

CH 23 Broad Patterns in Evolution (1)

Macro-evolution - the broad pattern of evolution above the species level

- i.e. the emergence of terrestrial vertebrates
- impact of mass extinction on diversity of life
- origin of KEY Adaptations - i.e. flight

Fossils

- sedimentary rocks are the richest source (layers called "strata")

- insects in amber, mammals frozen in ice

★ record is incomplete - favors hard shells, skeletons

★ record shows GREAT CHANGES

Relative Dating - order in which the strata were laid down

Absolute Dating - age given in years

↓
RADIO METRIC DATING → based on

nuclear decay → "Half-Life"

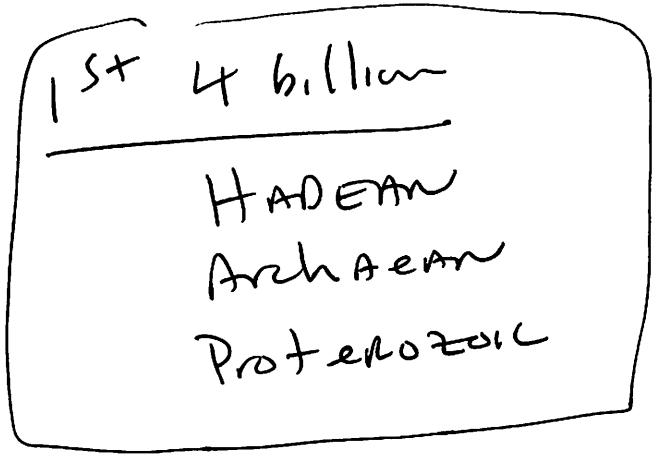
HL - the amount of time for 50% of the parent isotope to decay.

Examples

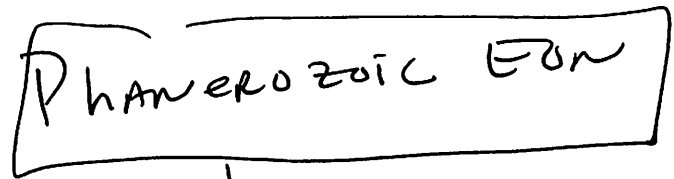
C-14 - half-life ($t_{1/2}$) = 5,730 yrs
 U-238 - $t_{1/2}$ = 4.5 billion years.
 → works up to 75,000 years.

Geologic Record

A standard time scale that divided Earth's history into 4 EONS



LAST HALF BILLION



- Paleozoic ERA - cambrian through permian
- Mesozoic ERA - age of reptiles
- Cenozoic ERA - age of mammals

Earliest evidence of Life

3.5 byA - stromatolites

Stromatolites - layered rocks that form when prokaryotes bind thin films of sediment together.

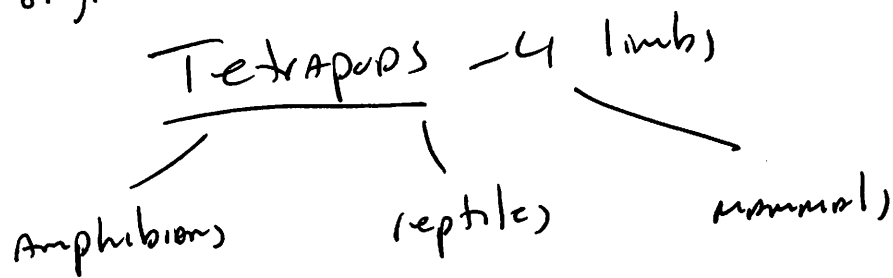
Early prokaryotes

↳ 3.5 - 1.5 byA
↳ released O₂ into atmosphere via photosynthesis.

Early eukaryotes - 1.8 byA

Multicellular eukaryotes - 1.5 byA

⇒ fossil record also record the changes leading to rise of new groups of organisms ⇒ i.e. mammals



Mammals (distinctive features)

(4)

- jaw is one bone in mammals, several in tetrapods
- different jaw hinges
- mammals have hammer, anvil, and stirrup in ear, tetrapods have only stirrup.
- mammals have differentiated teeth (incisors, canines, molars)

23.2 Speciation and Extinction Rates

★ changes in the distribution of groups of organisms can be affected by:

- PLATE TECTONICS
- MASS EXTINCTIONS
- ADAPTIVE RADIATION.

PLATE TECTONICS

- plates of earth's crust "float" on top of mantle (asthenosphere)
- cm's per year

- continents are "part" of the plates

★ most important Geologic processes occur
AT PLATE BOUNDARIES (FIG 23.7)

PANGAEA - super continent
- 250 myA

↳ caused changes which drove evolution.

↳ CLIMATE CHANGE caused by
movement of plates drove evolution.



When CLIMATE CHANGES, organisms:

- (1) ADAPT !!
- (2) MOVE, or
- (3) GO EXTINCT !

↳ when continents break apart, it promotes
Allopatric speciation on a GRAND SCALE

Mass Extinctions

- majority that ever lived are Extinct !!!
- sometimes extinction rate spikes



mass extinction - large numbers of species become extinct world-wide

Five Major Mass Extinctions (in last 500 million years)

- in each one, 50% or more went extinct

Permian

- 251 myA
- 96% of marine life lost
- occurred in less than 500,000 years
- volcanic eruptions \Rightarrow CO₂
- \Rightarrow 6°C rise in temp
- \Rightarrow ocean Anoxia \Rightarrow low O₂ levels
- \Rightarrow H₂S gas, loss of O₃ - more UV

Cretaceous

- 65.5 myA
- boundary between Mesozoic & Cenozoic
- 1/2 of marine lost, many terrestrial including ALL DINO SAURS

- periods of evolutionary change in which groups of organisms form many new species and fill many niches

ADAPTIVE RADIATION



After a mass extinction, it takes 5-10 million years for diversity to recover → sometimes 100 million years.

→ human caused 6th mass extinction possible

↳ losses not close to the Big Five

- more than a thousand species extinct in last 400 yrs.

6th Extinction?

→ YUCATAN CRATER (MEXICO)

- believed to be caused by a comet or asteroid impact → IRIDIUM !!

★ Large-scale ADAPTIVE RADIATIONS occurred after each of the 5 big mass extinctions 😊

⇒ with extinction of dinosaurs 65.5 mya, MAMMALS expanded in DIVERSITY and filled the terrestrial niches once held by them

23.3 CHANGES IN BODY FORM

★ SLIGHT GENETIC DIFFERENCES can produce MAJOR MORPHOLOGICAL DIFFERENCES

Heterochrony - evolutionary change in the rate or TIMING of development

- i.e. reduced jaw (infant-like) in humans
- i.e. accelerated development of finger bones in bats

PAEDOMORPHOSIS

→ Accelerated development of reproductive organs

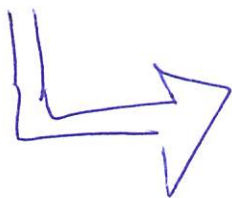


So... sexually mature stage of a species may retain BODY features that were JUVENILE structures in ancestral species

Homeotic Genes

- master regulatory genes
- control the placement and spatial organization of BODY PARTS.

Hox gene - one type of homeotic gene
- provide positional info in animal embryo.



CHANGES in Hox genes can have a MAJOR impact on morphology

Cambrian explosion

→ 535-525 mya

→ rapid diversification of animals

Mutations in Gene Sequence

↳ changes to nucleotide sequence in developmental genes leads to major evolutionary changes

BUT maybe changes in regulatory genes are even more important !!

↳ i.e. the expression of a developmental gene in some BODY PARTS but not others.

23.4 Evolution is NOT GOAL-ORIENTED

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But it has led to:

- ① organisms that are suited for their environments
- ② the shared characteristics of life
- ③ the DIVERSITY of LIFE

Evolutionary Novelties

i.e. the complex eye

↳ evolved through a series of INCREMENTAL
MODIFICATIONS that benefited the eye's owner
AT EVERY stage

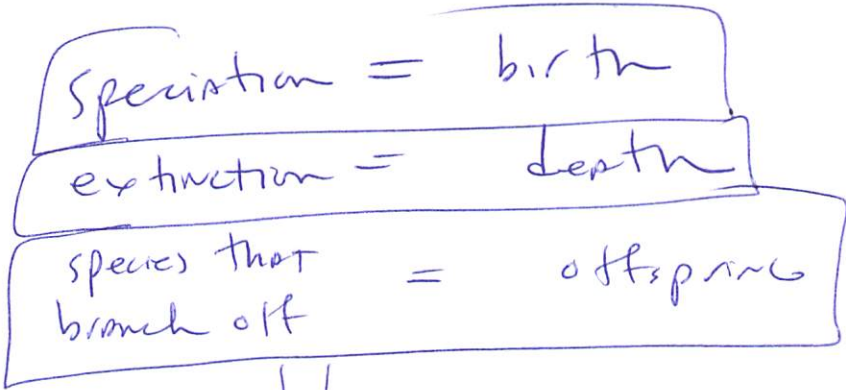
⇒ structures can evolve in one context
and become co-opted for another

⇓
called Exaptations !!

i.e. ear bones of mammals come from
jaw hinges of tetrapods

- Evolution is a "branching"

- species can be viewed as analogous to individuals



Species can undergo species selection

"differential speciation success" viewed as analogous to "differential reproductive success"

"endless forms most beautiful"
- C. Darwin.