Reptile Anatomy (cont.)

Muscular system:

We find intercostal muscles - muscles that move ribs.

Important in breathing (except in turtles)

Move rib cage up and down to pull air into lungs.

Reptiles do not have a diaphragm (some question as to whether or not other muscles assist with breathing)

These muscles are also important for locomotion in snakes.

Gliding lizards (Draco) can flare their ribs to allow them to glide.

Gliding snakes (several genera) can prey on gliding lizards and can also extend their ribs.

Turtles use muscles near shell opening to help expand lungs:

oblique abdominus and transverse abdominus (see amphibians).

Some turtles get help from other sources:

Softshells can pick up up to 70% of their oxygen through their shell.

Rheodytes in Australia as a highly vascularized cloaca and uses “cloacal breathing”.

(Some other turtles use this when hibernating).

Neck muscles are better developed.

Limb muscles are also much better developed than in amphibians.

Digestive system:

Most reptiles are opportunistic feeders - eat whatever they find.

Mouth:

Have several oral glands, much better than in amphibians

Saliva is produced by a palatine gland (which corresponds to the intermaxillary in amphibians)

Other oral glands to be aware of are supra- and sublabial, super- and sublingual

There is some confusion as to which of these holds venom in venomous snakes:

We know where the venom gland is, but what's confusing in the literature is which of these presumably gave rise to it.

There is also Duvorney's gland, which is known to produce toxic saliva, particularly in colubrids.

Venemous lizards generally deliver venom through their lower jaw

(Just recently there was a report showing that Komodo Dragon saliva is actually venomous (it's not bacteria causing death)).

We'll say more about venom later, but for now it contains toxins that immobilize and digest

Used primarily for prey capture, secondarily for defense.

Venom consists of salivary “juice” and many enzymes and other proteins (enzymes and proteins are what make up the toxins).

Venom glands are surrounded by muscles that can squeeze venom out of the gland.

Tongue in reptiles is attached at the rear.

In snakes and many lizards, the tongue is protusible (particularly well developed in chameleons)

In crocodiles and turtles the tongue is more “conventional”

Crocodiles (and some turtles) have a well developed hard palate.

Some crocodiles can use this to “smash” turtle shells and break them open.

Teeth:

Some definitions:

conodont - tooth is cone shaped.

polyphyodont - several generations of teeth

homodont - all teeth are alike

heterodont - different types of teeth

acrodont - no socket - tooth sits on jawbone

pleurodont - tooth sits on shelf on the inside of jawbone (think of “half a socket”)

thecondont - tooth sits in socket

Crocodiles: homodont, thecodont and conodont

Lizards: mostly homodont, a few heterodont. All three socket placements seen.

Draconia crushes snails and has molar like teeth

Some even have canine like teeth to help capture prey

Turtles - lack teeth

Tuataras: see picture (in class)

Snakes: homodont, pleurodont or thecodont.

Snakes can have grooved teeth:

Aglyphous: “without” groove.

Glyphous: have a groove.

Snake fangs are divided into three broad categories:

Opistoglyphous - rear fanged (some Colubridae)

Proteroglyphous: only in Elapidae:

First teeth are grooved or hollow.

Always erect (sit on maxillary)

Don't swivel.

Other teeth are also found on the maxillary.

Solenoglyphous: found in the Viperidae:

Found on maxillary, but the maxillary can rotate.

Fangs are long and hollow, and can swivel out when injecting venom.

When not in use, sit flat against the roof of the mouth.

Cervical vertebrae projections:

Egg eating snakes have projections off the cervical vertebrae that enter the esophagus and break open eggs as they move past.

Snake will squeeze contents down esophagus and regurgitate leftover egg shell.

Stomach:

Several different muscle layers allow for “churning” of stomach

Differentiated into cardiac and pyloric section (similar to humans).

Crocodiles will swallow rocks to help grind up food in the stomach (like birds)

Joins small intestine via pyloric sphincter.

Small intestine:

Typical, not much different than amphibian.

At junction to large intestine there is a distinct cecum

Larger in herbivorous species to help digest cellulose.

Large intestine:

Transition is more obvious in reptiles (diameter is significantly bigger than that of the small intestine).

As usual, absorbs water.

Digestive tract empties into cloaca and then to the outside.

Liver secretes bile (stored in gall bladder) and serves as temporary nutrient storage - also detoxifies materials.

Pancreas secretes remaining digestive enzymes into duodenum (is more compact in reptiles, though still a bit spread out).

Also secretes insulin/glucagon.

Circulatory system:

Much better in reptiles - have much higher blood pressure.

Trend is obviously towards lung breathing (and thus, development of four chambered heart).

Turtles - 3 chambered - two atria, single ventricle.

Lizards and snakes - incompletely 4 chambered. Blood from pulmonary and systemic circulation still mix in the single ventricle (which does have several divisions or chambers).

Crocodiles have complete four chambered heart.

However, the “right aorta” comes off heart and can pump blood directly back into the body.

This bypasses the lungs during dives.

Blood vessels are generally similar to those found in adult amphibians (you'd recognize most vessels).

What ever happened to those aortic arches?

3rd forms the carotids

4th forms the systemic arches (think aorta)

6th forms the pulmonary arches.

Note that since the embryo isn't using lungs, there is an arrangement (a bit similar to what happens in mammals) that bypasses the lungs in the embryo.

This forms from the pulmonary arches is termed the conus arteriosus.

We won't worry about the precise details.

Blood:

The same basic three types of blood cells as found in amphibians:

Erythrocytes, leucocytes, thrombocytes.

All nucleated. Red blood cells are quite a bit smaller than those in amphibians.

Lymphatic system:

Somewhat similar to that found in salamanders.

Only a single pair of lymph hearts found in the pelvic area.

Assisted by lots of one way valves.

Spleen and thymus found for the first time in reptiles.

Respiratory system:

No major changes:

Air enters through the internal nares, moves to the glottis, larynx (usually simple), trachea, bronchi and then into lungs.

Lungs are more sophisticated and may be subdivided into smaller chambers. Much better oxygen/carbon dioxide exchange.

Have a similar arrangement, though not termed alveoli yet (called “faveoli”).

Some lizards have air sacs that can hold extra air and/or can be used to inflate themselves to make them appear larger.

Excretory system:

Although reptiles can produce a concentrated urine (most produce uric acid), kidneys do not have a loop of Henle.

Osmoregulation is arguably the most important function of kidneys (waste removal is the other).

Most reptiles have a bladder, but some (snakes, limbless lizards) do not.

Some can actually store extra water in the cloaca (desert tortoises):

Use special chambers that come off the cloaca and help store water.

Uric acid (which isn't water soluble) is used by most reptiles.

Some aquatic turtles and crocodiles use urea (or eve ammonia).

Reproductive system:

Most reptiles lay eggs, but just as in amphibians, there are several that have various forms of live birth:

(obviously no metamorphosis)

Eggs:

Are “telolecithal” - large amount of yolk with an embryonic disc on top.

Consist of four membranes:

chorion - waterproofing layer (in addition to actual shell). Lines shell.

yolk sac - provides nutrients during development. This membrane is slowly pulled inside body as development progresses.

Becomes part of digestive tract.

Often still visible in newly hatched young.

allantois - waste storage area (and surprisingly also provides surface for gas exchange).

Amnion - liquid that surrounds embryo (cushions, prevents drying out (dessication), some thermoregulatory functions).

Oviparous:

Most reptiles, particularly Turtles, Crocodilians, tuataras, some snakes and lizards.

Ovoviviparous:

Some lizards and snakes, particularly in cooler climates:

Lacerta vivipara (all over Europe)

European viper (*Vipera berus*)

Viviparous

Some snakes actually provide nutrients to their young:

Thamnophis sirtalis, Nerodia, Virginia.

Some Australian skinks (e.g., *Eulamprus quoyii*, Eastern Water Skink).

Fertilization is always internal and takes place in the upper region of the oviducts.

Males:

Paired testes (even in snakes), epididymus, vas deferens, cloaca (no confusion this time!)

Seminal vessicles (contribute fluid to sperm in humans) exist n some reptiles.

In reptiles seem to function mostly as sperm storage and are found between the vas deferens and cloaca.

Penis:

Rudimentary in tuataras

Erectile penis similar to that found in mammals is found in turtles and crocodilians.

lizards and snakes have a "hemipenis" (bifurcated penis)

This is stored "inside out" in the cloaca when not in use.

Adorned with hooks spikes and fringes (will only fit females of the same species)

Particularly helpful in snakes as there is no real way to grasp the female

Females:

Ovary sacular in lizards and snakes

Solid in Crocodilians and turtles (egg expelled off of a solid surface).

Also have an egg sac - at the end of the oviduct, acts a bit like a uterus.

Females may store sperm in oviducts (particularly in snakes and turtles).

Sperm are fed from lipid glands and can be kept for years.

Diamondback terrapin (*Malaclemmys terrapin*) - has laid viable eggs up to 4 years after last copulation.

Cat eyed snake (*Leptodeira septentrionalis*) - up to 7 years after last copulation.

In general:

Males often produce sperm in the fall.

Females will often ovulate in the spring.

Sexual dimorphism (structural differences between sexes):

Lots of examples exist:

Tails of snakes are often different in size

Males (snakes) may have keeled scales near cloaca

Turtles (males) will have long claws, concave plastron

Lizards (males) with “wart” like structures on thighs

Male *Anolis* have a dewlap.

Sexual dichromatism (color differences between sexes):

Some examples:

Vipers - males silvery black, females more drab

In some turtles and snakes, males will change color during breeding season.

Copulation plugs:

gelatinous plugs that follow sperm - plug up vagina in female and keep other sperm out.

We will discuss other issues related to reproduction a bit later:

Combat dances, parthenogenesis, parental care, etc.

Nervous system.

In general, becomes more like that of mammals than in amphibians.

Increased importance of cerebrum

Brains show beginnings of convolutions and folding.

Neopallium - an area of nerve tissue on dorsal side of cerebrum that eventually develops into the cerebral cortex.

Starts in reptiles. Crocodiles even have a cerebral cortex.

(This doesn't mean (as a general rule) that reptiles are particularly bright!)

Reptiles have 12 cranial nerves (not 10).

The last two correspond to the first two cervical nerves in amphibians

Spinal chord extends to tail (in mammals this isn't the case)

Sense organs:

Cutaneous:

Usual: pressure, touch, temperature, pain, and even tension.

Taste and odor:

Similar to amphibians. Jacobson's organ is well developed.

Snakes and monitor lizards use their tongue to pick up scent and wipe this across the entrance of Jacoboson's organ.

Reptiles also have other sensory nerve endings for smell in the nasal cavity (description in text is very confusing).

Have a similar set of taste buds on their tongues as what is found in amphibians.

Sight:

Usually fairly well developed. Some burrowing species only have rudimentary eyes or eyes covered with scales.

Sclera may be supported by bony plates (scleral ossicles).

Pupils have various different shapes from round to elliptical (a few species actually have a horizontal pupil).

Retina varies, though most species have some type of cones to help with color vision (presumably).

A few snakes (more primitive forms) have only rods.

Eyes have associated structures mentioned first with amphibians:

Harderian glands (oil for eye).

Lacrimal - tear glands

Well developed nictitating membrane.

Some lizards even have transparent upper or lower eyelids (particularly burrowing species).

Phyrnosoma can squirt blood from their eyes as a defensive “startling” mechanism.

Infrared receptors:

In boas & pythons as well as pit vipers, there are receptors that pick up infrared radiation.

These allow the snake to sense endothermic prey.

But also help in navigation and in predator avoidance.

Some studies show they can detect a 0.003 degree difference (Celsius) in temperature.

Basically function in a similar way, but are arranged rather differently:

Boas and pythons: have heat sensitive pits lining their labial scales.

Pit vipers: have “loreal” pits. These receptors create an overlapping field and even gives them stereoscopic infrared vision.

Hearing:

Decent hearing in most reptiles.

Most have a full inner ear system for hearing and balance.

Crocodiles even have a cochlea.

Tympanum connects to middle ear bones:

Mostly consists of an elongated stapes that may articulate with the extracolumella (may be cartilaginous).

Snakes lack many of the ear structures:

Jawbone hooks into quadrate which then hooks into the inner ear.

Can pick up low frequency sounds.

No lateral line system (it's gone!)

Endocrine system:

Essentially similar to that found in amphibians. A few things to note:

Pineal gland/organ can pass through skull in some lizards and tuataras and form a pineal “eye”.

Pancreas (as mentioned) is more compact.