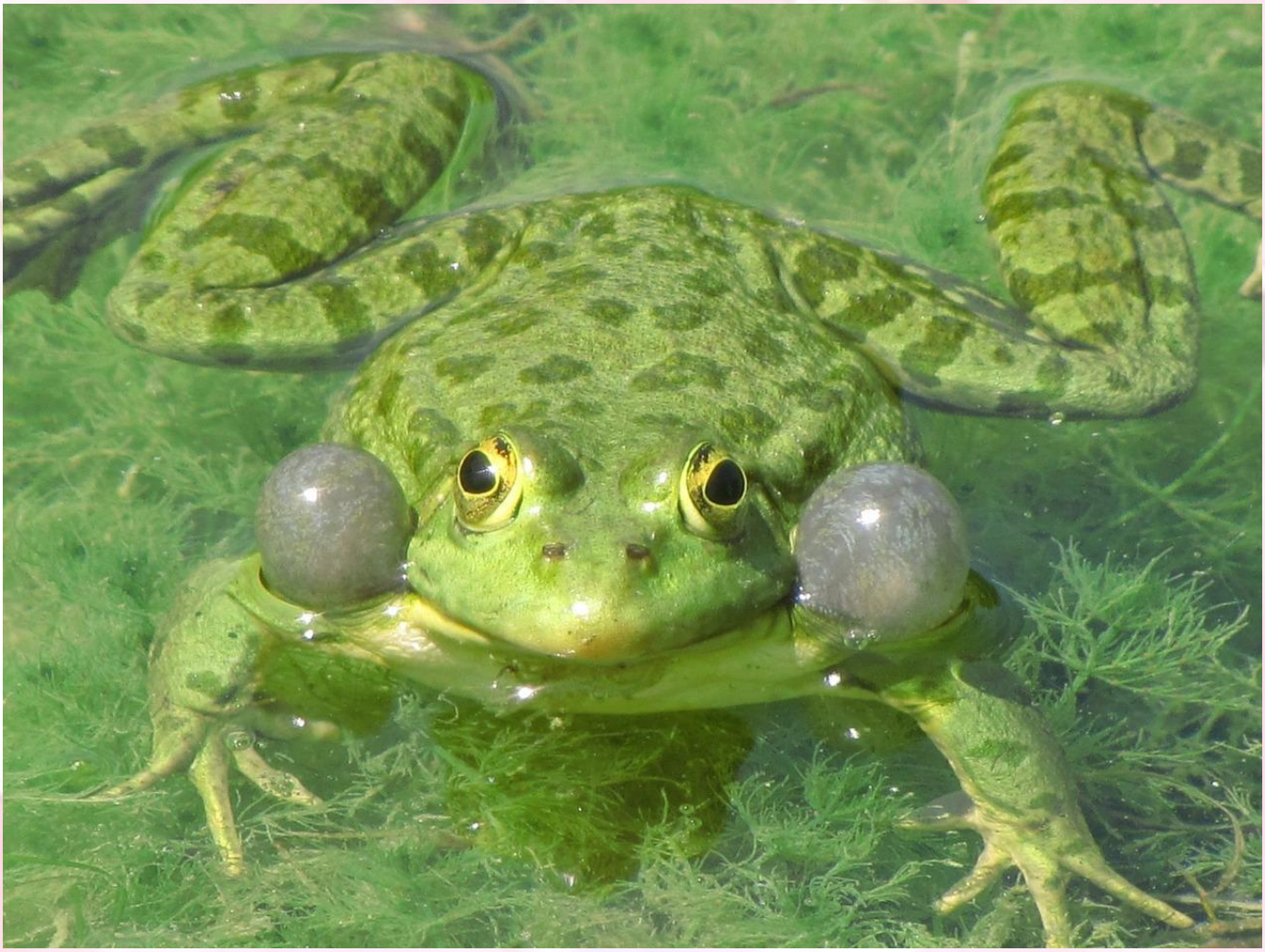
The Villablanca Connection

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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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 vertebras 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?

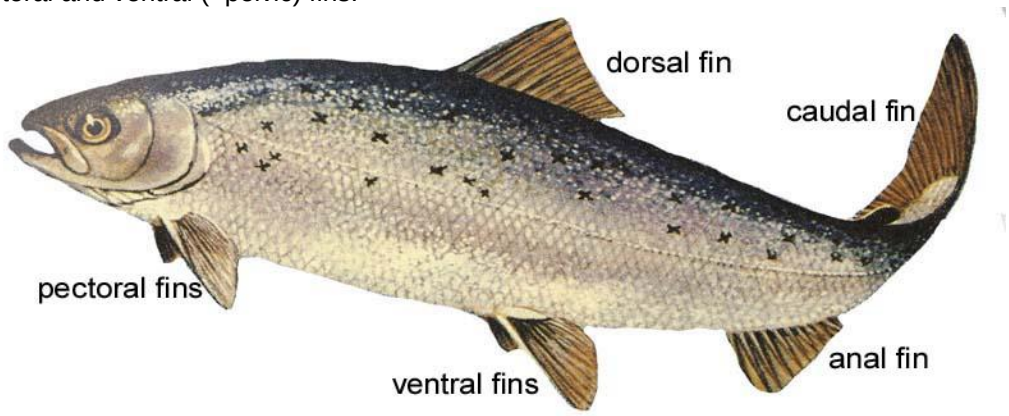
Activity 157.
Classify these animals into “endotherms” and “ectotherms”:





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.

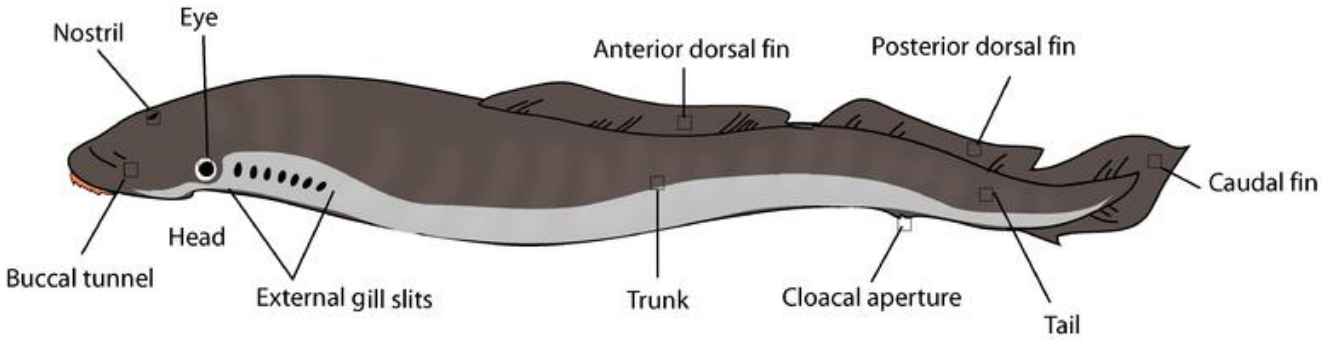


Fishes breathe by **gills** taking the oxygen that is dissolved in the water. The water enters by the mouth or by a spiracle and then it goes through the gills disposed in several branchial arcs. The gills have a lot of blood vessels that allow the exchange of O_2 and CO_2 between the animal and the 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).

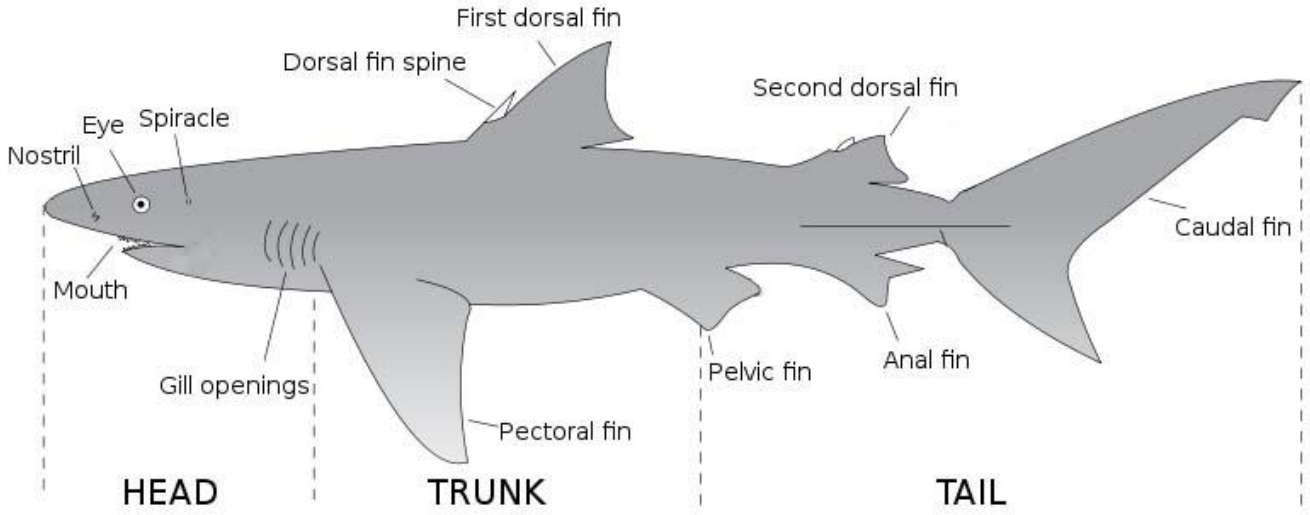
They are very primitive fishes without mandibles. Their mouth is transformed into a sucker with very hard teeth that they use to parasite other fish. Lampreys are members of this group.

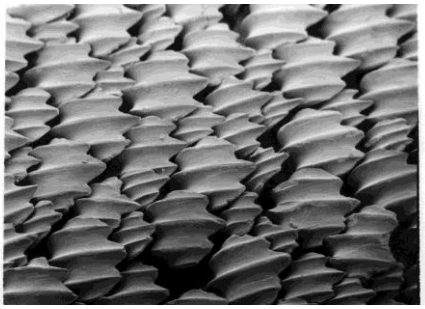

Lampetra fluviatilis.



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.

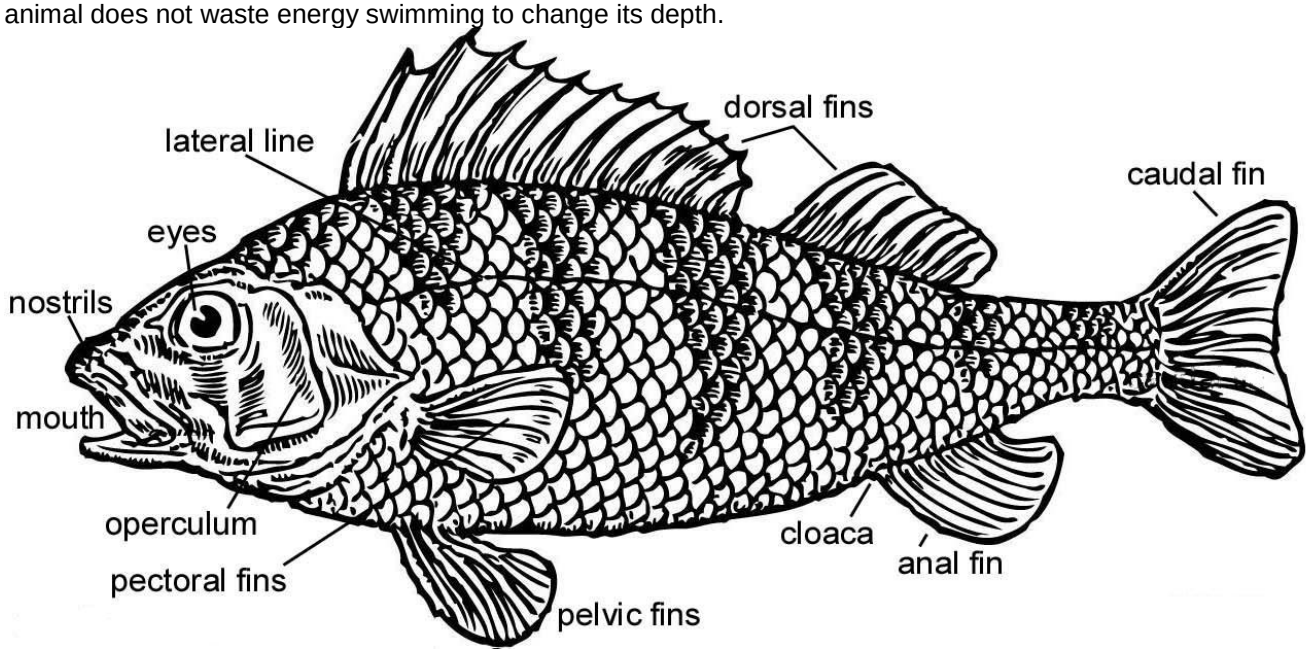
← Caribbean reef shark

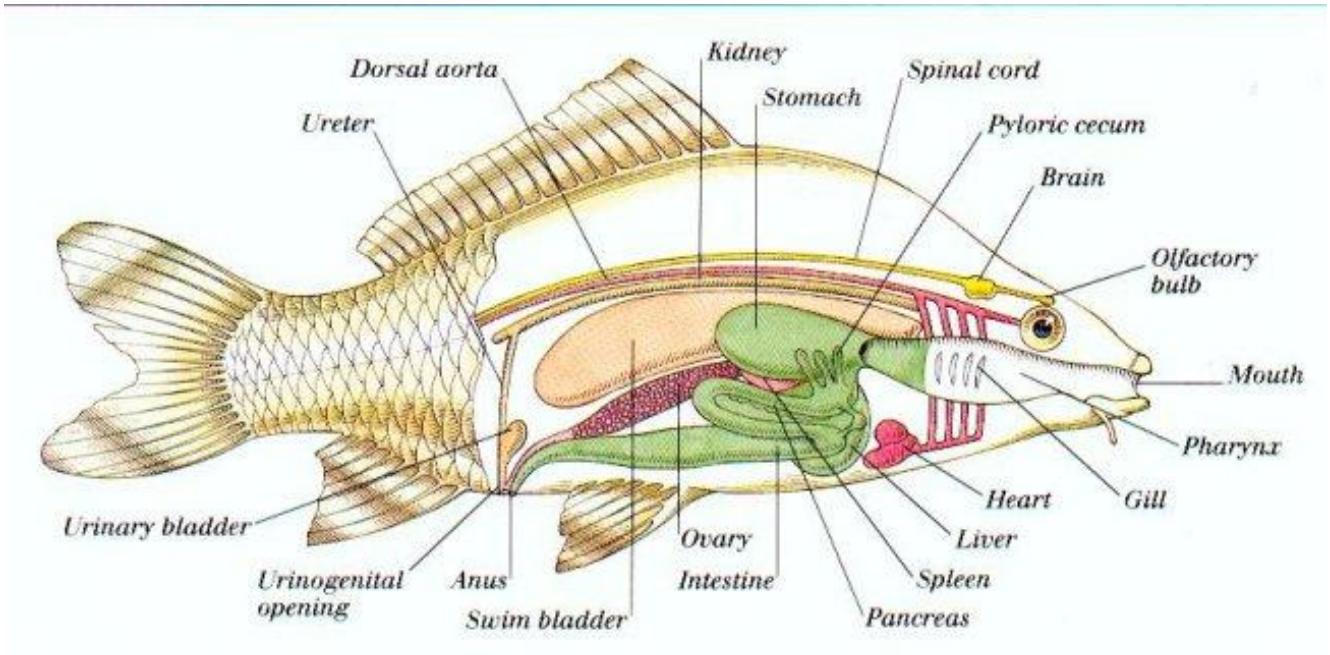
Spotted Eagle Ray (*Aetobatus narinari*) →

Manta Ray

2.3. Bony fishes.

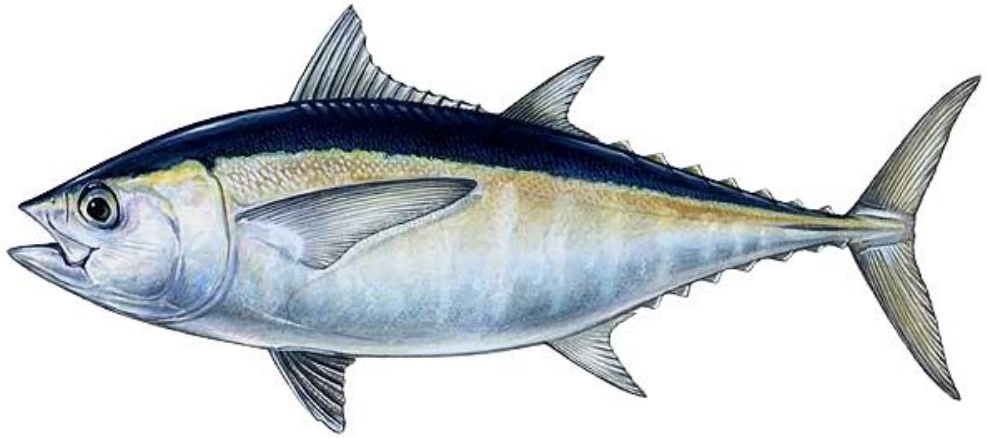
Bony fishes have a skeleton made of **bones** and their gill-openings are protected by a bony hard cover called **operculum**. The skin is covered with **soft scales** and their caudal fin is divided into two equal halves (**homocercal**).
Most bony fishes have a **swim bladder,** or gas bladder, that contributes to the ability of the animal to control the buoyancy. It works by filling up with a gas when the fish ascends and empting 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.

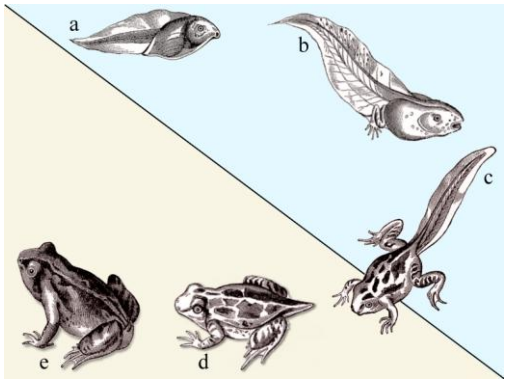
	Cartilaginous fishes	**Bony fishes**
Skeleton		
Position of the mouth		
Gill-openings		
Scales		
Type of caudal fin		
Swim bladder		

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

metamorphosis in *Bufo bufo*

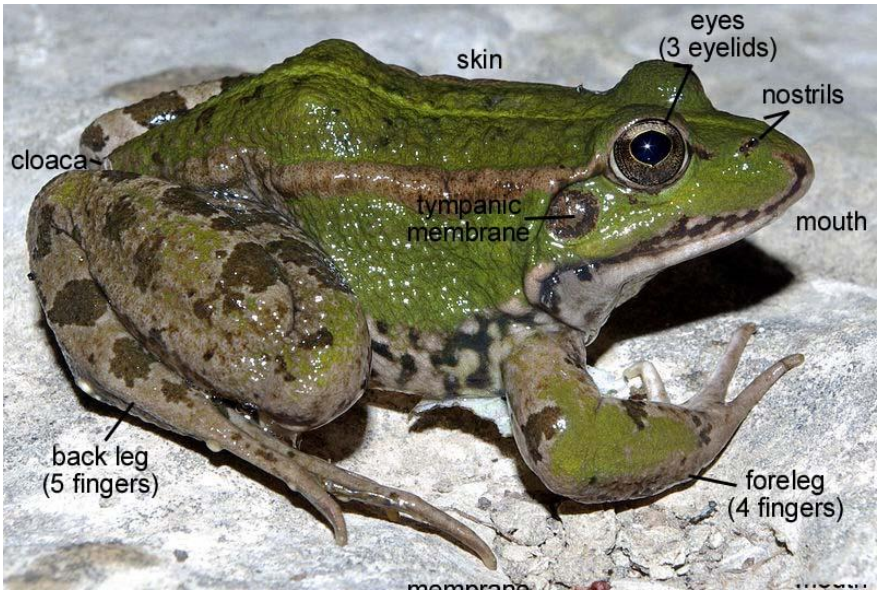
The class amphibia is divided into two main orders: anura (=”without tail”) and urodela or caudate (=”with tail”).

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		

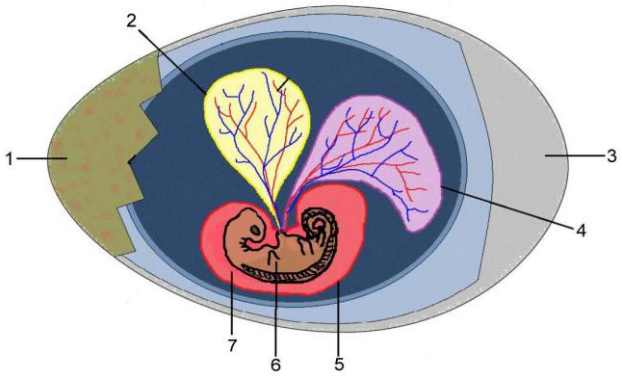
Activity 170.
Complete this table with the differences between salamanders and newts.

	salamanders	**newts**
skin		
tail		
environment		

Activity 171.
Draw a table with the differences between anurans and urodela.

4. Reptiles.

Reptiles are **tretrapod** 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.



1. eggshell
2. yolk sac
3. air chamber
4. allantois
5. amniotic sac
6. embryo
7. 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 that 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.

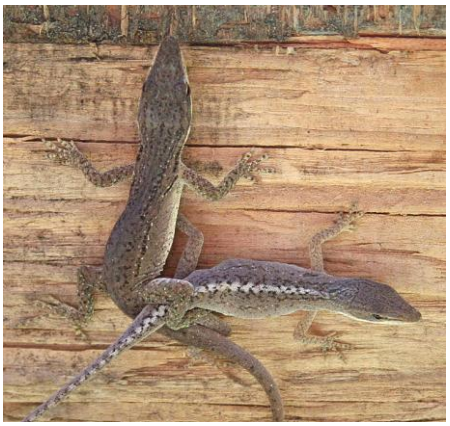

Ocellated lizard (*Timon lepidus*)


Jackson chamaleon (*Trioceros jacksonii*)

Komodo dragons (*Varanus komodoensis*)

Iguana iguana

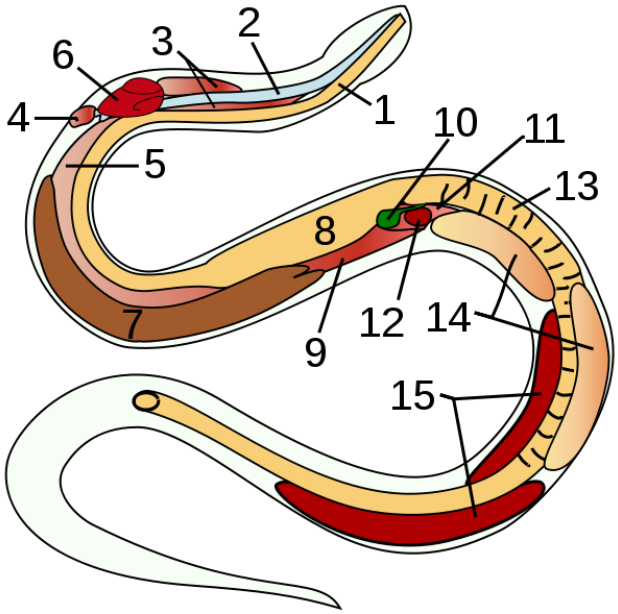
Tarentola mauritanica



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 **vomeronasal 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

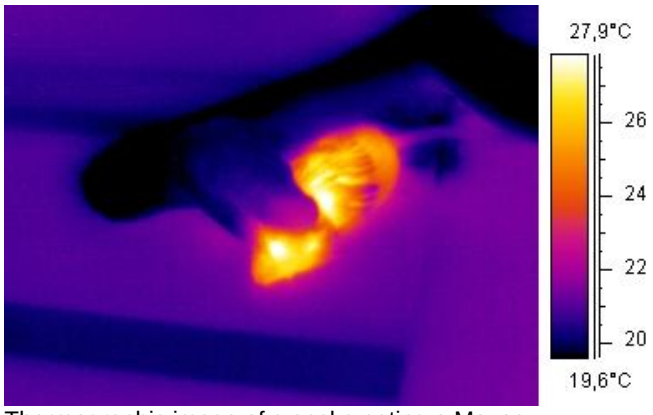
1 – esophagus
2 – trachea
3 – tracheal lungs
4 – rudimentary left lung
5 – right lung
6 – heart
7 – liver
8 – stomach
9 – air sac
10 – gallbladder
11 – pancreas
12 – spleen
13 – intestine
14 – testicles
15 – kidneys

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.

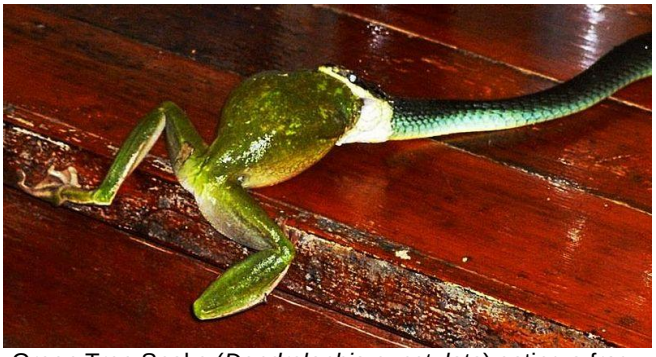
Activity 172.
One of these snakes can kill you while the other one is completely harmless. Would you be able to distinguish the dangerous animal from the inoffensive one?
Here is a clue: "Red and yellow kill a fellow. Red and black, friend of Jack."

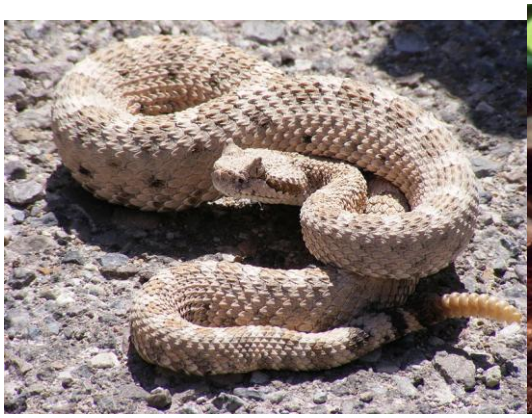

Lampropeltis triangulum


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:
a) Iguanas have the mandibles transformed into a beak.
b) Reptiles have to lay the eggs into the water.
c) Reptiles and amphibians are tetrapods.
d) Usually there are five digits in the forelimb of an amphibian.
e) The larva of the lizards is called tadpole.
f) Crocodiles can lose their tails if they feel in danger.
g) 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?		

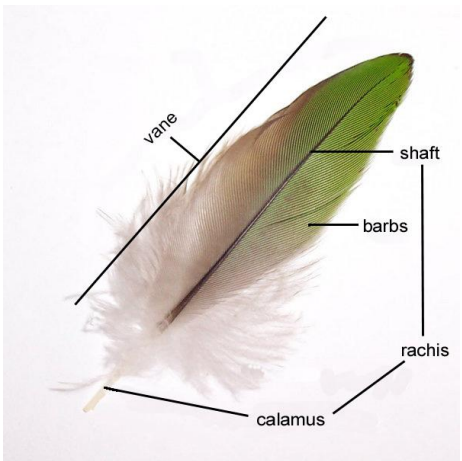
Activity 177.
Write the name of the group of reptiles to which the following animals belong:
a) American alligator b) sea iguana c) gecko d) cobra e) black mamba f) red ears tortoise g) Gila monster

Activity 178.
Write the group of reptiles that best fits to each sentence.
a) Legless animals with dangerous fangs.
b) They have a hard carapace to hide from their predators.
c) With overlapping scales and a forked tongue.
d) They are famous because they can change the color of their bodies.
e) They can sacrifice their tail to escape their predators.
f) Some species are carnivorous and others are herbivorous and they can live for 150 years.
g) The females take care of the hatchlings.
h) 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.

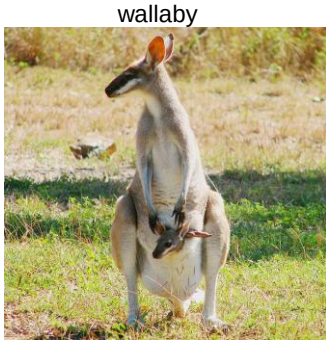
Koalas are very well known marsupials. (Don't they look adorable?)

Young kangaroos are called "joeys". 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) A few of species live in America.
b) Females produce milk.
c) The young hatch from eggs.
d) Females have a pouch where newborns stay for a long time.
e) Females have no nipples.
f) They feed on ants or are aquatic.
g) 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 CO_2 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.

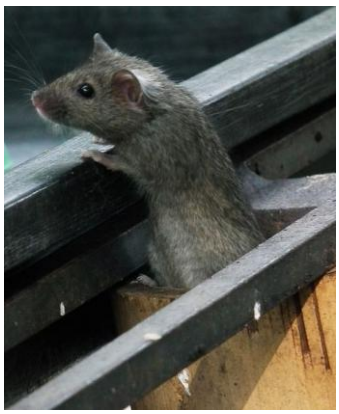

Southern short-tailed shrew


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

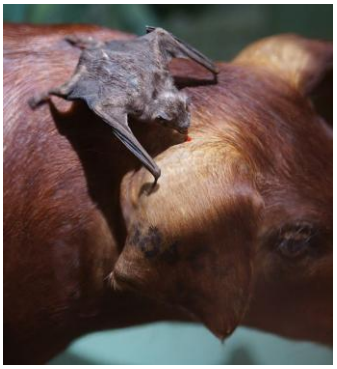
Arctic hare

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*)

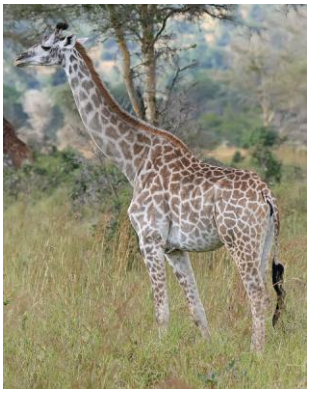
Brown bear (*Ursus arctos*)

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



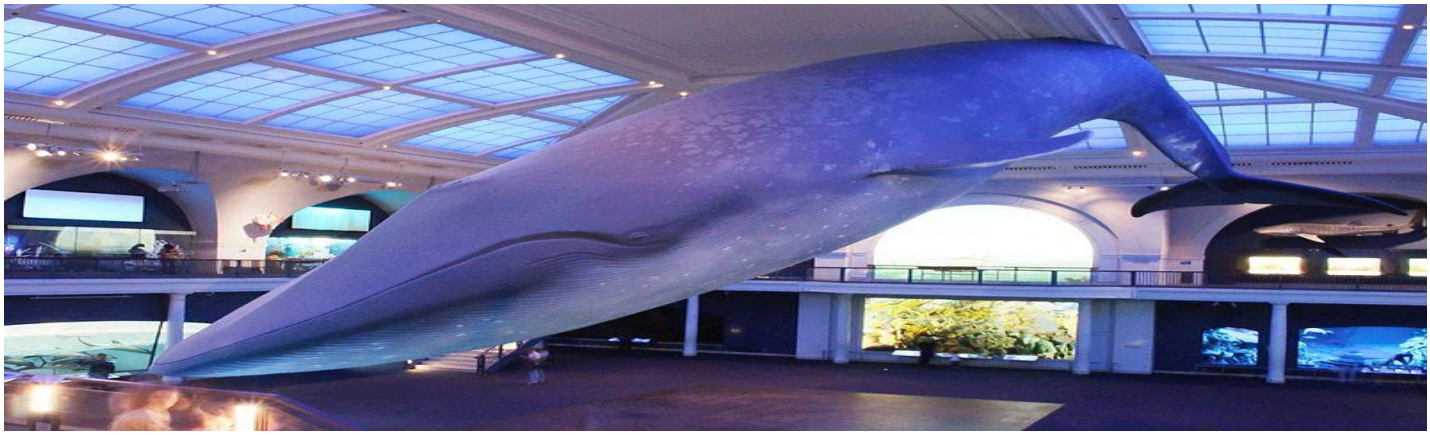
Giraffes are the tallest living mammals

- ***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 thumps 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 thumps 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

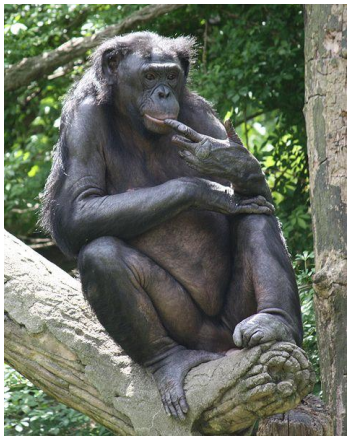
Proboscis monkey

These are the living apes more closely related to humans:

Pongo pygmaeus

Gorilla beringei

Pan troglodytes

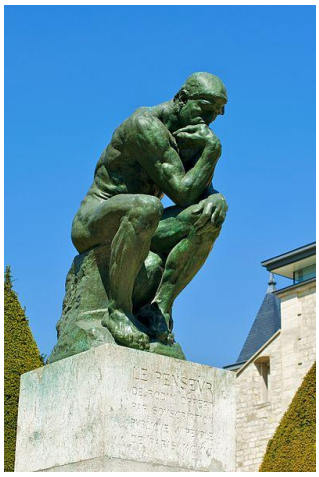


Pan paniscus

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”.

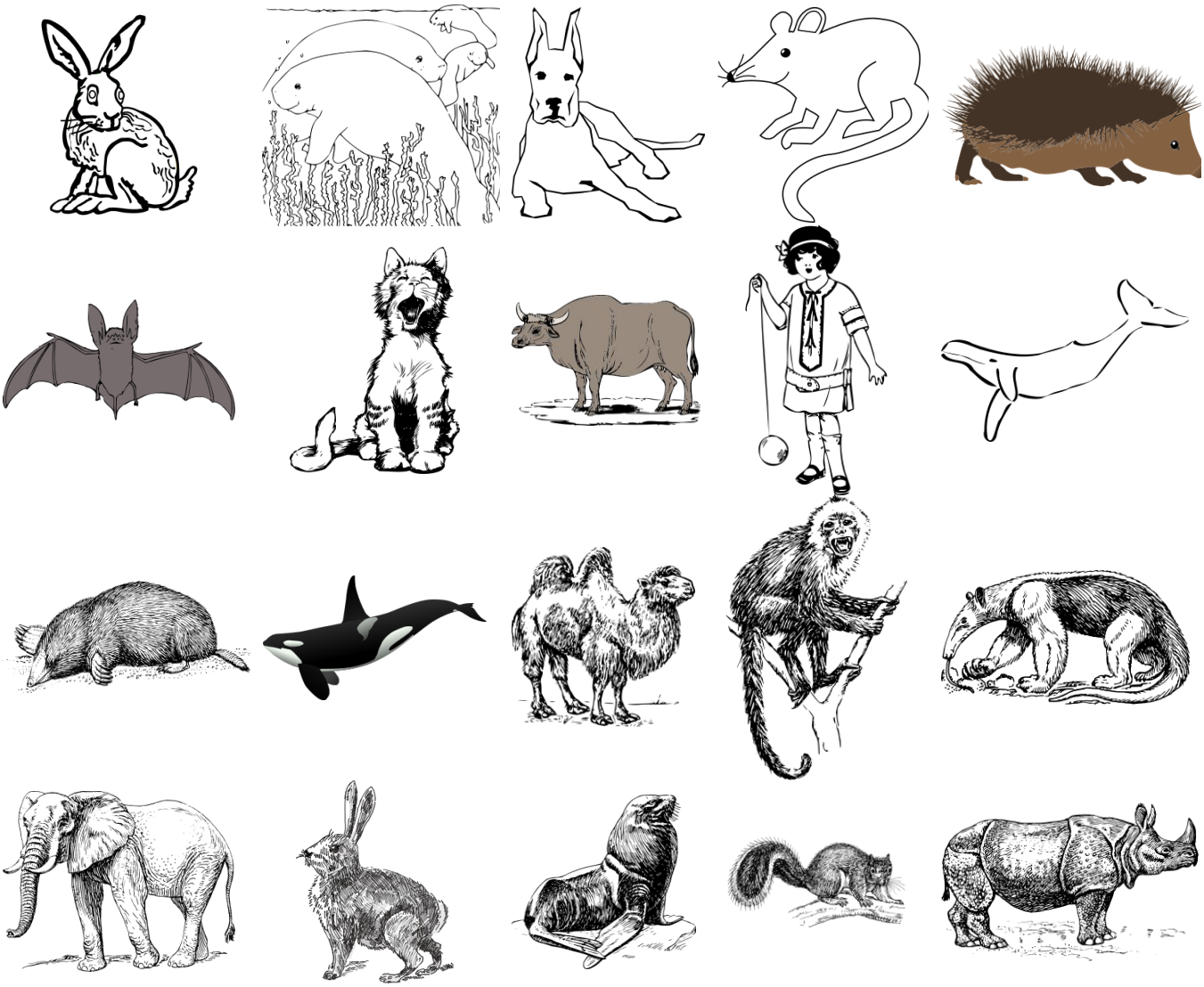
Activity 207.
Mate the two columns:

● Monotremes	● Uterus
● Marsupials	● Leathery egg
● Placental mammal	● Pouch

Activity 208.
Write the group of mammal that best fits with every sentence:
a) They are big herbivores and can live in swamps and rivers.
b) Their fore limps are transformed into wings.
c) Although they have a nose they use a different orifice to breath.
d) They move jumping with only two legs.
e) They have opposable thumps.
f) They are the largest living terrestrial animals.
g) They have hard pads covering the toes.
h) They have only one set of incisors in the upper jaw.
i) They lay eggs.
j) They are toothless and feed on ants.
k) 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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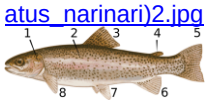

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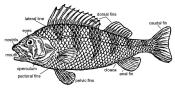
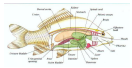
 By johnny_automatic. From https://openclipart.org/detail/7099/scaly-fish.

 "Internal organs of a fish" by Sharon High School - Source. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Internal_organs_of_a_fish.jpg#/media/File:Internal_organs_of_a_fish.jpg

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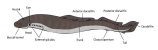 "Lamprey anatomy" by LadyofHats - →This file has been extracted from another file: Lamprey illustration side.png.. Licensed under CC0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Lamprey_anatomy.png#/media/File:Lamprey_anatomy.png

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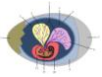
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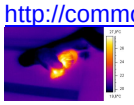
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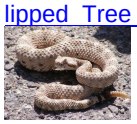
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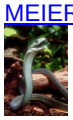
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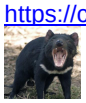 "Tasdevil large" by Wayne McLean (jgritz) Taken with Nikon D100. - Treball propi. Licensed under CC BY-SA 2.5 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Tasdevil_large.jpg#/media/File:Tasdevil_large.jpg

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