

# Amphibians

**Amphibians**



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transition onto land but dont solve it

- need to waterproof the respiratory surfaces so that they dont dry out
- need to be able to support their bodies against gravity because no longer in buoyant water
- mating, need to transfer sperm and have eggs develop so that they dont dry out on terrestrial

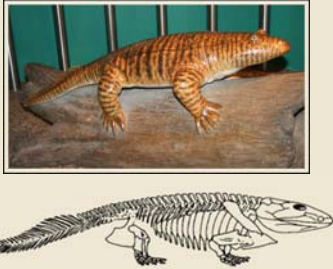
environment

- first animals that descend from lobe finned fish
- can only live on land in moist environments
- reptiles will fully figure out the problem and be able to live on land

-3 main groups

- salamanders
- snakes
- frogs and toads

**Ichthyostega**



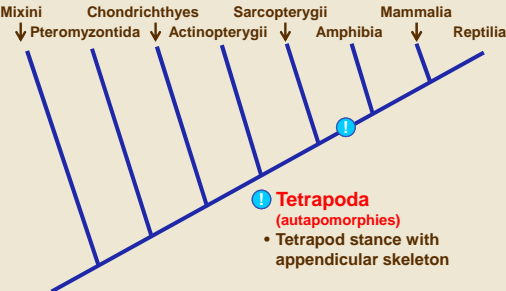
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first amphibian, looks very different to what is present now

**Vertebrate phylogeny**



Mixini Chondrichthyes Sarcopterygii Amphibia Mammalia Reptilia

↓ Pteromyzontida ↓ Actinopterygii

1 **Tetrapoda**  
(autapomorphies)  
• Tetrapod stance with appendicular skeleton

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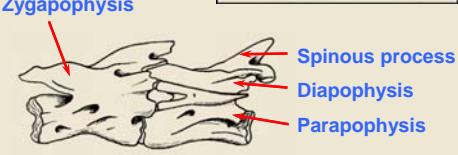
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have four legs - two pairs of appendages - tetrapods

- have a skeleton that includes the appendages (pectoral and pelvic) are use to lift the animal off the ground and used for locomotion

# Amphibians

## Vertebrae

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appendages are attached to the vertebral skeleton/axial skeleton  
 -if you push on the disks under gravitation, disk are going to slip passed each other  
 - get a major modification of the spinal column with overlapping bones  
 -zygapophysis, diapophysis, parapophysis  
 -take the vertebrae with disk to a vertebrae with overlapping structures that reinforce the vertebral column, giving rigidity

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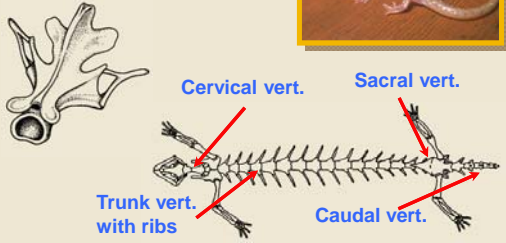
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## Skeletal support

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there will be changes with the vertebrae depending on where they are located  
 always a set of vertebrae between the first set of appendages and the head  
 -cervical vertebrae - create the mobility of the head  
 -vertebrae associated with the tail  
 -in between associated with the trunk - ribs or not  
 the most special, attach the two sets of limbs to the body

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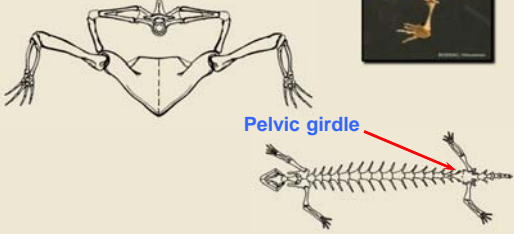
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## Axial skeleton

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pelvic girdle  
 have the axial skeleton with extensions coming off of the sides down to the limbs  
 have a bony plate underneath to help support the internal organs  
 and have to limbs that stick out to the side

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# Amphibians

**Axial skeleton**

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same at the anterior side

-morphology of the first amphibian - when it rests, has its stomach lying down on the ground

-has its limbs sticking out to the side, going to do a push up and start to move

-not effective because have to use part of the muscle to lift the body off of the ground

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**Walking and respiration**

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movement comes from the ancestor

-amphibians are going to push off of the ground and used undulations like the swimming lung fish

-whole body undulates - amphibians are going to use their limbs to create undulations that go down the back as it moves each limb forward

-end up with unique form of movement on land

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when up on land and there is a pair of lungs - when one appendage is swung forward and the other goes back, the body wall is going to be compressed on one side and the lung will not be available for respiration/air will be squeezed out

lateral movement causes problems for respiration

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**Tetrapod stance**

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|---|---|
| <ul style="list-style-type: none"> <li>• <b>Pectoral girdle</b></li> <li>- Joints:             <ul style="list-style-type: none"> <li>• Shoulder</li> <li>• Elbow</li> <li>• Wrist</li> </ul> </li> <li>- Bones             <ul style="list-style-type: none"> <li>• Humerus</li> <li>• Radius</li> <li>• Ulna</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>• <b>Pelvic girdle</b></li> <li>- Joints             <ul style="list-style-type: none"> <li>• Hip</li> <li>• Knee</li> <li>• Ankle</li> </ul> </li> <li>- Bones             <ul style="list-style-type: none"> <li>• Femur</li> <li>• Fibula</li> <li>• Tibia</li> </ul> </li> </ul> |
|---|---|

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give bone structure for the tetrapods that are going to come, always going to be the same

made up of a single large bone, a set of paired bones, a set of small articulating bones with a set of phalanges (came from the lobed fin)

-also have articulation of the shoulder, hip, elbow, knee, wrist, ankle - all the same

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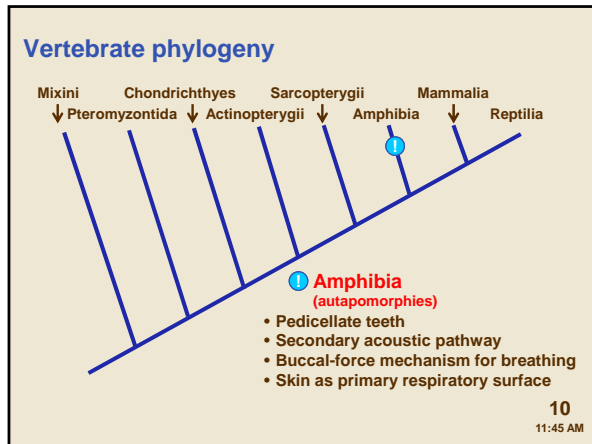
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# Amphibians



tetrapods/amphibian characteristics

amphibians give a solution to the drying out of land - water quality was declining (low in oxygen, drying out) and so water organism were threatened - lung fish were able to leave water to find better environment or were able to lift themselves up to breath fresh air

animals that are half adapted to life on land - will be fully completely when we get to mammals

4 characteristics that define amphibians

-teeth on the jaw - able to identify new organism from jaw

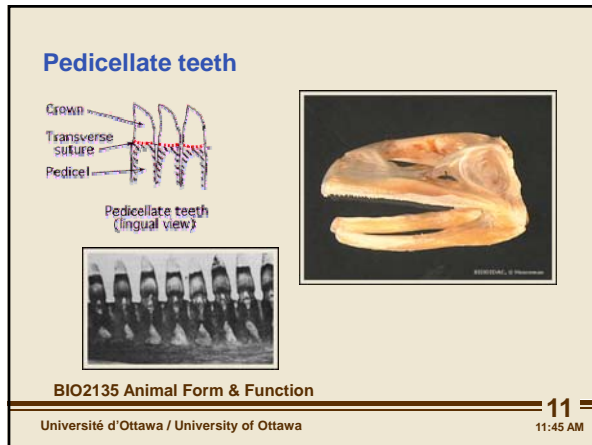
-pedicellate teeth

-skin is still main respiratory system

-eventually get lung that will be linked with the skin

-filling their lungs

-head is going to create a secondary acoustic pathway, where sound is going to be detected by vibration on the ear and other parts of the body

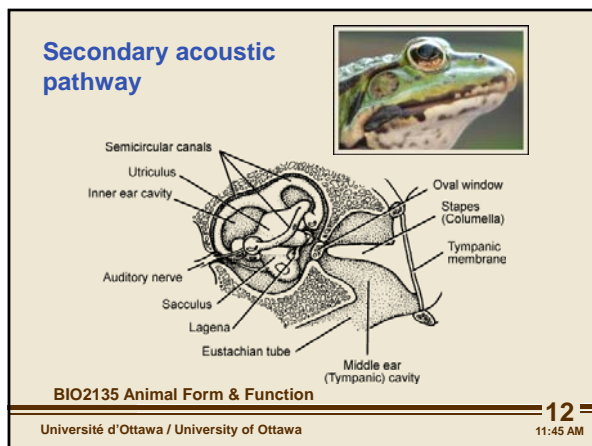


pedicellate teeth - all the way around the jaw, not modified into different types

-teeth have a constriction in diameter

-have tooth, then constriction, and the rest of the tooth in the jaw

-have a change in diameter in tooth as it goes into the jaw



associated with the skulls have secondary acoustic pathway

first amphibians - when on land would have stomachs on the ground - pick up low frequency vibrations from the ground by the jaw bone

-good for escaping approaching predators

over time the bone that is located between the branches of the jaw - the hyomandibular bone normally associated with the tongue - make a connection to the skull

-now attached to the pectoral girdle - the forelimbs - bone is continuous from the pectoral girdle (the foot that is on the group) into the skull to the structure of the ear - known as the stapes/columella

-timpanum vibrates the sensory structure within the ear to detect sound

-the new connection from the foot to the stapes lets the frog pick up low frequencies vibrations that are coming through the soil


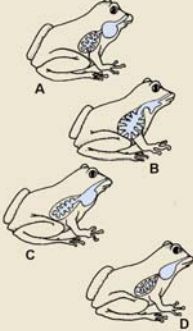
-able to pick up sound from the outer ear by regular air vibrations (medium to high) and the low vibrations from the foot (ultrasound)

-dual auditory pathway

frogs are sensitive to sound - communicate with others by making sounds

# Amphibians

**Buccal force mechanism of respiration**

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lung fish inflate their lungs by expanding their body wall  
 amphibians will use buccal force to fill their lungs  
 amphibian takes in air through the nostril into the expanded mouth cavity, closes its nostril and pushed the air into its lung by positive pressure  
 -to exhale, clamps down on the musculature of the lung -when it contract it will push the air back out  
 dont have complex ribs to hold their body, depend on the musculature of the body to hold them up  
 rest of the groups are going to take air in by negative pressure (suck it in by moving the rib cage out or moving the diaphragm down)  
 main respiratory system is still the skin

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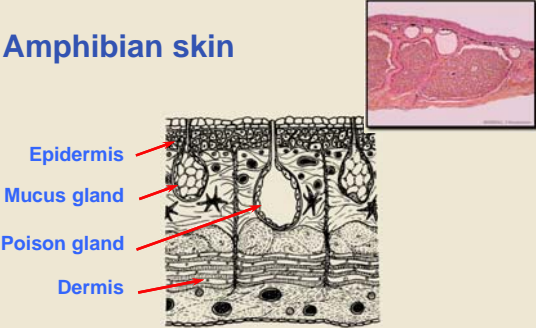
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**Amphibian skin**



Epidermis

Mucus gland

Poison gland

Dermis

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skin always have to be moist for gas exchange to occur  
 -diapsides and reptiles will have rigid skin - more keratin  
 have mucus glands all over the surface that are constantly creating a liquid to keep skin moist  
 toads have highly keratinized skin as they spend most of their time on land and use they lungs for respiration  
 -lose the protective scales - where is a predator came to chomp down on the fish, scales would take the force and distribute it across the body and decrease the crushing  
 -now have poison glands/granular glands that will secreted poison to the outside as a protective system  
 -predator will spit the frog out before it gets bitten

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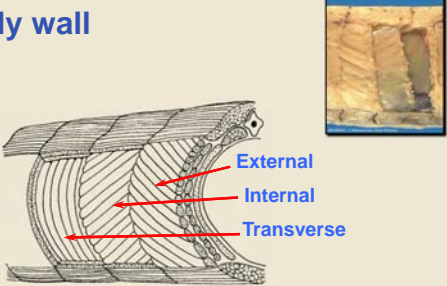
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**Body wall**



External

Internal

Transverse

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no ribs associated with the body wall  
 viscera held in place by a series of 3 layers of muscle that contract together and hold everything in place

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# Amphibians

## Skeletal support

**Urostyle**

**Sternum**

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highly adaptive lifestyle of jumping

-escape from predation - jump out of the water on to land, or if on land, they could just jump in water

-major modifications

-vertebrates of tail - modify two rod like structures

-make urostyle to transfer forces made from the jumping leg to the axial skeleton an turn it into lift

-sternum hold viscera intact as it jumps so body wall and viscera isnt dragged along

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## Hind limb

**Urostyle**

**Ilium**

**Metatarsals**

**Phalanges**

**Femer**

**Tibiofibula**

**Tarsus calcaneum**

**Tarsus astragalus**

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highly modified hind leg- multiple set of levers

a normal leg would have the axial skeleton, with the femur, the tibiotarsus and the phalanges have another bend so that leg can extend longer and jump higher

-femur and tibiofibula fused together get two long joints and a second set of bones that were originally the wrist bones form another extension, on top of that the tarsal bones and phalanges are extended and lengthened- so that foot is flat and has more surface area - results in more energy that can be distributed and a jump higher

anterior appendages are also modified in a similar way to absorb the shock in the landing when they swim - dont have lateral motion except for climbing - swim with synchronized motion of the hind legs- kick both legs at the same time -the extra bend and big phalanges with webbing - powerful swimmer

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## Lingual flip

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the movement of the bone to the secondary systems changes the nature of the tongues and how it works in the group

tongue is hinged at the front

-when lung fish moved on land, they were feeding on insect that were on land

-hinging of the mouth allowed the tongue to shoot out that was stick to capture prey

can shoot out their tongue to grab the food (lingual flip)

-eye help with swallowing, push down on the food

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# Amphibians

## Amphibian heart

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amphibian have lungs but depending on the type, they spend a lot of time in water or a lot of time on land have a circulatory system that accommodate either of the two environments have 3 chamber heart - have two circuits for lung and for body combine with the main gas exchange in water - is the skin -underwater, no point to send blood to lung -on land want to send blood to the lung for gas exchange to occur

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## Heart

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ventricle is only one chamber- spongy material so when it contracts it can make two pseudo-chamber (happens more often on land) inside the heart have a conus arteriosus which has a spiral valve that decides where blood will go - to lungs or out to the systemic circulation when blood comes from the lung - pulmonary vein move blood into the sinus venosus to the ventricle, and back up On land - when blood goes back to sinus venosus - blood moves up to the conus, and spiral valve position itself to block the blood to go to the systemic circuit so the only place the blood will move to is the pulmonary circuit to the lungs, when blood comes from the lungs through the pulmonary vein, the blood goes to the sinus venosus to the ventricle and the spiral valve will switch positions to send it to the systemic circuit -blood switches back and forth between systemic and pulmonary when it is on land (which four chamber heart, there is a division in the ventricle heart so that blood will be sent to both systems) when animal is underwater -spiral valve will block the blood from going to the lung and blood will only travel to the systemic system systemic (backwards) and carotid (forward) or goes to the lungs (pulmocutaneous) no blood leaves the ventricles and goes of the pulmocutaneous (blood that goes to the lungs and the to the skins) - always runs systemically (not as efficient but still works)

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## Circulatory system (frog)

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see reduction in aortic arches in the group - salamander

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# Amphibians

## Arterial circulation

Labels: Conus arteriosus, Systemic arch, Coelic and mesenteric, Dorsal aorta, Iliac, Carotid, Subclavian, Cutaneous, Pulmonary, Gonadal, Renals.

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had a reduction in the aortic arches - only 2 arches  
 arch 6 goes to the lungs  
 arch 4 delivers blood to the rest of the body  
 conus is where switching is being done - carotids take the blood forward  
 subclavian to the pectorals  
 iliac for the back legs  
 have a circuit that supply blood to the coelic and mesenteries, gonads and kidneys all branching from dorsal artery

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## Venous circulation

Labels: Hepatic portal, Ventral abdominal, Mesonephros, Iliac, Anterior vena cava, External jugular, Internal jugular, Subclavian, Cutaneous, Hepatic, Renal portal, Posterior vena cava.

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venous system - jugulars bringing blood back, joining the posterior vena cava - make the sinus venous structures are the same as before  
 end up with one ventral abdominal vein to bring all the blood back

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## Male urogenital system

Labels: Fat body, Testis, Adrenal gland, Mesonephros, Archinephric duct, Rectum, Urinary bladder, Cloaca.

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archinephric duct that picked up the filtrate from the metanephridia/nephrose and secreted it to the outside in male, gonadal tissue - trap sperm  
 funnel capture urine from the nephron and funnel for sperm

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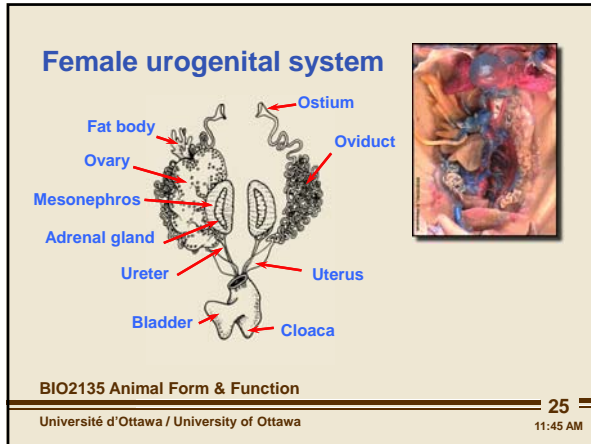
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# Amphibians



get a separation between urinary and reproductive tract

have dedicated duct to bring eggs to the outside

ovary releases a gamete the funnel that gets passed down the duct to the outside - ostium release the gametes to the coelomic space, co-opt an excretory funnel and there is a pathway that goes to the outside

oviduct will carry the gametes and there is a separate duct for the urine  
eggs and urine are released through a cloaca

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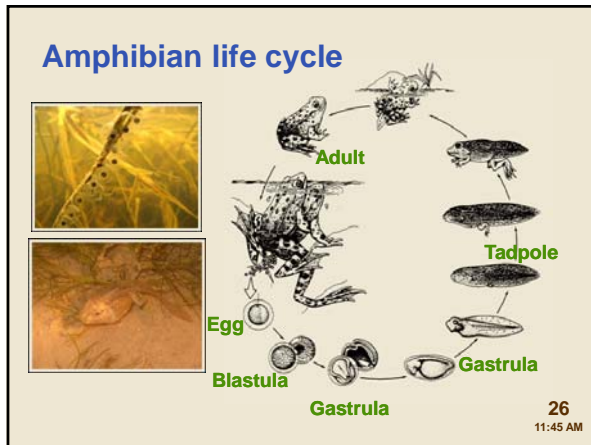
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amphibians must return to water to breed - have to lay their eggs in water

tadpole- specialized filter feeder - similar to chordates (collecting food in pharyngeal basket)

then when times comes - undergoes metamorphosis, grows its legs and loses the tail to become adult

solved issue of water- dont have to go to free-standing water

-female, after they mate- can climb up to canopy to deposit eggs for tadpoles to be hatched there  
mosquitoes for them to feed

if sterile, mom will climb up everyday to deposit unfertilized eggs for them to feed  
or water blister on their back or incubated them in their mouth, or shallow them to go into the stomach (get signal to stop producing acid so the fluids in the stomach would incubate the eggs- gastric pregnancy)

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