding that the wind and the rain drag it.
2. The root **collects water and mineral nutrients** present in the soil and takes them up to the rest of the plant. It can absorb the nutrients thanks to the **root hairs**.

Sometimes the root can also accumulate substances as a reservoir of energy (like carrots, for instance).



Types of roots:

- a) thread-like root.
- b) taproot.
- c) taproot of a bulb.
- d) fascicled root.
- e) fibrous root.

The stem.

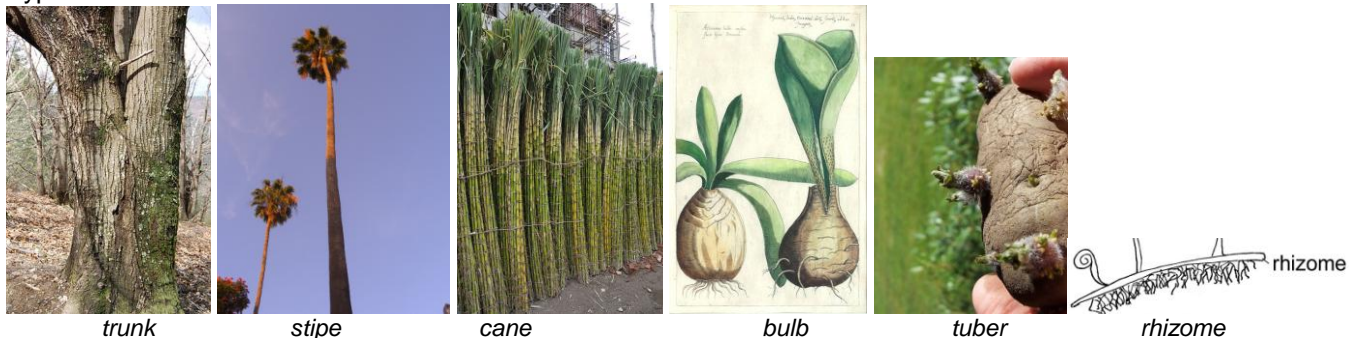
The stem is the organ that **supports** the plant and makes possible the **transport** of substances between the aerial and subterranean parts of the plant. These substances are dissolved in the **sap** that moves through the **conductive vessels**.

There are two types of conductive tissues in the plants: the **xylem** and the **phloem**.

The **xylem sap** is composed by the water and dissolved minerals that have been absorbed in the root and always moves upwards to the leaves and aerial parts of the plants to supply the cells with the water and mineral salts that are required to perform photosynthesis.

The **phloem sap** is composed by water, carbohydrates and other organic substances that have been produced by photosynthesis in the leaves and moves downwards to supply food to the underground parts of the plants.

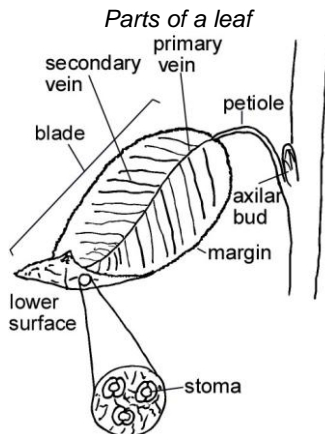
Types of stem:



The leaves.

The leaves are the organs of the plants specialized in the **photosynthesis**. They receive water and minerals from the root in the xylem sap and they get CO₂ directly from the air. With these inorganic ingredients the leaves produce organic matter (like carbohydrates) thanks to the sunlight energy they collect with the chlorophyll of the chloroplasts. The carbohydrates and the other organic substances are then distributed to rest of the organs of the plant with the phloem sap. A byproduct of the photosynthesis is the **oxygen** that the leaves release to the atmosphere.

The typical leaf is formed by a little segment that connects it to the stem (the **petiole**) and a laminar structure that is called the **blade**. In the lower surface of the blade there are many microscopic organs called **stomata** with an opening that the plant can open and close to regulate the intake of CO₂ and the output of water and oxygen (=transpiration).



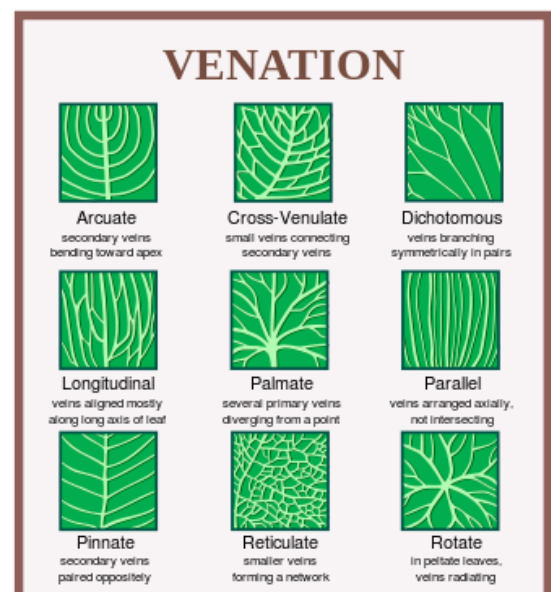
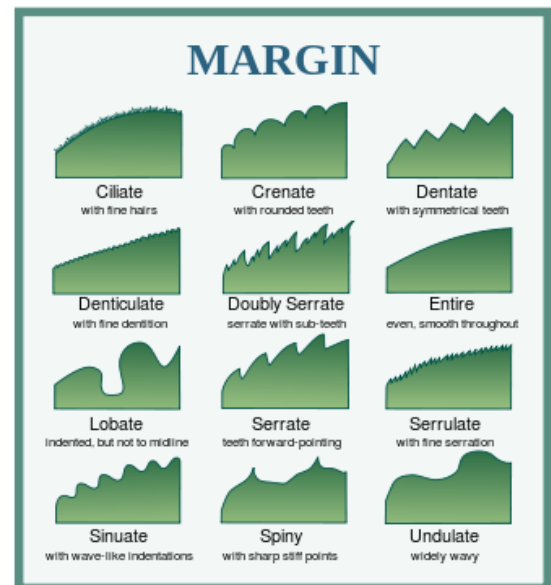
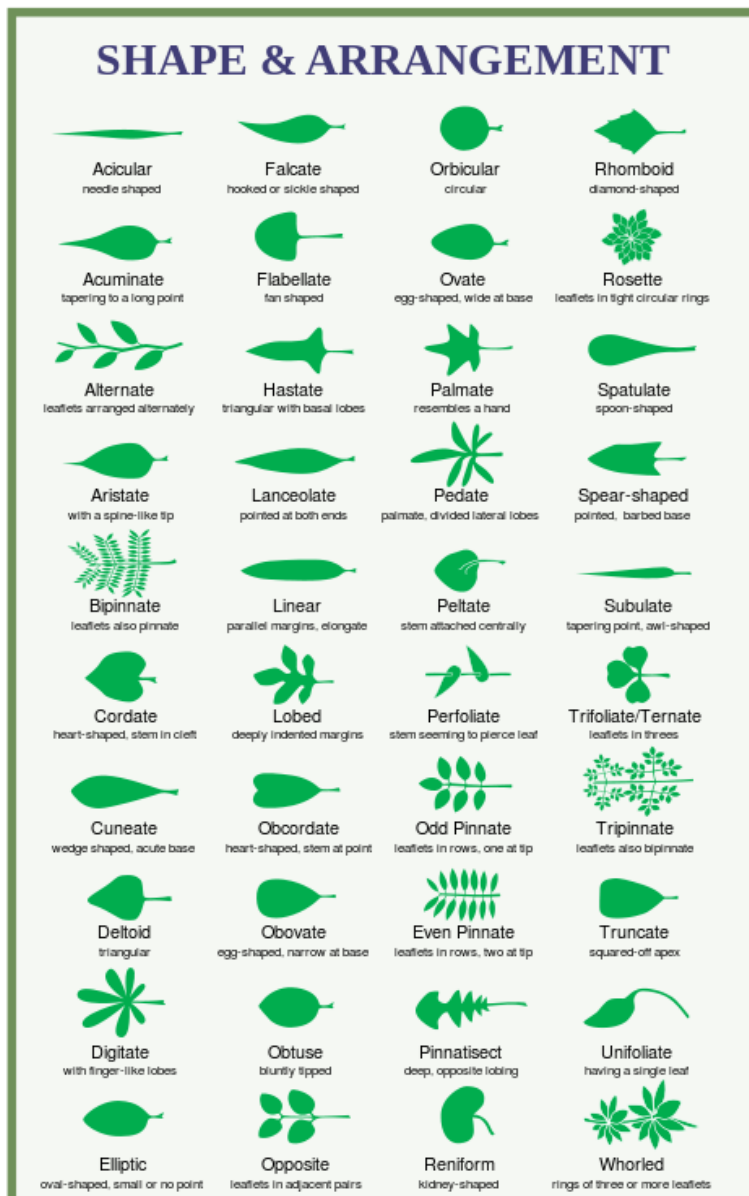
open stoma



closed stoma



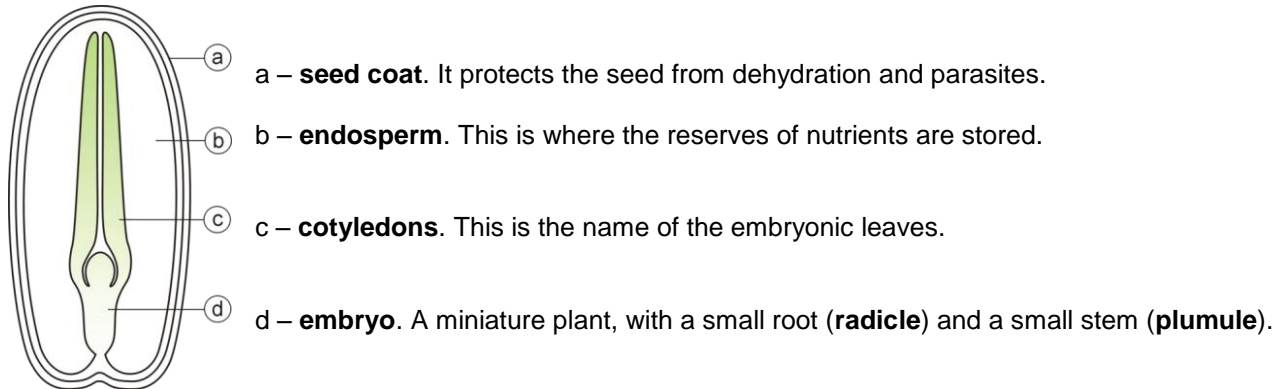
Types of leaves:



3.2. The seed.

The seed is the reproductive structure of the spermatophytes. The seeds are more resistant than spores and can resist in dry environments for a long time before they germinate. The seed accumulates nutrients so the new born plants can develop for some time without an external source of food.

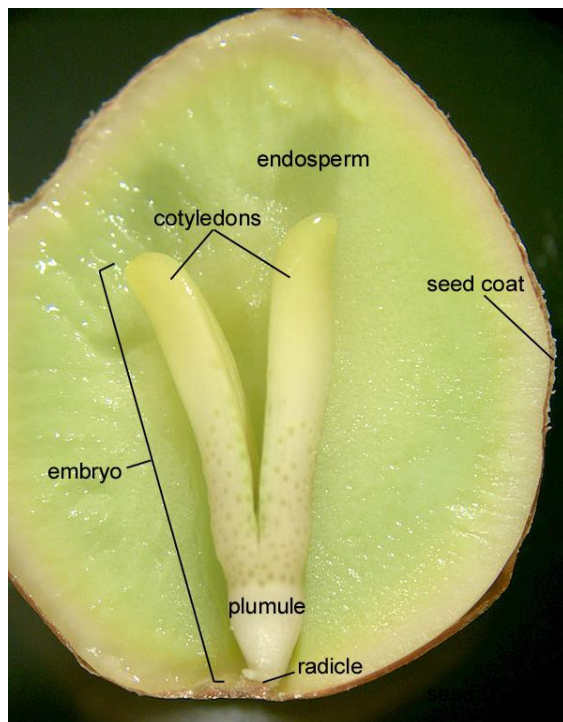
In a seed there are four basic elements:



Germination of the seed.

The seeds can remain lethargic for a long time, but when the rain falls and filters into the soil, the seeds swell because of the accumulation of water, and the embryo begins its development breaking the seed coat and emerging from the soil surface.

When the reserves of nutrients in the endosperm are finished the plant has already a functional root, with root hairs that can absorb water and minerals from the soil, and the first leaves have been formed to perform photosynthesis and obtain CO₂ from the air.



Cross section of a seed of *Ginkgo biloba*.

3.3. Gymnosperms: Plants with seeds but without fruit.

The spermatophytes are classified into **Gymnosperms** (*gymnos*=“naked” and *sperma*=“seed”, in Greek) and **Angiosperms** (*angeion*=“recipient” and *sperma*=“seed”, in Greek).

The most common gymnosperms are **conifers** like pines, cypresses and junipers. They are called that way because their flowers group together to make **cones**. Conifers are very common in the cold and template regions of the northern hemisphere. They usually have the following characteristics:

- Most of them are big **shrubs** and **trees** that can form very dense forests.
- They have leaves with the **shape of a needle**, presenting a small surface adapted to extreme temperatures.
- They have a **perennial foliation**. This means that the leaves are always present in the plant because it does not lose all of them at the same season.
- The flowers are grouped together forming **cones** and they are **unisexual**. There are male cones and females cones in different parts of the same plant. The female cones are covered with woody scales to protect the ovules.
- The pollen is produced in the male cones and it is transported to the female cone by the wind.



Female cones of a pine



Male cones of a pine



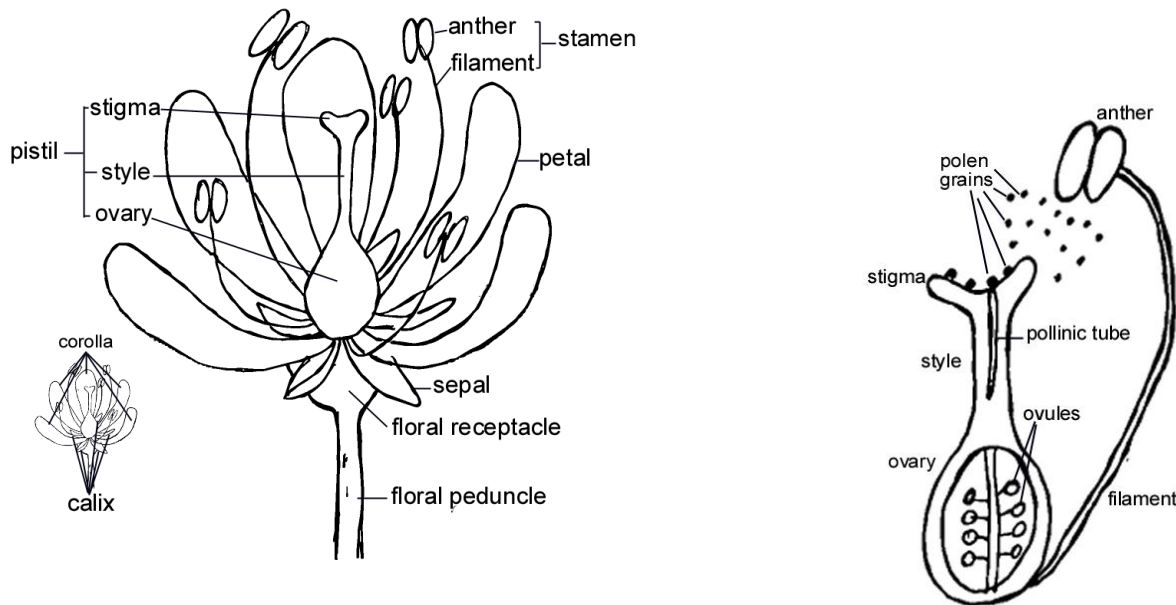
Acicular leaves, a male cone and a female cone in the same branch of a pine.

3.4. Angiosperms: Plants with seeds and fruit.

Angiosperms are the most widespread plants and live in most of the terrestrial ecosystems. They have **flowers** where the ovules are inside an **ovary** that will be transformed into a **fruit**. The fruit holds the **seeds** inside. The flowers of the angiosperms are the reproductive organs and they are hermaphrodite in most of the cases.

Structure of the flower.

The structure of the flower is like you can see in the following drawing:



The flower is the reproductive organ of the angiosperms and it is formed by four concentric circles of modified leaves called **calyx**, **corolla**, **stamens** and **carpels** or **pistils**.

The external circle is the **calyx** that protects the flower while it is still growing and it is formed by several **sepals**. The next circle is the **corolla**, formed by the **petals**, that usually has attractive colors because its function is to draw the attention of the **pollinators**.

The **stamens** are the male reproductive organs and produce the **pollen grains** inside the **anthers**.

The **pistils** or **carpels** are the female reproductive organs and contain the **ovules** inside the **ovary**.

Pollination and fecundation.

We call **pollination** to the process by which the pollen grains travel from the anther to the stigma of the pistil. Sometimes pollination depends on just the wind or the raindrops, but very often pollination is carried out by animals like birds, bats or insects that establish a **symbiosis** with the different plants they pollinate. These animals also benefit because they get **nectar**, pollen or some other food while the pollen gets attached to their body so it can travel to a different plant.

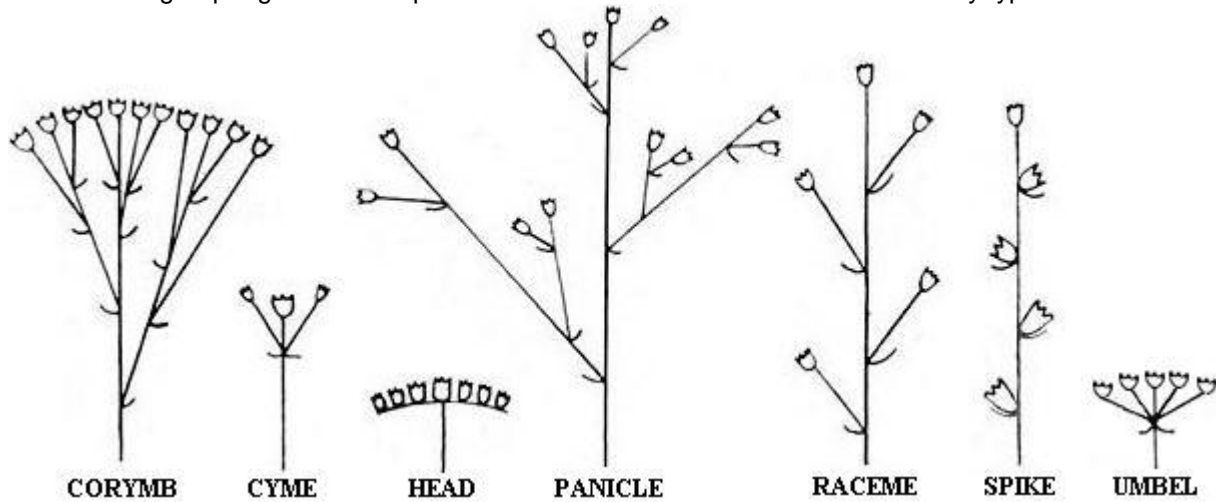
When a pollen grain arrives to the stigma of the pistil it gets stuck to it due to a sticky substance that is produced there. Then the pollen grain develops a structure, like a very small tube, that gets down from the stigma inside the style. This tube-shaped structure is called the **pollinic tube**. Eventually, the pollinic tube will get to the ovary and will attach to the ovule. Then the male gametes travel from the pollen grain to the ovule through the pollinic tube and **fecundation** takes place. As a result of the fecundation the ovule becomes a **seed** and the ovary becomes a **fruit**.

Types of flowers.

There are different types of flowers. The type that has been described above is a **complete** flower because it has the four circles of modified leaves, but sometimes some of these circles are not present and we talk about an **incomplete** flower. We also say that this flower is **hermaphrodite** because it has both male and female organs but

very often we can find flowers without stamens (and then it is a **female flower**) or without pistils (and then it is a **male flower**).

Flowers can group together in the plant to form an **inflorescence**. There are many types of inflorescences.



Fruits and dispersion of the seeds.

Angiosperms are more widely spread than gymnosperms. One of the reasons is that angiosperms are more efficient from the point of view of the **dispersion of the seeds**, and this is because of the fruit.

Fruits can have a dry consistence, like hazelnuts, or a fleshy one, like apricots. Sometimes fruits can also group together in a multiple fruit, like in the pineapple.



Fruits make possible the dispersion of the seeds in many different ways. Sometimes they develop wing-like or parachute-like structures to be dispersed by the wind, sometimes they form "hooks" to get hooked to passing-by hairy animals, sometimes they just float to be carried away by the water of the rivers or the oceans, and even sometimes their appetizing appearance makes that animals eat them and disperse the seeds with their depositions.



Maple tree



Dandelion



Proboscidea parviflora



Coconut



Watermelon

Other characteristics of the angiosperms.

- Angiosperms are the most widespread plants and they live in almost every terrestrial ecosystem.
- There are species adapted to cold environments and species adapted to hot or warm environments. Even some species are adapted to live in aquatic environments.
- They can be **herbs**, **shrubs** and **trees**.
- The trees of this group usually have **deciduous foliage**. They lose their leaves during the cold season.
- Some angiosperms are **unisexual** (they have separate sexes) while others are **hermaphrodite**, depending on the type of flower they have.

Activity 93.

Classify these photographs in one of the following categories: tree, shrub and herb.

*Allium schoenoprasum**Buxus sempervirens**Magnolia grandiflora*

Activity 94.

What type of root has a carrot?

Activity 95.

What is a root hair? How does it work?

Activity 96.

Explain how the sap moves in a plant.

Activity 97.

What is a rhizome?

Activity 98.

Why some gymnosperms are called "conifers"?

Activity 99.

Answer the following questions:

- What are the main differences between gymnosperms and angiosperms?
- What type of stem can we find in a palm-tree?
- How do we call the part of the leaf that connects it to the stem?
- What are the stomata for? Where are they placed?

Activity 100.

Draw a leaf and label its parts.

Activity 101.

Draw a seed and label its parts.

Activity 102.

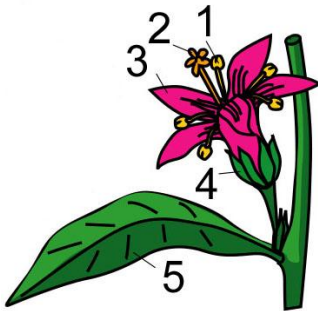
Explain the function of the parts of a seed.

Activity 103.

Draw a flower and label its parts.

Activity 104.

Name the structures numbered in the following drawing:



Activity 105.

Write the concepts of these definitions:

- The set of the sepals.
- The male reproductive organ of a spermatophyte.
- The female reproductive organ of a spermatophyte.
- Part of the pistil that contains the ovules.
- Part of a stamen that contains the pollen grains.
- Structure produced by a pollen grain to conduct the male gametes to the ovule.
- The elements that form the corolla.
- The process by which the pollen grains travel to the pistil.
- The plant that keeps its leaves all year round.
- The vessels that conduct the water and the minerals from the root to the rest of the plant.
- The part of the pistil where the pollen grains get stuck.
- The characteristic way in which a plant group its flowers.
- The plants that lose its leaves during the cold season of the year.
- The organ that contains the seeds and contributes to their dispersion.
- Part of the seed that stores the nutrients needed in the germination.

Activity 106.

Explain how a seed germinates.

Activity 107.

What type of relationship has a plant with its pollinators?

Activity 108.

Decide whether these statements are true or false and correct the false ones:

- Tomatoes are fruits.
- Beans are fruits.
- Fleshy fruits are often eaten by animals that disperse the seeds with their depositions.
- Potatoes and onions are fruits.
- Phloem sap has organic substances produced by the leaves by photosynthesis.
- The apple is the seed of the apple-tree.
- Plants are heterotrophic organisms and lichens are autotrophic organisms.
- Cyanobacteria are plants and perform photosynthesis, producing oxygen as a byproduct.



The Villablanca Connection

UNIT 7:

ANIMALS I. INVERTEBRATES



**“When you have seen one ant, one bird, one tree, you have not seen them all.”
Edward O. Wilson.**

Unit 7: Animals I. Invertebrates.
Biology and Geology 1º ESO
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Unit 7: ANIMALS I: INVERTEBRATES.

1. What is an animal?

Usually, the students of 1º ESO consider the animals as the most interesting of the organisms. It is easy for humans to develop such an interest because they are more similar to us than any other living being. In the natural world we are just another type of animal and we all belong to the animal kingdom.

Animals are basically **eukaryotic**, **multicellular** and **heterotrophic** organisms, without a cell wall and, with a few exceptions, with real **tissues**, **organs** and **systems**.

Animals have also other common characteristics:

- Although some of them are **sessile** organisms, most of them **can move** very quickly compared to plants or fungi.
- They are very **sensitive organisms** and react quickly to the changes in the environment.
- Animals stop their growth when they reach to an adult age with reproductive capacity.
- The high metabolic rate of the animals depends on their **breathing**, taking oxygen from the atmosphere and returning carbon dioxide.
- All the animals get the organic matter they need from other organisms: they are **heterotrophs**. Some of them can feed on plants or algae and are **herbivores**, while others feed on other animals and are considered **carnivores**. But some of them can feed on both plants and animals and are called **omnivores**.
- Depending on the relationship with the living beings they eat, animals can be **predators**, **parasites** or **saprotrophs**.
- Although some animals can also reproduce **asexually** through budding or through fragmentation, all of them have **sexual reproduction** by means of **spermatozoa** (=male gametes) and **ova** (=female gametes) that fuse together to form the **zygote**. When this happens inside the body of the female it is called **internal fertilization** and when this happens outside the body of the female, directly in the water, it is called **external fertilization**.
- In most of the animals we find **separate sexes** (=some individuals are male and the rest are female) but in some groups of animals we can find species that are **hermaphrodites** with both male and female organs in the same individual.
- In the **oviparous** animals the embryo develops inside of an egg that is laid by the female. If the egg is not laid and it remains inside of the female until the egg hatches we talk of **ovoviviparous** animals. And if the embryo develops directly inside of the mother's body, and it is actively fed by the female until the birth, we have **viviparous** animals.
- The offspring of some species of animals present an aspect that is similar to that of the adults, and they become gradually even more similar as they grow. These species have a **direct development**. But in other species the offspring are very different to the adults (they are **larvae**) and become adults only after a complex process called **metamorphosis**. These species have an **indirect development**.
- Most animals have a **bilateral symmetry** because their body presents right and left halves. Some of them have a **radial symmetry** because their body looks like the wheel of a bicycle, with many radiuses, and can be divided into equal halves by any of the diameters. And only a few are **asymmetrical**.
- Most animals have hard parts in their body that form a **skeleton**. The conch of the snails or the shell of the mussels are examples of an **exoskeleton** (= external skeleton). The bones of a human or the fishbone of a trout are examples of an **endoskeleton** (= internal skeleton). Some other animals, like the worms, have not a skeleton at all.



Some animals like this bat *Eptesicus fuscus* have bilateral symmetry.



Some animals like this moon jellyfish *Aurelia aurita* have radial symmetry.

2. Classification of the animals.

For didactical purposes, animals are classified into the following groups:

- ❖ **Invertebrates** (animals without a backbone)
 - Porifera (=Sponges)
 - Cnidaria
 - Platyhelminthes (=Flatworms)
 - Nematoda (=Nematodes or Roundworms)
 - Annelida (=Segmented worms)
 - Mollusca (=Molluscs or Mollusks)
 - Arthropoda (= Arthropods)
 - Echinodermata (=Echinoderms)
- ❖ **Vertebrates** (animals with a backbone)
 - Fish
 - Amphibians
 - Reptiles
 - Birds
 - Mammals

Activity 109.

Write the meaning of:

- a) eukaryotic organism
- b) multicellular organism
- c) heterotrophic organism
- d) tissue
- e) organ
- f) sessile organism

Activity 110.

Decide if the following statements are true or false and correct the false ones:

- a) Some unicellular animals are herbivores.
- b) Animals have cells with the cell wall made of chitin.
- c) Mosquitoes are sessile organisms.
- d) Some animals are hermaphrodites.
- e) The male gamete is called spermatozoon
- f) When the development of the embryo occurs inside of an egg the species is viviparous.
- g) Spiders are vertebrates because they have a backbone.
- h) In oviparous animals the egg develops inside the body of the female.
- i) Budding is a type of asexual reproduction.
- j) The domestic fly has bilateral symmetry.
- k) When the zygote is formed outside of the body of the female it is called internal fertilization.
- l) Animals with direct development undergo metamorphosis.

Activity 111.

Classify these animals into their group:



Activity 112.

Copy in your notebook the classification of the animals.

3. Porifera.

Porifera means “animals with the body perforated by pores”. They are also known as “sponges”.

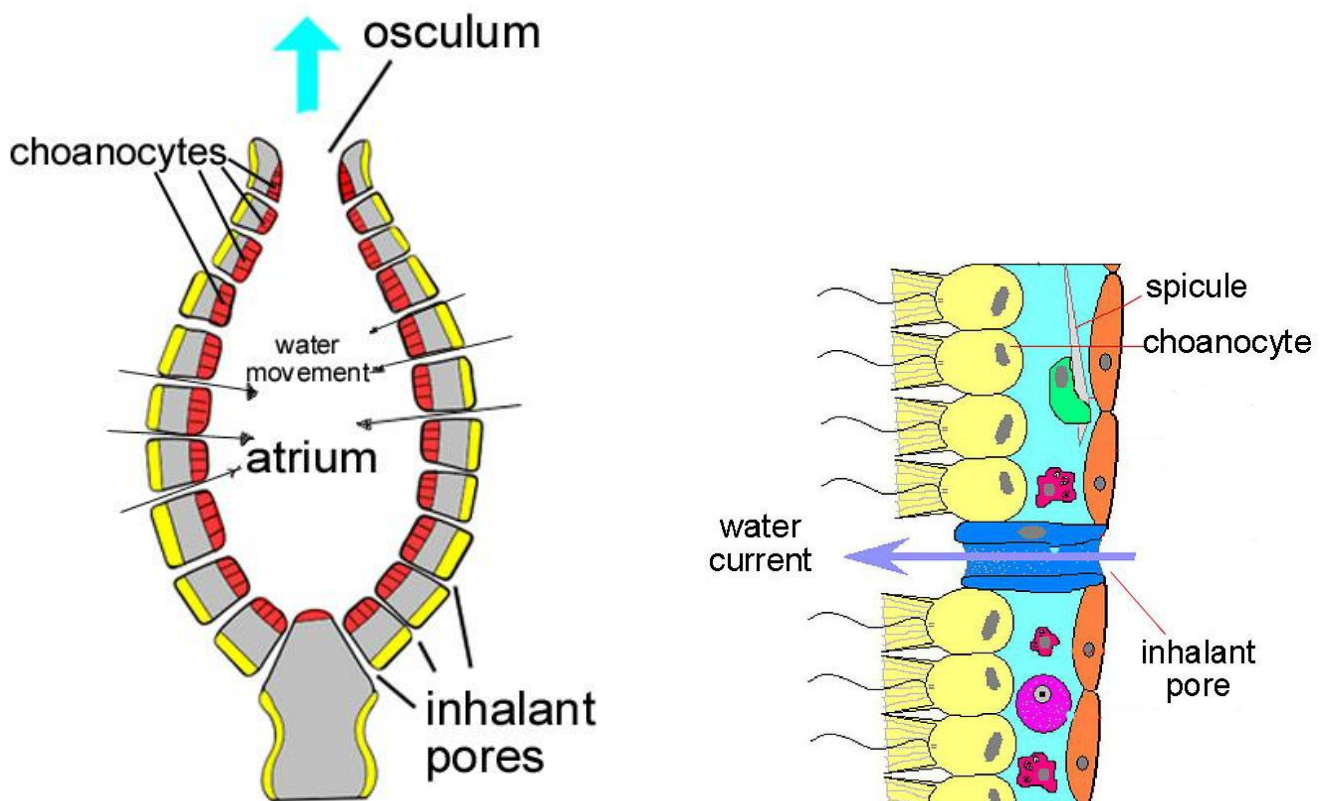
Porifera are **aquatic sessile** animals that live attached to the sand or the rocks in oceans and seas all over the world. Only a few species live in freshwater.

They are considered the simplest organisms in the animal kingdom. In fact it took some time to realize that they were not a weird type of algae or fungi, and it was not until 1825 when the studies of their structure under the microscope and the nature and characteristics of their cells convinced the scientists that they were animals.

Sponges present a great variety of shapes and colors and most of them are **asymmetrical**; but many of them look like a “cup” or “chimney” with a big internal cavity called **atrium** and a big hole in the top called **osculum**.

Sponges have an internal skeleton formed by microscopic needles called **spicules**. The chemical composition of these spicules is used as a criterion to classify these animals. Most of the times the spicules are made of calcium carbonate or silicon dioxide but sometimes they are made by a fibrous substance called **spongin**. The sponges with spongin can be used as a hygienic instrument for humans.

Sponges are **filtering animals**. They have specialized cells called **choanocytes** with a flagellum that is used to pump water through the **inhalant pores** into the atrial cavity. The small particles of food enter with the water and are captured by the cells that digest them and distribute the nutrients to the rest of the cells of the body of the sponge. The waste materials are discarded to the atrium where the current of water will take them out by the osculum.



Sponges have both types of reproduction **sexual** and **asexual**. They can reproduce asexually by **budding** and/or **fragmentation**. Most of the species are **hermaphrodites** and during the reproductive season can produce both **spermatozoa** and **ova** that are released to the surrounding water. When one **spermatozoon** finds an **ovum** the **zygote** is formed and it develops as a **larva** that can swim until it finds a new place to attach to and becomes a new adult sponge.

Activity 113.

When a recipient with alimentary colorant is opened near the inhalant pores of the body surface of a sponge a column of colorant can be seen flowing from the osculum of the sponge a minute or two afterwards. Explain why.

Activity 114.

Draw a choanocyte in your notebook.

4. Cnidaria.

This phylum includes medusas, corals, polyps, hydras and anemones. All of them are aquatic and most are marine organisms. We can find here some of the most beautiful invertebrates and also some of the most dangerous. The animals in this group have stinging tentacles with a characteristic type of cells called **cnidocytes** or **nematocysts**. All the members of this phylum can be classified into two different kinds of body shape: the polyp-shaped members and the medusa-shaped members.

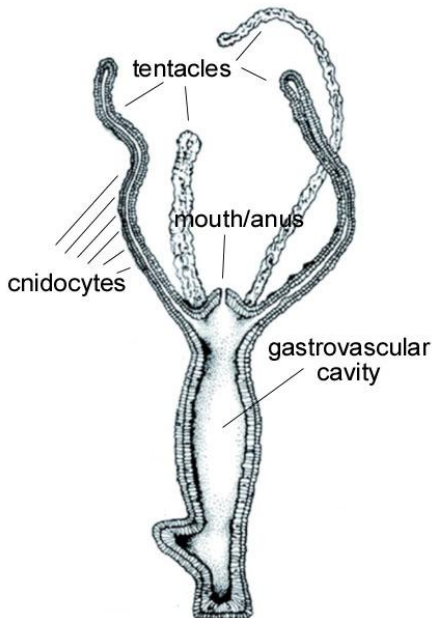
Polyps are sessile animals that live attached to a surface and have a body with the shape of a bag. Some species live individually, like the anemones or the hydras, but others, like corals, live in **colonies** of many individuals that remain together when reproduce by budding. Sometimes they cover themselves with a skeleton made of limestone that remains when the animal dies and constitutes the **coral reefs**, some of them, like The Great Reef Barrier at the East of Australia, are so big that can be seen as far as from the Moon.

Medusas, commonly known as jellyfish, look like gelatinous, delicate and transparent animals that swim elegantly by regular contractions of their umbrella-shaped body.

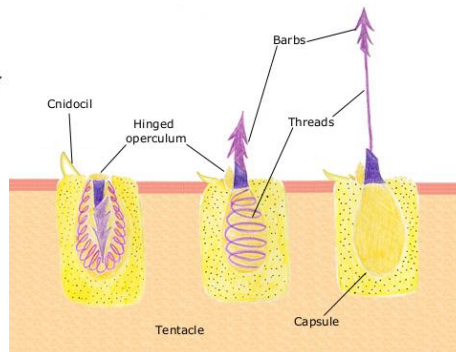
Both polyps and jellyfish have **radial symmetry** and they are **carnivores**. They capture their preys by means of the tentacles that have **cnidocytes**. When something gets in contact with a cnidocyte it fires a microscopic structure similar to a harpoon that injects a toxin that immobilizes or kills the prey. Then the tentacles take the prey to the mouth and it is swallowed into a **gastrovascular cavity** where digestion takes place. The residues are eliminated also by the mouth as these animals have not an anus.

Polyps can reproduce asexually by budding or fragmentation and sexually by male and female gametes that swim to produce a zygote and then a larva that eventually will attach to a new surface to develop a new polyp.

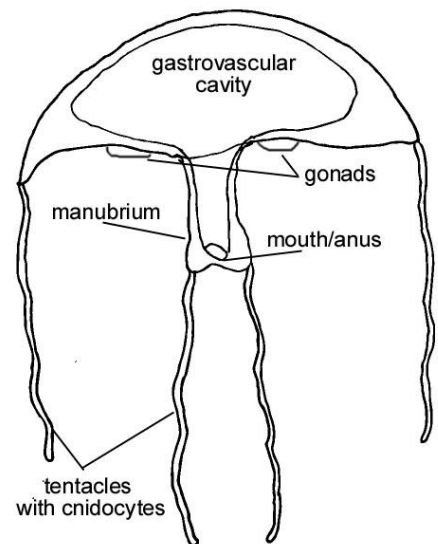
Jellyfish only reproduce sexually.



A polyp-shaped cnidarian: Hydra



Phases in the cnidocyte discharge



A medusa-shaped cnidarian: Jellyfish

Activity 115.

Decide if these sentences are true or false and correct the false ones.

- A bag-shaped cnidarian is a polyp.
- Corals are porifera with limestone skeleton.
- Jellyfish reproduce sexually.
- The atrium is the internal cavity of the cnidaria.
- The Portuguese man o' war (*Physalia physalis*) is a vertebrate animal.
- Porifera and cnidaria are sessile invertebrates.
- Spicules are present in sponges but not in polyps.
- Choanocytes are poisonous cells.



Activity 116.

Copy in your notebook the drawings with the anatomy of the polyps and the medusas.

5. Platyhelminthes, flatworms or tapeworms.

They are very simple invertebrates with **bilateral symmetry**. They look like worms that have been top down squished and their appearance is like a tape more or less long. Platyhelminthes have a simple head with a nervous ganglion that can be considered a **primitive brain** and, sometimes, one pair (or more) of **pigment spot ocelli** (sing. "ocellus"). Platyhelminthes have not a respiratory system and take the oxygen directly by their body surface. They are **hermaphrodites** and reproduce by eggs, although some of them can also reproduce asexually by budding or fragmentation. There are three main groups of platyhelminthes: **planarians**, **taenias** and **flukes**.

Planarians live in the oceans, in freshwater and in very wet soils. They have a free life moving by small cilia and



leaving a mucous trail similar to the one of the snails. The mouth is in the middle of their body and can be projected outside to catch their food. Their digestive system has not an anus and the food is digested in a gastrovascular cavity and then the residues are eliminated by the mouth. Planarians can reproduce by fragmentation detaching their tails and each half re-grows the lost parts by regeneration. Planarians can also reproduce sexually by producing both types of gametes (they are hermaphrodites) that they exchange with another individual to produce eggs.

Taenias are tape shaped parasites that can reach more than 10 meters long. They live inside the small intestine of the humans or other vertebrate animals. Their body is divided into **segments** and the first one (the head) is called the **scolex** that usually has a set of hooks, spines and suckers to fix to the wall of the intestine of their host.



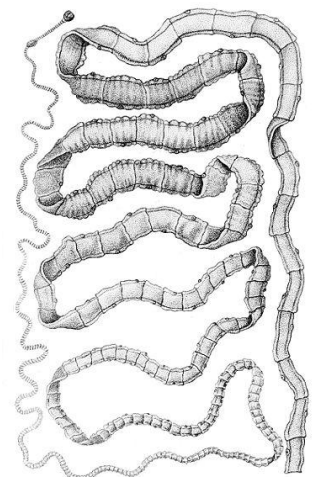
Taenia has not a digestive system and feeds on the nutrients digested by its host through its body surface.

They are hermaphrodites and can fertilize themselves producing eggs that accumulate in the last segments of their body.

These segments detach from their body and are eliminated with the excrements of their host. When they are eaten by an animal (pig, horse, rodent...) they hatch and the larvae remain in the muscles of

this intermediate host until it is eaten by a human. Then they develop a scolex that fixes to the small intestine wall and new segments are produced beginning the cycle once more.

Flukes are parasites with suction cups that infest the blood, the liver, the intestine or other organs of animals or humans. They can produce very important illnesses and propagate by means of residual waters and vegetables irrigated with these waters.



Botulus microporus

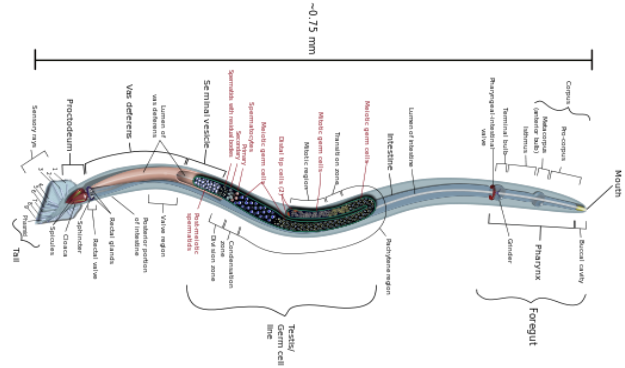
6. Nematodes or roundworms.

Nematodes are cylindrical worms with sharpened ends. They have tubular digestive systems with a mouth in one end and an anus in the other. Some species can live freely in the water (marine or fresh water) while other species are parasitic. There are also many species that can live in the soil and it has been said that they represent the 80% of the animal individuals present in the Earth.

Among the free-living species we can find *Caenorhabditis elegans*, a nematode that is commonly used in the laboratory in studies of genetics and development.



Caenorhabditis elegans



Among the parasitic species we can find the hookworms and the trichina.



Hookworm



Trichina

Activity 117.

Explain the difference in the symmetry of worms, cnidarians and sponges.

Activity 118.

Define parasite.

Activity 119.

Platyhelminthes and nematodes are both worms. Make a table to summarize their similarities and their differences.

Activity 120.

Draw in your notebook a flatworm and a nematode.

Activity 121.

Decide if these sentences are true or false and correct the false ones.

- a) Nematodes have a digestive system with mouth and anus.
- b) Platyhelminthes are always parasites.
- c) Nematodes and flatworms have radial symmetry.
- d) Like most of the invertebrates, platyhelminthes and nematodes are autotrophic organisms.
- e) *Taenia solium* is a parasitic nematode.
- f) *Caenorhabditis elegans* is a parasitic nematode.
- g) Nematodes are cylindrical worms with sharpened ends.
- h) Platyhelminthes can often reproduce asexually.
- i) Flatworms and roundworms can be considered oviparous animals.

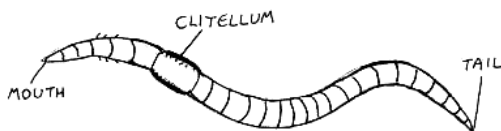
7. Annelids or segmented worms.

Annelids are worms whose body is divided into a series of **segments** that look like rings. Each segment has a set of organs that is repeated in any other segment of their body. They have a head with the mouth and sometimes a pair of ocelli to detect light. In the last segment they have the anus. They usually breathe through the skin and their blood is always inside the blood vessels (They have an enclosed circulation).

Annelids live both in marine and fresh water, and some very common species, like the earthworms, live in the soil. There are some parasitic annelids (like the leech) but most of them feed on decomposing organic matter. They can reproduce asexually by fragmentation and can regenerate the part of the body that has been lost when a predator attacks them, but most of the times they reproduce sexually, producing gametes in specialized sexual organs. Most of them are **hermaphrodites**.

Earthworms and **leeches** are very common species inside this group.

Earthworms excavate galleries in the soil feeding on the remains of animals and plants that are decomposing in the sand of the soil. They advance when they eat the soil in front of their mouth and eliminate the sand and the indigestible parts by their anus, aerating the soil as they build the galleries and enriching the soil, producing great benefits to agriculture. The gonads (=sexual organs) of the earthworm are in a group of specialized segments that form the **clitellum**. Although they are hermaphrodites they look for a partner during the reproductive season and they **copulate**.



Leeches usually live in the water. They have the head adapted like a suction cup with three sharp teeth that they use to attach to other animals to suck their blood. They are temporary parasites.

Leeches have been used by humans with medical purposes in the treatment of varicose veins and other illnesses. Their saliva has a potent anesthetic substance and several components that prevent the coagulation of the blood.



Hirudo medicinalis



Detail of the mouth

Activity 122.

Explain why earthworms and leeches can be considered beneficial organisms.

Activity 123.

What is the "clitellum"?

Activity 124.

- What is the difference between species with separate sexes and hermaphrodite species?
- What is the difference between self fertilization and cross fertilization?

8. Molluscs or mollusks.

This phylum groups together animals apparently very different but all of them have a **soft** body with **highly developed organs**. Other general characteristics of molluscs are:

- Their body can be divided into **head**, **visceral mass** and **muscular foot**.
 - In the **head** we can find the sense organs and the mouth
 - The **visceral mass** is formed by the internal organs like heart, stomach, digestive glands, etc. It is covered by the **mantle**.
 - The **muscular foot** is a part of the body of the molluscs that can perform different functions depending on the group we are talking about. It can be used to excavate, to move around or to catch their prey.
- In many cases the mantle secretes a protective calcareous **shell**. This shell can be made of one piece or can be made of two pieces called **valves**. Shells made of only one piece are often spiral in shape, while valves are joined by a hinge that makes possible that the animal can open or close them. The interior part of the shell is made of nacre.
- Most of the species of molluscs live in aquatic environments (marine or fresh water) and only a group of very common species are terrestrial (slugs and snails).
- Between the mantle and the visceral mass there are the respiratory organs: gills in the case of aquatic species and lungs in the terrestrial ones.
- Molluscs reproduce sexually with separate sexes most of the times and hermaphrodites in other cases. They are oviparous and some of them present a direct development while others produce a larva that eventually will become an adult.

Molluscs are classified into **bivalves**, **gastropods** and **cephalopods**.

Bivalves

They have a shell with two valves that the animal closes at any sign of danger. Their muscular foot has the shape of an axe and can be used to move around, excavate in the sand so the animal can hide from the predators or attach to the rocks secreting a substance that will become like threads.

The head of the bivalves is not differentiated from the rest of the body and they feed on plankton that they filter using their gills. Mussels, clams and oysters belong to this group.



Anatomy of a mussel



Tridacna gigas. (The giant clam).

Gastropods

They have a wide ventral foot that they use to move around slowly. Most of the species have a single spiral shell although there are also species without shell. The head is clearly differentiated and has two or four retractile tentacles that have tactile, olfactory and visual receptors. In the head is also the mouth with a rasping tongue called **radula**. Gastropods are usually herbivorous and can be found both in terrestrial and aquatic ecosystems. Snails and slugs belong to this group.



Slug



Snail



Mitra stictica

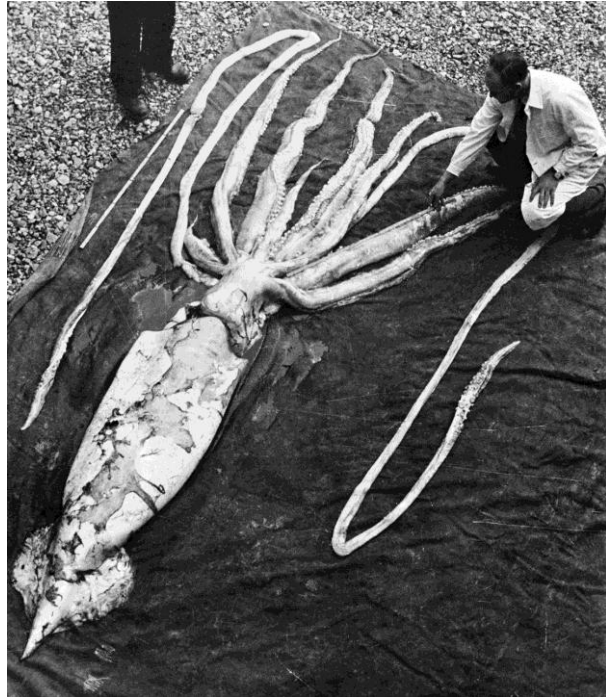
Cephalopods

The foot of the cephalopods has been transformed into tentacles with suckers to capture their preys. These tentacles surround the mouth that has two hard mandibles with the aspect of the beak of a parrot. In the head they also have two very complex eyes. Their shell is usually internal and has been transformed into a structure (the **cuttlebone**) that helps the animal to float; but some very old species like *Nautilus sp.* have a beautiful external spiral shell.

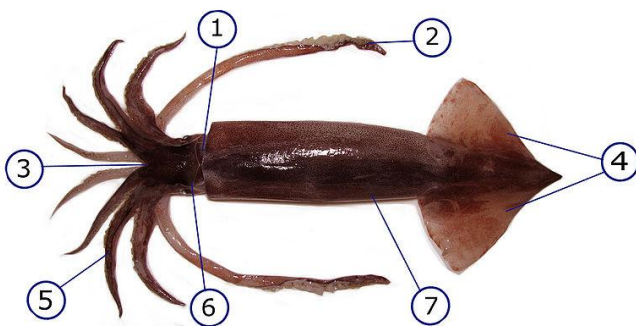
Cephalopods are carnivorous. Many species move by swimming and by jet propulsion, expelling streams of water by a tube called **siphon**. They also can expel clouds of dark ink to confuse their predators. Squids, octopuses, cuttlefish and nautilus are classified into this group of molluscs.



Common octopus



Giant squid captured in Tordheim (Norway)



External anatomy of a squid

1. Siphon
2. Tentacles
3. Mouth
4. Fins
5. Arms
6. Head
7. Mantle

*Sepia officinalis**Nautilus belauensis*

Activity 125.

List the body parts of a mollusk.

Activity 126.

Draw the body of a squid and label its parts.

Activity 127.

Draw the body of a snail.

Activity 128.

What part of the body of the molluscs produces the shell?

Activity 129.

What is the function of the radula?

Activity 130.

What is the meaning, in Greek, of “cephalopod”?

Activity 130.

Write what type of molluscs are we talking about in each of these sentences:

- a) They have tentacles and two complex eyes.
- b) The shell of this group is made of two valves joint by a hinge.
- c) Their foot has the shape of an axe.
- d) They do not have a defined head.
- e) Most of the species in this group have a spiral shell.
- f) They can confuse their predators expelling clouds of ink.
- g) Many of them have very simple eyes (ocelli) at the end of the tentacles.
- h) They have a flat, large and ventral foot that they use to move around.
- i) They are filtering animals.
- j) They present suckers in the tentacles to catch a prey because they are carnivorous.
- k) They feed on vegetables using the rádula.

Activity 131.

Decide if these sentences are true or false and correct the false ones.

- a) Terrestrial snails breathe through lungs while aquatic ones breathe through gills.
- b) Molluscs have bilateral symmetry.
- c) Bivalves are filtering animals.
- d) Pearls are made of nacre and are obtained from the shells of the cephalopods.
- e) Gastropods have a beak that looks like the one of the parrots.
- f) Snails and slugs are classified into the cephalopods.
- g) Cuttlefish are cephalopods with a spiral shell.
- h) The ink of the gastropods is used to catch their prey.

Activity 132.

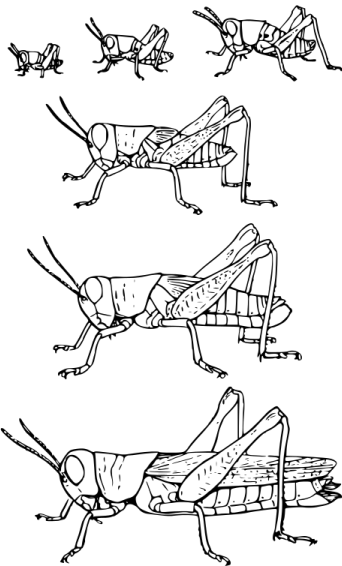
Imagine that you are in the supermarket. Make a list of the different molluscs that can be found there and group them into bivalves, gastropods and cephalopods.

9. Arthropods.

The phylum of the arthropods has more individuals than the sum of all the other phyla of the animal kingdom. There are arthropods in all the ecosystems of the planet both aquatic and terrestrial. Their name “arthropods” comes from the Greek and it means “animals with articulated extremities”. Their general characteristics are:

- Their body is covered with a hard **exoskeleton** made of **chitin** and composed of different pieces that fit together in an articulated way that lets them to move very efficiently.
- Their body is divided into **segments** that often are assembled into several body regions (like head, thorax and abdomen or other dispositions depending of the different groups). They have bilateral symmetry.
- Hard and articulated appendages appear from the segments fulfilling different functions (legs, antennae, wings, palps...)
- Arthropods have a complete tubular digestive system with the mouth in the head and the anus at the end of the abdomen.
- Arthropods breathe through **tracheas** (systems of thin tunnels that distribute oxygen to all the cells of the body) or **lungs** if they are terrestrial or through **gills** if they are aquatic.
- They have very complex sense organs.
- Their exoskeleton is hard and rigid so they have to replace it periodically in order to grow in a process called **molting** (=“moulting” in British English).
- They reproduce **sexually** with **internal fertilization** and are **oviparous** or **ovoviviparous**. The embryo can present **direct** development or **indirect** development with **metamorphosis**. There are two types of metamorphosis: direct or incomplete metamorphosis and indirect or complete metamorphosis.

Incomplete metamorphosis of the grasshopper



Stages:

1. Eggs
2. Nymph
3. Adult animal

Complete metamorphosis of the butterfly



Stages:

1. Eggs
2. Larva
3. Pupa
4. Adult animal

The phylum of the arthropods is classified into four main classes:

Arachnids: mostly terrestrial with cephalothorax and abdomen. They have chelicerae.

Crustaceans: mostly aquatic with cephalothorax and abdomen. They have antennae.

Insects: mostly terrestrial with head, thorax and abdomen. They have antennae.

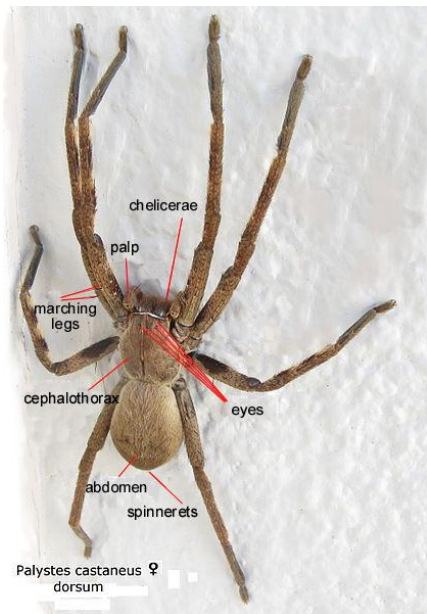
Myriapods: terrestrial with head and segments. They have antennae.

9.1. Arachnids.

Arachnids are terrestrial arthropods with their body divided into two main parts: the **cephalothorax** and the **abdomen**. In the cephalothorax they have a pair of **chelicerae** (one at each side of the mouth) that in many cases are connected to glands that produce venom. They are used to inject this venom to their prey. They usually also have a pair of sense appendages called **pedipalps** and four pairs of **marching legs**. In the cephalothorax they also have several ocelli and, in many species, several pairs of compound eyes. Arachnids are classified into spiders, scorpions, mites and ticks.

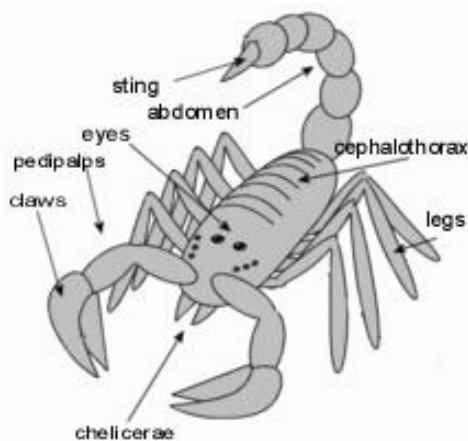
Spiders

In the abdomen they have glands that produce a liquid that solidifies in contact with the air and becomes the silk. These glands are called **spinnerets**. Most of spiders are carnivorous and catch their prey spinning a spider web. They usually inject in the captured prey enzymes that digest it and then they suck the nutrients. Spiders are oviparous and the females take care of the eggs until they hatch and then the little spiders use a thread of silk as a “paraglider” to get dispersed by the wind.



Scorpions

The scorpions have the end of the abdomen transformed into a dangerous sting that they use to capture their prey and defend themselves from the predators. Their pedipalps are transformed into a pair of claws. They are ovoviviparous and they care of their offspring until the little scorpions are able to feed themselves.

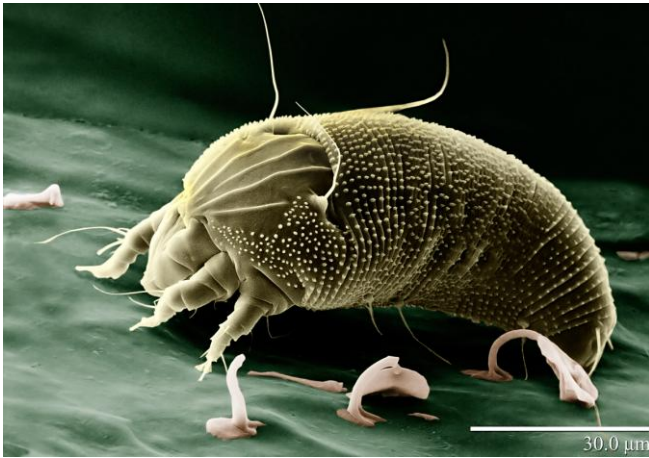


External anatomy of a scorpion

Pandinus imperator

Mites and ticks (*Acarí*)

They are very abundant in the soil and the water where they are decomposers animals. Most of them are microscopic. Some species are external parasites and can propagate illnesses or cause allergy.



Aceria anthocoptes (very common in the dust)



Sarcoptes scabiei (a parasite in human skin)



Ixodus ricinus (a tick very common in European mammals)



An adult tick compared to a ballpoint pen

Activity 133.

What are the advantages of having an exoskeleton?

Activity 134.

What are the disadvantages of having an exoskeleton?

Activity 135.

How many antennae can be found in an arachnid?

Activity 136.

What are the chelicerae and what are they used for?

Activity 137.

Make a grid with the main characteristics of the different kinds of arachnids.

Activity 138.

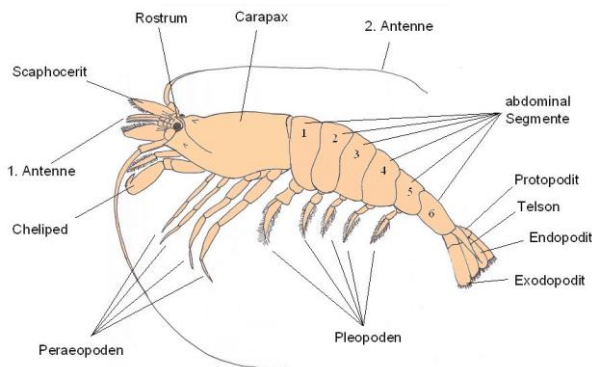
Draw in your notebook a spider and label the structures of its external anatomy.

Activity 139.

Draw in your notebook a scorpion and label the structures of its external anatomy.

9.2. Crustaceans.

With the exception of a few species, crustaceans are **aquatic** arthropods. Their body is divided into **cephalothorax** and **abdomen**. They have two pairs of **antennae** with tactile and olfactory functions. Lobsters, crabs, shrimps, barnacles, krill and prawns are very known marine crustaceans; crayfish are freshwater crustaceans; pill-bugs are terrestrial crustaceans. There are also many different species of microscopic crustaceans in the **zoo-plankton** of both marine and fresh water and they are very important in the food web of aquatic ecosystems. Most of the crustaceans that are interesting from the economic point of view belong to the group of the **decapods** that in Greek means “ten legs”.



Main external anatomy characteristics of a shrimp.



A ghost crab



Daphnia pulex. A microscopic crustacean.



Balanus improvisus. A sessile crustacean living on a shell.

Activity 140.

What are the functions of the antennae in the crustaceans?

Activity 141.

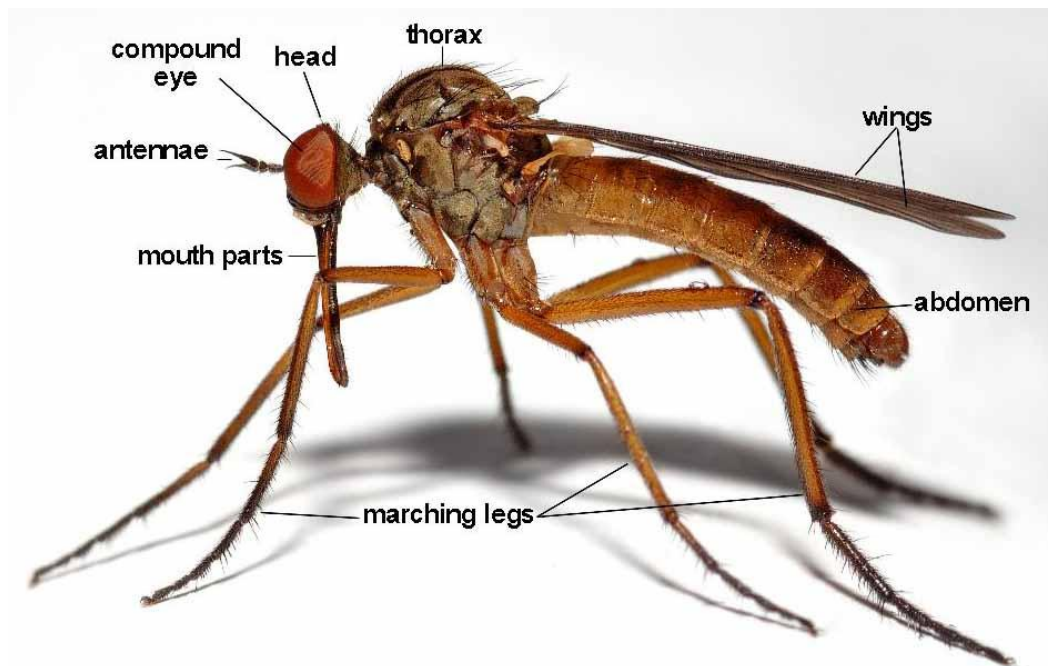
What is the meaning of “decapods”?

9.3. Insects.

Insects are among the **most succeeding organisms** of the planet Earth. There are a huge number of individuals living in every habitat, there is also an extraordinary variety of life forms in this group and they are adapted in the most incredible ways to live in the most extreme conditions.

The body of the insects is divided into **head**, **thorax** and **abdomen**.

- In the **head** the insects have one pair of **antennae** with olfactory and tactile functions, several **ocelli**, one pair of **compound eyes** and a **complex mouth** composed by many different parts depending on the type of food it is adapted to. There are insects that feed on blood while others feed on paper, on nectar, on other insects, on wood... It is difficult to find something that an insect cannot eat.
- In the **thorax** the insects have three pairs of **marching legs** and one or two pairs of **wings**. Insects are the only invertebrates that can fly.
- In the **abdomen** insects have the **spiracles**, the respiratory openings by which the oxygen enters the tracheae and is distributed to all the cells of the animal. There are no appendages in the abdomen of the insects.



Insects have sexual reproduction and are **oviparous**. When the eggs hatch the newborns can be similar to adults (direct development), slightly different (incomplete metamorphosis) or totally different (complete metamorphosis).

Insects are classified in many different orders. The most important are:

- **Coleoptera** → beetles.
- **Lepidoptera** → butterflies and moths.
- **Diptera** → flies.
- **Orthoptera** → grasshoppers and locusts.
- **Hymenoptera** → bees, wasps and ants.
- **Odonata** → dragonflies.
- **Hemiptera** → bedbugs.
- **Blattodea** → cockroach.

Some insects are **herbivorous** while others are **carnivorous** or **omnivorous**. Some of them are parasites but many others are beneficial.

Some insects live by their own but others present a complex social behavior like ants, honeybees and termites.

Benefits and damages of the insects	
Benefits	Damages
Insects pollinate many plants, including some of the most important crops.	Some insects eat plants and crops of human interest.
They are food for birds and other living beings.	Some insects can transmit illnesses to humans or other organisms of human interest.
Some insects are decomposers returning inorganic matter to the producers of the ecosystems.	Some insects attack the wood of buildings, furniture or eat the clothes.
They produce honey, silk, wax, colorants and other products of industrial interest.	
Some insects are used to fight plagues and contribute to protect human food sources.	

Activity 142.

In what part of the body of an insect can we find the following elements?

Wings, spiracles, compound eyes, legs, antennae and mouth

Activity 143.

What is the main difference between incomplete and complete metamorphosis?

Activity 144.

Summarize the benefits that insects produce to humans.

Activity 145.

Classify these insects:



9.4. Myriapods: millipedes and centipedes.

They are terrestrial arthropods with the body divided into segments. The first segments form a well defined **head** and the rest articulate in a way that gives the animal the aspect of a long train.

In the **head**, myriapods have a pair of **antennae**, several **ocelli** and the mouth. The rest of the body has between 15 and 200 segments with one (centipedes) or two (millipedes) pairs of legs each.

Myriapods are **oviparous** with **direct** development. They are classified into two main groups: **centipedes** and **millipedes**.

Centipedes have a flat body and only one pair of legs on each segment. They are carnivorous and the first segment of the body (the one that is near the head) has the legs transformed into **forcipules** that are appendages with the shape of a claw. These forcipules are connected to glands with venom and the animal uses them to catch their prey and defend from their predators.



In this photograph of the ventral head of a centipede can be distinguished clearly the antennae, the powerful mandibles and the poisonous forcipules.



Man holding
Scolopendra gigantea

Millipedes have a cylindrical body, their first segment has no appendages and the following four have only one pair of legs each but the rest of the segments have two pairs of legs. They are herbivores and some of them can curl into a spiral shape when disturbed.



A female *Illacme plenipes* with 618 legs (309 pairs)

Activity 146.

Explain the main differences between insects and myriapods.

Activity 147.

Decide if these sentences are true or false and correct the false ones.

- a) Forcipules are appendages specialized in movement.
- b) A species of myriapod with two legs for segment is a millipede.
- c) Insects, arachnids and myriapods have antennae while crustaceans have chelicerae.
- d) Centipedes are herbivorous.
- e) Butterflies and moths are classified as orthoptera.

Activity 148.

Draw a centipede and a millipede.

10. Echinoderms.

In Greek “echinoderms” means “skin with spines”. They are **marine** animals with a hard **dermal skeleton** (usually with spines) and **penta-radial symmetry**. The skeleton is under the skin and it is made of calcareous plates; it can grow with the animal so echinoderms do not need to molt (=“moult” in British English).

The main exclusive characteristic of the echinoderms is their **ambulacral system**. The ambulacral system is composed of a set of tubes or channels filled with water that spread for the whole body of the animal. This system regulates movement, breathing and circulation. The tubes of the ambulacral system have a lot of extensions called **ambulacral feet** that project themselves out of the body and end in suction cups that are used to move around or to attach to the sea floor.

The mouth is placed in the underside to look for the food in the sand and the anus is placed on top of the animal. Echinoderms reproduce sexually with external fertilization but some species can regenerate great parts of their body and can reproduce asexually by fragmentation.

Echinoderms are divided into four groups: sea urchins, starfish, brittle stars and sea cucumbers.

Sea urchins

Sea urchins have a round shaped body with long spines that come off it. They usually eat algae or decomposing matter from the coral or the rocks.



Starfish

Most starfish have five arms that radiate from a central disc. The mouth is in the lower surface. Most species are carnivorous and some of them prey on bivalves. The starfish pulls with its ambulacral feet to separate the two valves and inserts a section of its stomach, which releases enzymes to digest the bivalve. The stomach and the partially digested prey are later retracted inside of the body. They reproduce sexually, but some species can also reproduce asexually by fission of their central disc or by detaching one of the arms.



A starfish regenerating from one arm.



Ambulacral feet of a starfish.

Brittle stars

Brittle stars are closely related to starfish but they have more flexible arms so they can crawl across the sea floor using them for locomotion. They live at almost any depth down the sea and their ambulacral feet have a sensory function. They reproduce sexually and most species have separate sexes but, as it happens in starfish, some species can reproduce asexually by fission. A handful of species have been found to be bioluminescent and they emit a green light that they use to deter predators.



Sea cucumbers

Sea cucumbers or holothurians are detritivorous animals that live on the sea floor and have a soft cylindrical body. Some species are appreciated as delicious food for humans.

*Holothuria fuscopunctata**Actinopyga echinites*

Activity 149.

Draw a sea urchin, a starfish, a brittle star and a sea cucumber.

Activity 150.

What is the ambulacral system?

Activity 151.

Decide if these sentences are true or false and correct the false ones.

- a) The body of many echinoderms is covered with spines.
- b) Ambulacral feet are used for reproduction.
- c) Sea cucumbers can swim with its long arms.
- d) Starfish breathe by lungs.
- e) Starfish are carnivores.
- f) All the invertebrates have an exoskeleton.

Activity 152.

Write the group of animal we are talking about in each sentence:

- a) They have claws and a dangerous sting at the end of the abdomen.
- b) Their beautiful four wings and their spiral proboscides make them unique.
- c) Parasites that live in the human small intestine.
- d) Animals with the body divided in rings.
- e) They have a spiral shell.
- f) Their name means "legs in the head".
- g) They have eight marching legs and sometimes they inject venom.
- h) Their other name is "hexapoda"
- i) Their soft body is protected by a shell with two hinged parts.
- j) Animals without a backbone.
- k) This group is divided into insects, arachnids, crustaceans and myriapods.
- l) Their shell often helps them to float.
- m) The only invertebrates that can fly.
- n) They can digest their prey putting their stomach on them.
- ñ) They are insects that can jump very high.
- o) These animals can form colonies and reproduce by budding.
- p) Their specialized cells pump the water moving a flagellum.
- q) They look like an umbrella and have poisonous cells.
- r) Their body is covered with spines and their mouth is in their underside.
- s) These worms can suck your blood.

Activity 153.

Make a chart with the classification of all the invertebrates.



The Villablanca Connection

UNIT 8:

**ANIMALS II.
VERTEBRATES**



“Brave men are all vertebrates; they have their softness in the surface and their toughness in the middle.”
Gilbert K. Chesterton.

Unit 8: Animals II. Vertebrates.
Biology and Geology 1º ESO
Villablanca Connection

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"Rook Lane Chapel Frome1" by The original uploader was Nabokov at English Wikipedia - Transferred from en.wikipedia to Commons.. Licensed under CC BY-SA 3.0 via Wikimedia Commons -

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Unit 8: ANIMALS II: VERTEBRATES.**1. Introduction.**

All the vertebrate animals are classified into the phylum **Chordata**. There are more than 65.000 different species into this phylum that can live in very different habitats. They have these characteristics in common:

- Vertebrates have an **endoskeleton** made of bones or cartilages. This endoskeleton has a **vertebral column** made of articulated pieces called vertebrae and usually also some extremities or **limbs** are present. These limbs can be wings, legs or fins so the animal can walk, jump, swim or fly.
- Also in the skeleton are the **mandibles** that give shape to the mouth and adapt the animal to different types of food. There can be teeth in the mandibles or they can be transformed into a beak. Sometimes the mandibles play a role in the defense or the attack.
- The **skin** presents different adaptations. It can be covered with different substances or different structures like scales, corneous plaques, hairs or feathers.
- The main **sense organs** are in the head and they are usually very complex. Eyes, ears, nose... These organs provide to the vertebrates a very good idea about the world surrounding them and enable them to survive in a changing environment.
- The **nervous system** is also very complex, with the brain enclosed into the cranium and the main nervous cord running inside the spinal column always in a dorsal position.
- The digestive system is **complete** (with mouth, several digestive organs, glands and anus).
- The respiratory system can be adapted to take the oxygen directly from the air (**lungs**) or adapted to take the oxygen that is dissolved in the water (**gills**).
- The circulatory system is made of **vessels** where the **blood** moves pumped by the **heart**.
- Vertebrates reproduce **sexually** with separated sexes, internal or external fertilization and they can be oviparous, viviparous and ovoviviparous.
- Like all the invertebrates, most vertebrates are **ectotherms**, because their internal temperature depends on the temperature of their environment. But birds and mammals are **endotherms**, because they can regulate the temperature of their body and it remains constant, independently of the temperature of their environment.

Vertebrates are classified into five classes:

1. Fishes
2. Amphibians
3. Reptiles
4. Birds
5. Mammals

Activity 154.

Explain the differences between internal and external fertilization.

Activity 155.

a) What is an ectotherm?

Write three examples of this type of animals.

b) What is an endotherm?

Write three examples of this type of animals.

Activity 156.

Lungs and gills are both respiratory organs, why some animals have lungs while others have gills?

Activity 157.

Classify these animals into "endotherms" and "ectotherms":

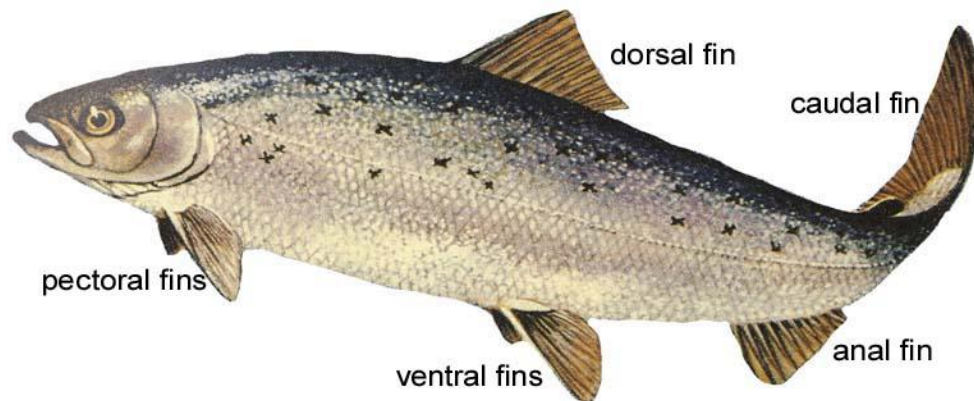


2. Fishes.

Fishes are **ectothermic** aquatic vertebrates with a **spindle-shaped body** covered with **scales**. Or, in other words, they cannot regulate their temperature (it depends on the temperature of the environment); they live in the water; they have a body that is wider in the middle than at the ends and their skin is covered with small hard plates which are arranged like the tiles on a roof. The limbs of the fishes are **fins** which help them to swim and to keep balance in the water. The fins are classified into paired and impaired fins:

Impaired fins: dorsal, caudal and anal fins.

Paired fins: pectoral and ventral (=pelvic) fins.



Fishes breathe by **gills** taking the oxygen that is dissolved in the water. The water enters by the mouth or by a spiracle and then it goes through the gills disposed in several branchial arcs. The gills have a lot of blood vessels that allow the exchange of O_2 and CO_2 between the animal and the water. From the branchial chamber the water gets out of the animal by the gill-openings that sometimes are covered by an operculum.

Fishes reproduce sexually and are **oviparous**, laying eggs with no shell.

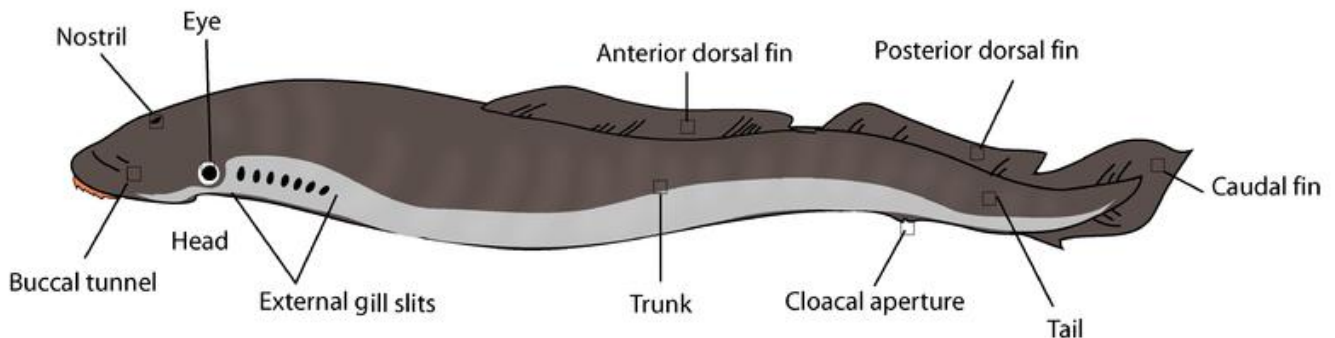
Fishes are classified into three main groups: **agnathans**, **cartilaginous fish** and **bony fish**.

2.1. Agnathans (=Jawless fishes).

They are very primitive fishes without mandibles. Their mouth is transformed into a sucker with very hard teeth that they use to parasite other fish. Lampreys are members of this group.

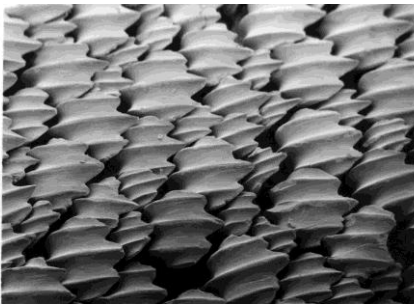
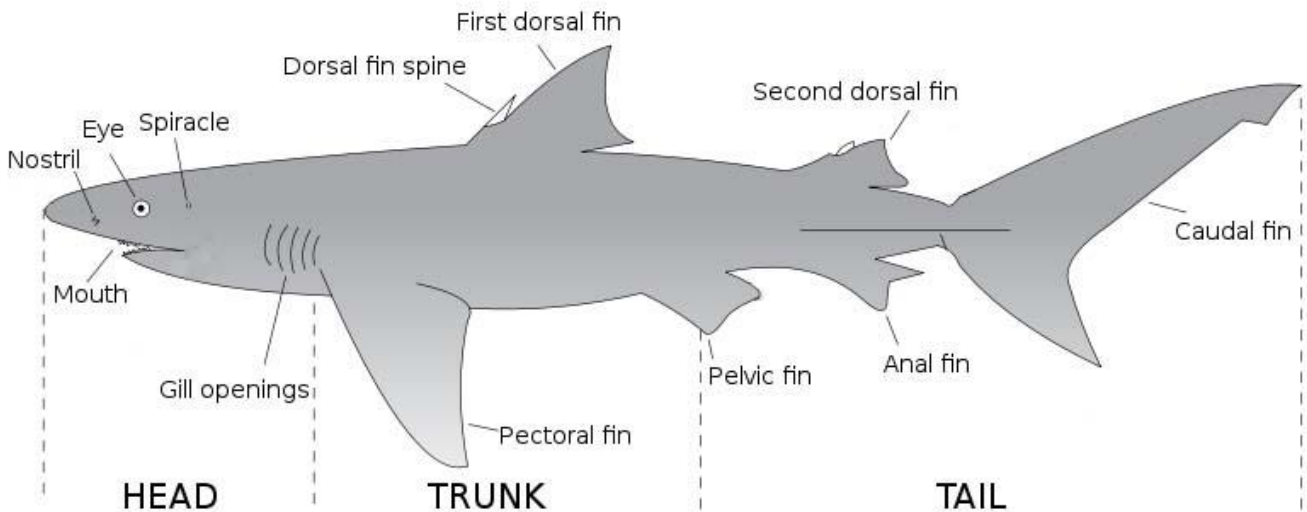


Lampetra fluviatilis.



2.2. Cartilaginous fishes.

Their skeleton is made of **cartilage**, a tissue more flexible and elastic than the bone. Their gill-openings are always visible because they are not covered with an operculum. Their skin has very hard scales called **dermal denticles**. They do not have a swim bladder (we will talk about this organ later). Their mouth is on the underside of the head and their caudal fin is divided into two parts of different sizes (**heterocercal**). Sharks, rays and manta rays belong to this group.



Dermal denticles of a shark.



← Caribbean reef shark



Spotted Eagle Ray (*Aetobatus narinari*) →

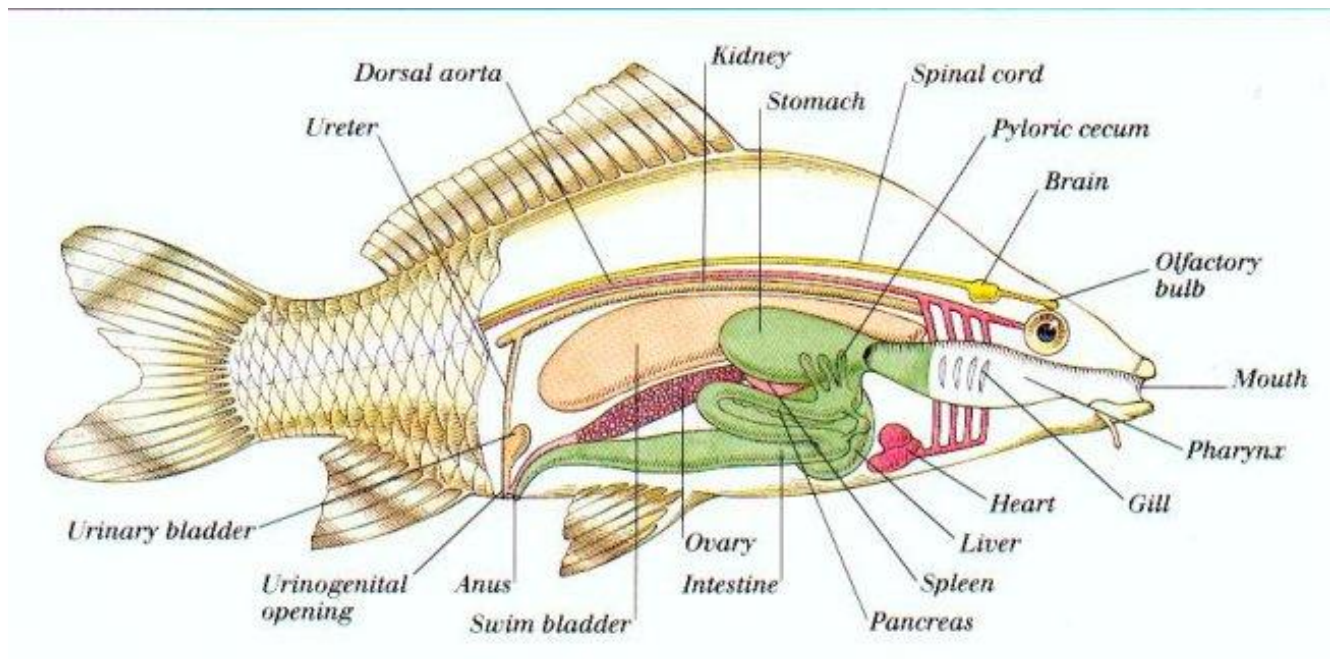
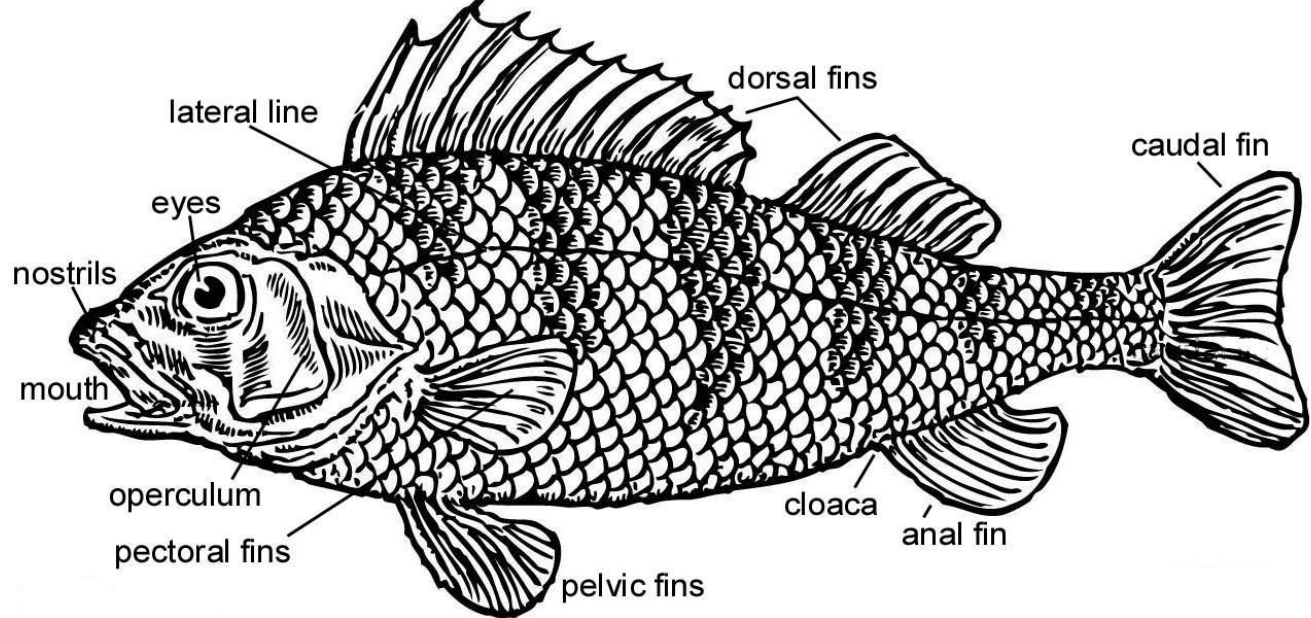
Manta Ray



2.3. Bony fishes.

Bony fishes have a skeleton made of **bones** and their gill-openings are protected by a bony hard cover called **operculum**. The skin is covered with **soft scales** and their caudal fin is divided into two equal halves (**homocercal**).

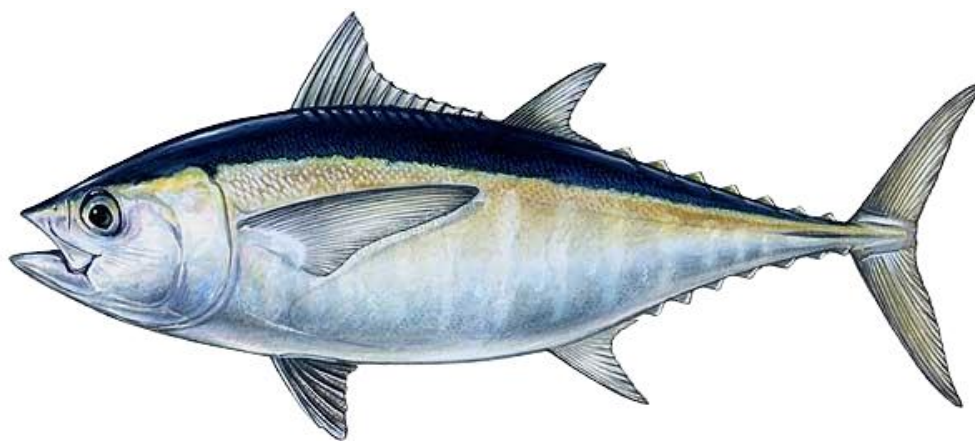
Most bony fishes have a **swim bladder**, or gas bladder, that contributes to the ability of the animal to control the buoyancy. It works by filling up with a gas when the fish ascends and emptying when the fish descends; this way the animal does not waste energy swimming to change its depth.



Sea horse



Amphiprion percula (clownfish)

Black fin tuna (*Thunnus atlanticus*)**Activity 158.**

Fishes are vertebrates that can breathe in an aquatic environment. What is the name of the organs that allow them to do so?

Activity 159.

What is the difference between paired and impaired fins?

Activity 160.

It is said that the body of the fish is “fusiform”. What is the meaning of this word?

Activity 161.

Explain how the swim bladder works.

Activity 162.

In this photograph you can see the four branchial arcs removed from a tuna fish:



These structures are protected by an organ that looks like a “flap”. What is the name of this organ?

Activity 163.

If we compare a piranha (a tropical fish) with a sardine of the Northern Atlantic Ocean we can find very obvious differences related with their respective environments. Would you be able to name two of them?

Activity 164.

Classify these animals into their group:

Bull-shark, salmon, ray, lamprey, anchovy, guppy, sword-fish, hammerhead-shark and flying fish.

Activity 165.

Complete this table with the main differences between cartilaginous and bony fishes.

	Cartilaginous fishes	Bony fishes
Skeleton		
Position of the mouth		
Gill-openings		
Scales		
Type of caudal fin		
Swim bladder		

3. Amphibians.

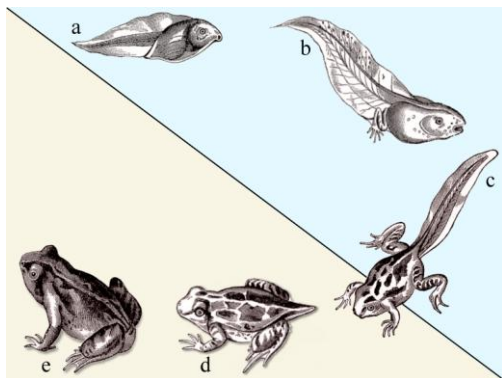
Amphibians are a class of vertebrates with a “double life” (that is the meaning of the word “amphibian” in Greek). They are terrestrial vertebrates, but a great part of their lives are linked to the aquatic environment. They have four limbs, like reptiles, birds and mammals; this is the reason why these four classes of vertebrates are called “tetrapods”. In fact, fishes are the only group of vertebrates that is not considered inside the tetrapods, although the limbs have evolved from the paired fins of the fishes.

Important characteristics of the amphibians are:

- They have a **thin naked skin** without scales, feathers or hairs. This skin is not impermeable so it must be kept wet to prevent dehydration. That is why the skin has a lot of **glands** that produce a mucous substance that reduces the amount of water that is lost by evaporation. Besides, these glands can also produce several **poisonous** substances to dissuade parasites and predators. Most types of amphibians can use the skin to breathing. If the skin is not kept wet the animal cannot breathe through it.
- Amphibians are **ectotherms**. The temperature of their body is not constant; it varies with the temperature of the environment. Many of them have to reduce their activity during the cold season and even some of them **hibernate**.
- They reproduce **sexually** with **external fertilization** although sometimes males and females experiment a pseudo-copula called **amplexus**.
- Amphibians are oviparous and females lay eggs usually in the water because they have no shell and will dry quickly if they are not humid all the time.
- When the egg hatches an **aquatic** larva is produced called **tadpole**. Tadpoles have gills and are herbivorous. They undergo a gradual and amazing metamorphosis to become adults with lungs, limbs and a carnivorous diet. Forelimbs usually have 4 digits while hind limbs have usually 5 digits.



Amplexus in the common European toad *Bufo bufo*



metamorphosis of a frog



1 cm

metamorphosis in *Bufo bufo*

The class amphibia is divided into two main orders: anura (=“without tail”) and urodela or caudate (=“with tail”).

3.1. Anura.

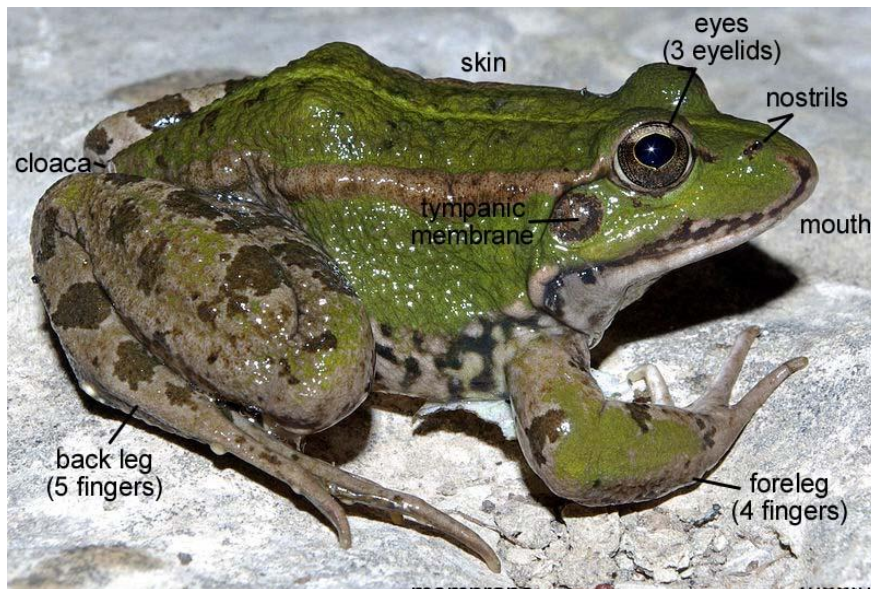
Anurans have a compact body without a tail and a big mouth. They have long and powerful back legs with which they can jump, swim and climb. Frogs and toads are members of this group. The differences between frogs and toads are not always conspicuous. Frogs usually have more protuberant eyes, longer webbed hind feet adapted to leap and to swim and a smoother and moister skin. Toads, on the contrary, have smaller eyes, shorter hind limbs more adapted to walk and a drier skin with warts.



Red eye tree frog *Agalychnis callidryas*



Alytes obstetricans



Pelophylax perezi

You can see a frog eating in the video of the following link: <https://youtu.be/BAUqC8Uvfts>

3.2. Urodela (=Caudate).

Urodela are amphibians with a tail. Their body is elongated and their four legs are similar in length. Salamanders and newts belong to this group. Salamanders have a moist and slimy skin and a round tail. Newts have a rougher skin and a flat tail and they are usually less terrestrials than salamanders.



Salamandra salamandra



Triturus marmoratus

Activity 166.

Why do amphibians have to live in aquatic environments?

Activity 167.

Write about how many types of breathing we can find in amphibians during their lives.

Activity 168.

Draw a salamander and label the following parts: eyes, nostrils, head, neck, legs, toes, trunk and tail.

Activity 169.

Complete this table with the differences between frogs and toads:

	frogs	toads
eyes		
skin		
back legs		

Activity 170.

Complete this table with the differences between salamanders and newts.

	salamanders	newts
skin		
tail		
environment		

Activity 171.

Draw a table with the differences between anurans and urodela.

4. Reptiles.

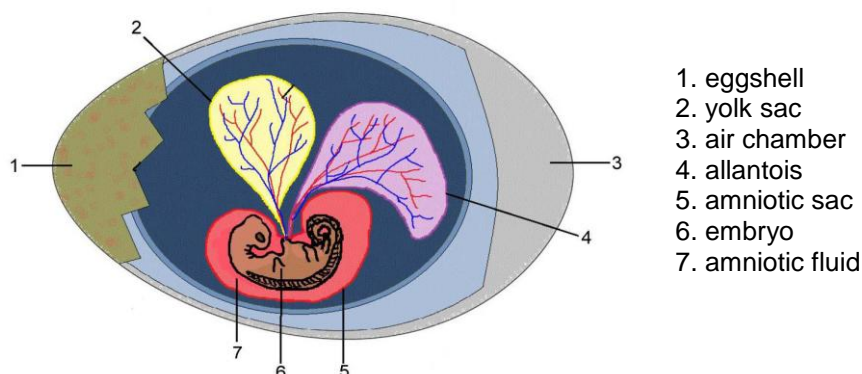
Reptiles are **tetrapod** vertebrates (even the snakes are descendants of ancestors with four limbs). Most of them live in a terrestrial environment and even those that spend most of their lives in the water have to **lay the eggs in the land** as reptiles have not aquatic larvae like the amphibians.

Their bodies show different shapes according to the group they belong; but they always have a **tail** and their limbs (if present) have **five digits** with sharp nails. The skin is covered with **thick scales** or corneous dermal plates that make it **impermeable**. Some reptiles (lizards and snakes) shed their skin.

Reptiles are **ectotherms**.

All the reptiles breathe through **lungs** and have a heart divided into 3 chambers where the oxygenated blood partially mixes with the deoxygenated blood (except in crocodilians where the heart has 4 chambers and it is basically identical to the one of the birds and the mammals).

Reptiles reproduce sexually with internal fertilization. Most reptiles are **oviparous** and their eggs have a **hard** and porous calcareous **shell** that makes them impermeable. So, unlike fish and amphibians, reptiles lay eggs in terrestrial environments. The shell prevents dehydration and inside the egg the embryo develops in an aquatic environment surrounded by the amniotic fluid.



The egg equipped with an **amnios** defines the reptiles (and also the birds and the mammals) as amniotes.

Reptiles are divided into **chelonians** (=turtles), **lizards**, **ophidians** (=snakes) and **crocodilians**.

4.1. Chelonians.

Turtles have a hard bony shell (the carapace) covering most of their body. Only the head, the tail and the legs emerge and even these parts can be hidden if the animal is disturbed. Their mandibles have been transformed into a beak without teeth. There are turtles that live on the land and others that live in the water of the rivers, lakes or oceans. But all of them have to lay the eggs on the land. There are carnivorous species as well as herbivorous ones. Some turtles are very big, like the several species that can be found in the Galapagos Islands. They also have fame for being able to live sometimes more than 150 years.



Diamond back terrapin (*Malaclemys terrapin*)



Geochelone nigra



Chelonia mydas



Leatherback turtles (*Dermochelys coriacea*)

4.2. Lizards

Lizards have not a carapace. Their bodies are thin and their limbs cannot raise the animal much above the floor so they move in a way that, in Latin, has given the name to all the class. Lizards usually can shed their skin. If they feel in danger most of them can get rid of their tail that still will be moving for several minutes so they have a chance to escape from their possible predator. In this group we can find lizards, wall lizards, iguanas, chameleons and skinks.



Ocellated lizard (*Timon lepidus*)



Jackson chameleon (*Trioceros jacksonii*)

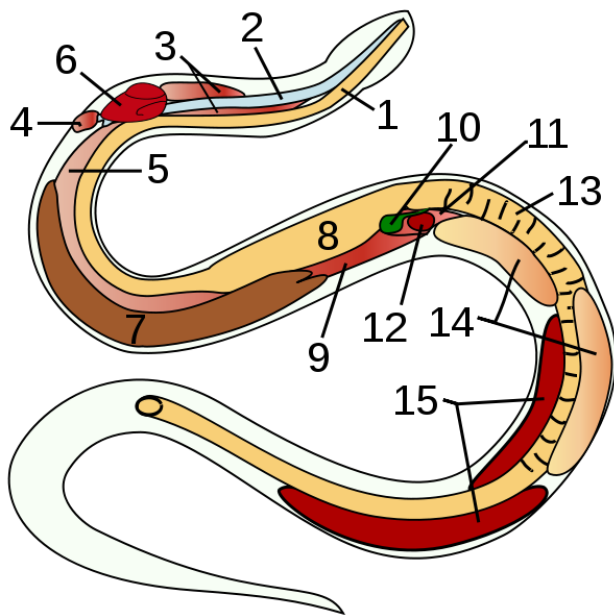
Komodo dragons (*Varanus komodoensis*)*Iguana iguana**Tarentola mauritanica**Polychrotidae sp. mating*

4.3. Ophidians.

Snakes are vertebrates with a long **legless** body covered with overlapping scales. They can be distinguished from legless lizards or amphibians because they do not have external ears and their eyelids are fused together and are transparent so they cannot close their eyes (in fact they are always closed). There are aquatic and terrestrial snakes but they are always **carnivore**. They usually shed their skin to get rid of possible parasites as mites and ticks.

Snakes have a characteristic **forked tongue** that they use to catch airborne particles and then passing them to the **vomerionasal organ** they have inside their mouth for examination. This way, with their tongues constantly in motion, sampling particles from the air, ground, and water and analyzing the chemicals found, they have a sort of directional sense of smell and taste simultaneously.

Some snakes can detect infrared radiation (=heat) using special organs they have near the nostrils or in the proximities of their mouth. This ability makes them good predators of mammals and birds as their bodies will still emit heat even if they hide in the darkness. They also can detect vibrations on the ground.



Internal anatomy of a snake

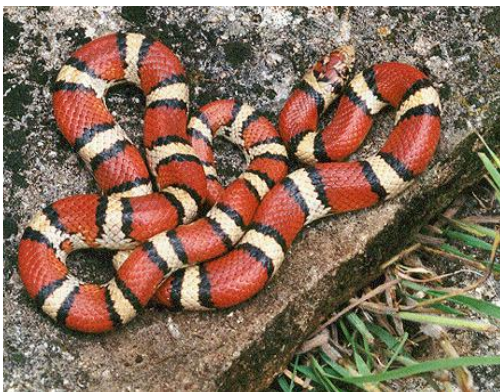
- 1 – esophagus
- 2 – trachea
- 3 – tracheal lungs
- 4 – rudimentary left lung
- 5 – right lung
- 6 – heart
- 7 – liver
- 8 – stomach
- 9 – air sac
- 10 – gallbladder
- 11 – pancreas
- 12 – spleen
- 13 – intestine
- 14 – testicles
- 15 – kidneys

Some snakes have hollow fangs connected to venom glands and they can immobilize or kill their preys. The venom can be dangerous even for humans in many cases.

Activity 172.

One of these snakes can kill you while the other one is completely harmless. Would you be able to distinguish the dangerous animal from the inoffensive one?

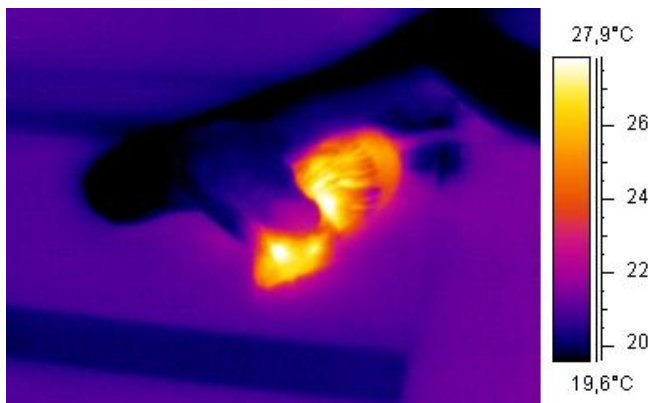
Here is a clue: "Red and yellow kill a fellow. Red and black, friend of Jack."



Lampropeltis triangulum



Micrurus sp.



Thermographic image of a snake eating a Mouse



Green Tree Snake (*Dendrelaphis punctulata*) eating a frog

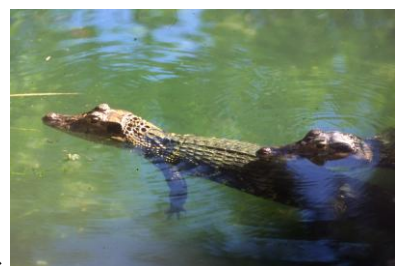
*Crotalus cerastes* (rattlesnake)*Dendroaspis polylepis*
(black mamba)*Naja naja* (spectacled cobra or Indian cobra)Green anaconda (*Eunectes murinus*). This animal is 3 meters long and was found in a garden of Universidade Federal do Pará

4.4. Crocodilians.

Crocodilians are lizard-like reptiles with semi-aquatic habits, laterally compressed tails and a thick skin covered with non-overlapping scales reinforced by bony plates. They have conical sharp teeth and a powerful bite. The eyes, the ears and the nostrils are at the top of the head so the animal can rest or stalk its prey with the rest of the body hidden below the surface. They are ectotherms, carnivorous and have a four-chambered heart. They live mainly in the tropics but some species also inhabit the temperate zones.

Crocodilians reproduce sexually with internal fertilization and the copula takes place normally into the water where the male and the female can elaborate a courtship display. Female crocodilians lay the eggs in a nest that can be inside a hole or in a mound depending on the species. The temperature at which the eggs are incubated determines the sex of the hatchlings. Temperatures above 32 °C produce males, while those below 31 °C produce females. Although they do not incubate directly the eggs, the crocodilian mothers are always near the nests supervising the process and taking care of the newborns. The mother takes the hatchlings to the water in her mouth and protects them until they are ready to take care of themselves.

Crocodilians are classified into crocodiles, caimans, gavials and alligators.

← *Gavialis gangeticus**Caiman crocodilus* →



Saltwater crocodile (*Crocodylus porosus*) reaches 7m and weighs up 2000 kg. (Prehistoric species reached 11m and 3.500 kg).



Crocodylus niloticus is the biggest killer of large animals, including humans, on the African continent.



Alligator mississippiensis

Activity 173.

What is the main difference between the eggs of the amphibians and the eggs of the reptiles?

Activity 174.

Draw the egg of the reptiles and label its parts.

Activity 175.

Decide if the following statements are true or false and correct the false ones:

- Iguanas have the mandibles transformed into a beak.
- Reptiles have to lay the eggs into the water.
- Reptiles and amphibians are tetrapods.
- Usually there are five digits in the forelimb of an amphibian.
- The larva of the lizards is called tadpole.
- Crocodiles can lose their tails if they feel in danger.
- Snakes are the only venomous reptiles.

Activity 176.

Complete the following table with the differences between amphibians and reptiles:

	Amphibians	Reptiles
Skin		
Place where they lay the eggs		
Metamorphosis		
Digits in the forelimb		
Digits in the hind limb		
Fertilization		
Presence of a tail		
Ectotherms or endotherms?		

Activity 177.

Write the name of the group of reptiles to which the following animals belong:

a) American alligator b) sea iguana c) gecko d) cobra e) black mamba f) red ears tortoise g) Gila monster

Activity 178.

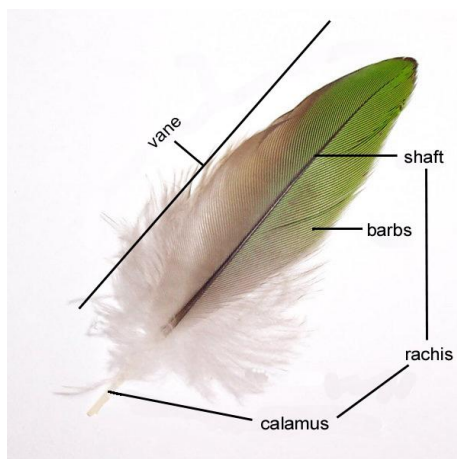
Write the group of reptiles that best fits to each sentence.

- Legless animals with dangerous fangs.
- They have a hard carapace to hide from their predators.
- With overlapping scales and a forked tongue.
- They are famous because they can change the color of their bodies.
- They can sacrifice their tail to escape their predators.
- Some species are carnivorous and others are herbivorous and they can live for 150 years.
- The females take care of the hatchlings.
- They can breathe, watch and hear although most of their body remains underwater.

5. Birds.

Birds are **vertebrate** animals that have evolved from the reptiles. Their feet and legs are covered with **scales** very similar to those of the reptiles and the eggs they lay are also **amniotic** with a **hard shell**. On the other hand, birds have unique characteristics like the **feathers** that cover their bodies and the **wings** they use to fly. Unlike reptiles, birds have a corneous **beak** without teeth and can regulate the temperature of their body (they are **endotherms**). The feathers that cover most of the body of the birds are the key characteristic of their skin because they are involved in very important processes like **thermoregulation**, **flying** and **mating**. There are two main kinds of feathers: **down feathers** and **contour feathers**.

- Down feathers** are fluffy feathers that are in a close contact with the body of the animal. They trap the warm air next to the body so it do not escape, and this **keeps the bird warm** preventing the loss of heat.
- Contour feathers** are stiff feathers that cover the body and the wings of the animal. They have a central **shaft** with many side branches called **barbs**. These barbs also have side branches called **barbules** that hook together forming a smooth, plane and tight surface. This structure helps the birds to **fly**.



Parts of a contour feather



Detail of the barbs and barbules in the feather of a Guinea fowl



Down feather

The feathers of the birds are waterproof because they are covered by a wax that birds usually spread with their beak from a gland they have near their tails. Besides, most birds shed their feathers by moulting once a year. We can find birds that are **herbivorous**, **carnivorous** and **omnivorous** but all of them need to eat high energy food like seeds, nuts, insects or meat because flying spends a lot of energy. The hummingbirds, for instance, feed on nectar with high concentration of sugar so they are able to keep their amazing metabolic rate. Birds do not have teeth and they do not chew their food. In their digestive system they have a **crop**, to store the food and a **gizzard** with little stones inside to grind the food so it can be digested properly.

The flight adaptations that can be found in the birds are:

- They have wings that they can flap to gain momentum or spread still to glide over the landscape.
- Birds that fly have powerful flight muscles inserted in the **keel**, a large breastbone in which the sternum has been transformed.
- The skeleton of the birds is compact and strong as a result of the fusion of many bones that makes it more rigid but more efficient from the point of view of the movement of the wings.
- The bones of the birds are hollow with internal cross supports to provide both lightness and strength.
- Attached to the lungs, the birds have **air sacs** to store air. These organs guarantee that the supply of oxygen to the flight muscles is continuous it does not matter if the animal is inhaling or exhaling.
- The heart of the birds beats at an incredible speed (more than 1000 times per minute in small birds). This way the flow of oxygen-rich blood to the flight muscles is very fast.
- Birds have big eyes and their eyesight is perfect to detect food, preys or predators from a long distance. It is said that hawks or eagles can see 8 times better than humans.

Birds reproduce sexually with internal fertilization (as reptiles do). They also lay amniotic eggs but, unlike reptiles, birds have to keep the eggs warm in order to the embryo can develop. Birds do so by **brooding**. They basically sit on the eggs until the eggs hatch. Sometimes it is done by the female, sometimes it is done by the male and sometimes they take over in turns. When the eggs hatch the chicks can be **precocial** or **altricial** depending on the species. Precocial chicks (ducks, chickens, etc...) are covered with feathers and can follow their parents around walking or swimming; they depend on their mother for warmth and protection but they can feed themselves. On the other hand, altricial chicks (hawks, sparrows, etc...) are weak and helpless for a long time after hatching; they have no feathers, their eyes are closed and they cannot walk or get out of the nest; they depend on their parents to keep warm and to get food for weeks or months.

Birds are classified into **ratites** and **carinatae**.

- **Ratites** have no keel and no flight muscles. These birds cannot fly and their wings are atrophied. They are sometimes called running birds. The **ostrich** is the largest living bird. It can weigh 125 kg and reach a height of 2,5 m. The ostrich can run faster than 60 km/h. The **kiwi** is other example. Kiwis are nocturnal birds from New Zealand, with the size of a chicken, that every night look for caterpillars, worms or berries to eat.



Struthio camelus (male and females)



Apteryx australis



Despite their flightless condition penguins are not ratites. They have keel and flight muscles. In fact they "fly" under the water.

- **Carinatae** have keel and flight muscles. Most of them can fly. Penguins also belong to this group because they “fly” under the water. Inside of this group there is a great variety of birds. We can select the water birds, the perching birds and the birds of prey.
 - **Water birds** like ducks, cranes, geese, swans or pelicans either have webbed feet for swimming or long leg for wading.

Blue crane (*Anthropoides paradisea*)Mallard (*Anas platyrhynchos*)

- **Perching birds** have special adaptations to rest on branches. The toes of their feet grab the branches automatically so the animals do not fall even if they get asleep on the tree. Robins, finches, sparrows or parrots are examples of this group.

Blue and yellow macaw (*Ara ararauna*)European goldfinch (*Carduelis carduelis*)

- **Birds of prey** have sharp claws on their feet and a strong curved beak to hunt and eat other vertebrates. They feed on invertebrates also if they have the chance. They have very good eyesight. Some of them are diurnal like the osprey or the imperial eagle while others are nocturnal like the spotted owl or the barn owl.

Barn owl (*Tyto alba*)Osprey (*Pandion haliaetus*)

Activity 179.

Which of the following groups includes birds that do NOT have a large keel?

- a) birds of prey b) perching birds c) ratites d) water birds

Activity 180.

The long legs some water birds have are for:

- a) swimming b) wading c) flying d) running

Activity 181.

Which of the following is NOT a flight adaptation in birds?

- a) hollow bones b) rapidly beating heart c) air sacs d) down feathers

Activity 182.

Explain the difference between precocial chicks and altricial chicks.

Activity 183.

Complete the following table with the differences between birds and reptiles:

	Birds	Reptiles
Structures in the skin		
Forelimbs		
Mouth		
Eggs		
Ectotherms or endotherms?		

Activity 184.

What are the feathers used for?

Activity 185.

Suppose that a bird that weighs 150g loses 30% of its body weight during migration. What will be its weight when it arrives to its destination?

Activity 186.

Most birds of prey have a good eyesight. Why do you think good vision is important for these birds?

Activity 187.

How could being able to run 60 km/h be helpful for an ostrich?

Activity 188.

Would it be helpful for a duck to have the feet of a perching bird? Explain why or why not.

Activity 189.

Decide if the following statements are true or false and correct the false ones:

- a) Rachis and barbs are parts of the keel.
- b) Ratites can not fly.
- c) Kiwis are ectotherms,
- d) Birds and mammals are the only endothermic living animals.
- e) Geese and pelicans are perching birds.
- f) Precocial chicks can walk a short moment after leaving the egg.
- g) There is not a bird with teeth.
- h) Penguins classifies into the ratites as they are unable to fly.
- i) Birds have internal fertilization.

Activity 190.

Draw a feather and label its parts.

6. Mammals.

This is the group of vertebrate animals best known by the students of 1º ESO. The reason of that is probably that we, humans, are also mammals; and so are most of our pets and farm animals.

6.1. Common characteristics of mammals.

As amphibians, reptiles and birds, mammals are vertebrate tetrapod animals. They have other taxonomic characteristics like:

- Mammals are **endothermic** living beings, like birds. This means that their body temperature does not depend on the temperature of the environment as they have metabolic mechanisms to keep a constant temperature whatever the climate.
- Mammals have **mammary glands**. Mature females produce milk to feed the newborns. There is a period of time at the beginning of the mammals life where milk is the only food they can take to keep alive.



← A dromedary nursing her calf.

The number and the position of the mammary glands vary depending on the species. Dromedaries have two, like humans, but they are inguinal (placed in the groins) instead of thoracic. You can find other examples in this page:

https://en.wikipedia.org/wiki/Mammary_gland

Male mammals usually have rudimentary mammary glands and nipples with a few exceptions (horses) and sometimes male lactation takes place. It is well known the case of the Dayak fruit bat (*Dyacopterus spadiceus*) where the male contributes almost as much as the female in the lactation.

- Mammals have a skin with **hair**. Hair is exclusive of mammals and it is used as a taxonomic characteristic. Even aquatic mammals have hair. Hair plays a role in thermoregulation providing thermal isolation from the environment. Mammals that usually live in cold climates have thick coats of hair and their naked skin cannot be seen. This is when we say they have **fur**. Most mammals have also a layer of fat under the skin for extra warmth.
- Mammals have **specialized teeth**. Although fish and reptiles have teeth, they are usually identical. On the contrary, mammals have teeth with different shapes and sizes to perform different functions. Incisors to cut, canines to tear and molars to grind. The number and position of these dental pieces into the mouth is a taxonomical trait that can be used to distinguish between the different species of mammals. Carnivores usually have sharp and big canine teeth with small or no molars while herbivores have sharp incisors and many flat molars with small or no canines.
- Mammals have a **diaphragm** to help them breathing and separating the thorax and the abdomen.
- Mammals reproduce **sexually** with **internal fertilization**. Newborn mammals depend on their parents care for a long time. Only three species are oviparous, the rest of them are viviparous.
- Mammals have high developed **senses** and a **big brain** that allows them to respond quickly to environmental changes and learn.

Activity 191.

What is the name of the dome-shaped muscle that is attached to the lower ribs and that function as the main muscle in respiration?

Activity 192.

Draw your mouth, label the different dental pieces and explain the job they do.

Activity 193.

Write three characteristics that are unique to mammals.

Activity 194.

How are mammal teeth different from fish teeth?

Activity 195.

How many mice (2g each) are necessary to equal the weight of a 90 000 kg whale?

Activity 196.

Write two characteristics of the mammals that are related to their condition of endotherms.

Activity 197.

Explain all you can deduce about the diet of the following animals:



a)



b)

6.2. Classification of mammals.

Mammals are classified into three important groups depending on how the embryo develops: **monotremes**, **marsupials** and **placental mammals**.

Monotremes: They are oviparous. Females lay and incubate eggs with thick, leathery shells.

Marsupials: They are born still undeveloped and the embryos have to complete the development inside a pouch or marsupium.

Placental mammals: The embryo develops entirely inside the mother's uterus. They have an organ called placenta that guarantees the supply of nutrients from the mother's blood and the elimination of wastes.

6.2.1. Monotremes.

These are mammals that lay eggs. Monotremes are endotherms; they have a diaphragm, hair and mammary glands. When the eggs hatch the newborns feed on the milk produced by the mother. They do not have nipples but the young monotremes lick the milk from the skin and hair around their mother's mammary glands. There are only three living species of monotremes: the **long-beaked echidna** (New Guinea), the **short-beaked echidna** (New Guinea and Australia) and the **platypus** (Australia).



Long-beaked echidna



Short-beaked echidna



Platypus

Echidnas are the size of a house cat and have large claws and long snouts to dig ants and termites out of their nests.

Platypuses are swimming mammals that live in rivers and ponds. They have claws to dig the tunnels in the riverbanks where they usually lay the eggs. Their webbed feet and long flat tails are used to move through the water. They have a very sensitive bill that they use to find their food underwater (they close their eyes and ears when they dive). The male platypus has a spur in the ankles of their hind limbs that delivers a poison that can be extremely painful to humans.

6.2.2. Marsupials.

Most of the species of living marsupials live in Australia and New Guinea. Only a few of them live in the American continent. The embryos of marsupials abandon the uterus at a very early stage of development, and they crawl up the body of their mother to get into a pouch called **marsupium** where they will attach to the nipples. The newborns can remain into the marsupium for months before they are “encouraged” by their mothers to leave the safety of their shelter and face the world.



Koalas are very well known marsupials. (Don't they look adorable?)



Young kangaroos are called “joey”. The one in this photo still spends most of the time inside its mother's marsupium.



Kangaroos can travel very long distances very efficiently.



Tasmanian devils are the extant largest carnivorous marsupial. They have the size of a small dog.

This marsupial that looks like a kangaroo is in fact a wallaby



The last Tasmanian tiger, or thylacine, died on 7 September 1936 in the Hobart zoo.



This marsupial is a numbat.



This little marsupial is a bettong.



Marsupials in Australia and New Guinea have been isolated from the rest of the world for millions of years, and that circumstance has made them unique in many senses. They have evolved independently in defined territories with ecological relationships of their own. In the latest 100.000 years the humans have introduced in these territories new species that compete with native marsupials for resources and living space. Many marsupials today have become extinct because of human activities, and many more are considered endangered species. During the XVIII and XIX centuries Europeans coming to Australia brought rabbits, cats and foxes. And even earlier the aborigines brought dogs, pigs and rats. Marsupials have no adaptations to protect themselves from all these exotic species. Exotic species and habitat destruction are the most common mechanisms that threaten the marsupials in Australia and New Guinea and many other endangered species all over the world.

Activity 198.

How are monotremes different from all other mammals? How are they similar?

Activity 199.

Explain the reason why many marsupials have become extinct or are considered endangered.

Activity 200.

Write which of these characteristics belong to the monotremes, the marsupials or both:

- A few of species live in America.
- Females produce milk.
- The young hatch from eggs.
- Females have a pouch where newborns stay for a long time.
- Females have no nipples.
- They feed on ants or are aquatic.
- Their body is covered with hair.

Activity 201.

This animal is an opossum, an American marsupial. When they are in danger they “play dead”, mimicking the appearance and smell of a sick or dead animal. Why do you think they present this behavior?



An opossum in the winter



An opossum “playing dead”

6.2.3. Placental mammals.

Most species of mammals are placental mammals. The embryos of the placental mammals develop entirely inside the **uterus** of their mother. During the gestation period the nutrients and the oxygen flow from the blood of the mother to the blood of the embryo through an organ called **placenta**, while the CO₂ and the other wastes flow the opposite direction from the embryo to the blood of the mother.

Placental mammals are classified into many different orders. The most important groups are:

- **Xenarthra**. They have small teeth, or no teeth at all, and a long sticky tongue to catch insects or small animals. Anteaters, armadillos and sloths belong to this group.



Brown-throated three-toed sloth.

Sloths eat leaves and spend most of their time sleeping hanging on a tree.



Nine-banded armadillo.

Armadillos roll up into a ball or jump suddenly to scare a predator. They eat roots, mushrooms, insects and frogs.



Giant anteater.

Anteaters feed on ants, termites and other insects. They never destroy the nests of the insects. They open the nest and eat only a few individuals before moving on to another nest.

- **Insectivores**. They are usually small with long, pointed and sensitive noses. Moles, shrews and hedgehogs belong to this group. Some of them can eat worms, fish, frogs and other small animals besides insects.



Southern short-tailed shrew



This mole lives in North America

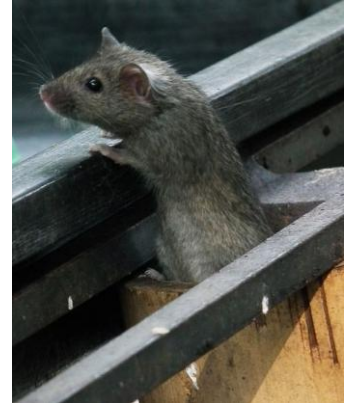


European hedgehog

- **Rodents.** They have only one set of incisors in the upper jaw that they use all the time. The incisors have to grow all life long to compensate the continuous chewing. Most of the animals in this group also have sensitive whiskers. Rodents are one of the most widespread orders of mammals and they are present in every continent except Antarctica. Rats, mice, squirrels, porcupines and chinchillas belong to this group.



A group of Capybaras, the largest rodents in the world. These South American rodents can reach a weight of 70 kg.



The house mouse, one of the smallest rodents.

- **Lagomorphs.** They have two set of incisors in the upper jaw and a short tail. Their large ears are used both to enhance their hearing and to keep them cool. Rabbits, hares and pikas belong to this group.



European rabbit eating grass



Arctic hare



Alpine pika

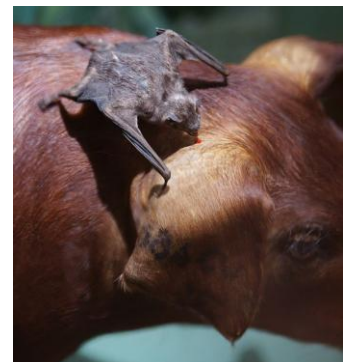
- **Chiropters.** Bats are the second largest order of mammals and the only one which includes flying animals. Some species are fruit eaters (=frugivores), like the flying fox; but most of them are insectivores and capture their prey using **echolocation**; a few species, the vampire bats, feed on blood (=hematophagous) and there is even one species that feed on fish and seafood. Bats play an important ecological role pollinating plants, consuming insect pests and dispersing seeds and fruits.



Flying fox



Big-eared bat looking for moths



Vampire bat feeding

- **Proboscides.** Also known as trunk-nosed mammals. The only extant animals in this group are the elephants. Elephants use their trunks in many different and versatile ways. Nowadays there are two different species of elephants with different subspecies. The African elephant has larger ears and concave back while the Asian elephant has smaller ears and convex back. The bush African elephant is larger and lives in the savanna while the forest African elephant is smaller and lives in the jungle. Male bush African elephant is the largest terrestrial mammal (in fact it is the largest extant terrestrial animal). The incisors of the elephant grow to become tusks.



African bush elephant



Asian elephant

- **Carnivores.** The name of the group refers to the fact that most of them eat only meat but there are also herbivores and omnivores inside of this group. The best known families inside this group are ***Canidae*** (coyotes, wolves, dogs, dingos, etc.) ***Felidae*** (tigers, cheetahs, cats, leopards, lions, etc.), ***Ursidae*** (bears) and ***Pinnipedia*** (seals, sea lions, walruses, sea elephants, etc.). Pinnipeds are fish-eating ocean mammals.

Iberian wolf
(*Canis lupus signatus*)Domestic cat (*Felis catus*)Brown bear (*Ursus arctos*)Southern elephant seal (*Mirounga leonina*), the largest carnivoran

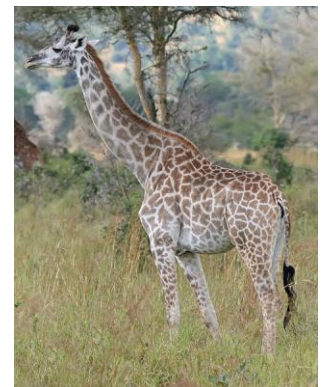
- **Ungulates.** They are mammals with hoofs. Hoofs are thick, hard pads that cover mammals toes. They are usually herbivores and run away from their predators running fast. Hoofed mammals are classified in odd-toed and even-toed. Odd-toed hoofed mammals have one or three toes like horses (1 toe) or rhinoceroses (3 toes). Even-toed hoofed mammals have two or four toes like camels (2 toes) and deer (4 toes).



When food is scarce camels can rely on their humps to get the energy they need



Wild boars are even-toed ungulates



Giraffes are the tallest living mammals

- **Sirenia.** Sometimes known as “sea cows”. In this order there are four living species of fully aquatic herbivorous mammals that inhabit swamps, rivers, estuaries, marine wetlands, and coastal marine waters. Dugongs and manatees are animals of this group.



Dugong



Manatee

- **Cetaceans.** In this group are classified fully aquatic mammals that at first sight may look like fish. But they breathe through lungs, have a placenta and nurse their young, along with the rest of the traits that are present in other mammals. These animals are highly social and intelligent and have powerful communication skills that the researchers are beginning to understand now. They also can use **echolocation** and move naturally in the aphotic zone. Dolphins, whales and porpoises belong to this group.



The blue whale (*Balaenoptera musculus*) is the largest animal that has ever lived and, in my opinion, one of the most beautiful. These impressive animals were hunted almost to extinction by whalers until they were protected by international law. Some countries still kill them taking advantage of the imperfections of the law. We know very little of how they live, but they seem to be very intelligent animals with a communication system based on “songs”. You can hear some whale songs in this webpage:

https://en.wikipedia.org/wiki/Blue_whale



Juvenile Atlantic spotted dolphin
(*Stenella frontalis*)



Narwhals (*Monodon monoceros*)



This sperm whale (*Physeter macrocephalus*) was already dead when it stranded on the sand

- **Primates.** This is the group to which we, humans, belong. Prosimians, monkeys, apes and humans have five fingers on each hand and five toes on each foot, usually with flat fingernails instead of claws. They have opposable thumbs and forward-facing eyes that can focus on a single point. These traits make primates specially adapted to live in the trees and most of them still remain at least partially arboreal. They eat leaves and fruits although some primates even hunt animals. Among the extant primates the more similar to humans are the apes (they do not have tail).



Opposable thumbs are one of the taxonomic traits of the primates



This tarsier is a prosimian with ancestral characteristics. Forward-facing eyes is another taxonomic trait of the primates



The ring-tailed lemur is also a prosimian. Its habitat is in Madagascar



Squirrel monkey



Patas monkey

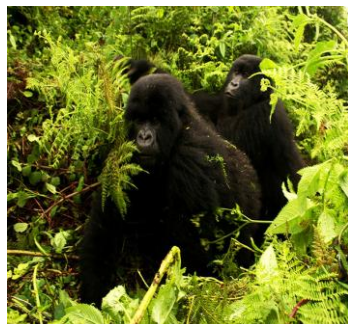


Proboscis monkey

These are the living apes more closely related to humans:



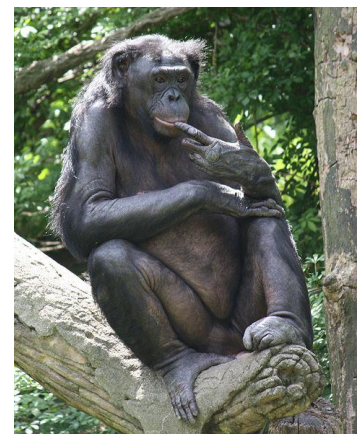
Pongo pygmaeus



Gorilla beringei



Pan troglodytes



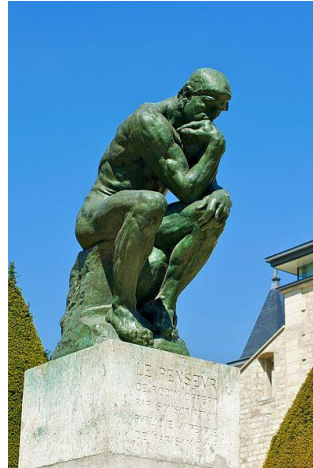
Pan paniscus

In the past, several species of human beings inhabited the Earth but nowadays only one species remains. All humans belong to the species *Homo sapiens*. Consider the photographs in the next page, are we really so different?

Several examples of extant humans:



Writing makes possible the transmission of ideas in a way that new generations can learn from the precedent ones. Culture makes us "sapiens". And some humans as 'Mahatma' Gandhi help us to learn the importance of peace to keep growing as species



Art and abstract thinking are distinctive features of humans. Auguste Rodin sculptured this "Le penseur" (= "the thinker")



The adult female human on the left is Dr. Jane Goodall an outstanding primatologist. She is teaching to some children the importance of the wetlands

Activity 202.

What are the differences between marsupial and placental mammals?

Activity 203.

The gestation period of the African elephant is 645 days while the gestation period of the mouse is 19 days. Calculate the gestation periods of the mouse and the African elephant in months.

Activity 204.

Why do you think elephants have a longer gestation period than mice do?

Activity 205.

The fully aquatic mammals belong to the groups:

a) sirenids b) cetaceans c) sirenids and cetaceans d) sirenids, cetaceans and pinnipeds

Activity 206.

Define "uterus" and "placenta".

Activity 207.

Mate the two columns:

- | | |
|--------------------|----------------|
| • Monotremes | • Uterus |
| • Marsupials | • Leathery egg |
| • Placental mammal | • Pouch |

Activity 208.

Write the group of mammal that best fits with every sentence:

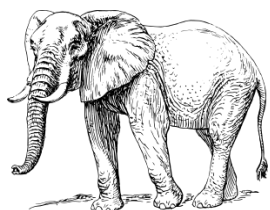
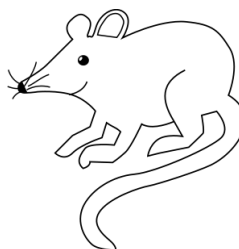
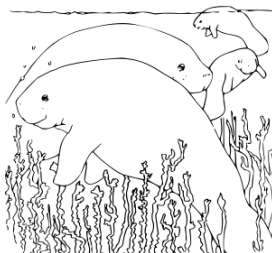
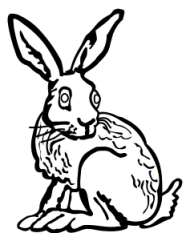
- They are big herbivores and can live in swamps and rivers.
- Their fore limbs are transformed into wings.
- Although they have a nose they use a different orifice to breath.
- They move jumping with only two legs.
- They have opposable thumbs.
- They are the largest living terrestrial animals.
- They have hard pads covering the toes.
- They have only one set of incisors in the upper jaw.
- They lay eggs.
- They are toothless and feed on ants.
- Most of them eat meat and their teeth are sharp and cutting.

Activity 209.

What are the only groups of mammals with echolocation?

Activity 210.

Classify these mammals into their group.



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PROCEDENCIA DE LAS IMÁGENES

Unit 1. Life on Earth



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Unit 2. Cells



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Unit 3. Classification of the living beings



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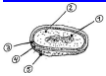
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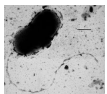


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Unit 4. Unicellular living beings



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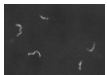
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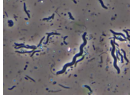
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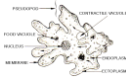
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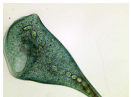
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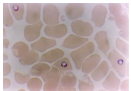
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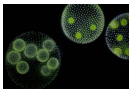
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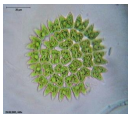
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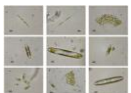
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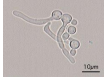
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Unit 5. Algae, fungi and lichens



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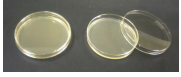
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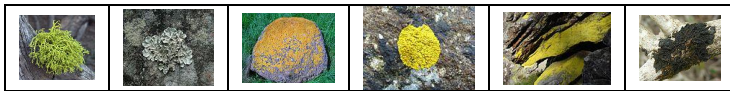
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Unit 6. Plants



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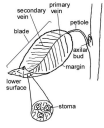
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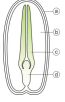
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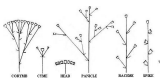
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Unit 7. Animals I: invertebrates



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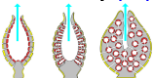
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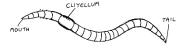
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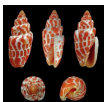
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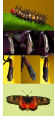
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Unit 8. Animals II: vertebrates



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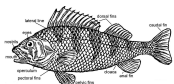
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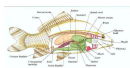
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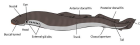
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