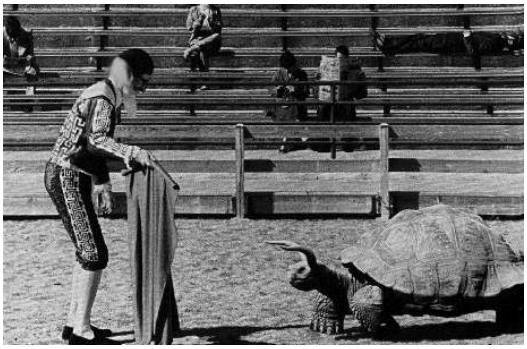
From Slime to Scales: Evolution of Reptiles



Review: Disadvantages of Being an Amphibian

Gelatinous eggs of amphibians cannot survive out of water, so amphibians are limited in terms of the environments in which they can lay their eggs.

Water is needed for the external fertilization that is characteristic of amphibians so, again, amphibians must return to some sort of water body to reproduce.

Amphibians have gas-permeable skin to aid their inefficient lungs in breathing. This skin must be kept moist, so restricted to moist environments !

Major Innovations in Reptiles

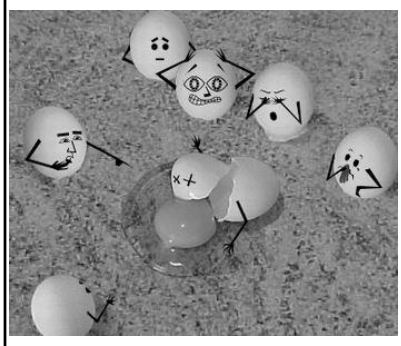
Development of Amniote Egg

Change in Body Covering

Change in Skull Structure

Change in Post-Cranial Skeletal Structure (Sprawling to Upright)

Amniote Egg

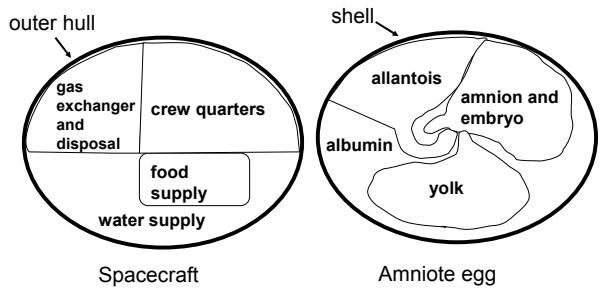


The appearance of the amniote egg was a great leap forward for tetrapods (four-legged, land-dwelling vertebrates).

The amniote egg is certainly not immune to various dangers posed by terrestrial conditions…

…However, the amniote egg provided a greater range of lifestyles that did the eggs of fishes and amphibians.

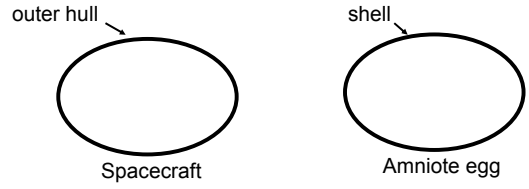
The Amniote Egg: A Spacecraft Prototype ?



Spacecraft Amniote egg

We can view the internal amniote egg as being analogous to a spacecraft.

Outer Hull / Egg Shell



Spacecraft Amniote egg

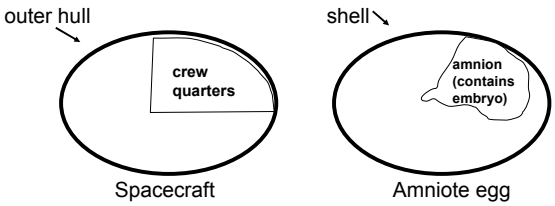
A spacecraft is a closed system, designed to accommodate astronauts.

The outer hull protect astronauts from extreme conditions outside the spacecraft.

An egg shell (made of leathery or hard material) maintains space for embryo. (not needed by amphibian eggs that were surrounded and supported by water).

The shell protects contents of the egg from outside conditions (but, unlike the hull of a spacecraft, is permeable to gases).

Crew Quarters / Amnion



Spacecraft Amniote egg

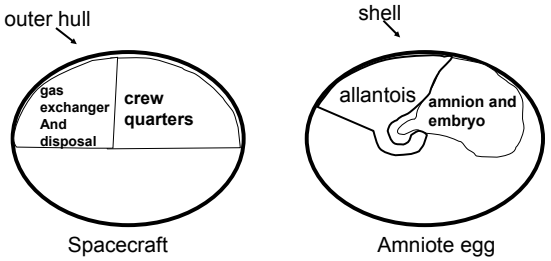
An isolated compartment is required to house the crew (crew quarters)

The crew quarters compartment is filled with a fluid (air) that mimics the composition of Earth's atmosphere

The amnion is a fluid-filled sac in which the embryo floats.

Amniotic fluid (approximating composition of seawater) mimics the conditions that the embryo would require if the egg lacked a tough shell (i.e. aquatic conditions)

Outer Hull / Shell



Spacecraft Amniote egg

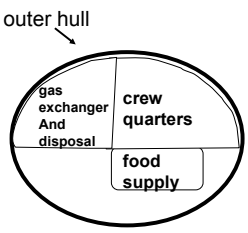
Two important needs in a spacecraft are:

1. A system to regulate gas conditions in the crew quarters.
2. A disposal compartment for waste.

The allantois serves two important functions:

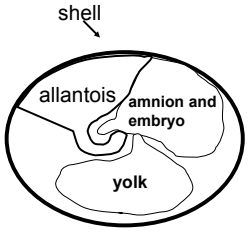
1. To deliver oxygen to the embryo and to take carbon dioxide away.
2. To store excretory products (waste).

Food Supply / Yolk



Spacecraft

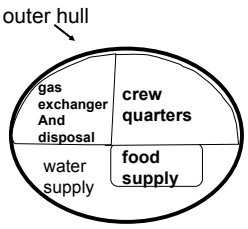
Astronauts need food (this food has to be stored in yet another compartment)



Amniote egg

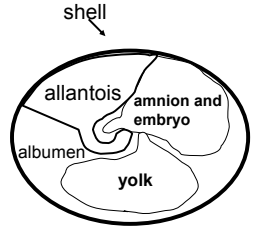
The yolk serves as the embryo's principal food supply.

Water Supply / Albumen



Spacecraft

In addition to food, astronauts also need water. This is stored in yet another compartment.



Amniote egg

The albumen of the egg (the "egg white") serves as the embryo's water supply.

It serves as an effective shock absorber.

Advantages of the Amniote Egg

1. Because amniote eggs were self-contained units, they could be laid on dry land, away from water bodies.

2. Embryos in amniote eggs were less prone to being adversely affected by changing environmental conditions (e.g. drying up of ponds, changing temperature, agitation due to storms and floods, etc.).

Advantages of the Amniote Egg

Frog hatchling (tadpoles)

Alligator hatchling

3. Greater strength of shells allowed animals to lay larger eggs.

This, allowed a longer development period for the baby animal.

Longer development time within the egg meant that babies were better equipped for survival after hatching.

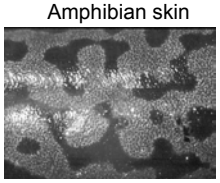
Changes in Skin Texture

Another major modification made in the evolution of reptiles from amphibians was the development of a tough, dry, covering of *keratin* (the same protein is in our hair and nails) on the surface of the skin.

Scales and similar hardened structures on reptilian skin are made of keratin.

The acquisition of a dry, tough skin meant that reptiles were not in constant danger of "drying out" as are the amphibians.

Amphibian skin



Salamander

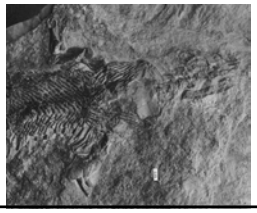
Reptile skin

Snake

Captorhinomorphs: Stem Reptiles

The oldest known reptiles (although not necessarily the first), called captorhinomorphs, appeared in the Carboniferous Period. This group of reptiles is presumed to have been the stem group for all later reptiles, and are therefore called "stem reptiles"

Hylonomus, one of the oldest known captorhinomorphs, has been found in Carboniferous rocks dating to about 315 million years, exposed at Joggins, Nova Scotia . Interestingly, these specimens have been found in sandstone-filled tree trunk casts.

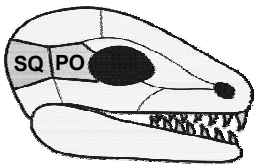


Skull Structure

Now that we have looked at the earliest group of reptiles, we can consider how amniotes (reptiles in a loose sense) are classified.

The basis of amniote classification is the number and arrangement of holes (temporal fenestrae) behind the eye socket in the skull

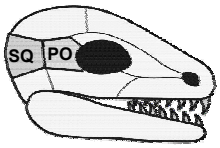
With respect to these fenestrae, the most important bones are the POST-ORBITAL and SQUAMOSAL bones.



PO = post orbital bone

SQ = squamosal bone

Anapsids

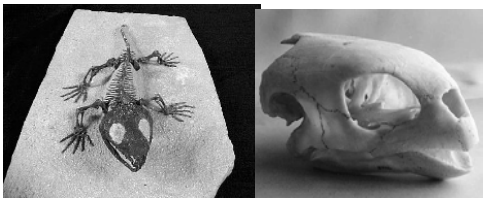


The anapsid condition is characterized by the absence of temporal fenestrae.

It is the most primitive skull type among the amniotes.

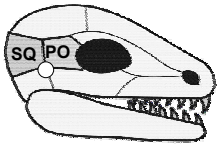
Anapsids

The anapsid group includes the earliest “stem” reptiles (captorhinomorphs) and perhaps the turtles and tortoises (although this is debated).

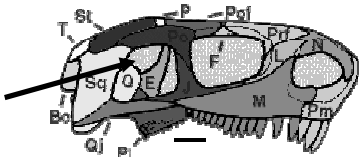


captorhinomorph turtle

Synapsids



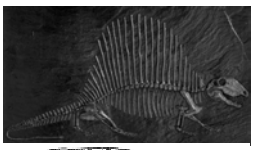
The synapsid condition is characterized by a single opening below the junction of the post orbital and squamosal bones.



Synapsids

The synapsid group includes:

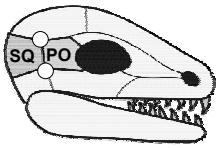
Pelycosaurs
(sail-backed reptiles)



Mammal-like reptiles
(therapsids)

True mammals

Diapsids



The diapsid condition is characterized by two openings – one above and one below the junction of the post orbital and squamosal bones.

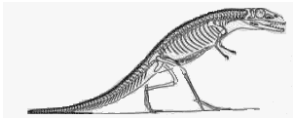
Diapsids

The diapsid group is represented by all of the archosaurs ("ruling reptiles").

The diapsid group includes:

Snakes and lizards

Thecodonts (ancestral group of higher diapsids)



Diapsids

Crocodilians (e.g. crocodiles and alligators)

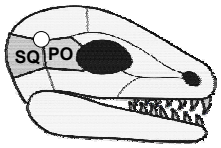
Pterosaurs (flying reptiles)

Diapsids

Dinosaurs

Birds

Euryapsids



The euryapsid condition is characterized by a single opening above the junction of the post orbital and squamosal bones.

Euryapsids

The euryapsid group is represented by extinct "marine reptiles"

Ichthyosaurs

Plesiosaurs

To Summarize:

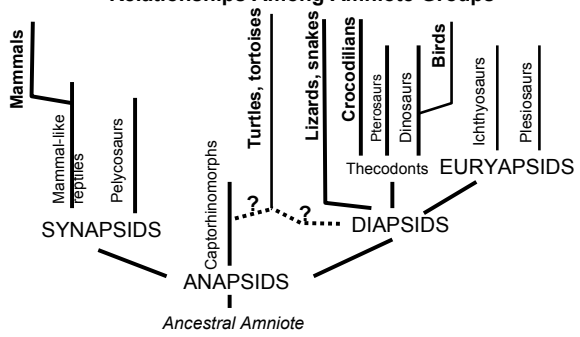
Anapsids:
(no temporal fenestrae)
Turtles/tortoises
Captorhinomorphs

Synapsids:
(one temporal fenestra low in skull)
Pelycosaurs
Mammal-like reptiles
Mammals

Diapsids:
(two temporal fenestrae)
Lizards and snakes
Crocodilians
Pterosaurs
Dinosaurs,
Birds

Euryapsids:
(one temporal fenestra high in skull)
Icthyosaurs
Plesiosaurs

Relationships Among Amniote Groups



This is a ***very*** generalized schematic diagram indicating the relationships among the four major amniote groups (and various important subgroups). Note that a few of these relationships are still being debated.

Limitations of Post-Cranial Skeleton In "Primitive" Amniotes

One setback remaining for primitive reptiles (and a characteristic still retained by present-day lizards) was the sprawling stance imposed by the position of the legs relative to the body.

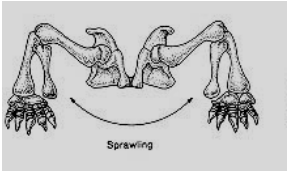
A sprawling stance is fine for reptiles that are active only sporadically (e.g. lizards that ambush prey or escape quickly, but briefly).

Limitations of Post-Cranial Skeleton

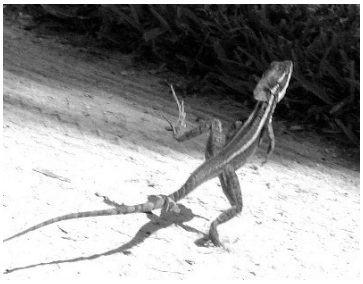
But…the side-to-side motion of the body that accompanies walking deforms the "chest cavity," with each bend and prevents lungs from expanding to their full capacity.

-the animal cannot sustain speed for long periods of time (and the "waddle" wastes a lot of energy)

-lots of stress is imposed on shoulders and hips (because most of the animal's weight is supported at the junction between the limbs and the body).



The problem of weight support would ultimately be solved by members of both the diapsids and synapsids.



END OF LECTURE