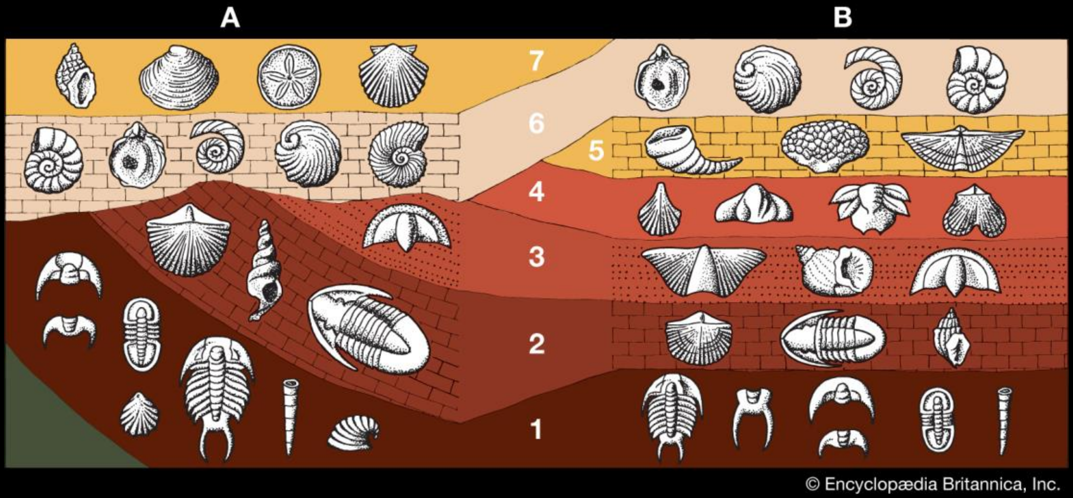
Fossils and Geologic Dating

Principles and Applications



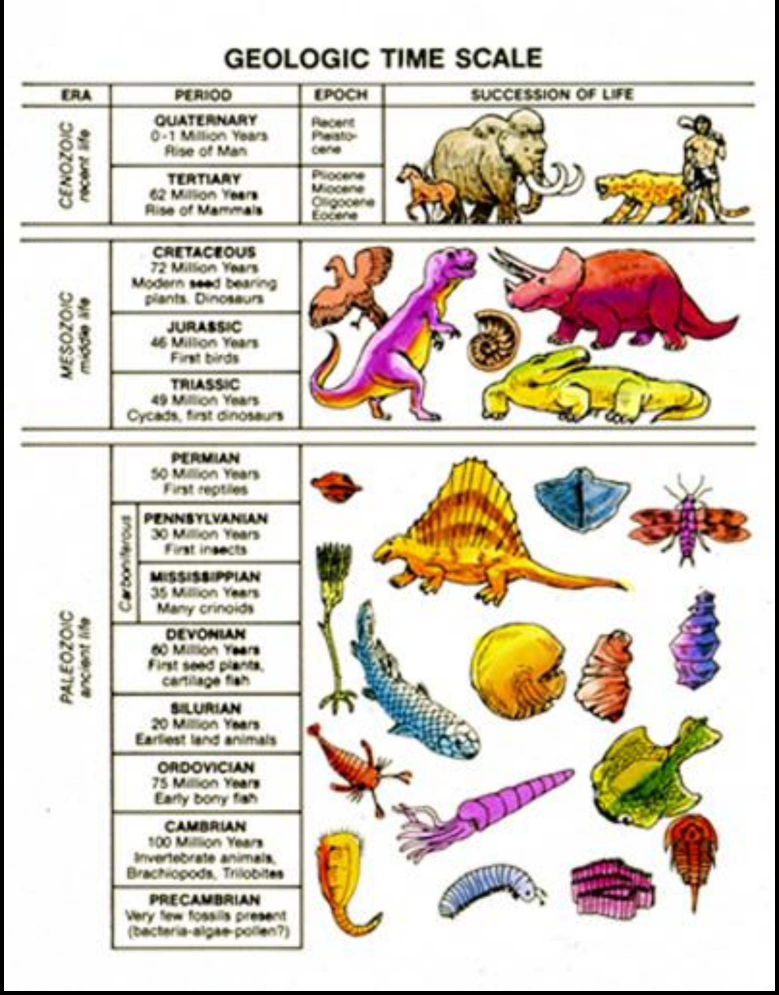
Earth Science Laboratory – EOSC 110

Ray Rector - Instructor

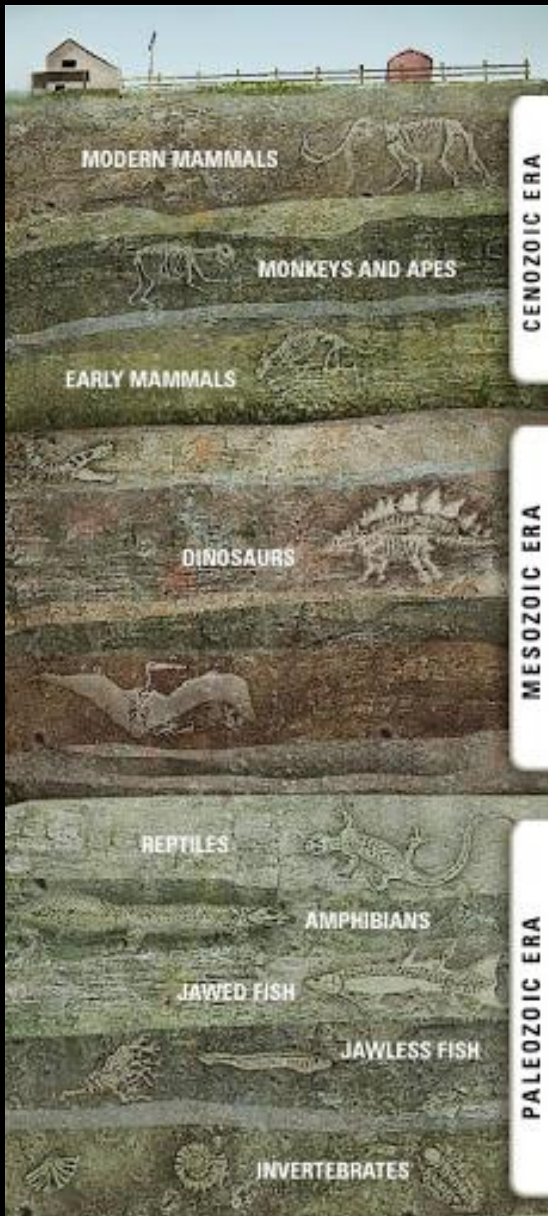
Fossil Laboratory

Today's Topics of Inquiry

1) Origin of Fossils
2) Types of Fossils
3) Preservation of Fossils
4) Fossil Succession and the Geologic Time Scale
5) Using Fossils to Date Rocks
6) Index Fossils of Each Era



Earth's History is Recorded in its Rocks



Scientific Means of Dating Rocks

Two Primary Means of Dating Rocks:

1) **Relative Dating**
   - ✓ Determines the temporal order of rock forming events
   - ✓ Does not give numeric ages
   - ✓ Use of stratigraphic principles and index fossils

2) **Absolute Dating**
   - ✓ Determines the numeric age of rock forming events
   - ✓ Only appropriate for ages of igneous rocks and minerals
   - ✓ Primary method is the ***radiometric technique***
   - ✓ Used in conjunction with stratigraphic principles and fossils

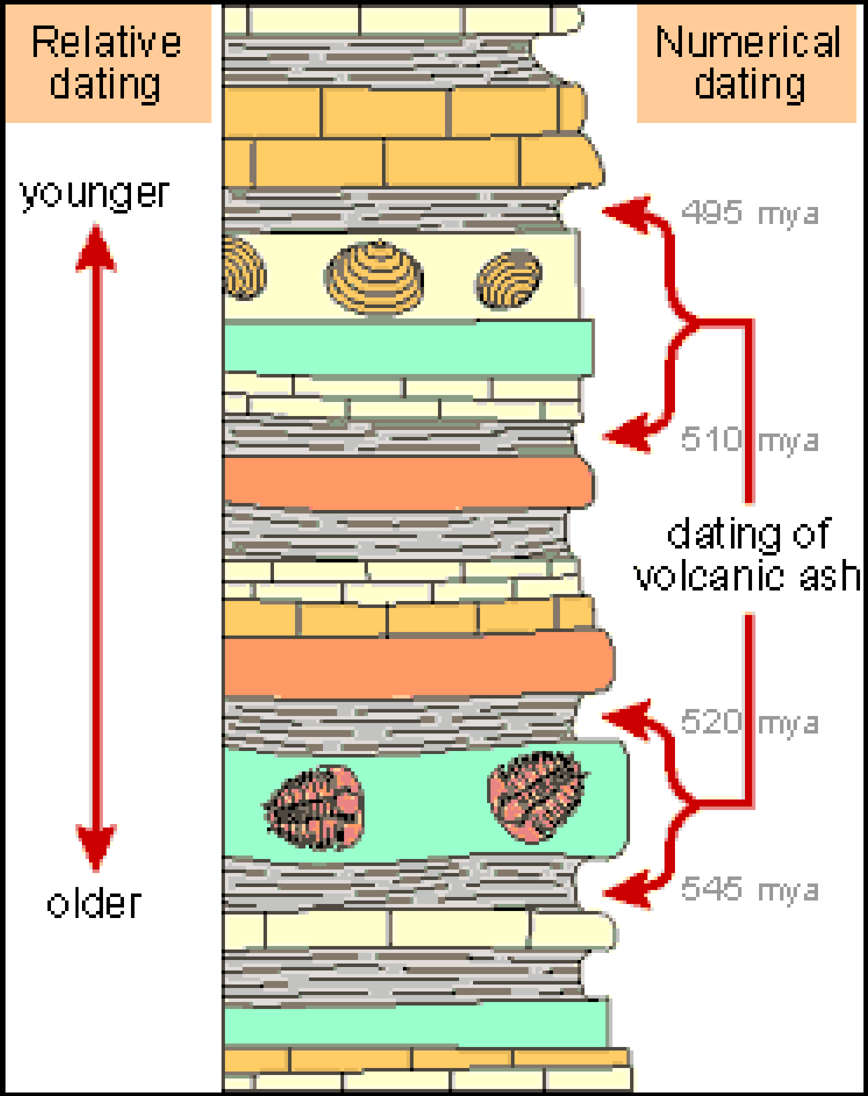
Relative Versus Absolute Dating

Relative Dating

- Stratigraphic principles
- Fossil Succession

Absolute Dating

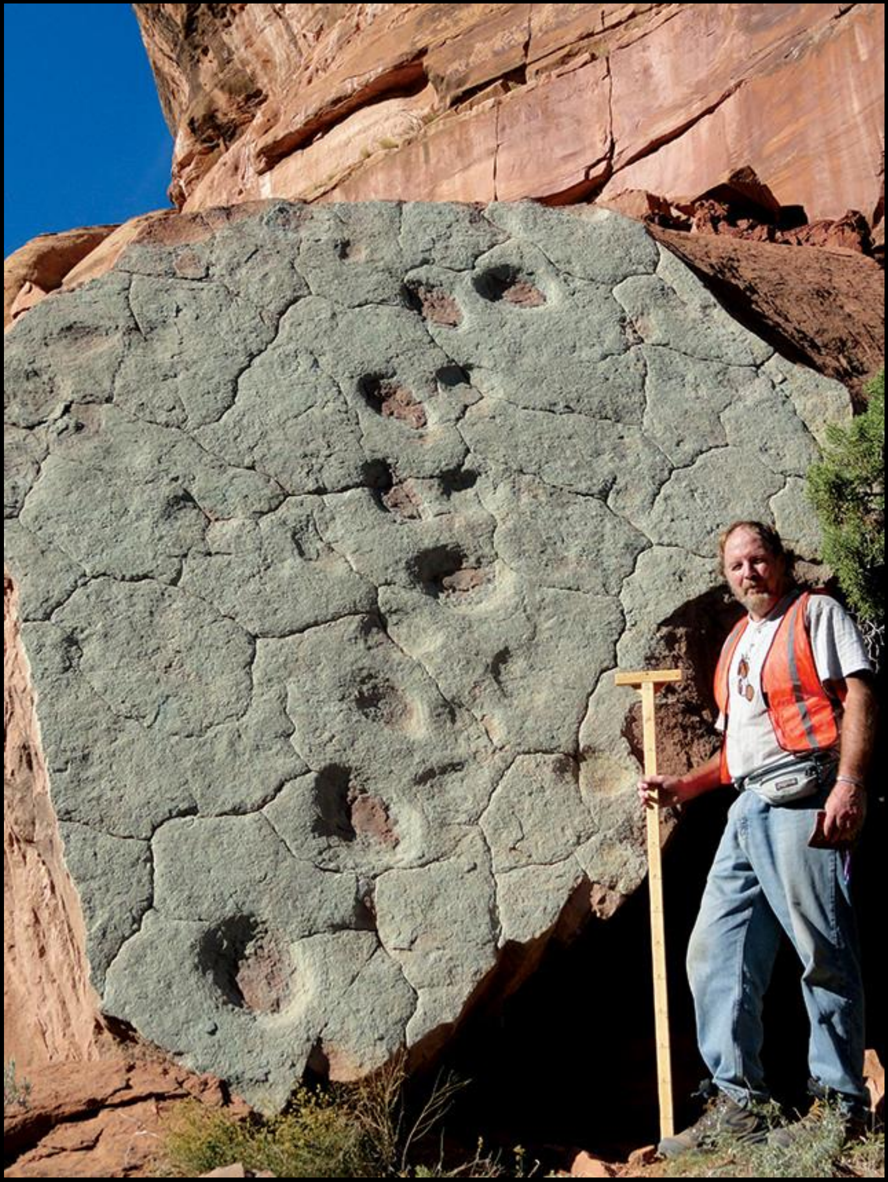
- Radiometric techniques
- Igneous layers



The Geologic Timescale is Organized by the Fossil Record

Eon	Era	Period		Epoch		
Phanerozoic (*Phaneros* = "evident"; *zoic* = "life")	Cenozoic	Quaternary		Recent, or Holocene	10,000	Age of Mammals
				Pleistocene	1.6	
		Tertiary	Neogene	Pliocene	5	
				Miocene	24	
			Paleogene	Oligocene	38	
				Eocene	58	
				Paleocene	66	
	Mesozoic	Cretaceous			140	Age of Reptiles
		Jurassic			205	
		Triassic			248	
	Paleozoic	Permian			286	Age of Amphibians
		Carboniferous	Pennsylvanian		320	
			Mississippian		360	
		Devonian			408	Age of Fishes
		Silurian			438	
		Ordovician			505	Age of Marine Invertebrates
		Cambrian			544	
Proterozoic ("Early Life")	Precambrian				2500	Age of Unicellular Life
Archean ("Ancient")					~3800	
Hadean ("Beneath the Earth")					~4600	

What are Fossils?

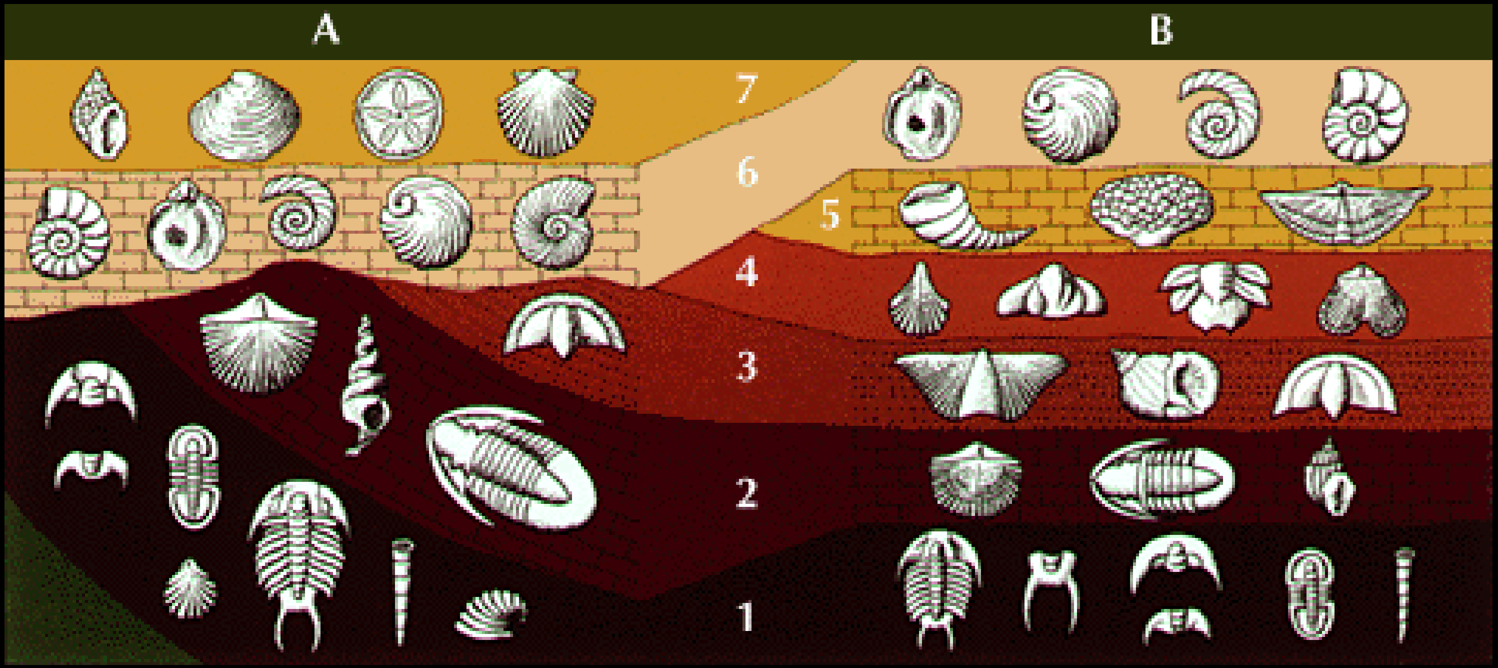


Fossils

- **Fossils** are the **preserved remains** or **evidence** of living things

Question:

- Fossils are usually formed when the organism dies and gets buried in mud or sand. As a result, the hard parts are preserved. What type of rock are fossils usually found in?



Questions:

- Why are fossils NOT usually found in igneous rock?

Questions:

- What are the 5 types of fossils?

Types of Fossils

1. **Body (hard parts) Fossils**
2. **Trace Fossils** - the remains of an organism's activities
   - trackways,
   - burrows,
   - footprints,
   - borings,
   - nests,
   - eggs,
   - coprolites (fossil feces),

3. **Chemical Fossils**
   - biomolecules such as proteins, amino acids, lipids, and nucleic acids (RNA, DNA).

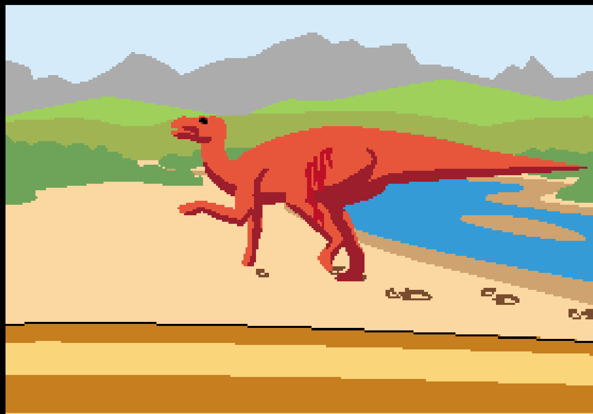
Types of Fossils

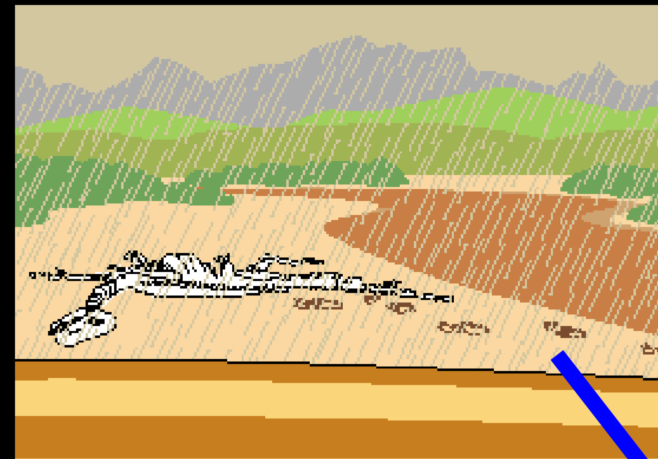
1) <u>Original Remains</u>: **The unchanged** remains of plants and animals

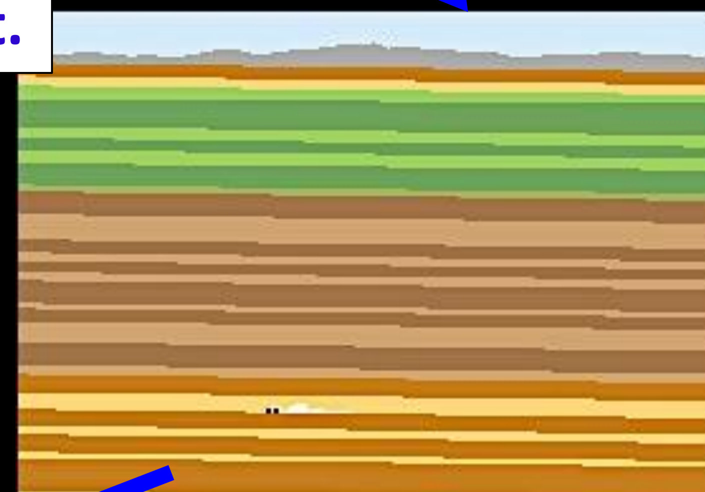
– Examples

- **<u>Hard parts</u>**: Bones, Shells
- Animals trapped in **<u>ice</u>**: Wooly Mammoth
- Animals trapped in **<u>tar</u>** or in **<u>amber</u>**
- **<u>Shell trapped in sediment</u>**


Fossil defined: The natural remains or traces (preservation) of past life.



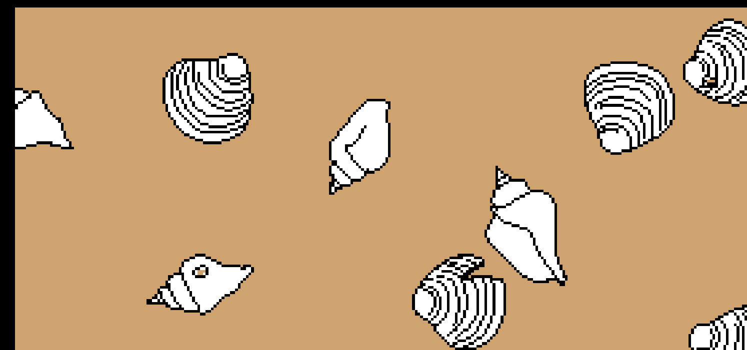


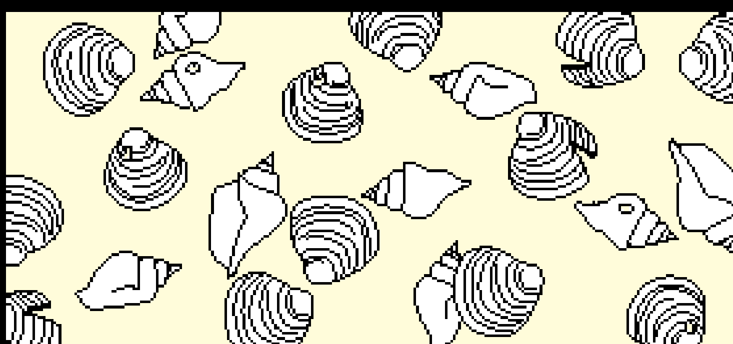


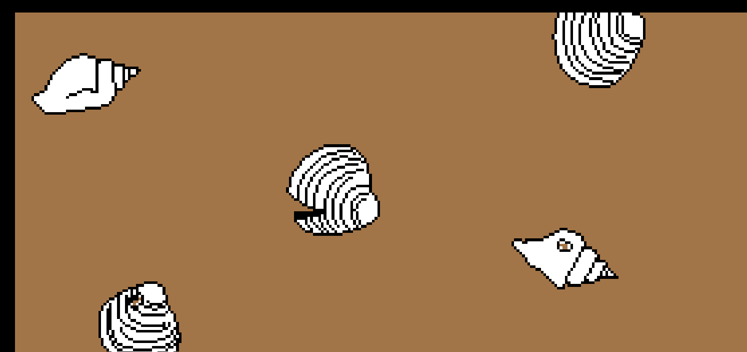
Paleontology: The study of life in the past.

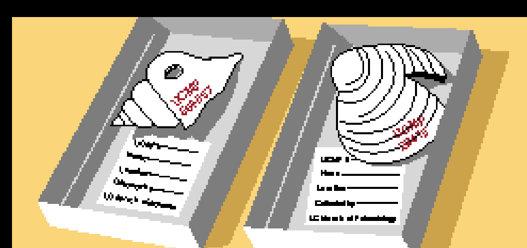
Trace fossils: include any impression or other preserved sign of activity (for example, feeding, scratching, burrowing, walking, or resting).

Bias in the Fossil Record









Modes of Fossilization

1) Unaltered remains-

- Bone or plant material is still porous, shells may still possess mother of pearl inner linings

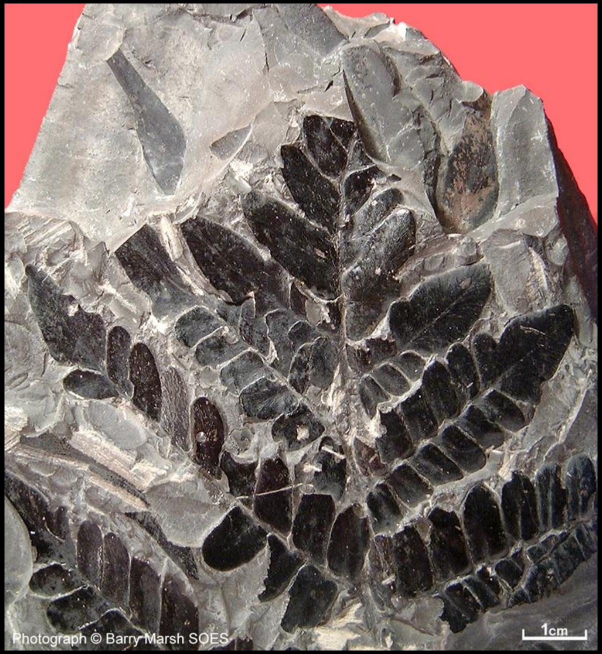
2) Soft part preservation

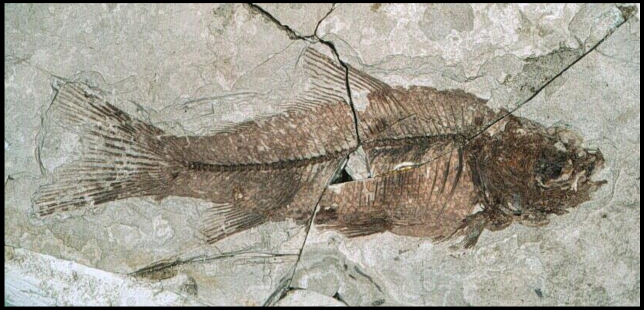
- freezing in permafrost
- dessication,
- lithified tree sap (amber)
- tar

3) Carbonization

Organic-laden hard parts and soft parts preserved as a thin film of organic carbon.

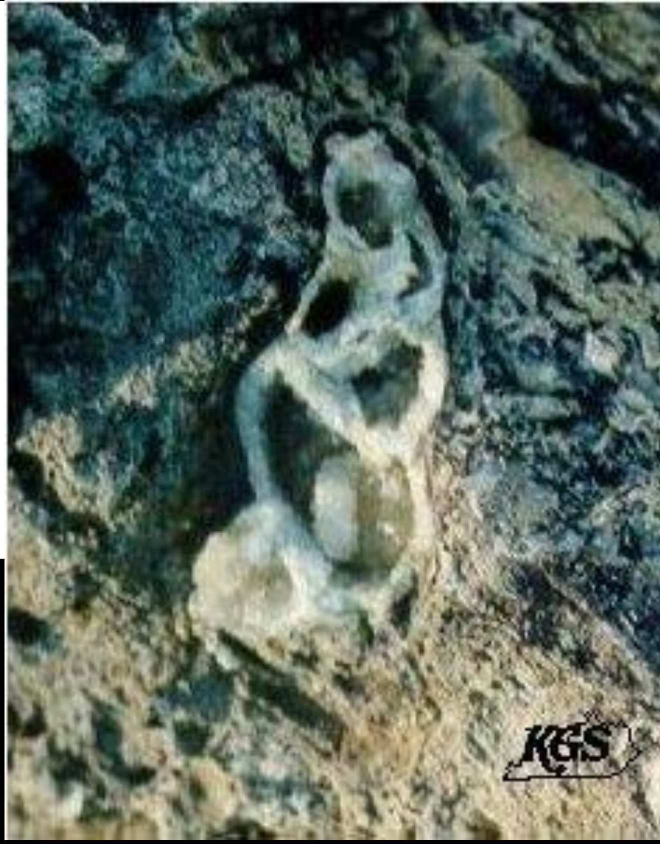
volatile materials (N, O, H, and S) are driven off leaving a thin film of black carbon behind.





4. Recrystallization of hard parts

- Unstable to stable mineral:
  - Aragonite to calcite
- Recrystallization of same mineral
  - Usually to larger crystals



Replacement: is an atom for atom substitution of a mineral's components with the elements composing the replacing mineral

pyritization

5. Permineralization/ Petrification

porous materials such as bones & trees

a) Burial
b) groundwater percolates through its pore spaces.
c) A solution supersaturated in a mineral (usually silica) precipitates minerals in the microscopic pore spaces.
d) Structure of the original wood or bone is preserved

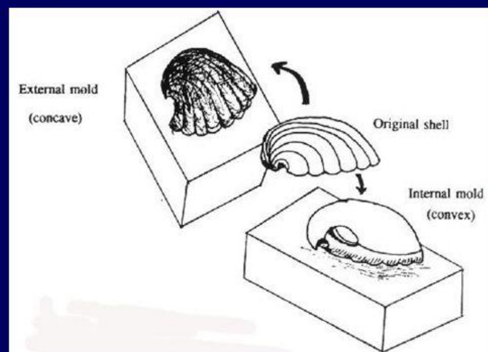
5) Permineralization / Petrification

Modes of Fossilization: Molds and Casts

Two types of molds

External mold- imprints of the outside of a fossil. For example, if the original fossil shell was convex, the external mold will be concave.

Internal mold- imprints of the inside of a fossil. They are produced when an organism such as a shell, is filled with sediment that becomes cemented and then the shell dissolves away.



Molds

Cast Fossil

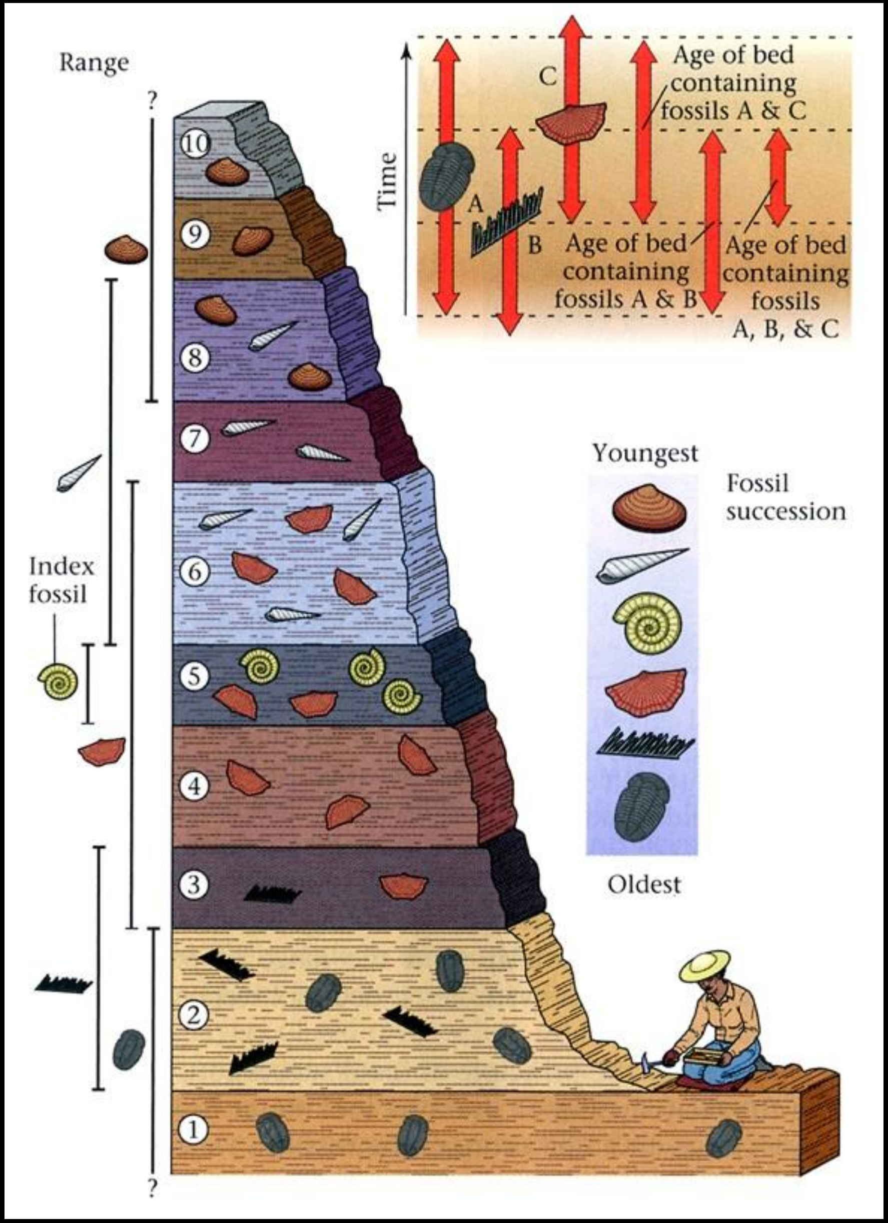
- Forms when a mold is filled with sand or mud that hardens into the shape of the organism.

Casts

Molds and Casts


Pamela Gore, 1998

Principle of Fossil Succession



Key Ideas:

Life Evolution: Life on Earth changes over time – marked by extinction and speciation

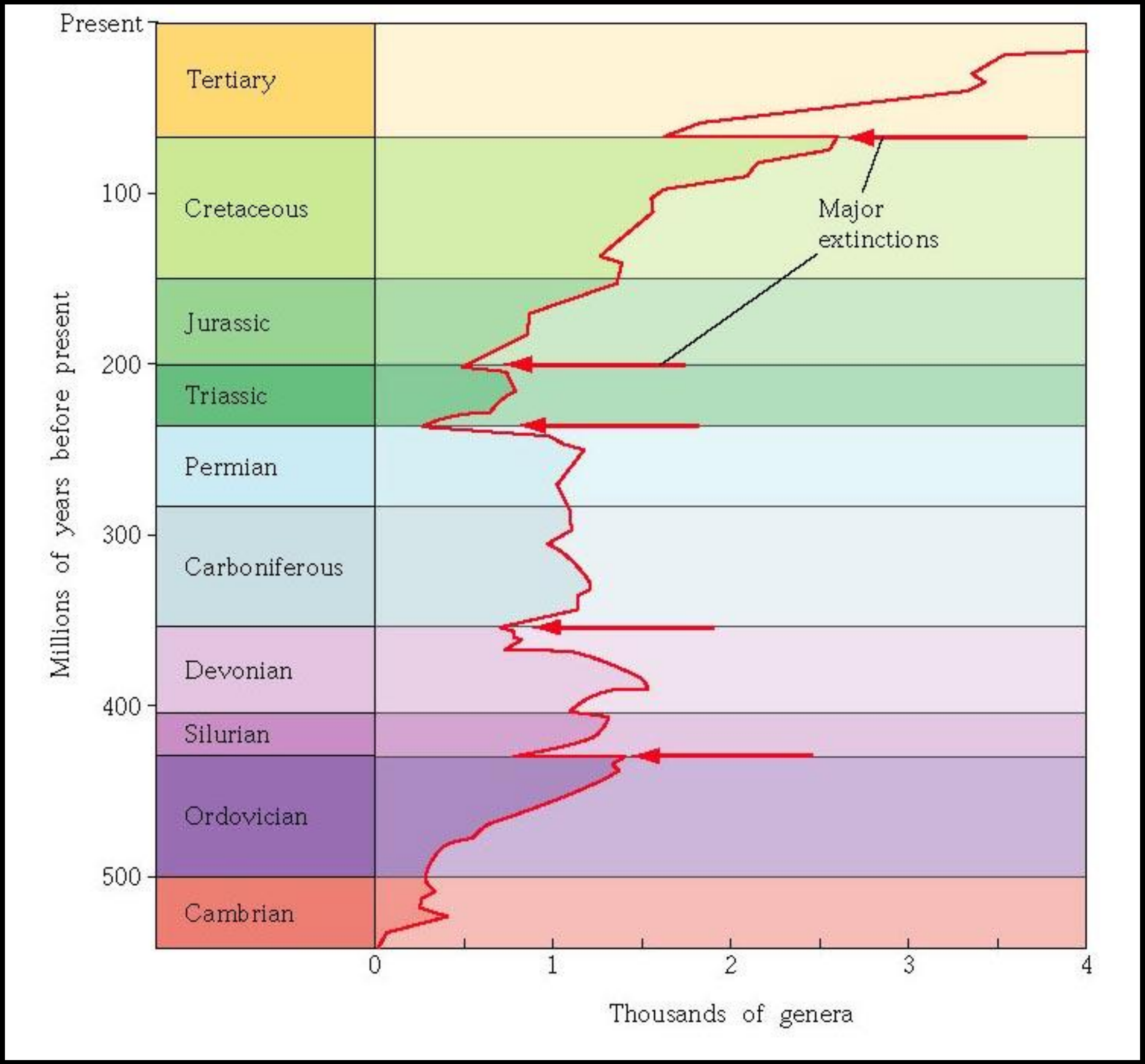
Major life-changing mass-extinction events punctuate Earth history - vast numbers of old species vanish while new species take their place

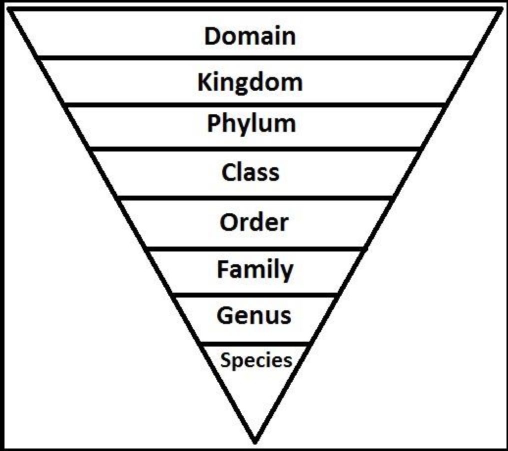
Every period of geologic time had a unique assemblage of life

A fossil-containing rock has an age equal to that of the fossil

The principle of superposition applies to fossil succession

Changes in the abundance and diversity of life





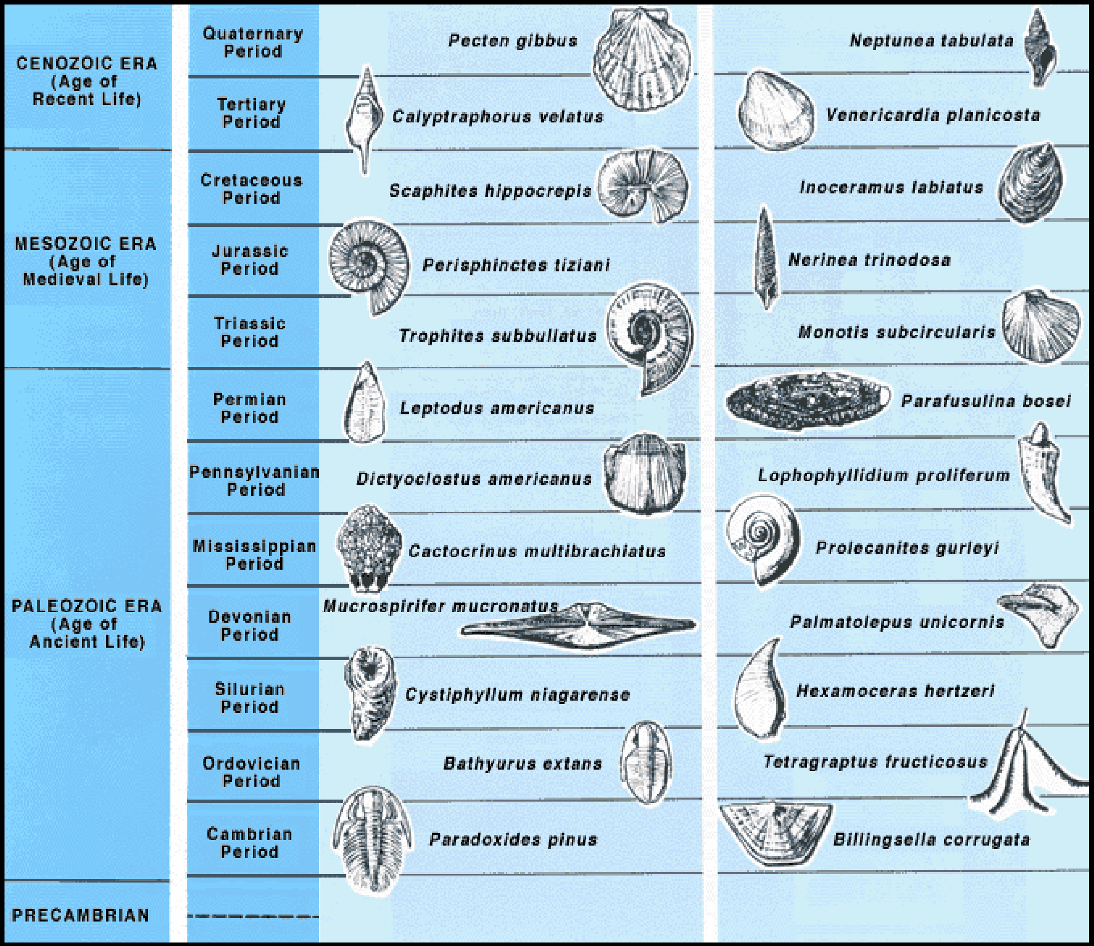
99 % of all of the species that ever existed on Earth are now extinct

Index Fossils

Criteria to be a Useful Index Fossil:

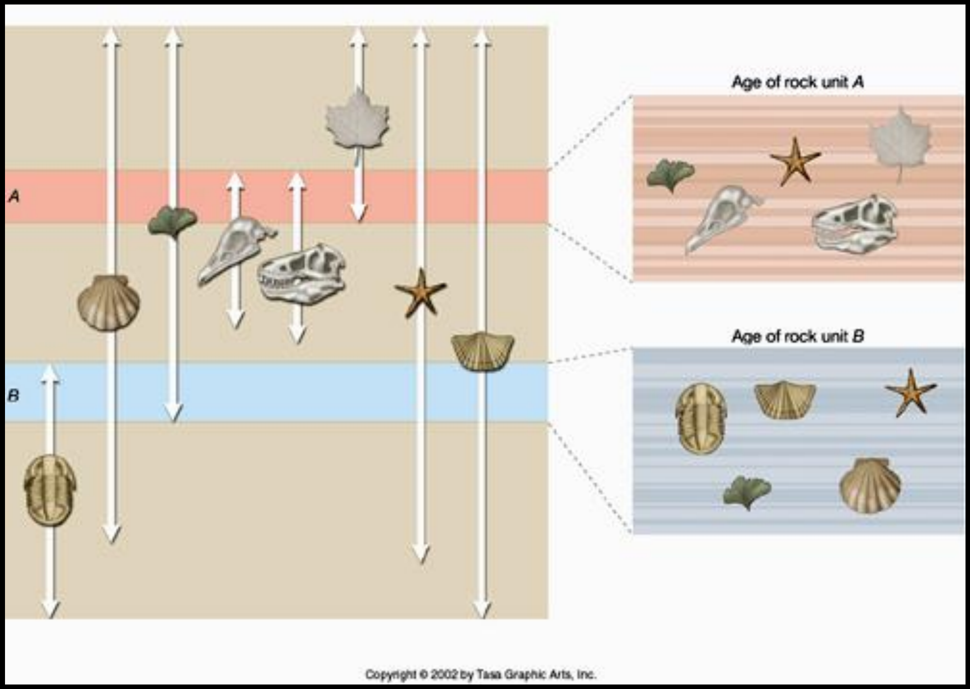
Must have:

1) Narrow time range age
2) Worldwide distribution
3) Preserve in a wide range of depositional settings

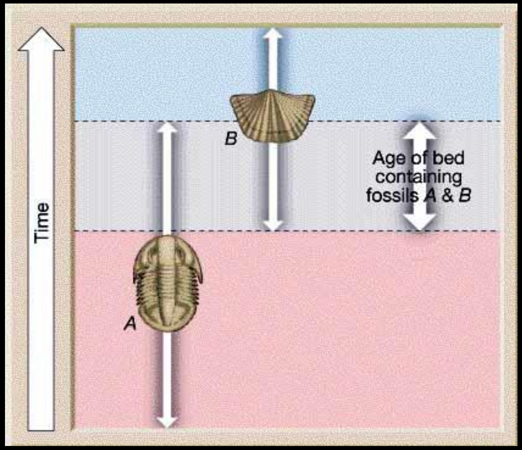


Index Fossil Age Ranges

1) Each index fossil species has a specific determined age range.
2) A rock that has an index fossil will be assigned an age range to that of the fossil's age range.
3) Finding two or more index fossils in the same rock narrows the age range due to overlap of fossil age ranges

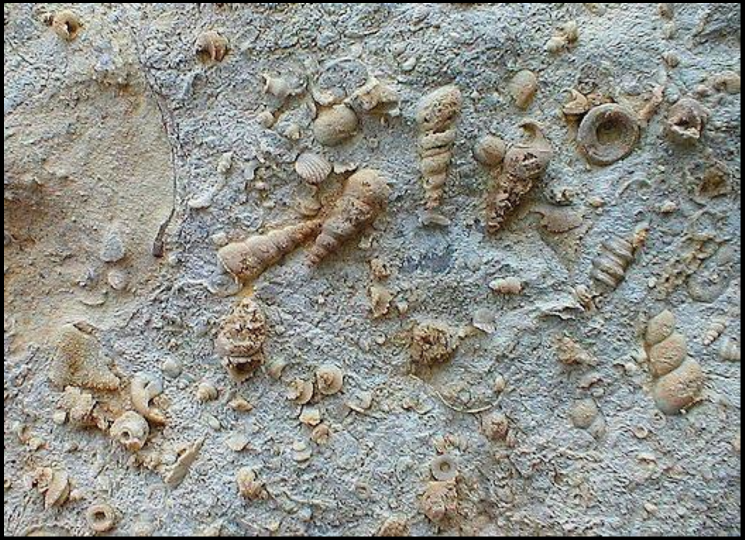


Constraining the age (range) of an index fossil assemblage



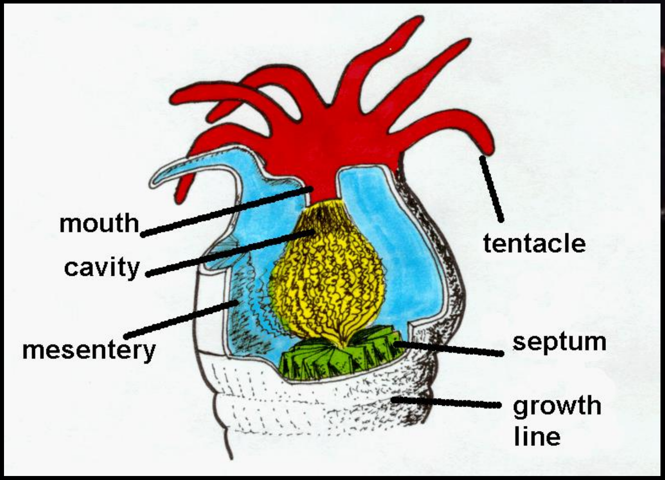
Introduction to Marine Invertebrate Fossils

- "stromatolites"
- P. Porifera
- **P. Cnideria**
- P. Bryozoa
- **P. Brachiopoda**
- **P. Mollusca**
- **P. Arthropoda**
- **P. Echinodermata**



Phylum Cnideria
(corals, anemones, jelly fish)

Only the corals precipitate a hard carbonate skeleton



Class Anthozoa (corals)
Three Orders:

- **Or. Scleractinia**
  - Modern corals
  - Cenozoic
- **Or. Rugosa**
  - Horn corals
  - Paleozoic
- **Or. Tabulata**
  - Tabulate corals
  - Paleozoic

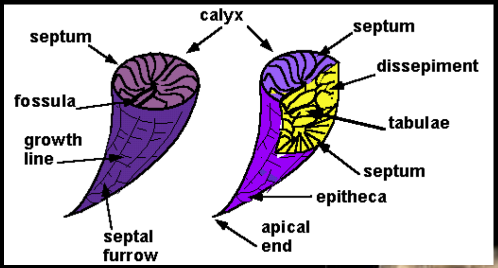
Rugose Corals

In rugosan colonies, each corallite skeleton had its own chamber wall while horizontal partitions (tabulae) were absent and septae longer and generally more complex than those in tabulate corals. Although most rugose corals were solitary animals shaped like a horn (horn corals), some grew in groups such that their skeletons were touching and formed mound-shaped colonies.

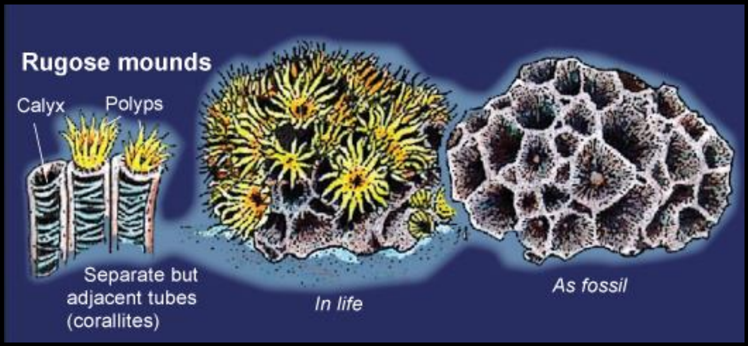
Tabulate Corals

The Tabulata are an extinct form of coral. Their distinguishing feature is their well-developed horizontal internal partitions (tabulae) within each cell, but they have reduced or absent vertical internal partitions (septae) . They share the cell walls. The entire tabulate coral is called the corallum, while the individual tubular chambers within the corallum, in which the coral animal (polyp) lived, are called corallites. Most tabulates were colonial and they were the principal Silurian reef former.

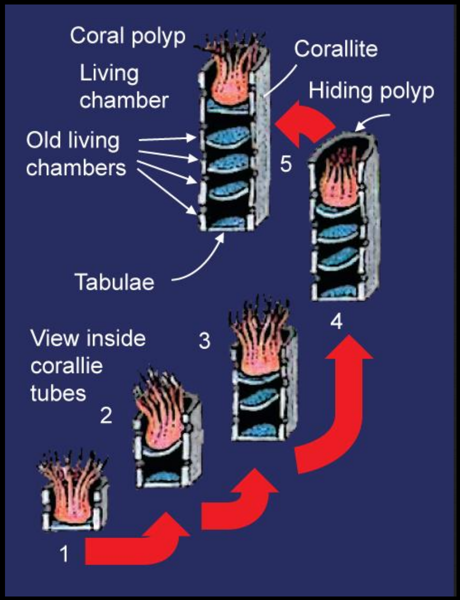
Or. Rugosa (Horn corals)



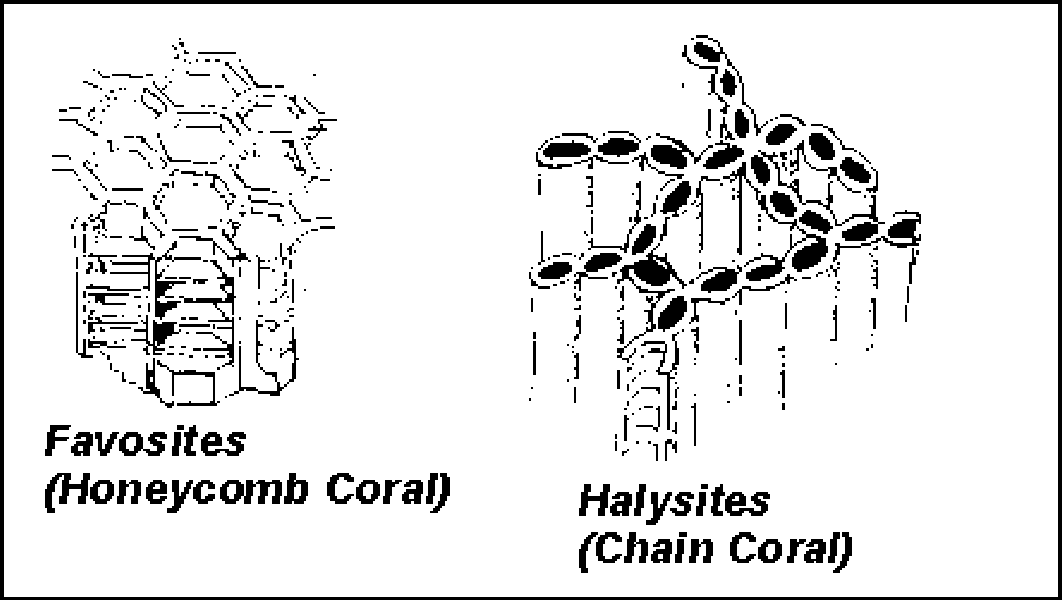
Ordovician through Permian



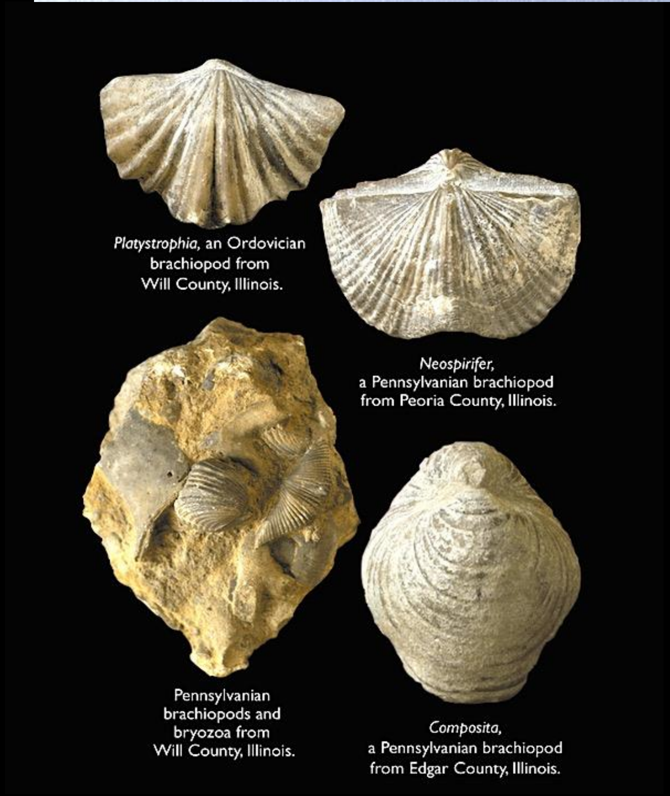
Or. Tabulata (Tabulate corals)

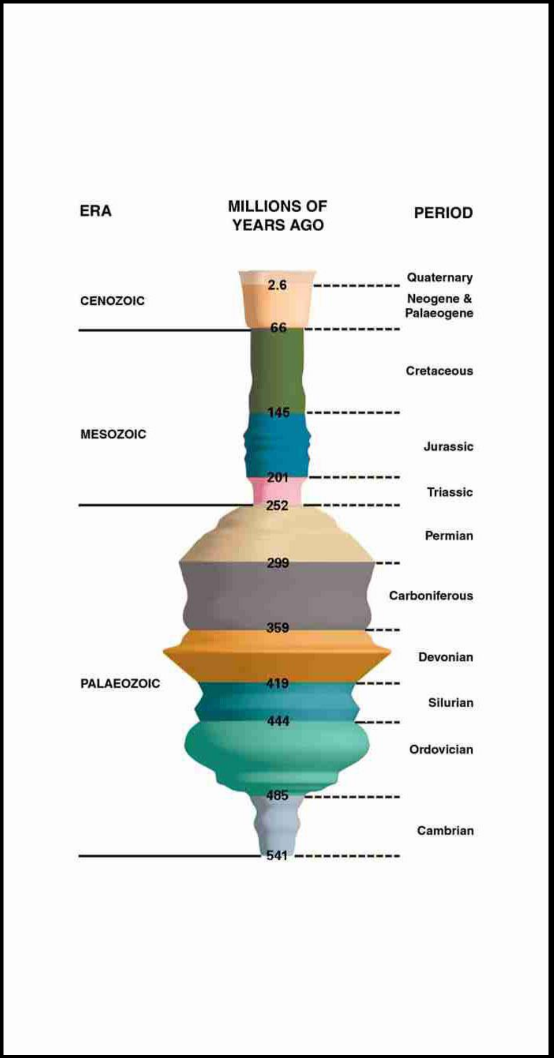


Ordovician through Jurassic

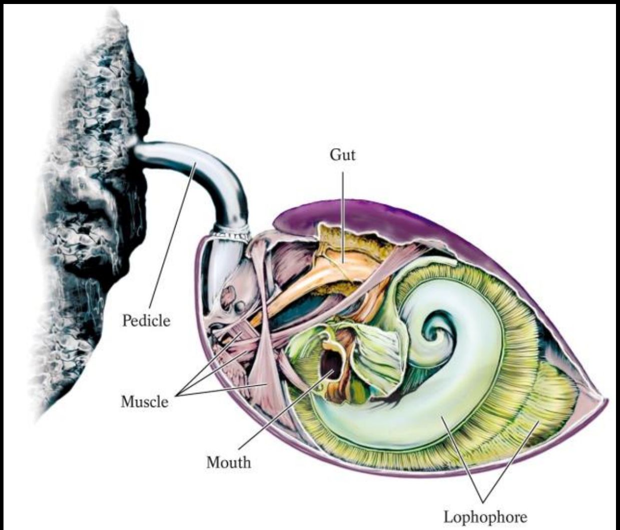


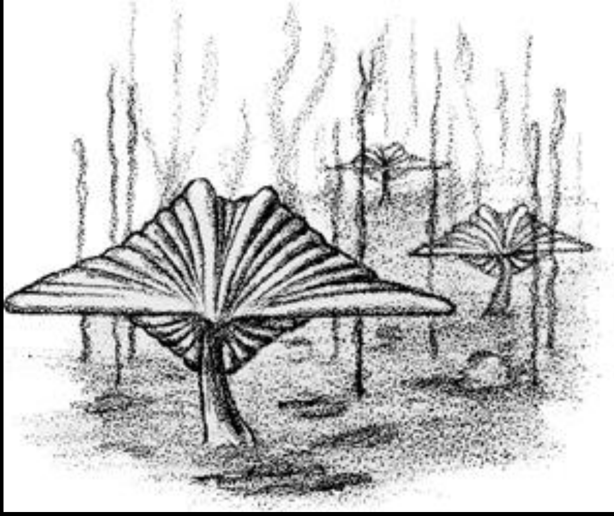
Phylum Brachiopoda





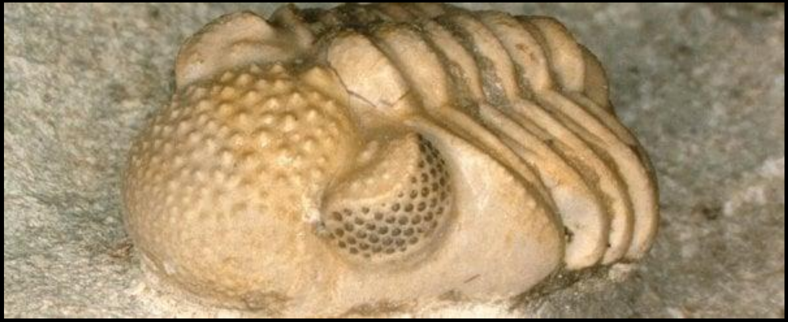
Most diverse during the Paleozoic

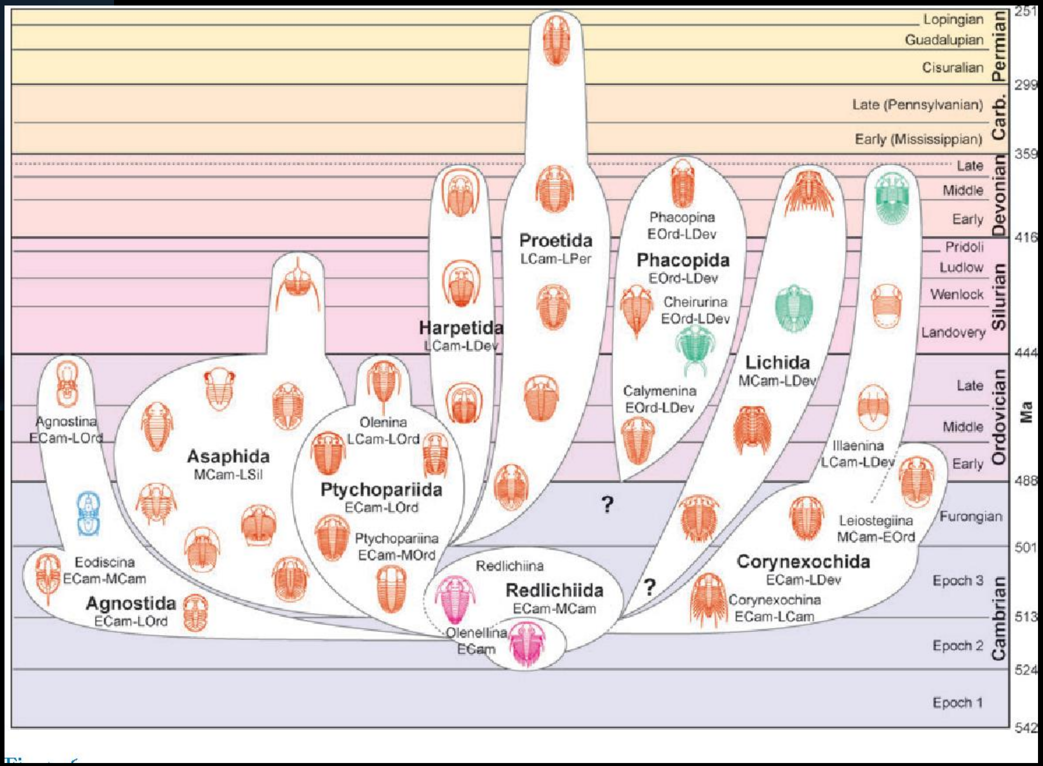


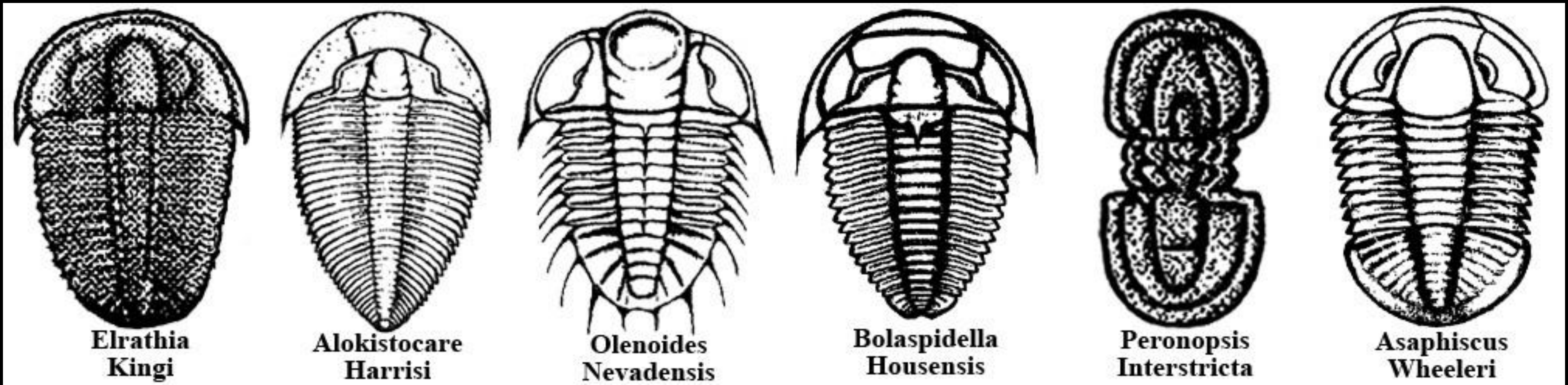


Phylum Arthropoda - Class Trilobita

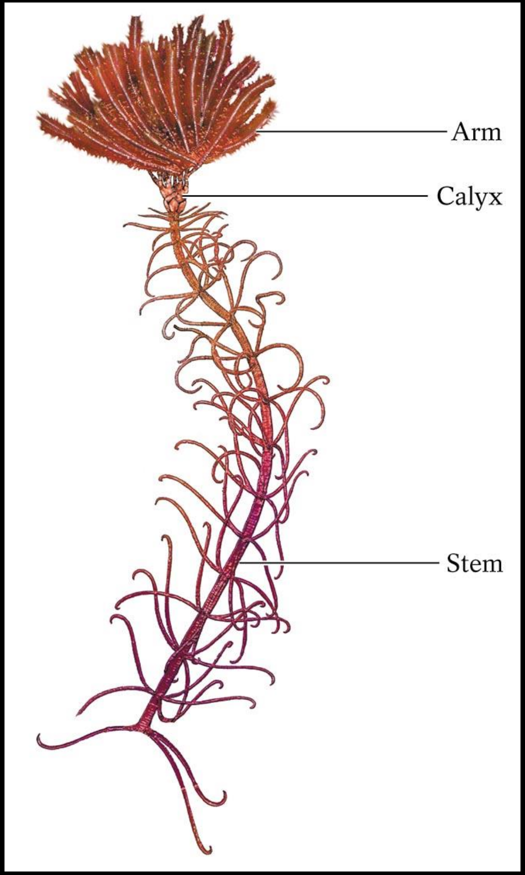
Cambrian to Permian





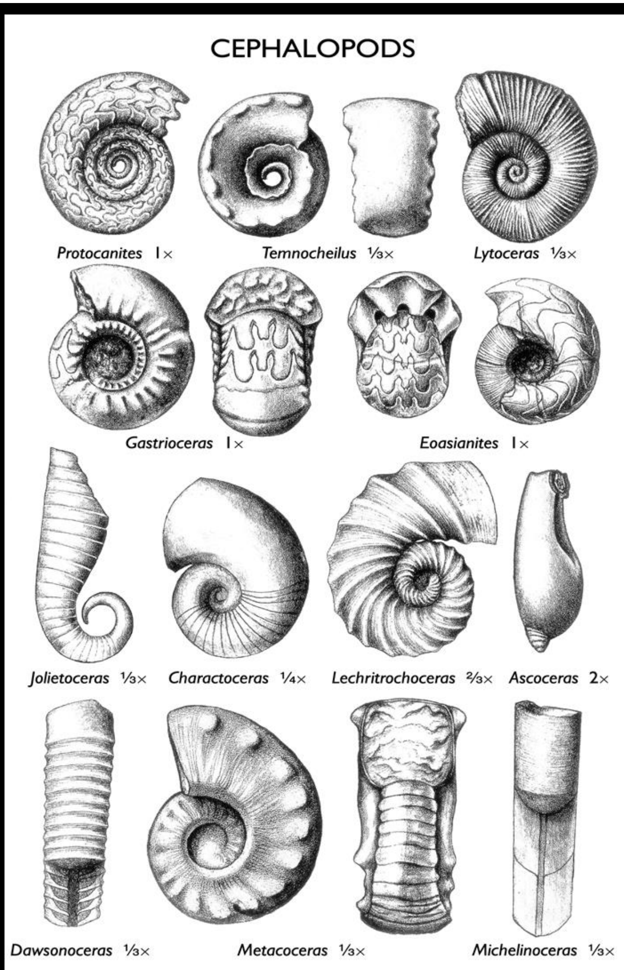


P. Echinodermata – Class Crinoid



- Greatest diversity in the Paleozoic
- Most groups went extinct at the P/T boundary (225 Ma)
- ***Good indicator of a Paleozoic fossil assemblage***

Phylum Mollusca - Class Cephalopoda



Ammonites and Belemnites

Paleozoic and Mesozoic

Geologic range for some of the Cephalopods

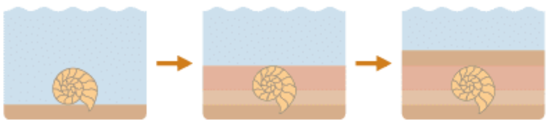
Ammonites, belemnites, othoconic nautiloids:

- **Greatest abundance in the Mesozoic**
- Many groups went extinct at the K/T boundary (66 Ma)
- **Good indicator of a Mesozoic fossil assemblage**

HOW DID AMMONITE FOSSILS FORM?

HOW AMMONITE FOSSILS FORM

Dead ammonites were buried by sediment millions of years ago. Chemical processes then eventually produced a fossil.



AMMONITE SHELLS

Ammonite shells are made of the calcium carbonate mineral aragonite. Over long time periods the aragonite can change into a more stable mineral form of calcium carbonate, called calcite.

Calcium carbonate

$CaCO_3$

Aragonite → **Calcite**

FOSSILISATION AND MINERALS

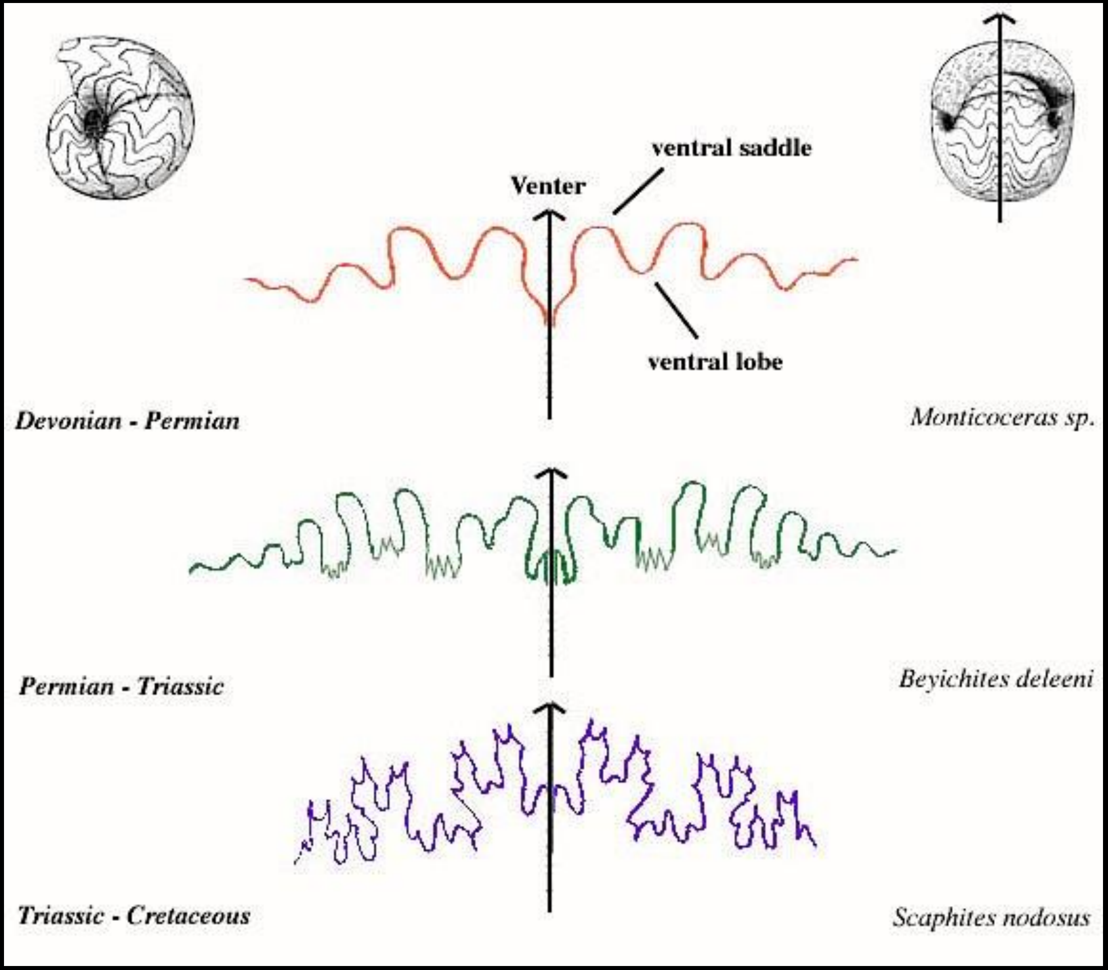
Over time the chambers of the buried ammonite shell can fill with mineral deposits. This produces detailed fossils and some shell can remain intact. In other cases the shell dissolves and mineral deposits fill the cavity to produce a cast.

SILICIFICATION

PYRITIZATION

In silicification, silica-rich solutions replace calcium carbonate with silica. Pyritisation occurs in sediment saturated with iron sulfides. Pyritised fossils can oxidise and slowly disintegrate in humid conditions.

Ammonite suture patterns

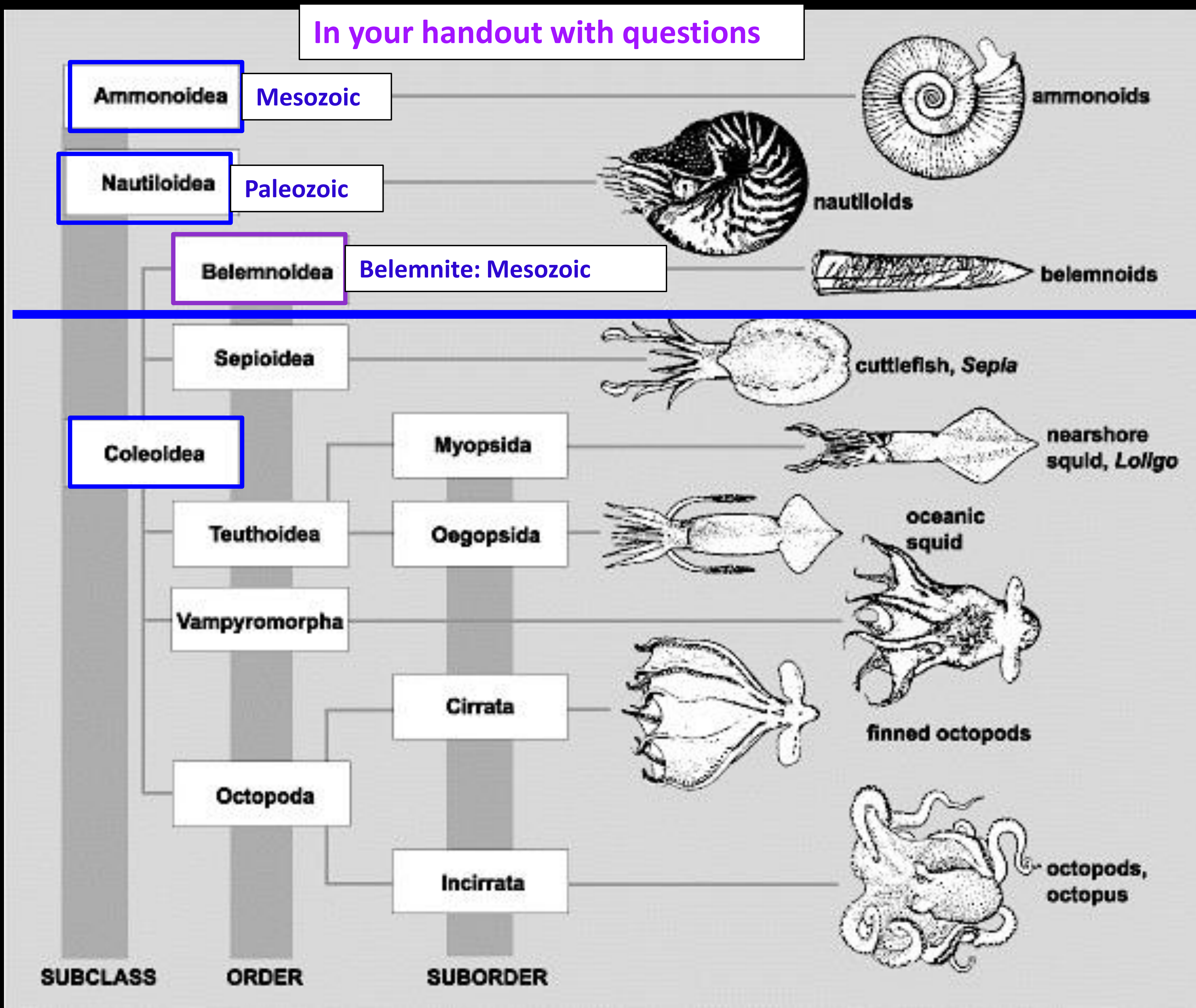


Suture pattern more complex through time

Baculites: Mesozoic

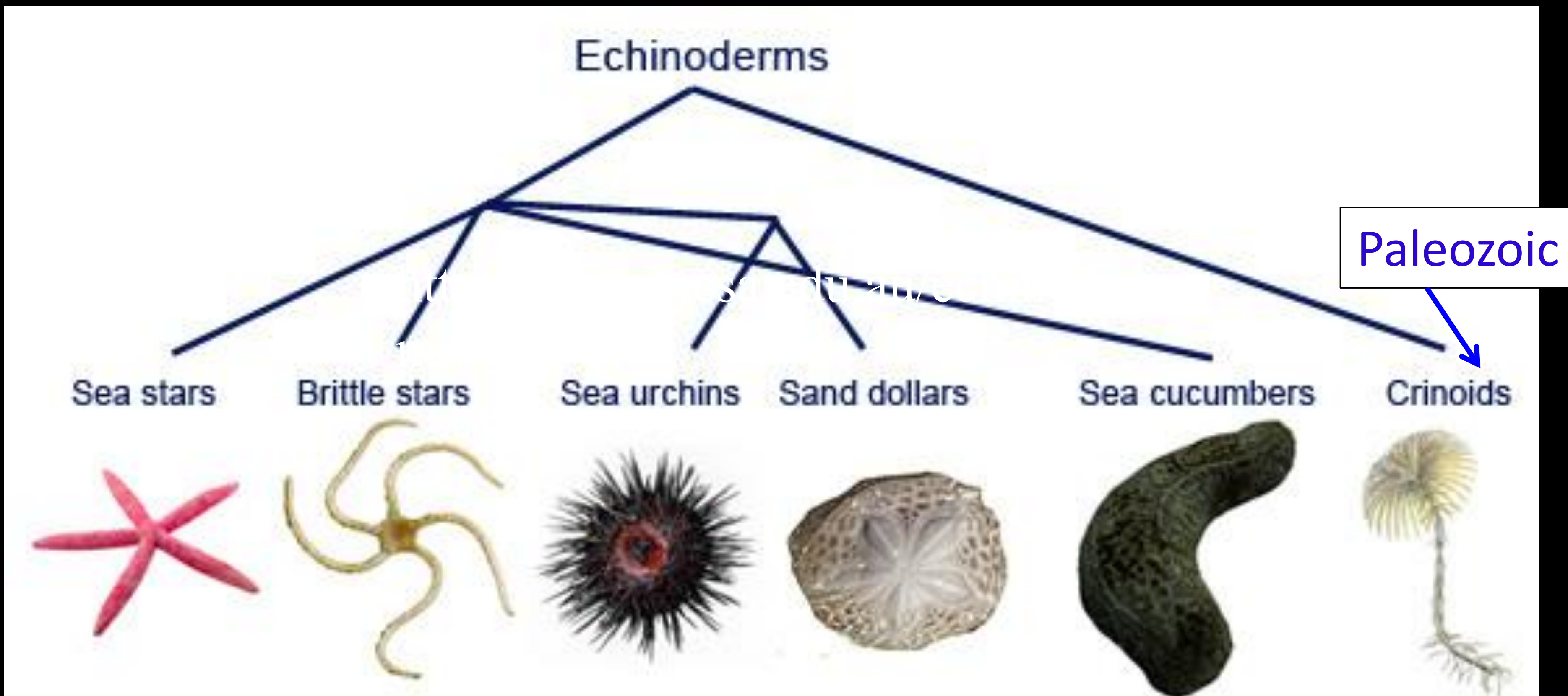
orthoconic nautiloid: Paleozoic

Belemnite: Mesozoic



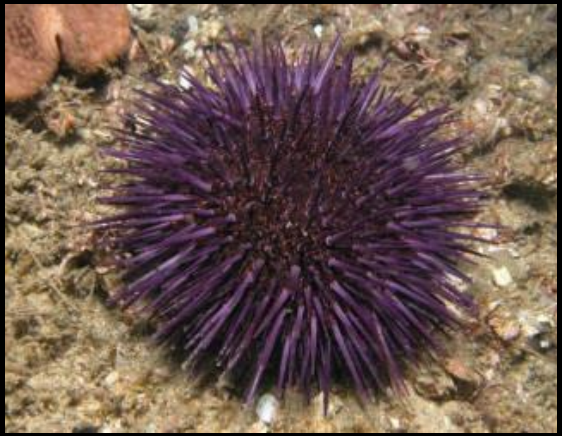
In your handout with questions
Ammonoidea
Mesozoic
ammonoids
Nautiloidea
Paleozoic
nautiloids
Belemnoidea
Belemnite: Mesozoic
belemnoids
Sepioidea
cuttlefish, *Sepia*
Coleoidea
Myopsida
nearshore squid, *Loligo*
Teuthoidea
Oegopsida
oceanic squid
Vampyromorpha
Cirrata
finned octopods
Octopoda
Incirrata
octopods, octopus
SUBCLASS
ORDER
SUBORDER

P. Echinodermata



http://www.mesa.edu.au/echinoderms/

P. Echinodermata



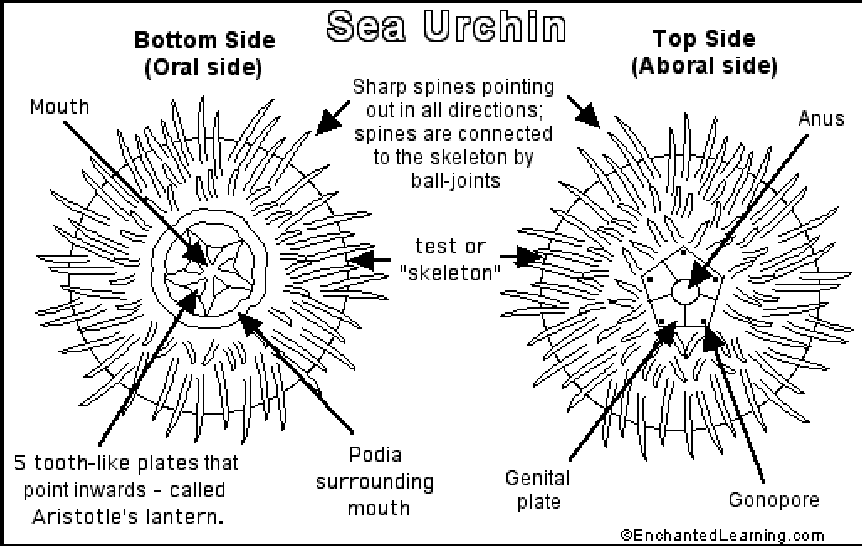
C. Echininoidea
"Echinoids"

"sea urchins"

"heart urchins"

"sand dollars"

Echinoderms have **radial symmetry**, many having **five or multiples of five arms**. They have a shell, made mainly of calcium carbonate, which is covered by skin.



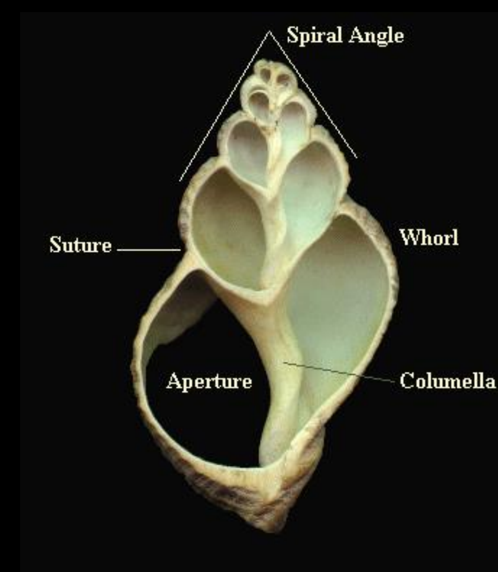
Phylum Mollusca
(clams, snails, squids etc.)

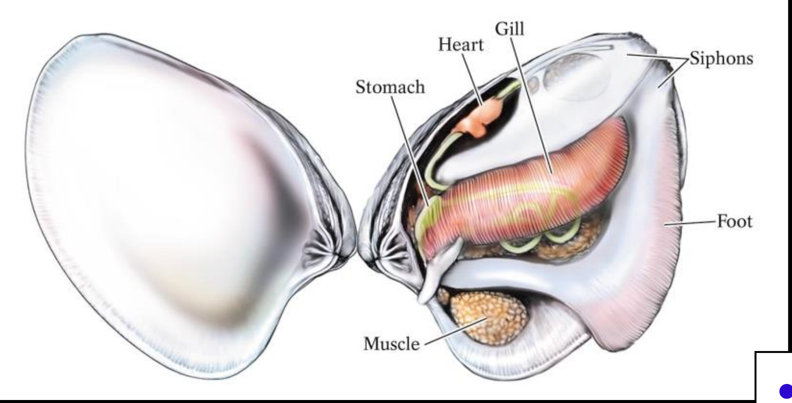
- Class Gastropoda: Paleozoic
  - Snails
- Class Bivalvia: Paleozoic
  - Bivalves or clams
- Class Cephalopoda: Mesozoic
  - Squid, octopus, nautilus, ammonites

“Archaeogastropods”

Phylum Mollusca
C. Gastropods

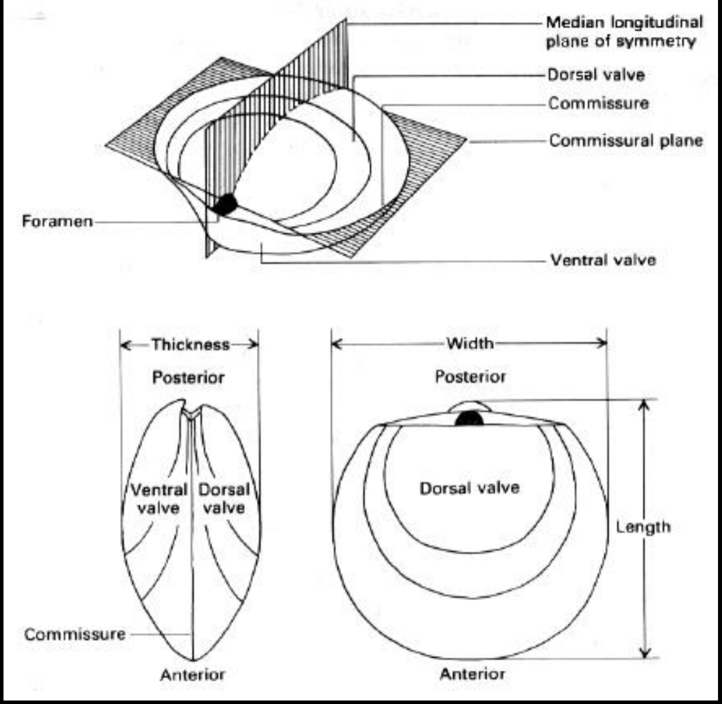
“neogastropods”

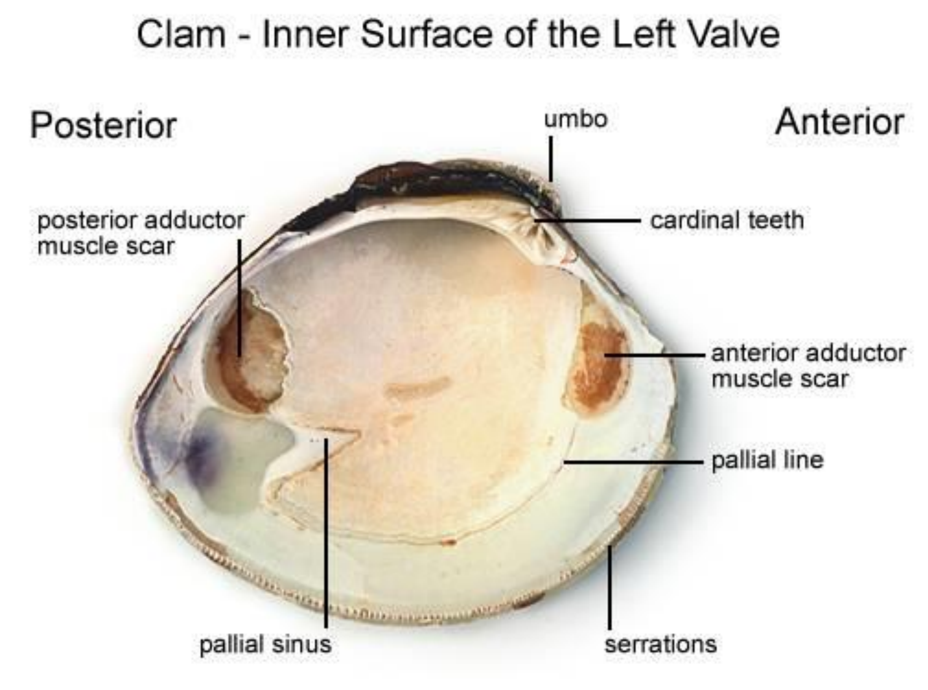




Phylum Mollusca
C. Bivalvia

- Found throughout the Phanerozoic
- Cenozoic:
  - Greatest diversity & range of habitats
    - Adaptions for deep burrowing, etc





Mesozoic assemblages

- Belemnites
- Ammonites (complex sutures)
- Dinosaurs

Cenozoic assemblages

- Gastropods
- Echinoids
- Bivalves
- ~~Scleractinian (modern) corals~~

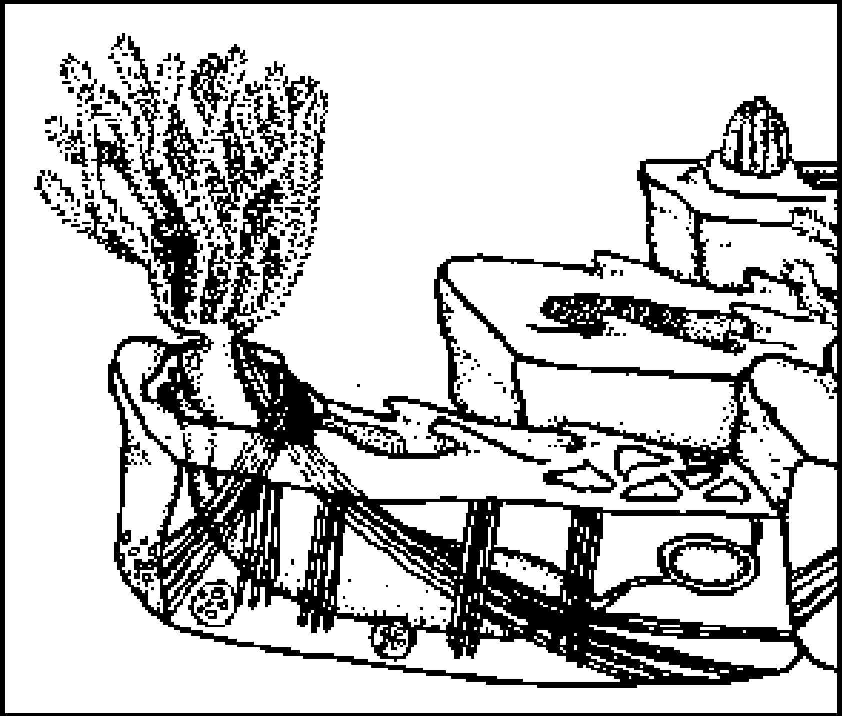
Paleozoic assemblages

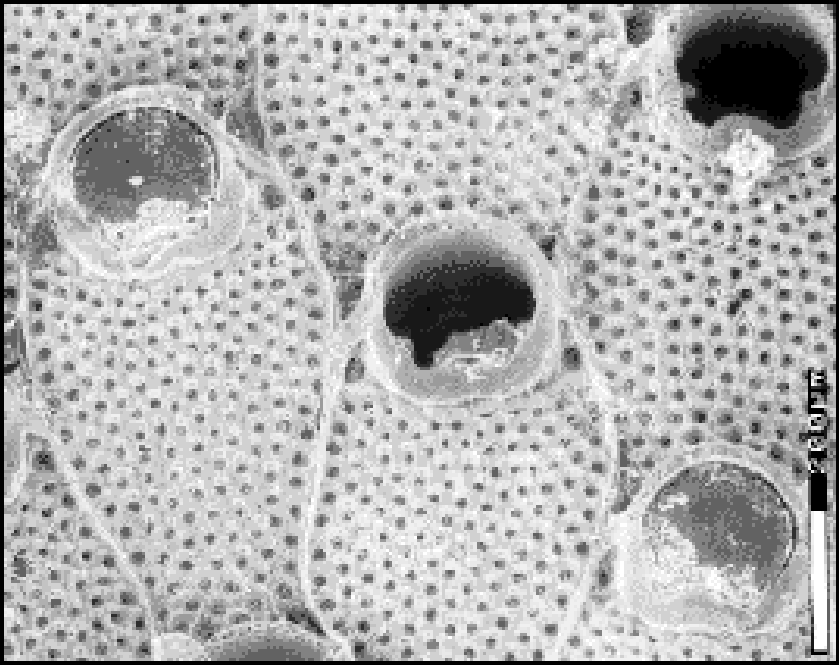
- Tabulate corals
- Rugose corals
- Brachiopods
- Crinoids
- Trilobites

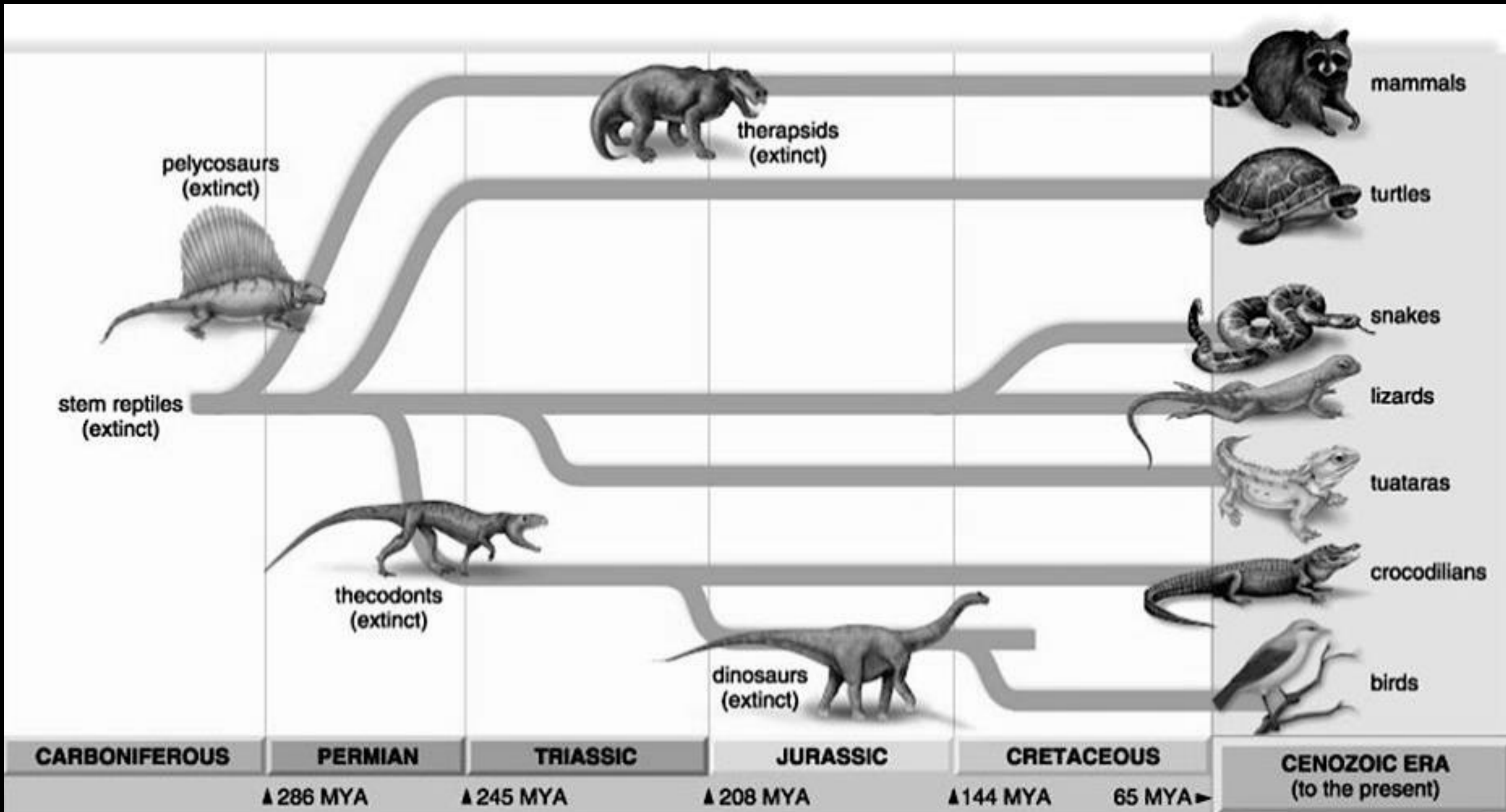
Phylum Bryozoa
(moss animals)

Branching forms most diverse during the Paleozoic

Phylum Bryozoa
(moss animals)






mammals
therapsids
(extinct)
pelycosaurs
(extinct)
turtles
snakes
lizards
stem reptiles
(extinct)
tuataras
crocodilians
thecodonts
(extinct)
dinosaurs
(extinct)
birds
CARBONIFEROUS
PERMIAN
TRIASSIC
JURASSIC
CRETACEOUS
CENOZOIC ERA
(to the present)
286 MYA
245 MYA
208 MYA
144 MYA
65 MYA