

## **Evolution of the Vertebrates**

### **The Cambrian Revolution - The Big Bang of Life**

soft-bodied multicellular animals evolved in the late Precambrian

some of these were primitive ancestors of modern invertebrates such as corals

invertebrate animals with hard skeletal parts (incl. mollusks) evolved about 543 m.y. ago

essentially all of the ancestors of modern animal phyla evolved during the Cambrian period  
plus many forms that became extinct

### **Evolution of Vertebrates - Part I, The Fishes**

vertebrates are phylum chordata, subphylum vertebrata

oldest chordates were pikaia of the middle Cambrian

oldest vertebrate fossils (scales of jawless fish) are from the upper Cambrian

vertebrates have backbone and braincase

jawless fish (agnathans) had cartilage skeletons, some had bony plates on the head

lampreys and hagfish are about the only remaining jawless fish

Placoderms probably evolved in the Silurian (common in Devonian) - now extinct

had jaws but no teeth - jaws modified into tooth-like shapes

cartilage skeletons and bony plates armoring their head

some very large predators

Acanthodians probably evolved by the Silurian - now extinct

cartilage skeletons

more streamlined form than placoderms

probably ancestors of the bony, ray-finned fish

Sharks, rays & skates probably evolved by the Silurian, common in Devonian

cartilage skeletons

produce thousands of enamel covered teeth in their lifetime

sharks, rays, and skates still survive very successfully

Bony Fish - Ray-fins evolved in the Devonian (from acanthodian!?)

bony skeleton

fine bones support fins

ray-fins are the most diverse of all fish

Bony Fish - Lobe fins evolved in the Devonian

bony skeleton

muscular fleshy lobes support finer bones of the fins

the modern coelacanth and a few others still survive

### **Evolution of the Vertebrates - Part II, Invasion of the Land**

problems in adapting to life on the land (support, drying out, reproduction)

first land plants (ferns) and land animals (amphibians) need water for reproduction

age of fossil evidence for first land plants (late Ord. spores) and first land animals ("bugs")

first tetrapods (Late Dev) - evolved from a lineage of lobe-fins

Carboniferous: Age of "Amphibians"

early tetrapods included large land animals, but they had to lay eggs in water

eggs fertilized with sperm swimming to egg; egg would dry out on dry land

first amniotes: Carboniferous

amniotic egg includes a semipermeable membrane: allows gas in/out; keeps water in  
amniotes could colonize dry areas away from water

two major amniote branches:

  sauropsids (2 holes in palate)

  synapsids (holes behind the eye sockets)

Permian drying (Pangea vast interior dry regions & rain shadows plus glaciation (cool/dry)

led to the dominance of seed ferns (the first gymnosperms) and synapsids

gymnosperms ("naked seeds"), such as modern conifers, use airborne fertilization

Permian: Age of the "Reptiles"

dominant "reptiles" were the synapsids (they didn't give rise to any modern reptiles)

early, primitive synapsids: pelycosaurs; later, more advanced synapsids: therapsids

**Permo-Triassic mass extinction** - the biggest known

All together, in two extinction pulses

90-95% of all marine species (80-85% of all marine and terrestrial species)

and 75% of all vertebrate families became extinct by the end of the Permian

cause unclear though may somehow be related to a period of massive volcanism

**Mesozoic Life - Age of the Dinosaurs**

early Triassic low fossil diversity then re-diversification (adaptive radiation)

therapsid (synapsids) remain dominant land animals in Triassic

all therapsids (except mammal lineage) became extinct in the Triassic-Jurassic event

dinosaurs and other sauropsids became dominant after Triassic-Jurassic mass extinction

mass extinction occurred at time of major volcanic activity with early rifting of Pangea

Mesozoic sauropsids included: turtles, crocodiles, lizards, snakes

marine reptiles (ichthyosaurs, plesiosaurs), flying reptiles (pterosaurs)

dinosaurs (evolved Middle Triassic)

dinosaurs (hole in the hip-socket) evolved Middle Triassic

(saurischians="lizard hipped" & ornithischians "bird-hipped")

birds evolved in the Jurassic from some small, saurischian (lizard-hipped), raptor

Archaeopteryx: the oldest bird fossils (Jurassic)

mammals evolved from a branch of the therapsids in the Late Triassic

remained small throughout the Mesozoic

Dinosaurs became extinct at end of Cretaceous (Cretaceous-Tertiary mass extinction)

all except the birds, which had evolved in mid Jurassic from a group of dinosaurs

**Cretaceous-Paleogene (K/P) mass extinction**

killed dinosaurs and many others

evidence for cause: iridium anomaly and glass spherules in K/P boundary sediments, globally

Chixulub crater off Yucatan and tsunami deposits in Caribbean and Gulf Coast,

charcoal in western US

- all above point to meteor impact (not extraordinary volcanism) as cause of extinction

"nuclear winter" scenario (smoke & ash obscures sun, it gets cold, plants die, herbivores die...)

also, a "thermal transient" would have swept around globe with shock wave, baking animals

**Cenozoic - Age of the Mammals**

mammals underwent rapid diversification after the dinosaurs became extinct

success on land, sea (whales), and air (bats)