

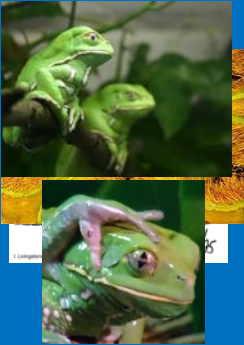
Amphibian Physiology

Lecture Road Map

- Amphibian organ systems
 - Function of systems
- Physiological adaptations

Integumentary system

- Amphibian Integument
- Epidermis-single or few layers of Epidermis-keratinized cells
 - Aquatic amphibians-no keratinized cells
- Extremely permeable Absorb water directly from environment
- Dermis-chromatophores and glands produce secretions which help protect the amphibian's skin



Vision

- Lacrimal and harderian glands present in most amphibians
- Produce secretions that combine to form the tear film
- Eyes protected by nictitactin membranes
- Caecilians-eyes covered with skin
- Amphibian eyes-often protrude ventrally into the oral cavity when animal swallowing



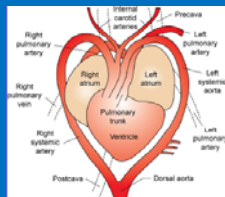
Circulatory system

- Double circulatory system
- Heart is not always completely separated into two pumps.
- Three-chambered heart.



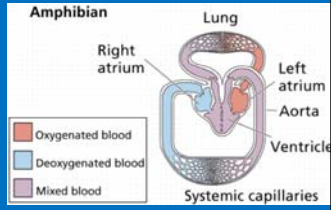
Heart

- Two atria
- One ventricle



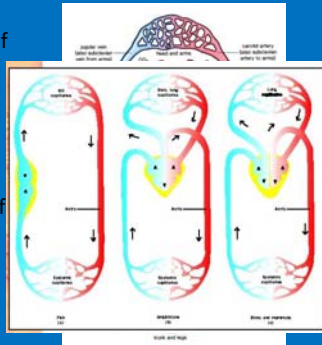
Heart

- Ventricle Regions
- Cavum venosum: paired aortic arches, lead to aortic circulation
- Cavum arteriosum: receives blood from pulmonary veins and directs oxygenated blood to cavum venosum
- Cavum pulmonale: receives blood from right atrium and directs into pulmonary circulation



Heart

- Pressure differences of out flow tracts and muscular ridge that partially separates cavum venosum and cavum pulmonale maintain separation of oxygenated and deoxygenated blood





Heart rate

- Depends on species, size, temperature, activity level, and metabolic function
- Heart rate = $33.4 \times (\text{Weight in kg} - 0.25)$



Hibernation



- Go dormant during the winter
- Slow metabolism
- Decrease respiration
- In ponds
- Swim to the bottoms and rest on the bottom or partially burrow into the mud.
- must be deep enough that they will not be frozen into solid ice,
- water must have an adequate amount of oxygen.
- Many species can survive underwater for months, their bodies very slowly burning fat stored in their bodies.



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Hibernation

- Dig below the frost line to avoid freezing.
- Salamanders use abandoned burrows or other natural holes.
- Some frogs in the far north can actually freeze solid.
- Reduce water in their bodies (more than half), its veins fill with an antifreeze-like mixture of sugars and sugar alcohols, and freezes.
- While it's frozen, it's hard, and ice forms around the frog's organs. However, the frog's individual cells remain unfrozen and intact.
- When frozen doesn't breathe nor does its heart beat. Brain activity is immeasurable.



Aestivation

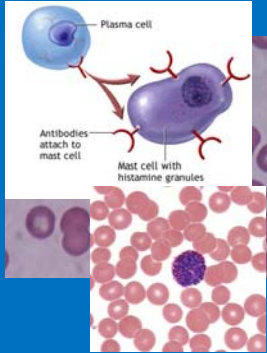
- Hot, dry weather
- Move underground where it is cooler and more humid.
- During estivation breathing, heart rate, and metabolic processes such as digestion all dramatically slow down.
- Decreases the organism's need for water.
- Some frogs and salamanders form a mucus cocoon around themselves to prevent water loss through their skin.
- When rains return, estivating organisms become active again



LISTEN MATE, I PLAN TO BE IN SHAPE AFTER SIX MORE MONTHS OF AESTIVATING

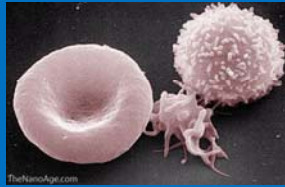
Immune system

- Heterophils: round with eosinophilic rod-shaped granules and round to oval nuclei
 - Analogous to mammalian neutrophils
 - First responders (Bacteria)
- Eosinophils: similar appearance to heterophils but granules are round (parasites)
- Basophils: small round cells with deeply basophilic cytoplasmic granules that may obscure the nucleus (Histamine)



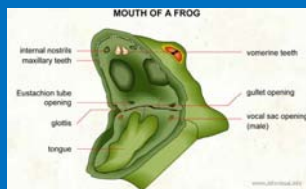
Immune system

- Lymphocytes: vary in size; no cytoplasmic granules
- Monocytes: may contain small vacuoles or very fine granules
- Thrombocytes: may contain small granules



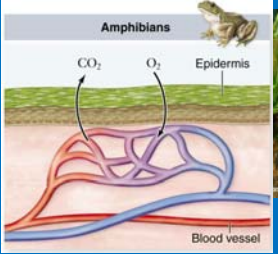
Respiratory system

- Frogs and toads-vocal sacs arise from trachea
- Honey comb appearance
- Openings of honey comb end at faveoli
 - Fixed structures surrounded by capillaries
 - Site of gas exchange



Respiratory system

- Simple saclike lungs
- Some salamanders have no lungs
 - Cutaneous respiration
- Pulmonary ventilation results from pumping of buccal cavity and pharynx
- Gas exchange can also occur across mucous membranes of buccal cavity, pharynx, and cloaca

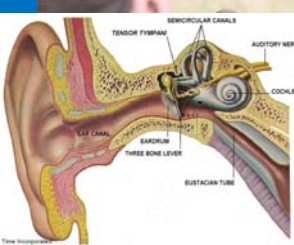


The diagram shows a cross-section of an amphibian's skin and internal organs. Arrows indicate CO₂ leaving the body through the skin (cutaneous respiration) and O₂ entering through the skin. Below the skin, a network of blood vessels is shown, with a label 'Blood vessel' at the bottom. A small frog is shown in the top right corner. The text 'Amphibians' is at the top, and 'Telmatobius culeus' is at the bottom.

[Video](#)

Hearing

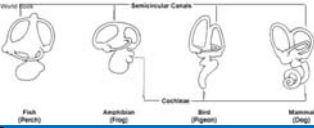
- Ears- both sides of head
- Tympanum- may lie in depression and/or be covered by folds of skin
- Columella- single bone in middle ear Connects to tympanum and quadrate bone Transmits vibrations to oval window of cochlea
- Converted to nerve impulses and transmitted to the brain via the vestibulocochlear nerve



The diagram shows a human ear with various parts labeled: EAR CANAL, TYMPANIC MEMBRANE, MALLEUS, INCUS, STAPES, THREE BONE LEVER, SEMICIRCULAR CANALS, COCHLEA, AUDITORY NERVE, and EUSTACIAN TUBE.

Hearing

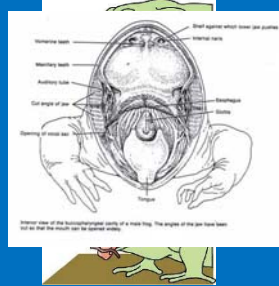
- Semicircular canals control balance and equilibrium
- Salamanders and caecilians- no tympanic membranes; columella may be degenerate



The diagram shows the evolution of the inner ear. From left to right: Fish (fish), Amphibian (frog), Reptile (lizard), Bird (pigeon), and Mammal (dog). Labels include 'Semicircular Canals' and 'Mammal (dog)'.

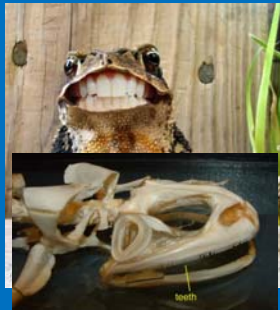
Digestive system

- Tongue used to capture prey
- lingual flipping
- Numerous salivary glands
- Salivary secretions provide lubrication that aids in ingestion of large prey
 - Also has enzymatic properties



Dentition

- Most amphibians have teeth
- Caecilians and salamanders-both maxillary and mandibular teeth
 - Palatal teeth in some species
- Maxillary dentition present in some anuran species



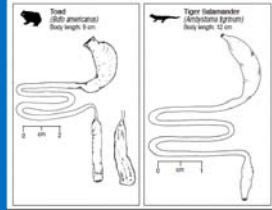
Larvae

- Very specialized
- Most lack a stomach
- The gastric region of the digestive tract usually forms a thickened sheath, which produces mucus, a proteolytic cathepsin, and a low pH
- The intestine is relatively long, with no distinct separation into a midgut and hindgut.



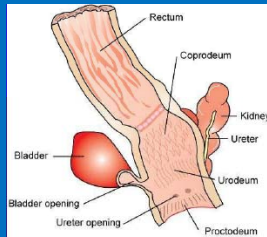
Digestive system

- shortening of the intestine, removal and regeneration of intestinal epithelium, and the appearance of a distinct hindgut that is lined with columnar epithelium and goblet cells
- Esophagus very short and wide, especially in anurans



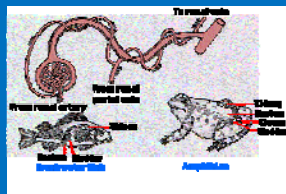
Cloaca

- Common out flow tract for GI and urogenital tracts
- Three chambers: coprodeum, urodeum and proctodeum

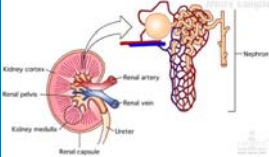


Kidney

- Excreting excess water
- The permeable skin allows fresh water to enter by osmosis.
- The problem is to conserve water, not eliminate it.
- adjust rate of filtration at the glomerulus
- When blood flow through the glomerulus is restricted, a renal portal system is present to carry away materials reabsorbed through the tubules.

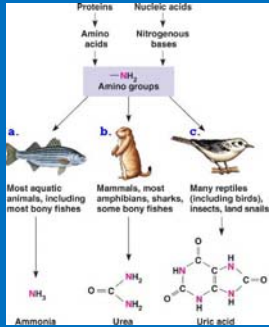


- Able to use its urinary bladder to aid water conservation.
- When in water, the frog's bladder quickly fills up with a hypotonic urine.
- On land, this water is reabsorbed into the blood helping to replace water lost through evaporation through the skin.
- The reabsorption is controlled by a hormone similar to mammalian ADH.



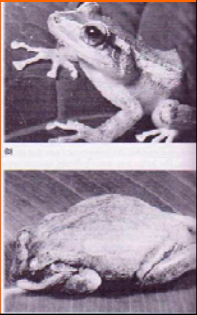
Kidney

- Some amphibians excrete ammonia as a nitrogenous waste product; others excrete urea, some excrete uric acid
- No ability to concentrate urine



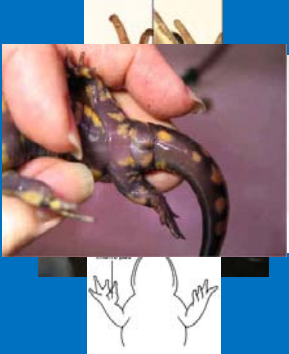
Controlling water loss

- Terrestrial and arboreal frogs have less permeable skin.
 - Some tree frogs spread lipids on skin.
- During dry periods, tree frogs minimize surface area exposed to air.
- All water acquired via skin (no drinking)
 - **water patch:** area of highly vascularized pelvic skin used to absorb water.
- Store water in bladder and reabsorb it during dry periods.



Reproduction

- Sexual dimorphism in some species
 - Size and color
 - Enlarged toe pads
 - Large tympanic membranes
 - Vocal sacs
 - Prominent cloacal glands in male salamanders



salamanders

– **Spermatophore:** large packet of lipid and sperm used for fertilization in various ways:

- a. Male pushes spermatophore into female's cloaca.
- b. Female picks up spermatophore with cloaca.
- c. Female deposits eggs on spermatophore (external fertilization)





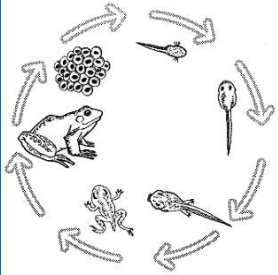
Fig. 10-11

Reproduction

- Paired gonads in dorsocaudal coelomic cavity
- Bidder's organs- ovarian remnants near testes in male toads
- Most caecilians are viviparous
- Most anurans and salamanders are oviparous
- Eggs are usually deposited in or near water




- Larval anurans (tadpoles) have completely aquatic lives prior to metamorphosis
- Tadpole metamorphosis-varies among species
 - Metamorphosis is stimulated by thyroid hormones



Anuran Metamorphosis

Stages: regulated by **thyroxine** released from thyroid.

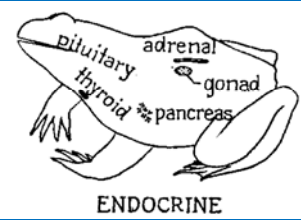
1. **Premetamorphosis:** tadpoles increase in size.
2. **Prometamorphosis:** hind legs appear; slower growth.
3. **Metomorphic climax:** forelegs appear and tail regresses; rapid portion of metamorphosis (when frog is most vulnerable).



[Video](#)

Endocrine system

- Single thyroid gland
- Size of thyroid gland varies according to season and metabolic state
- Parathyroid glands and ultimobranchial bodies in cervical region
- Exact location of endocrine organs in amphibians varies



ENDOCRINE

Nervous system

- Brain-well developed for basic functions (sight, olfaction, and movement)
- 10 cranial nerves
- Spinal cord extends to the tip of the tail in salamanders and caecilians; ends in lumbar region in frogs and toads
- Animal dependent upon spinal segmental reflexes to control movement

