BIO 111: **Ecology and Evolution**

Varsha 2022

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School of Biology

MODULE: BIODIVERSITY AND CONSERVATION BIOLOGY

Part II – DIVERSIFICATION OF LIFE – A PHYLOGENETIC PERSPECTIVE

http://www.ucmp.berkeley.edu/alllife/threedomains.html
http://tolweb.org/ (Tree of Life Project)

Domains of Life

- Eubacteria (true bacteria)
- Archaea (bacteria-like prokaryotes)
- Eukaryotes (protists, plants, fungi, animals, etc)

5 Kingdom classification (older)

Monera (Bacteria + Archaea)
Protista (single-celled Eukaryotes)
Fungi
Plantae
Animalia

Viruses

Can only reproduce in their hosts

Hypotheses of origin

1) arose from genetic elements that gained the ability to move between cells
2) remnants of cellular organisms

Multiple origins?

Archaea

Earlier called Archaebacteria

Anaerobic, prokaryotic (no organelles, no nucleus)
Morphologically very similar to bacteria.

Can survive extreme conditions
- thermophiles (high temp, record: 113 degrees!)
- psychrophiles (very cold temp)
- acidophiles (low pH)
- alkaliphiles (high pH)
- halophiles (high salinity)

Also found in human gut, soils, oceans, marshes, etc

Bacteria

Eubacterial clade -“true bacteria”

Prokaryotes

Extremely diverse in habitats

Many are photosynthetic

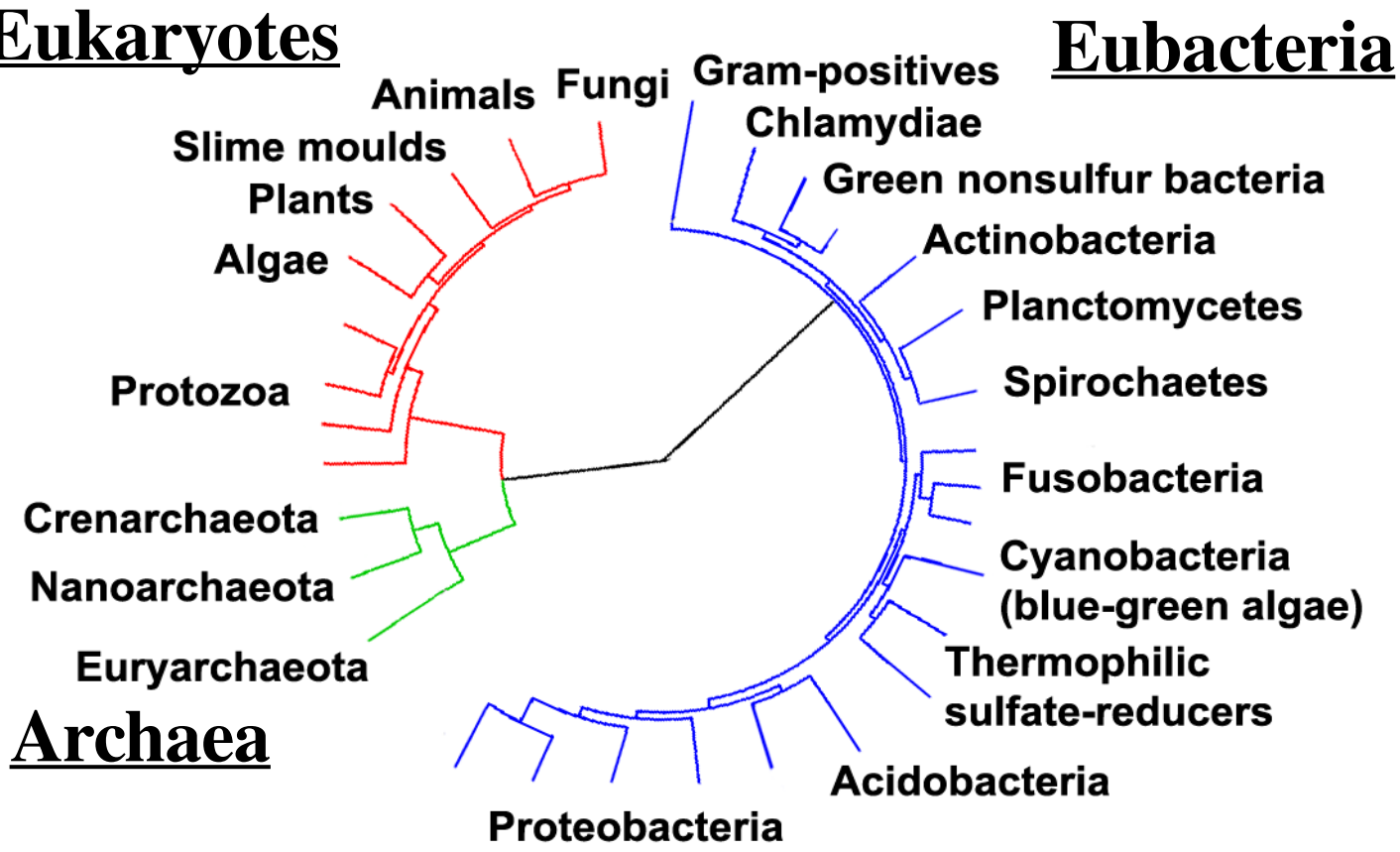
Eukaryotes

= Eukarya, Eucarya, Eukaryota

Nucleus and membrane-delimited compartments (organelles)

May have evolved from Archaea – *endosymbiosis*

Controversy about relationships among the three domains. Phylogeny depicts most widely accepted. **Recent evidence suggests geneflow across the three domains**



Source: Wikimedia Commons/Tim Vickers

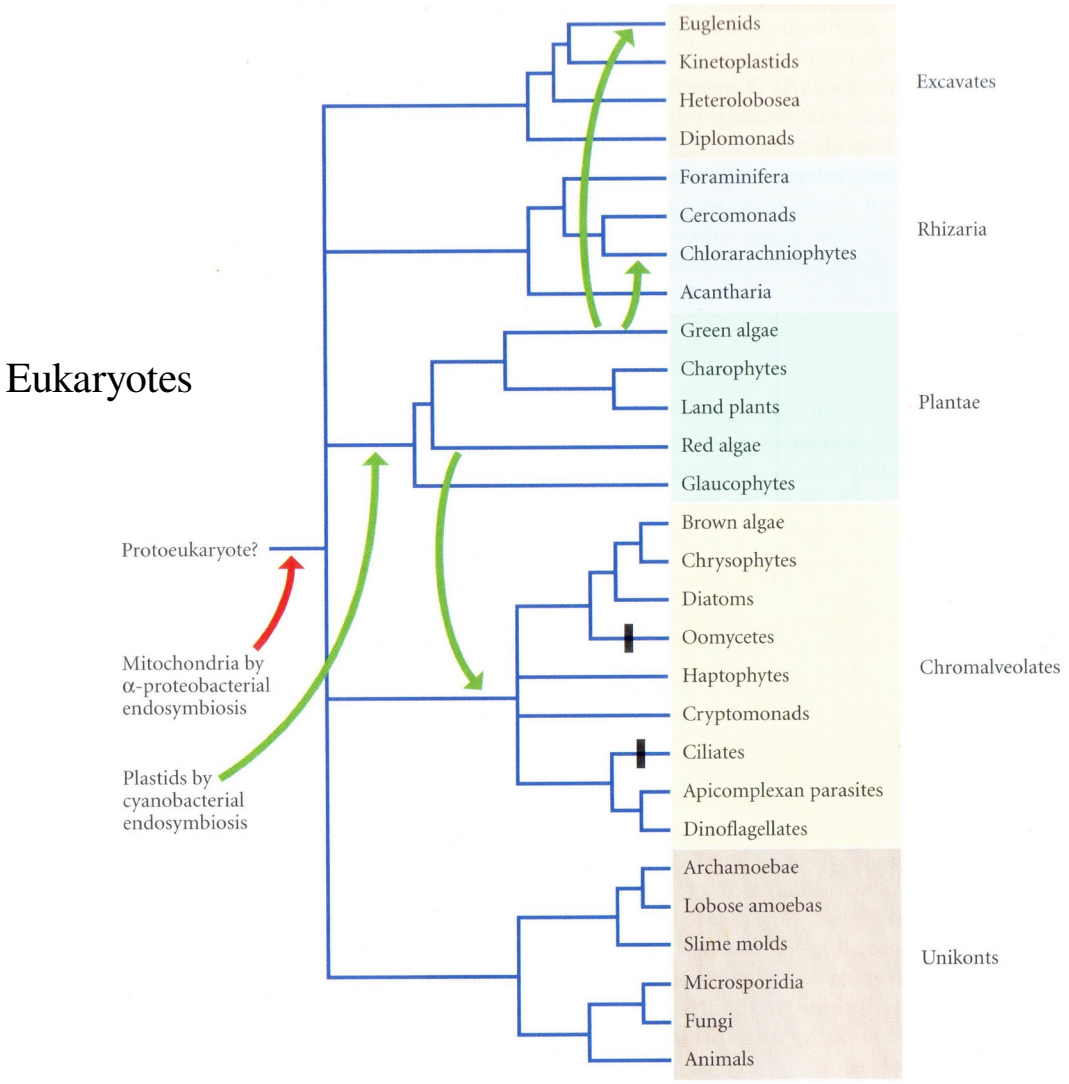
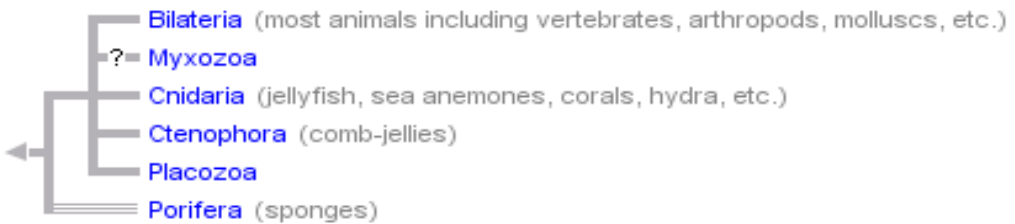


Figure 5.5; Evolutionary Biology 2nd Edition, Futuyma

Animals - Metazoa



http://tolweb.org/Animals

See Zhang et al 2011 *Zootaxa* 3148: 7–12 for information about diversity of animal groups

Porifera (sponges)

15,000 extant species

Unique feeding system: filter feeders, no true tissues

Asymmetrical

Source: www.mbgnet.net

Cnidaria (jellyfish, corals, sea anemones, hydras)

> 9000 spp

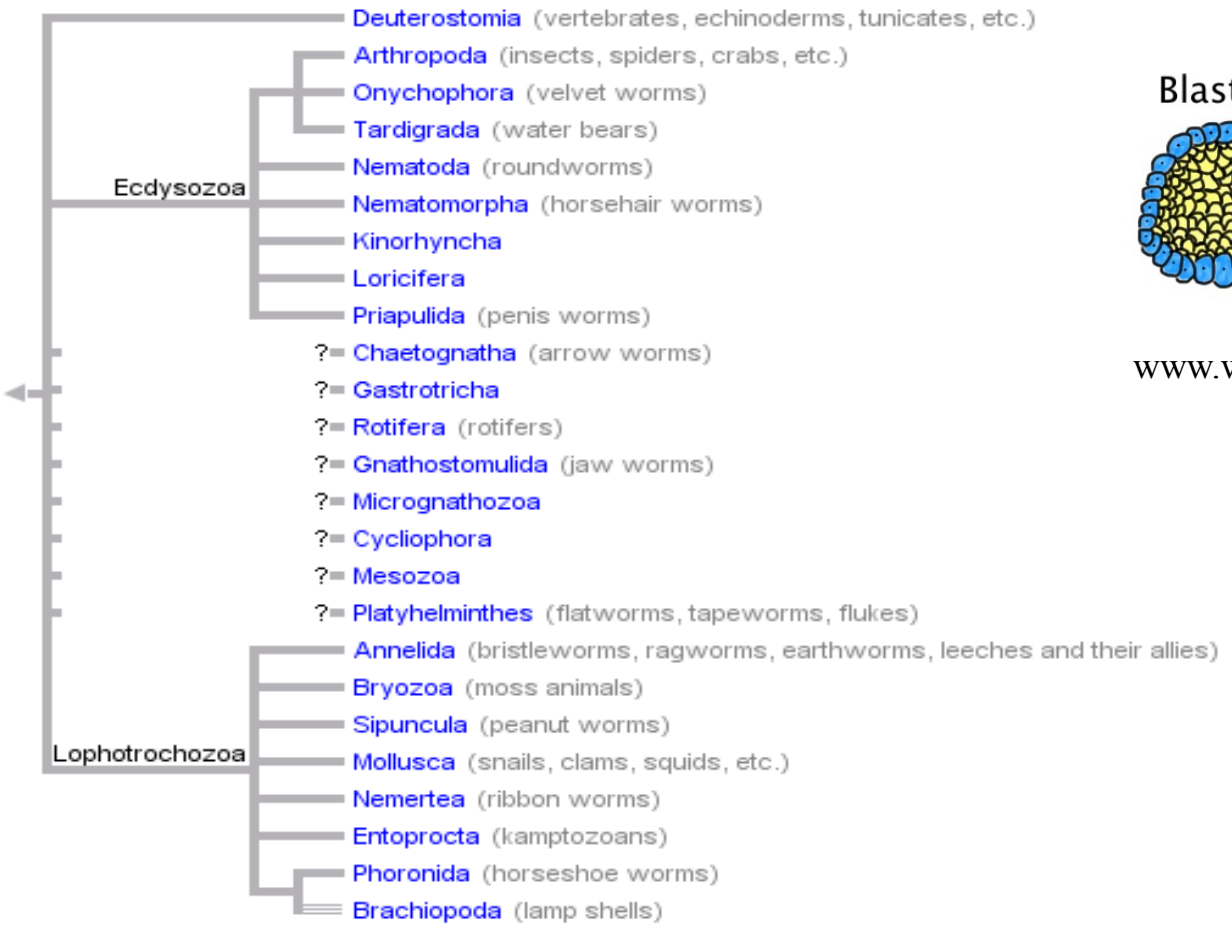
Greek "cnidos" = stinging nettle
Nematocysts – stinging cells

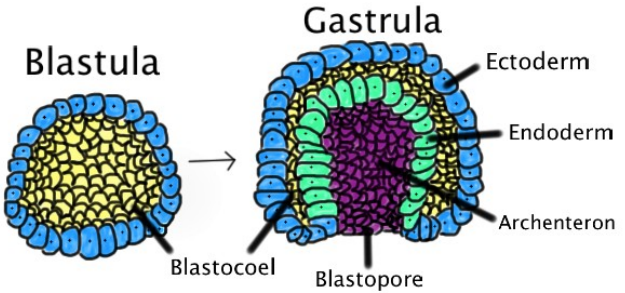
Cells organized into 'tissues'
Considered to be simplest organisms with tissues

Radially symmetric

Chrysaora fuscescens
(Jellyfish)
Photo: Wikimedia Commons/Hodgers

Bilateria: bilaterally symmetrical animals with three germ layers

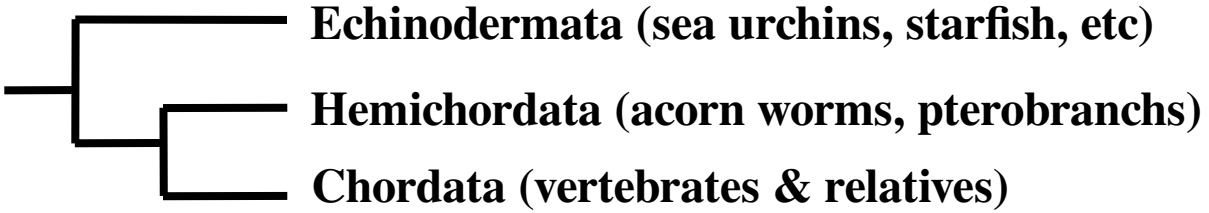




www.wikiwand.com/en/Gastrulation

Deuterostomia = deuterostomes

Distinguished by the type of embryonic development



Phylum: Echinodermata (star fishes, sea cucumbers, sea urchins, etc)

Radial symmetry (usually 5 fold)
7000 spp

Ophioderma rubicundum
(Ruby brittle star)

Photo: Benjamin Cowan

Oxycomanthus bennetti
(a Feather Star)

www.starfish.ch/c-invertebrates/

Hemichordata (acorn worms, etc)

ca 120 spp

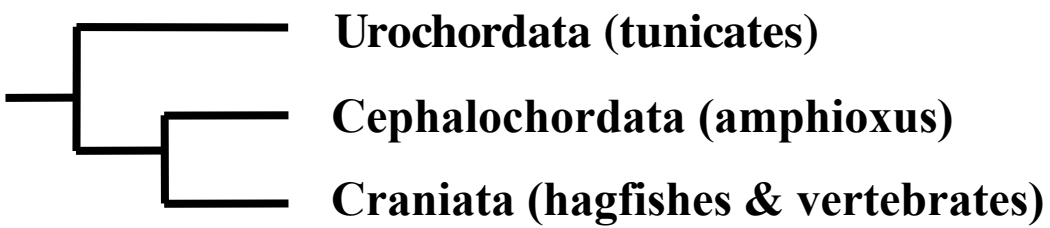
Tripartite body division

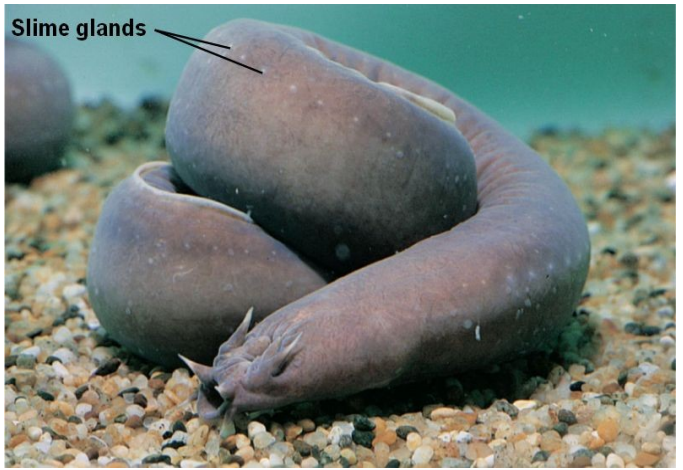
Saccoglossus kowalevskii
(an acorn worm)

Photo: David Remsen

Phylum: Chordata (vertebrates & relatives)

- Notochord: semi-flexible rod along the length
- Pharyngeal slits
- Dorsal nerve chord





Hagfish
http://bio1151b.nicerweb.net

Phylum Chordata

Subphylum Urochordata (Tunicates)

- marine filter feeders with a water-filled, sac-like body structure and two tubular openings; ca 2,150 spp

Clavelina moluccensis
(Bluebell tunicate)

Photo: Nick Hobgood

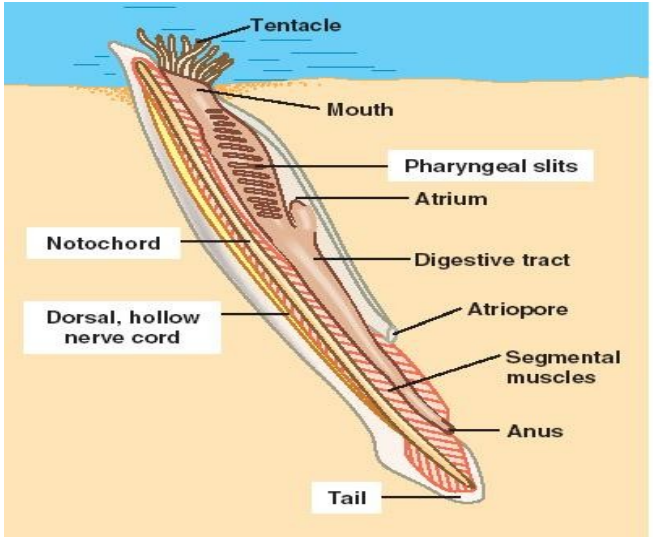
Sycozoa cerebriformis (Brain ascadian)

Photo:
http://www.starfish.ch/c-invertebrates/chordata.html

Phylum Chordata

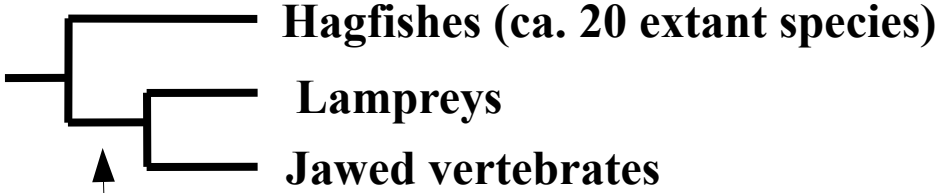
Subphylum Cephalochordata (amphioxus/lancelets)

ca. 25 species in shallow seas/oceans
Usually buried in sand



http://bio1151b.nicerweb.net

Craniata – with skulls (lampreys and jawed vertebrates)



Pacific Hagfish
Photo: Mark Conlin/Alamy

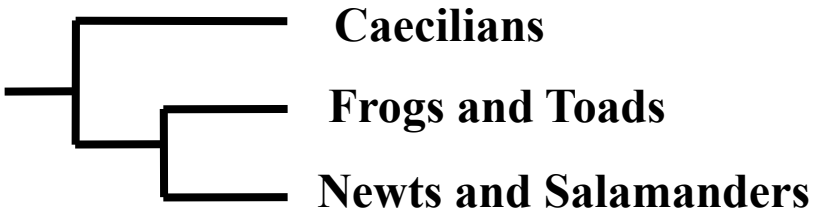
Sea Lamprey:
Ellen Edmonson/Wikimedia Commons

Vertebrata (lampreys and jawed vertebrates)

Jawed vertebrates

Terrestrial vertebrates

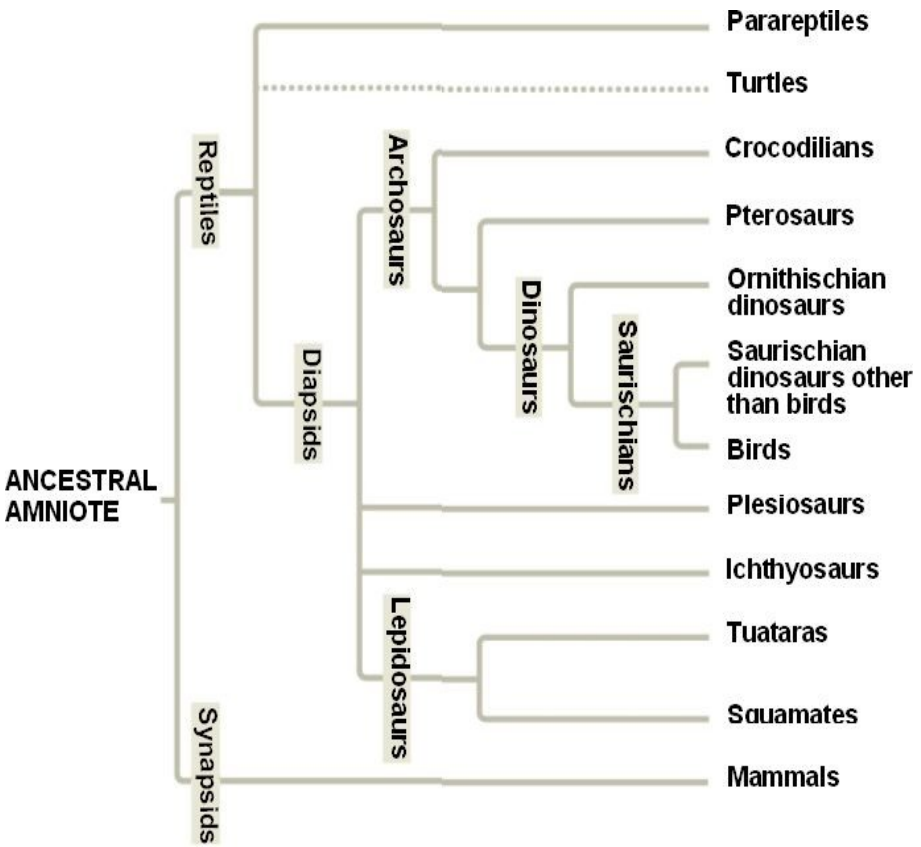
Amphibians



>7000 spp

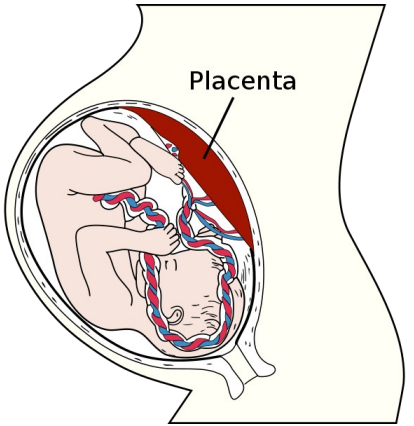
Images: http://bio1151b.nicerweb.net

Amniota (egg with amniotic fluid)

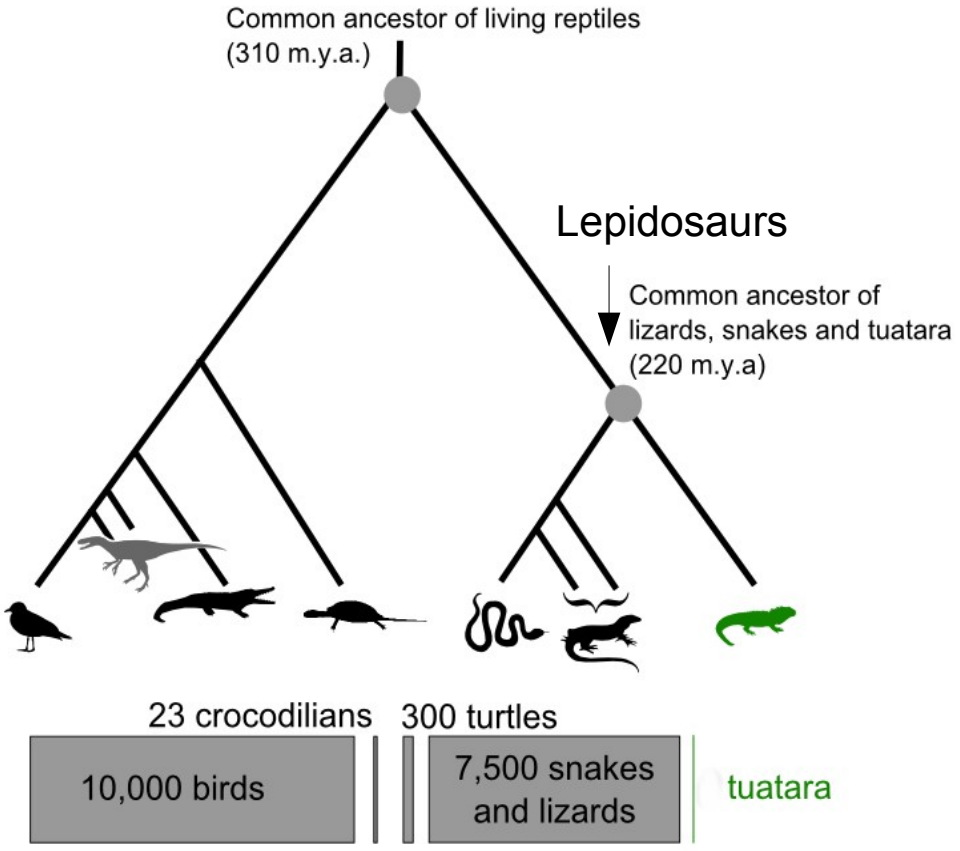


Source: http://bio1151b.nicerweb.net

Amniotic fluid – protects embryo from drying up, facilitates reproduction on land. Mammals are derived amniotes. The placenta is derived/modified from the membranes surrounding embryos in other amniotes



Source: Amada44/Wikimedia Commons



Squamates: snakes+lizards

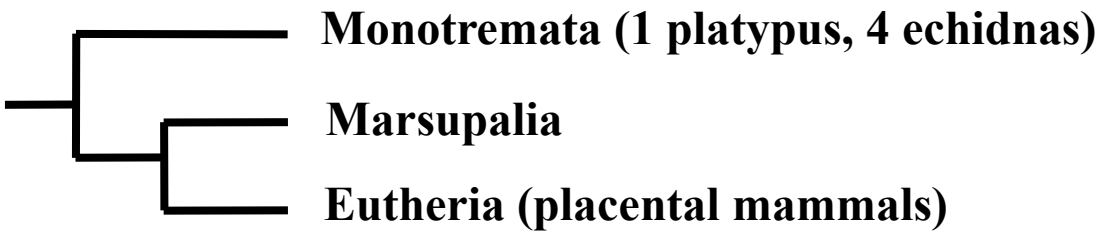
Source: Wikimedia/Benchill

Tuatara: single extant species in New Zealand

Sphenodon punctatus
Source: http://natural-wild-life.blogspot.in

Mammalia

> 5000 spp



Ornithorhynchus anatinus

(Duck-billed Platypus)

Photo: Nicole Duplaix

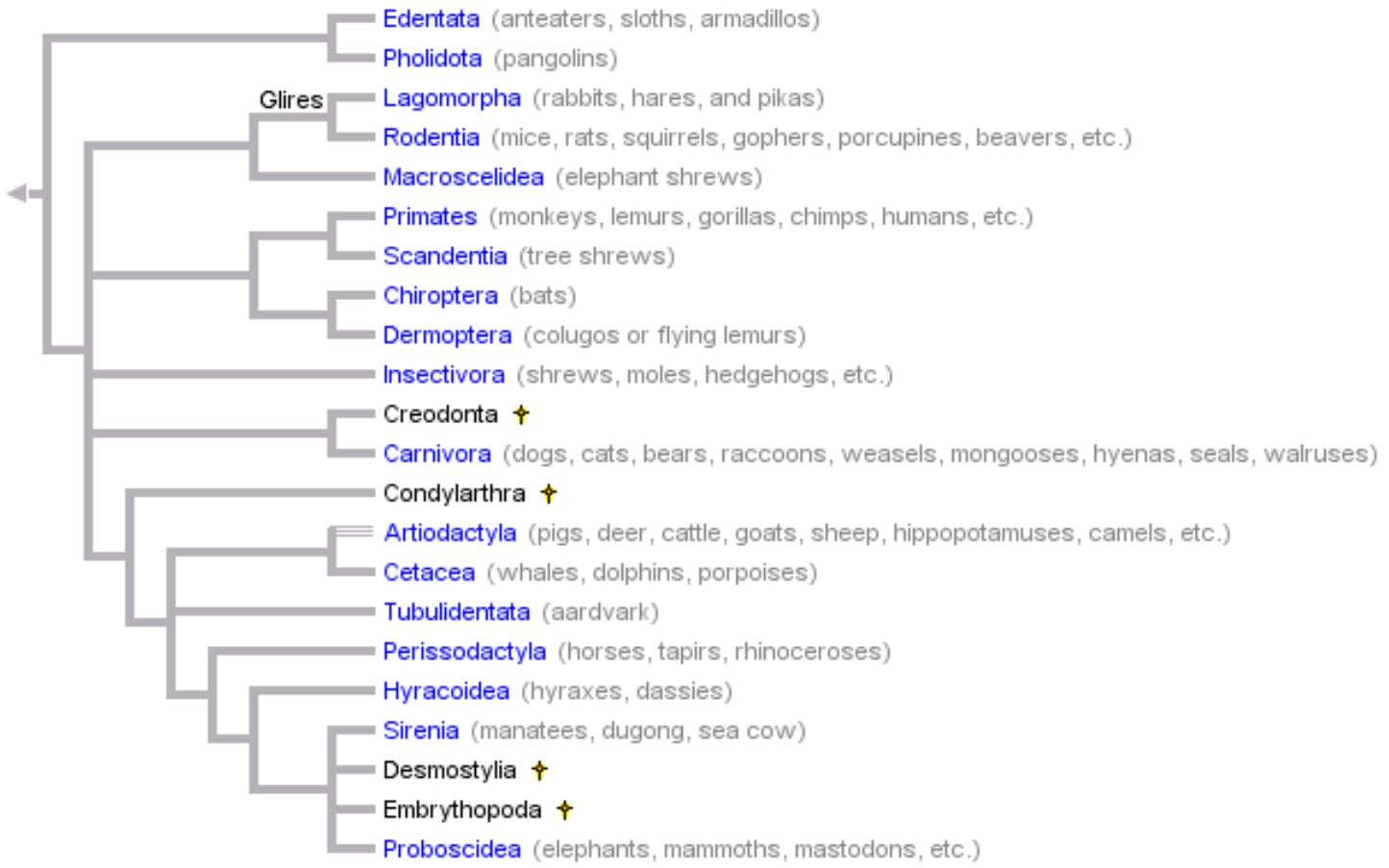
Macropus rufus

(Red Kangaroo). Photo: Wikimedia Commons

Phocoenoides dallis

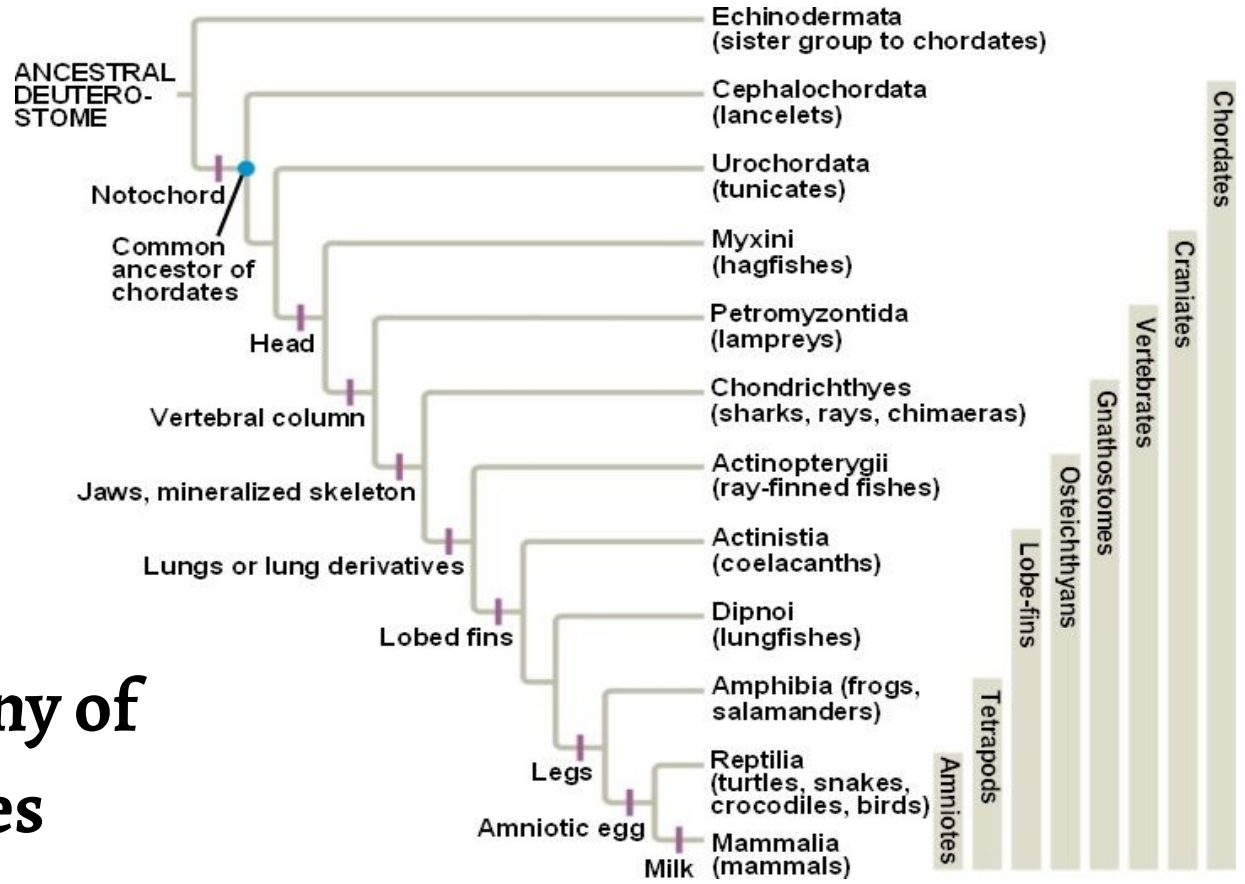
(Dall's Porpoise)

Eutheria



http://tolweb.org/Eutheria/15997

Phylogeny of chordates



Source: http://bio1151b.nicerweb.net

(Note: There is some disagreement about the divergences of Urochordata and Cephalochordata)

Phylum Chordata

Subphylum Vertebrata (backbones)

Class Agnatha (jawless fish)

Class Chondrichthyes (Cartilage skeleton fish)

Class Osteichthyes (bony fish)

Class Amphibia (moist enviro., metamorphosis)

Class Reptilia (scales)

Class Aves (birds)

Class Mammalia (mammary glands)

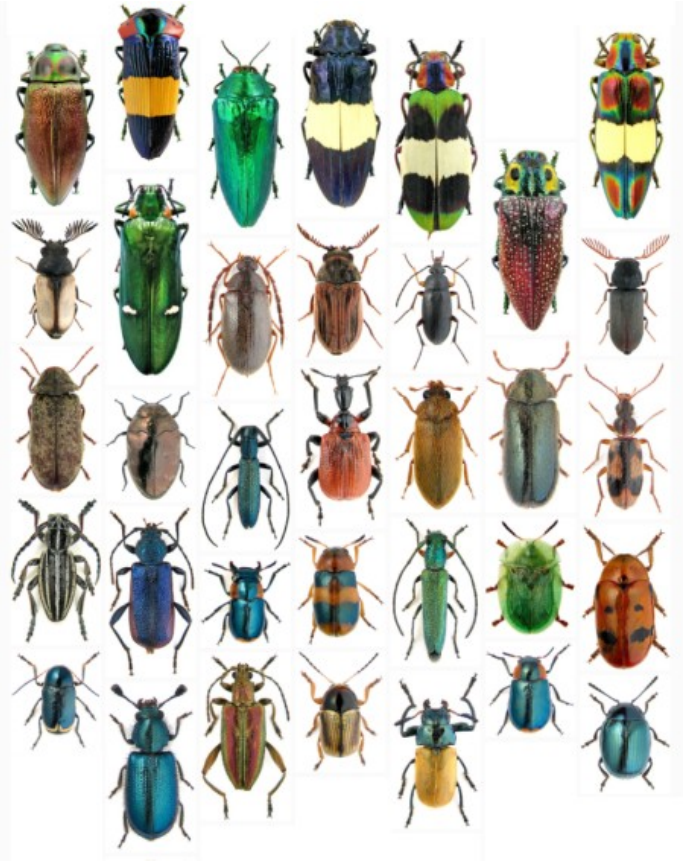
Bilateria: Phylum Arthropoda (crabs, insects, spiders, shrimp, etc)

- Jointed appendages; Exoskeleton made of chitin
- Segmented body, ventral nerve cord

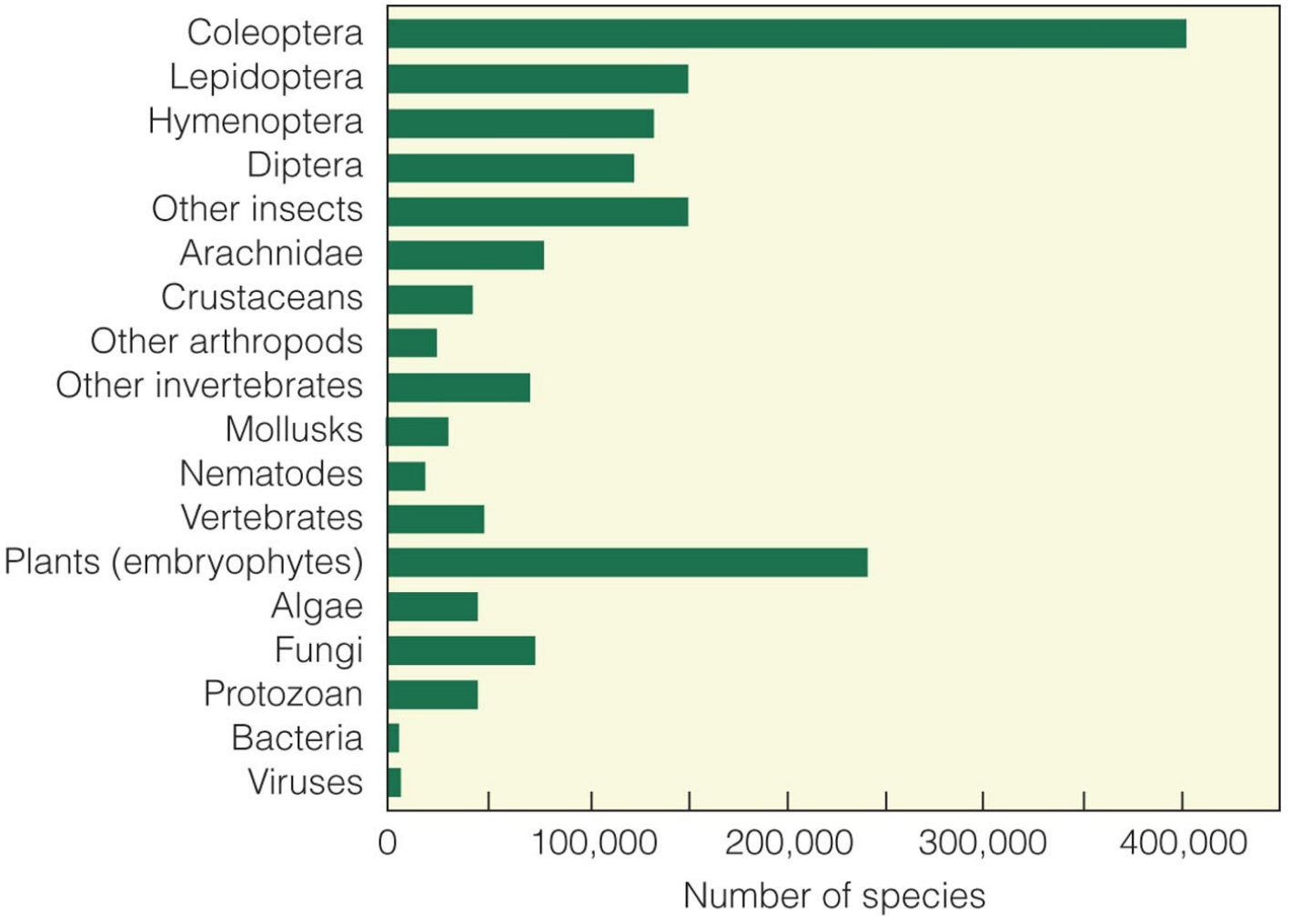
Largest animal phylum

Order Coleoptera (beetles, weevils)

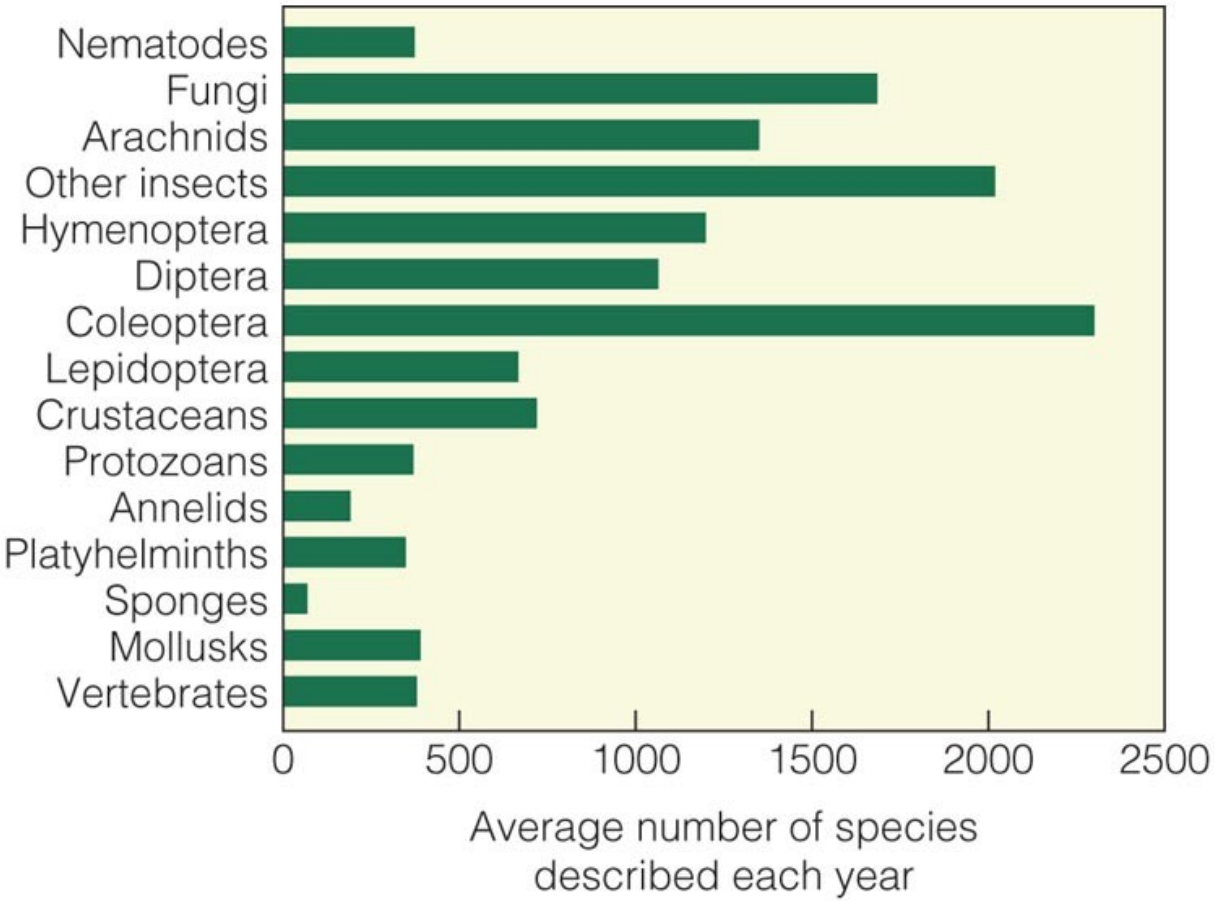
- *Largest order*: > 3,50,000 spp
- JBS Haldane - “An inordinate fondness for beetles”



Source: Bunk Strutts / www.tackyraccoons.com

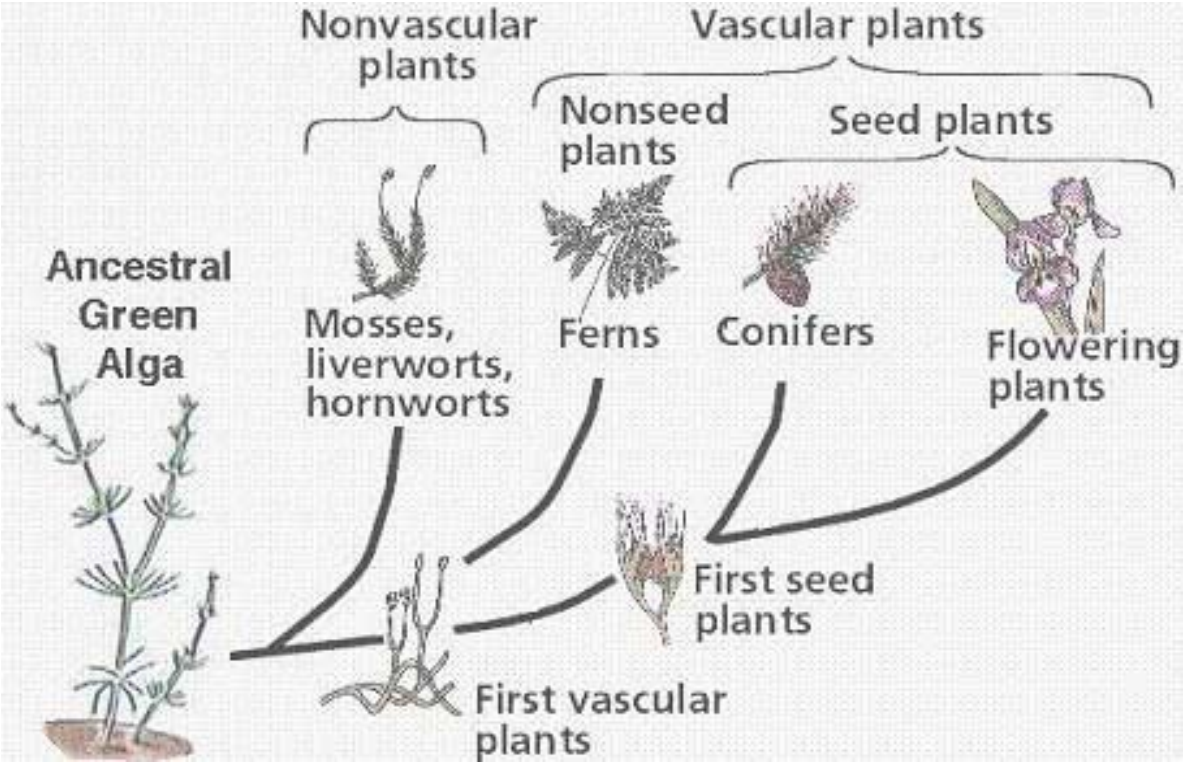


Source: Pearson Education Inc



Source: Pearson Education Inc

Kingdom Plantae (> 300,000 spp)



Source: www.onekp.com/essential.html

Part III– DIVERSIFICATION OF LIFE: A TIMELINE

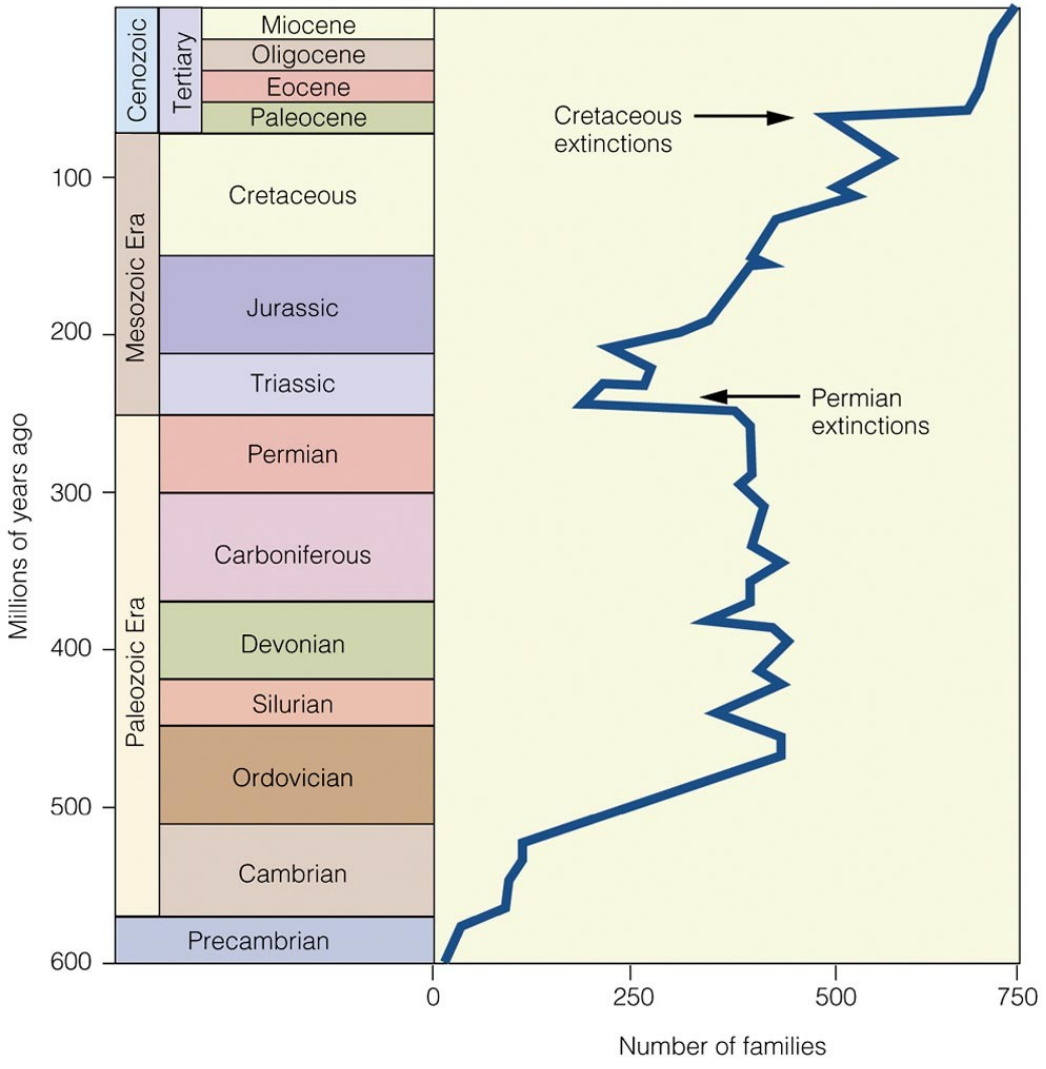
Life through time

Geological time scale is divided into eons, eras, periods, epochs and stages

Interval of each is defined by the diagnostic fossils

Precambrian (evolution of simple life forms)

Phanerozoic eon (complex life forms)
Paleozoic era (ancient life)
Mesozoic era (middle life)
Cenozoic era (recent life)



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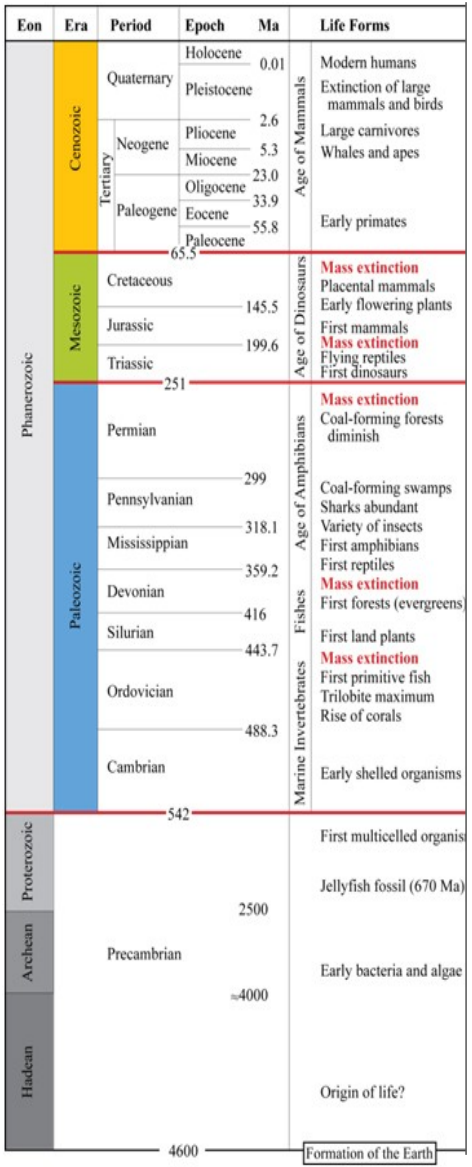


The Pennsylvanian & Mississippian are two subperiods of the Carboneiferous

Precambrian

Billions of years ago: bya

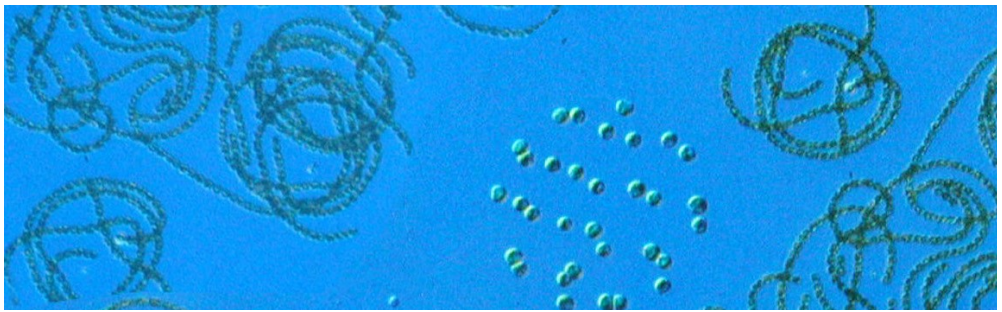
Hadean eon: 4.6 – 4 bya

Archean eon (4 – 2.5 bya)

Proterozoic eon (2.5 bya – 542 mya)

All three domains evolved

Stromalites in Shark Bay, Australia.
Photo: Tom Tregenza



Dr Gordon Beakes © University of Newcastle upon Tyne
ImageBank,http://www.bioscience.heacademy.ac.uk/imagebank/"

Ediacaran fauna

– late Proterozoic (ca 575 mya)

Oldest multicellular animals

softbodied, sessile filter feeders, floating predators feeding on planktonic organisms

Dickinsonia (3.5 cm across)

Rangea (scale bar = 0.25 cm)

Paleozoic era: Cambrian explosion (Multiple adaptive radiations)

Most animal phyla found today appear in the fossil record of the Cambrian period from 543-506 mya (segmented worms, arthropods, crustaceans, chordates)

The Cambrian period represents about 1% of the earth's history but most large and complex life forms appeared in this period (adaptive radiations)

Cambrian fauna

Burgess shale fossils

Best examples of Cambrian fauna from Burgess Shale fossils (British Columbia, Canada) and Chenjiang fossils (Yunnan Province, China)

Features of Cambrian fauna

Increase in body size

Hard exosekletons

Complex parts like limbs, antennae, head, segmented body

Diversity of form and organisation

Cambrian diversity

Benthic and pelagic predators, filter feeder, grazers, scavengers, detritivores, active predators that chase their prey

Cambrian explosion filled many vacant niches that were not exploited so far

New lifestyles - crawling, swimming, burrowing, walking etc

What caused the Cambrian explosion?

Possible reasons

Rising oxygen concentrations in seawater: photosynthetic algae

- multicellularity and large body size (*key innovations*)

Additionally, a mass extinction event eliminated Ediacaran fauna (*opportunity* for adaptive radiation)

The Cambrian ended with large-scale extinctions

Paleozoic era: Ordovician to Devonian periods

Diversification of many animal phyla

Most Ordovician animals: on the sea-floor

Ordovician period – ended with mass extinctions

Terrrestrial life: spore-bearing plants in the Ordovician

Paleozoic era: Carboniferous & Permian periods

Diversification of seed plants

Winged insects appear

Diversification of amphibians

Mammals & reptiles appeared

Lowest sea-level

End-Permian mass extinction – ca 50% of plant families and ca 95% of species

FIGURE 10.28. Late Carboniferous coal swamp forest. Plants from *left* to *right*, a calamite tree, scrambling cordaite, tree fern, lycopsid, seed fern, lycopsid, and mangrove cordaite.

10.28, adapted from Dimichele W.A., *Palaeobiology 2*, Briggs D. et al., eds., p. 79, © 2001 Blackwell Publishing

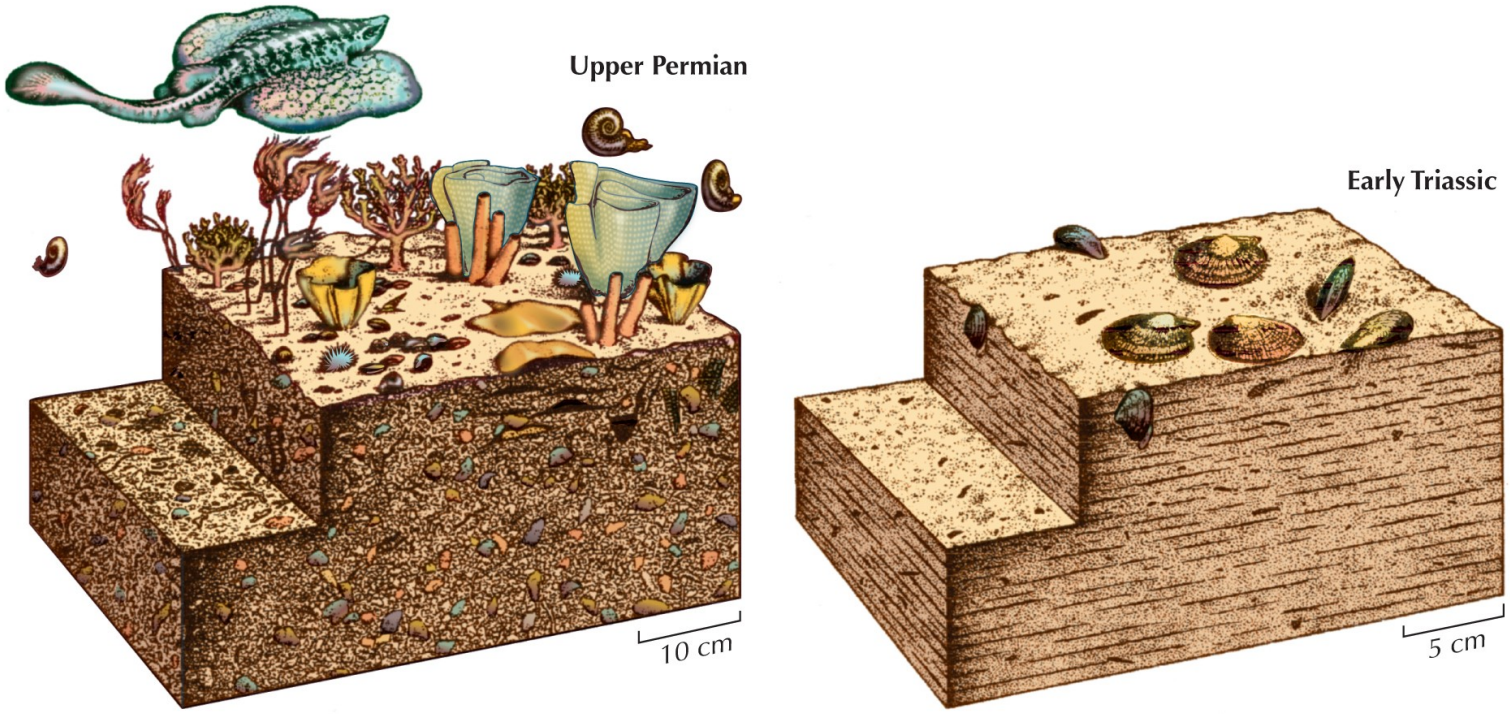


FIGURE 10.37. Effects of the Permian extinction. The latest Permian tropical seafloor compared with that of the Early Triassic, based on the section at Meishan, China, showing the loss of reef-dwelling organisms.

10.37, © John Sibbick

Mesozoic era (Triassic, Jurassic and Cretaceous periods)

'Age of reptiles'

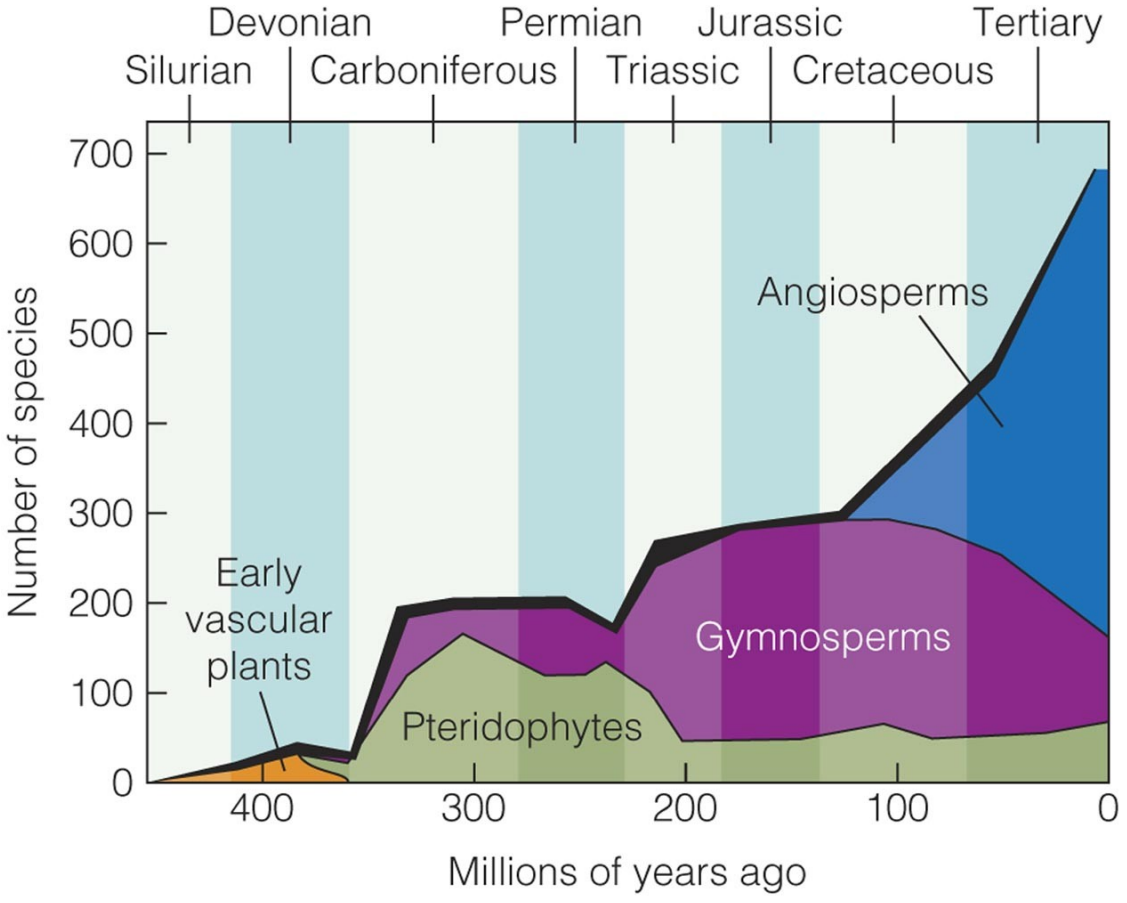
High global temperature

Dominated by gymnosperms, although angiosperms (flowering plants) first appeared

Dinosaurs

Ended with the Cretaceous-Tertiary (KT or K/T) mass extinction – 65 mya

Plant diversity over time



Cenozoic

'Age of mammals'

Radiation of angiosperms & dominance over gymnosperms

Radiation of snakes, passerine birds, etc

Pleistocence (1.8 my to present)

Multiple glaciations

Refugia (speciation, postglacial colonizations)

Sea-level changes

K-T extinction event best understood

- ca 15 % of marine animal families

- non-avian dinosaurs

Asteroid/meteorite impact?
Chicxulub crater (Mexico)

Deccan Traps volcanism?
Southern India