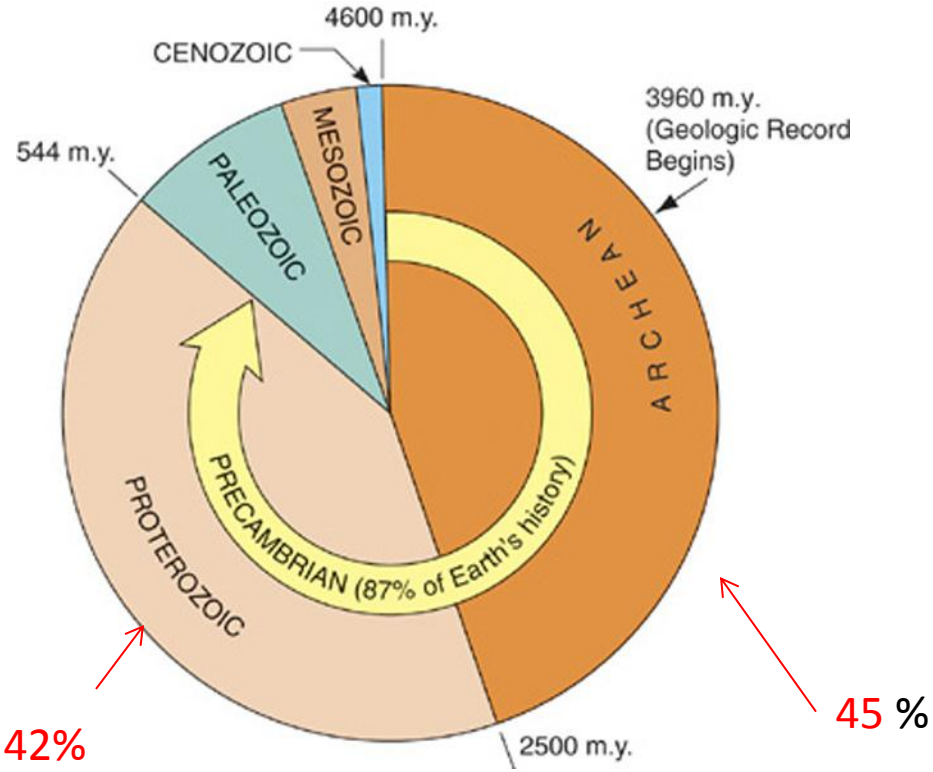
Test 3 Review

Hadean, Archean, Proterozoic, Paleozoic

The Precambrian

The Hadean, Archean and Proterozoic Eons comprise the Precambrian, which spans 87% of the geologic time scale.



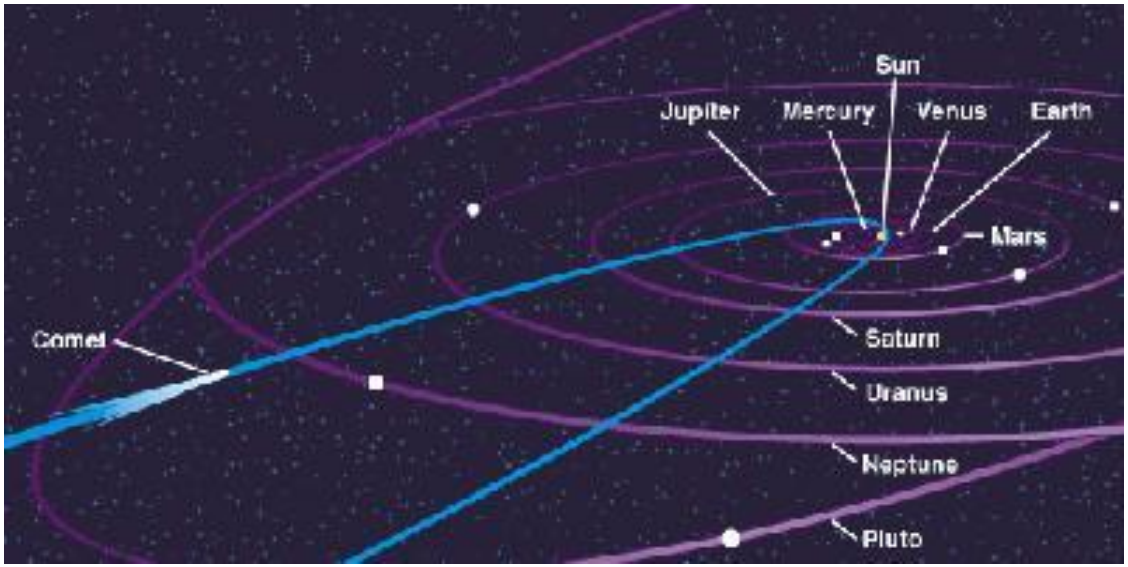
Galaxies

- The Universe hosts billions of galaxies. A **galaxy** = group of stars, planets, dust, and gases.
- Earth, belongs to the Milky Way galaxy.

Whirlpool galaxy. Image courtesy of NASA and The Hubble Heritage Team (STScI/AURA)

The Solar System

The Sun and the planets, moons, asteroids, comets and other objects that orbit it, comprise the **Solar System**.

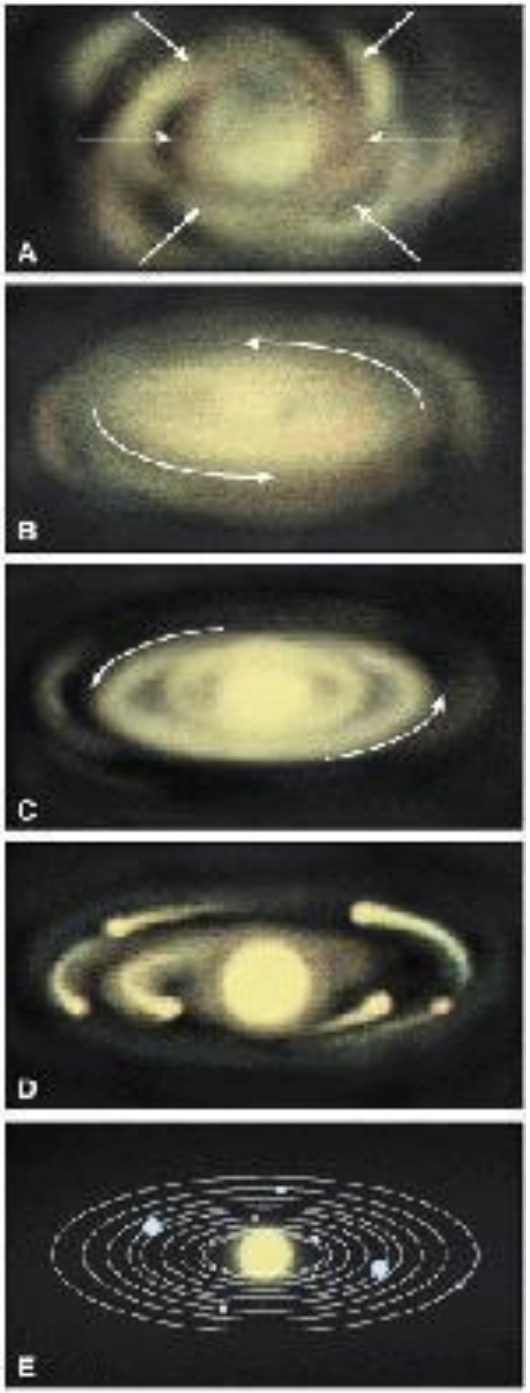


Formation of the Solar System - The Solar Nebula Hypothesis

Solar Nebula Hypothesis or Nebular Hypothesis

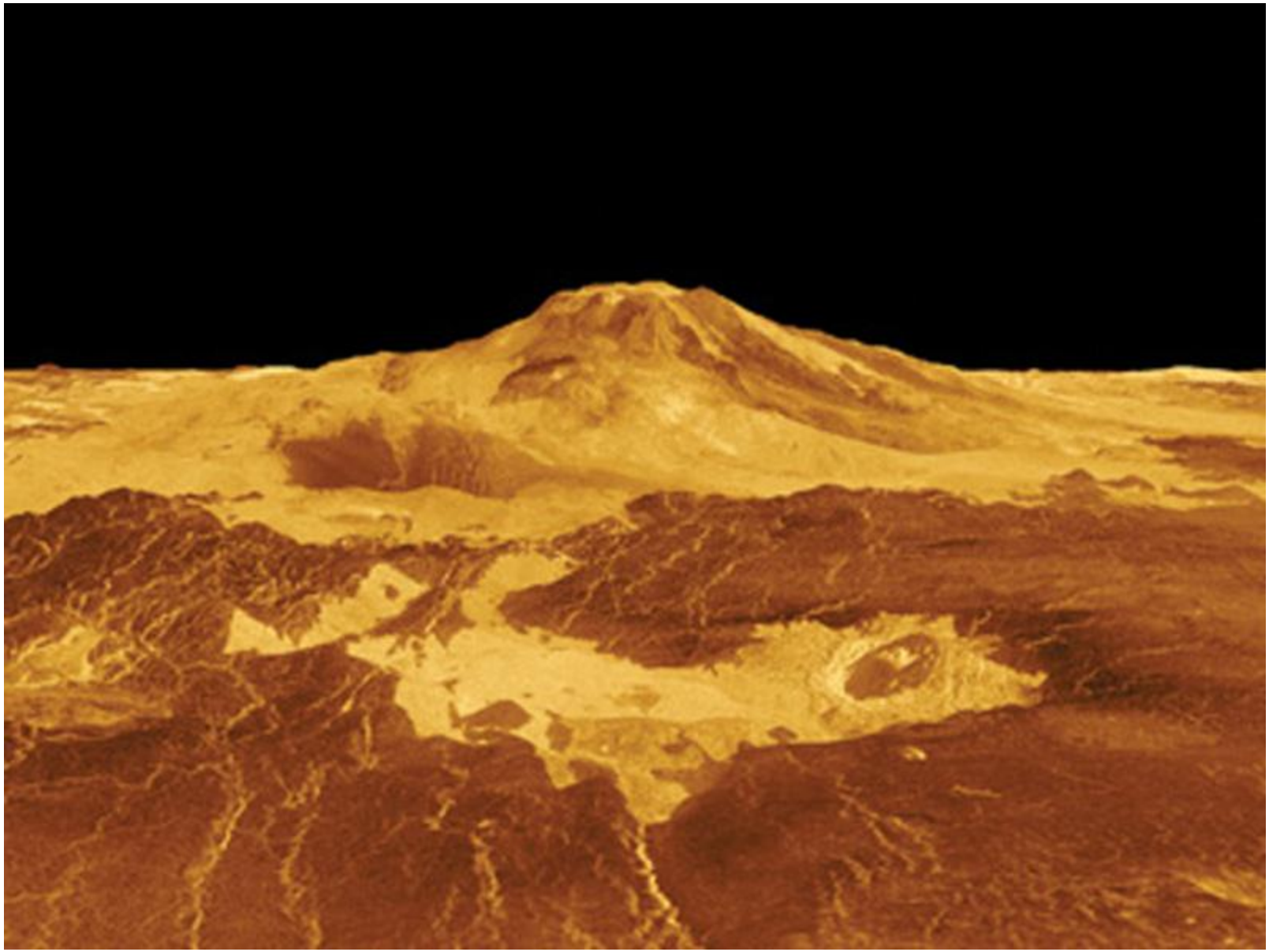
1. Cold cloud of gas and dust contracts, rotates, and flattens into a disk-like shape.
2. Clumps of matter begin to form in the disk.
3. Accretion of matter (gas and dust) around clumps by gravitational attraction
4. Solar nebula cloud condenses, shrinks

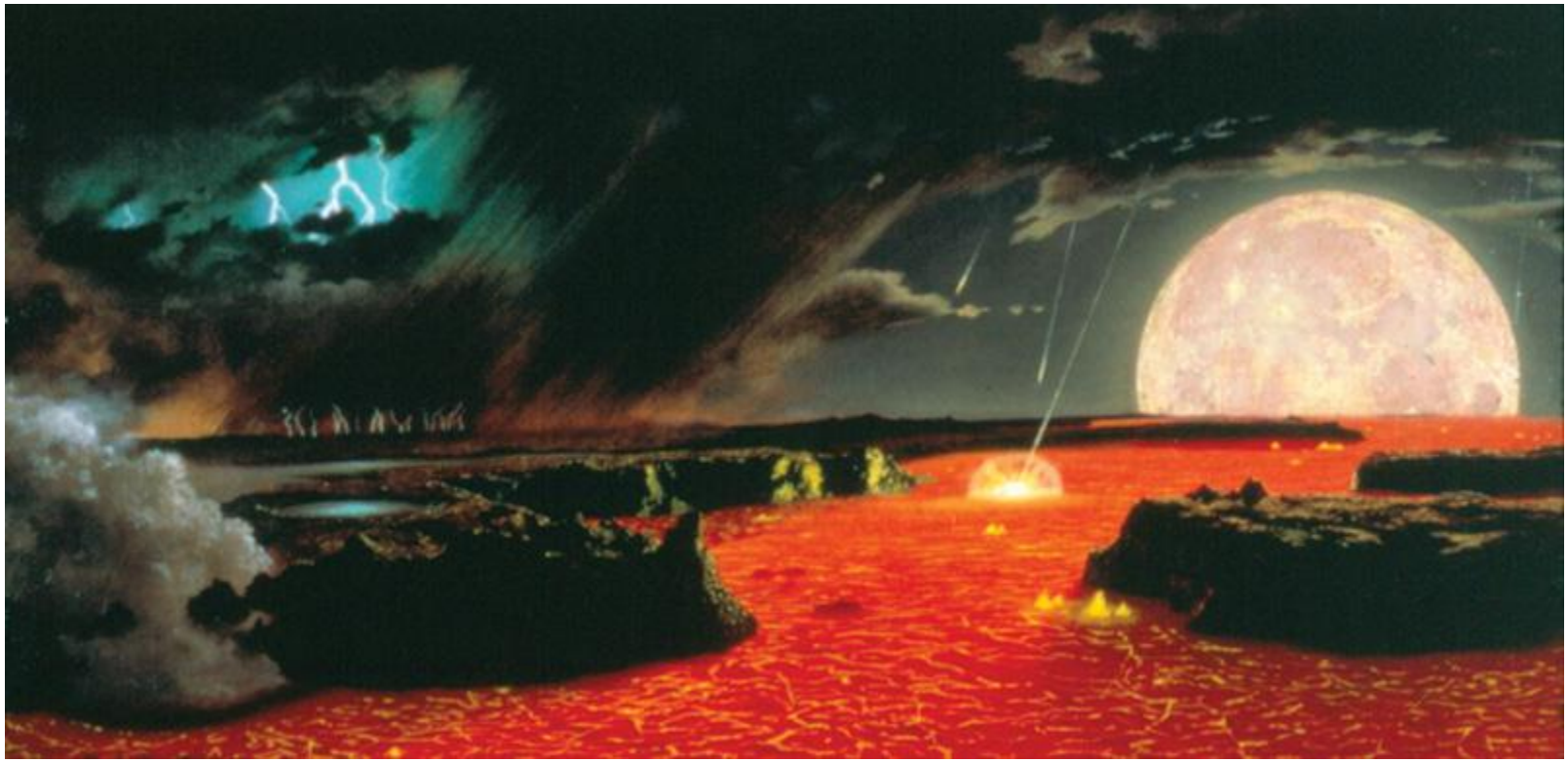
The Nebular Hypothesis



How old is the Solar System?

Based on radiometric dates of moon rocks and meteorites, the Solar System is about 4.6 billion years old.





Evolution of Earth's Atmosphere and Hydrosphere

- Earth's first atmosphere = H, He
- Made from gases associated with the comets and meteorites during earth formation

Earth's First Atmosphere (4.6 BYA)

Composition:

Hydrogen and Helium

- **This atmosphere was constantly "leaking".**

Gases Associated with Comets

- Comets are made of frozen gases, ice and dust.
- Halley's comet is composed of:
  - 80% **water ice**
  - Frozen **carbon dioxide** (dry ice)
  - Hydrogen cloud surrounds comet
  - Dust near the nucleus contains iron, oxygen, silicon, magnesium, sodium, sulfur, and carbon

Volcanic Outgassing

- Outgassing = release of water vapor and other gases from Earth through volcanism.
- Gases from Hawaiian eruptions consist of:
  - 70% water vapor (H_2O)
  - 15% carbon dioxide (CO_2)
  - 5% nitrogen (N_2)
  - 5% sulfur (in H_2S)
  - chlorine (in HCl)
  - hydrogen
  - argon

Formation of the Hydrosphere

.

1. Water vapor condensed and fell as rain.

2. Liquid water probably began to fall on the Earth's surface as early as 4.4 billion years ago.

3. Rain water accumulated in low places to form seas. The seas were originally freshwater (rain).

Earth's Second Atmosphere (4.4 BYA)

Composition:

Hydrogen, Carbon Dioxide, Ammonia, Methane and Water Vapor

- **This atmosphere contained 100 times more gas than the first one.**
- **The planet's size was large enough to retain gases.**
- **The Earth had differentiated to form a solid iron core.**
- **No Oxygen.**

The **Hadean Era** is the oldest unit on the geologic time scale (4600 to 3800 MYA)

The name comes from Hades, the underworld of Greek mythology. (early Earth was "hellish" = the Earth's surface was molten.)

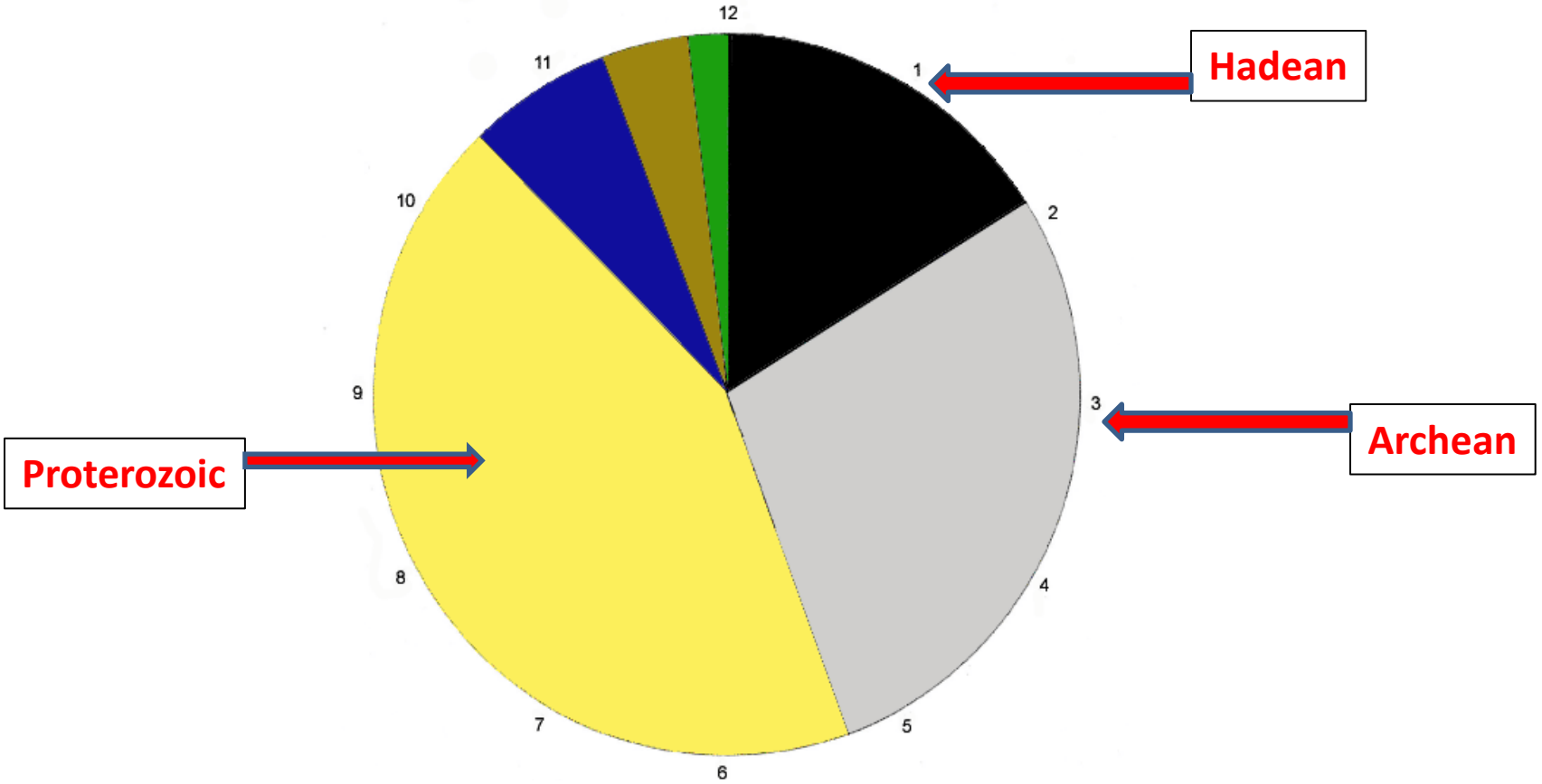
Beginning = birth of the solar system, including Earth
Ends with the formation of the oldest rocks

The giant impact hypothesis states = Moon was formed out of the debris from a collision between the Earth and a body the size of Mars

Water vapor = outgassing

Earth's surface was apparently cool enough for oceans to form at 4.4 Billion years

Most of the water on the surface of the Earth and in the atmosphere was outgassed in the first billion years of Earth history.



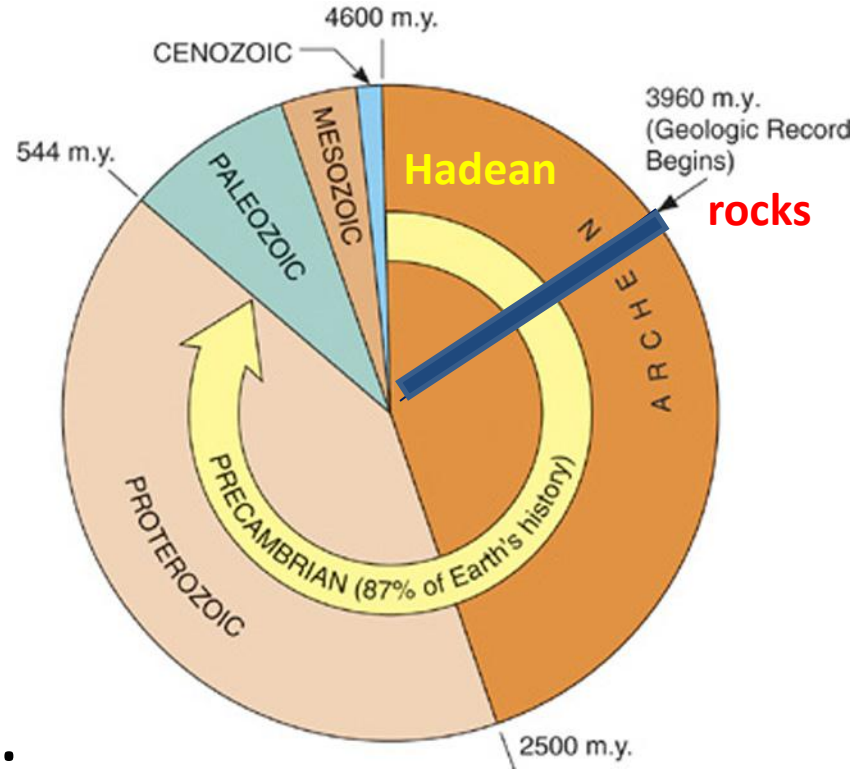
Clock of Eras

1 hour = 375,000,000 years

	Era	Years	Clock Time
	Hadean	700,000,000	1 hour 52 minutes
	Archaean	1,300,000,000	3 hours 28minutes
	Proterozoic	1,957,000,000	5 hours 12 minutes
	Paleozoic	295,000,000	47 minutes
	Mesozoic	183,000,000	29 minutes
	Cenozoic	65,000,000	10 minutes

The Precambrian rocks

Hadean & ARCHEAN= 45%= almost ½ of all earth time



The **Hadean**, **Archean** and **Proterozoic** Eras make up the Precambrian, = 87% of the geologic time scale.

The Archean Crust

- Magma cooled to form rocks = forming the first crust =

BEGINNING OF

THE ARCHEAN ERA

Primordial Soup

Life began in the ocean as a result of the combination of chemicals from the atmosphere and energy to make amino acids.

First Documented Life On Earth

- Achaean Life was dominated by Prokaryotes like the Cyanobacteria.

- Prokaryotes lack a nucleus and produce their own food by photosynthesis.

- This photosynthesis process increased Oxygen levels in Earth's atmosphere.

- Bacteria, algae form colonies= Stromatolites= GREAT OXYGEN PUMPS

Archean Life

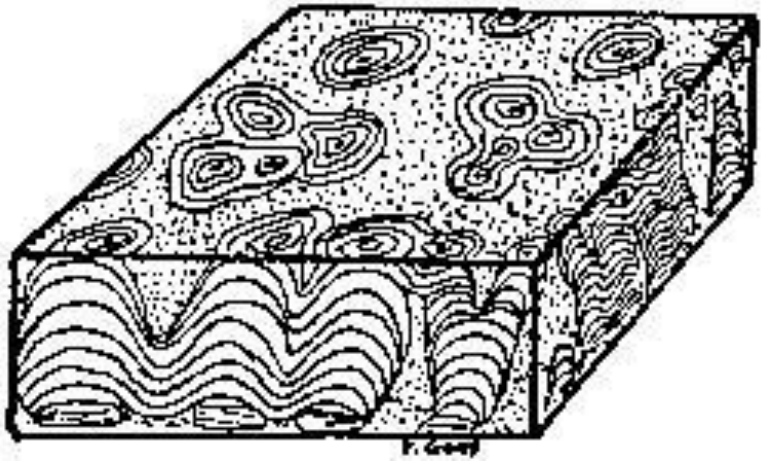
Prokaryotes

Stromatolites

Stromatolites

Modern stromatolites, Shark Bay, western Australia

Sketch of stromatolites, showing top and side views. Sketch courtesy of Pamela Gore.



Stromatolites

- **During the Archean eon, the first fossilized evidence of life on earth appeared.**

- **Stromatolites fossils from Australia are earliest fossils from Archean eon, many older than 3 billion years.**

Photosynthesis by bacteria began to produce oxygen

Third Atmosphere= presence of Oxygen

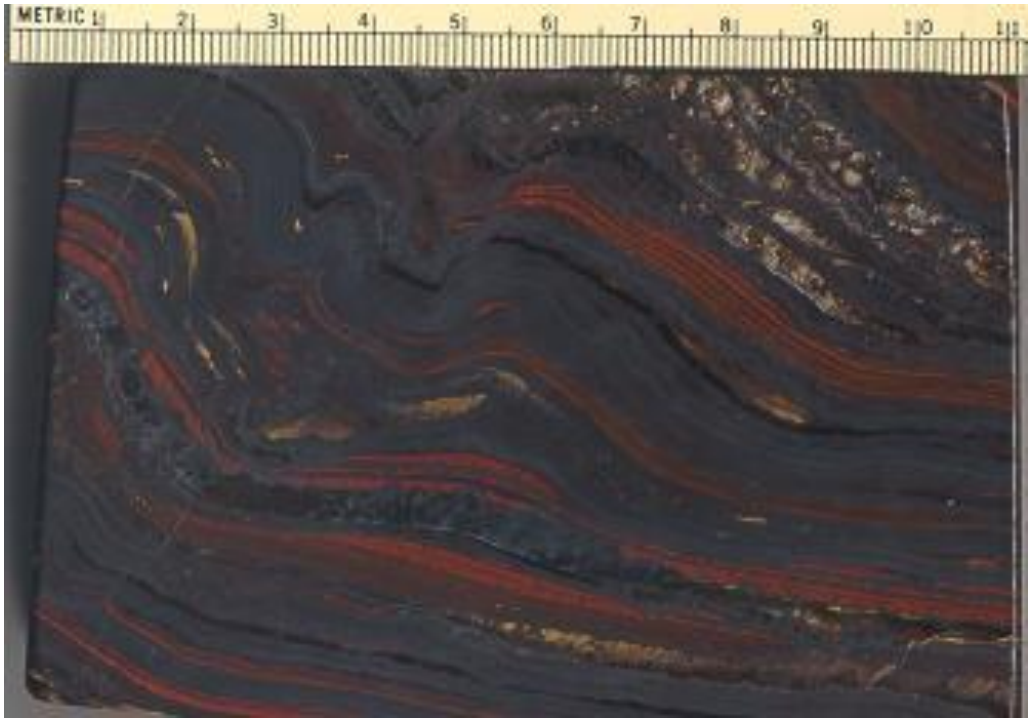
Earth's Third Atmosphere (2.7 BYA)

Composition:

**Oxygen, Carbon Dioxide, Ammonia,
Methane and Water Vapor**

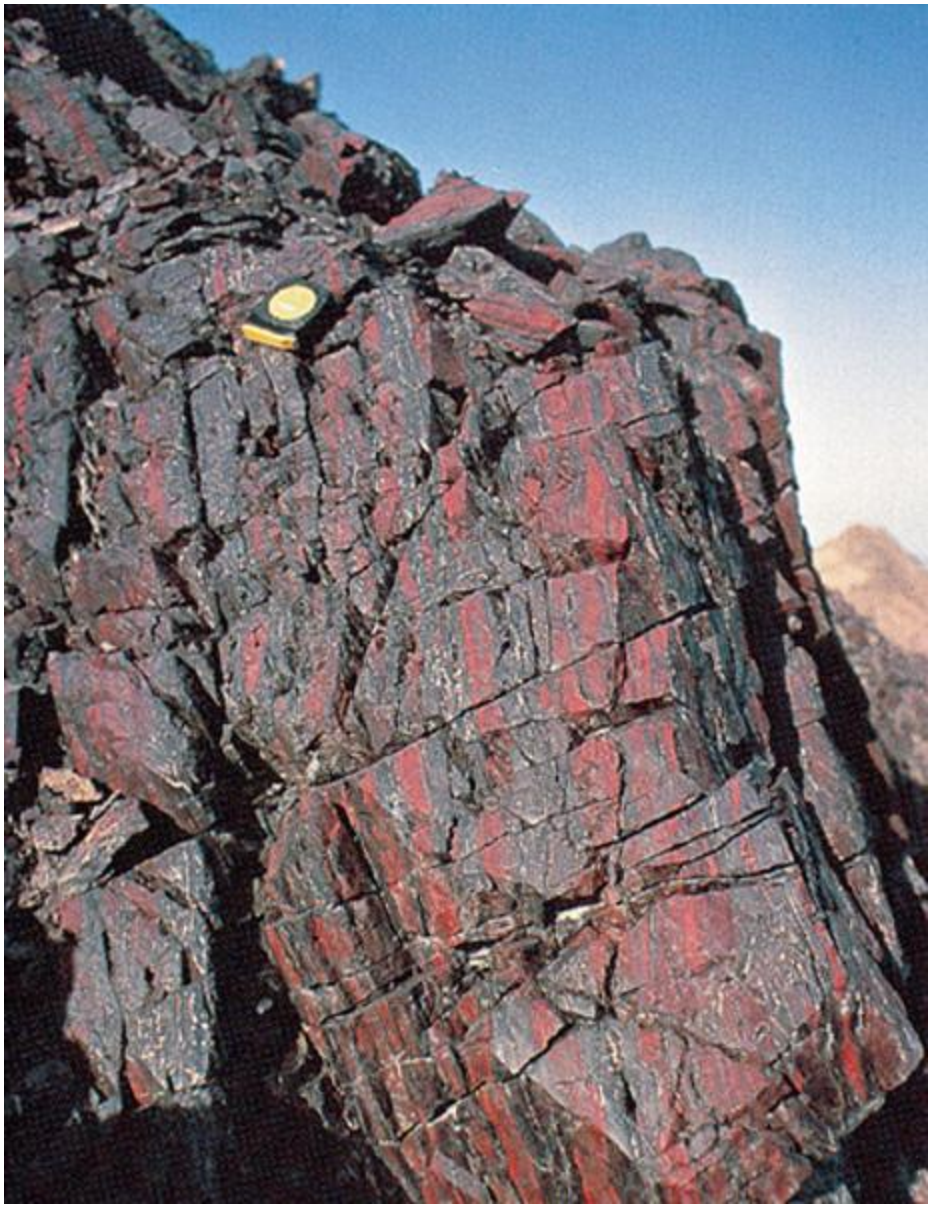
- **Cyanobacteria oxygenates the atmosphere.**

Banded Iron Formation



Polished specimen of banded iron from Australia. A common name for this type of banded iron is "Tiger Iron". Metric ruler for scale.
Photo courtesy of Pamela Gore.

Red= Oxygen



The Precambrian is not well known or completely understood. Why?

- Precambrian rocks = Buried deep.
- have been eroded or **metamorphosed**.
- inaccessible or nearly uninhabited areas.
- Fossils are seldom found in Precambrian rocks.

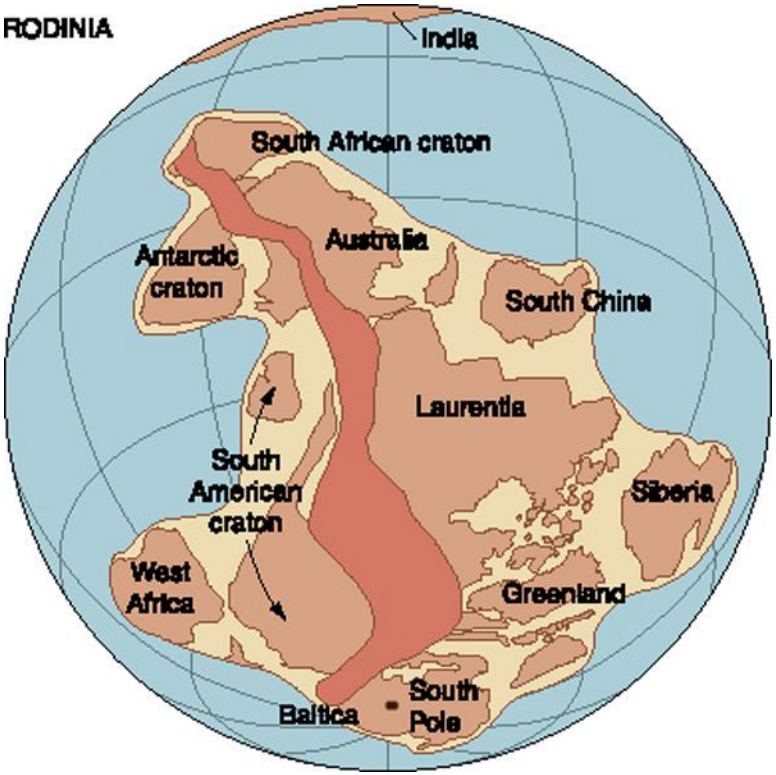
Proterozoic Eon

- 2.5 billion years to 542 million years ago
- Comprises 42% of Earth history

The Beginning of the Proterozoic Marks the Beginning of:

- More modern style of plate tectonics
- More modern global climate with glaciations
- Establishment of the beginnings of an oxygen-rich atmosphere
- Emergence of eukaryotes(cells with a nucleus)

A Super Continent is born



- Collisions of land masses in the proterozoic create a super continent called
- **RODINIA**
- **The first super continent**

All the continents were connected in a single enormous land mass called *Rodinia*,

WHAT DID IT LOOK LIKE?

Desolate sandy, rocky landscape which contained no trees, grass, or even moss.

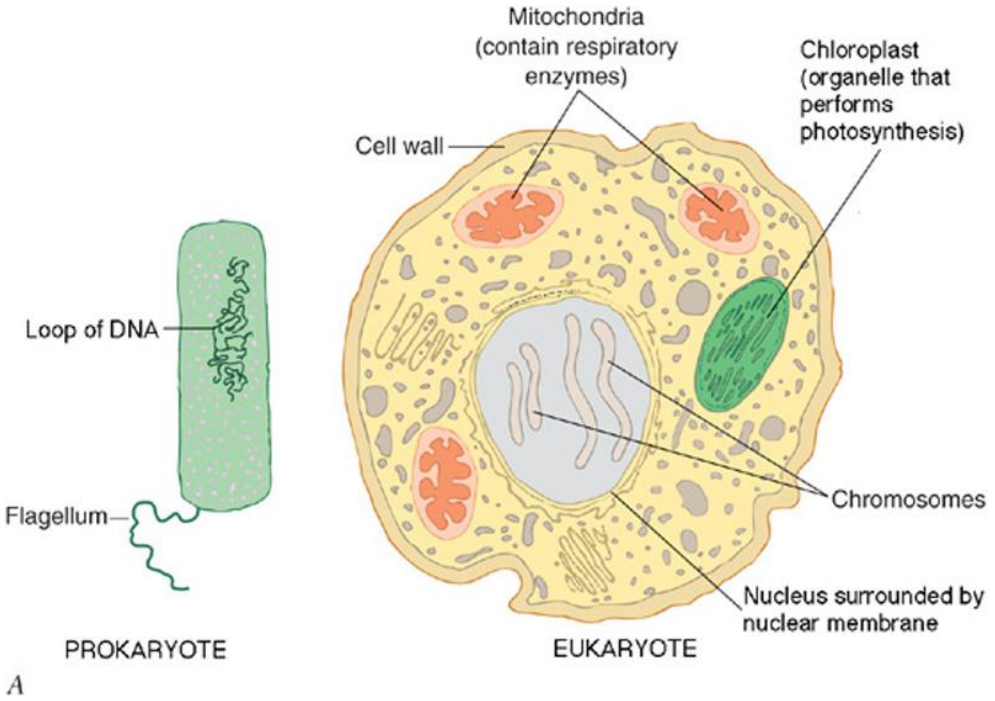
This break-up of Rodinia had HUGE effects on life forms, infusing the ocean with oxygen, As oxygen levels rose, life began to change and grow

Life forms

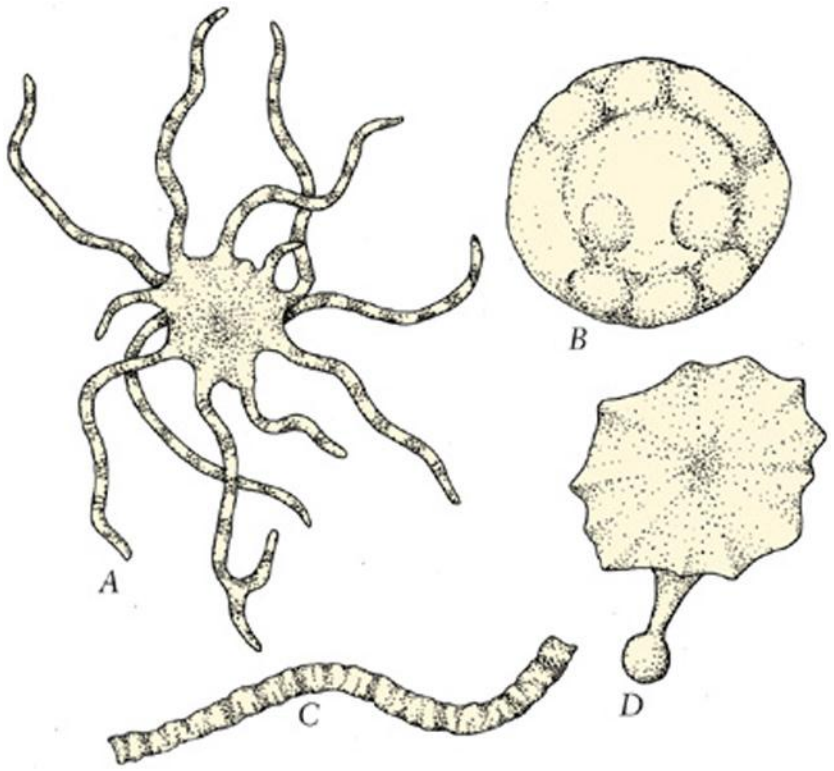
Due to lack of oxygen in the ocean and atmosphere, life = smaller and simple organisms during the late Archean Era

Life forms begin to change

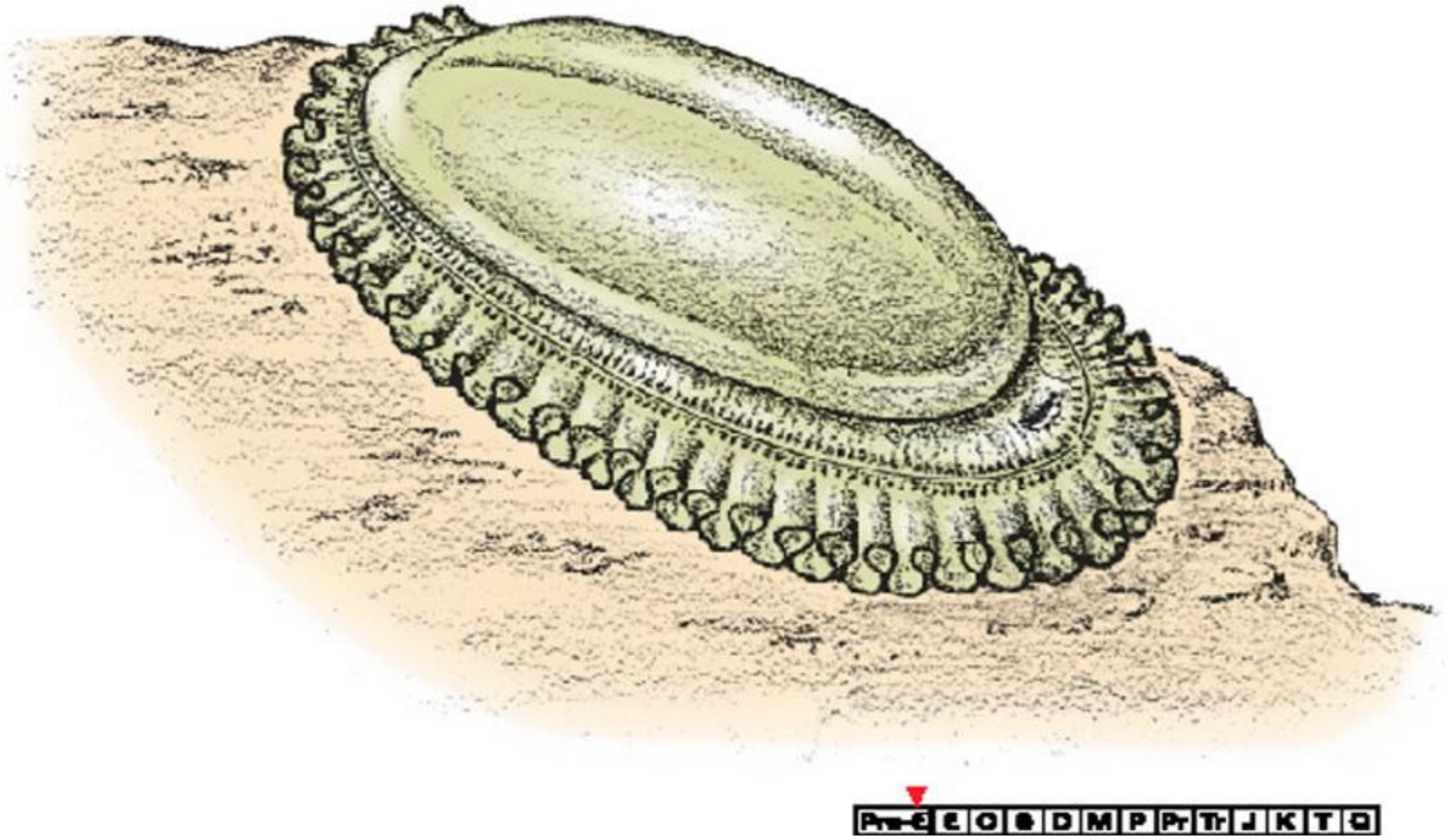
Multi celled organisms develop in the Proterozoic

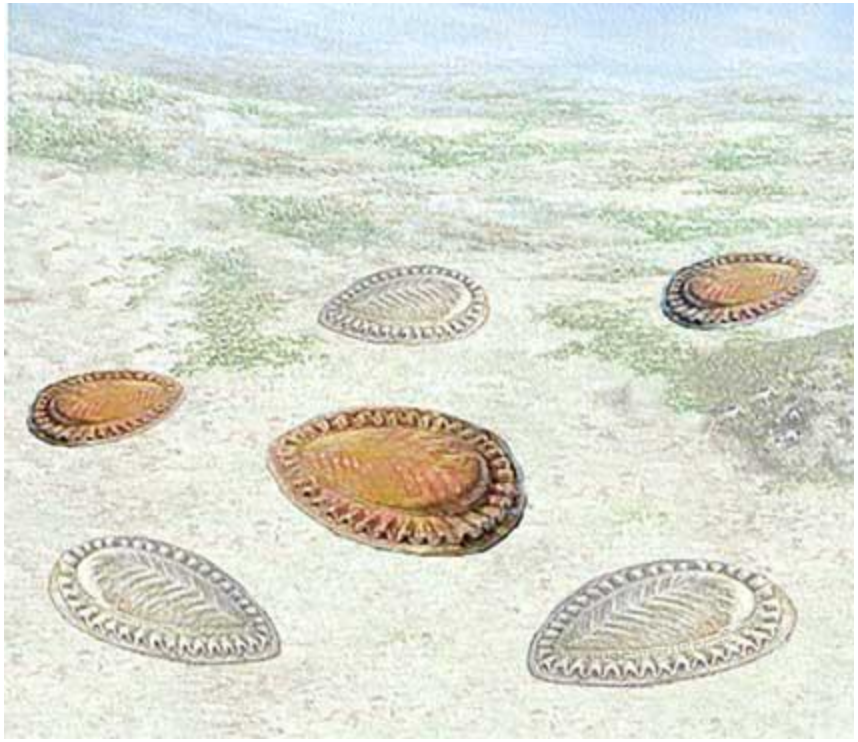


Early Proterozoic life



Kimberella





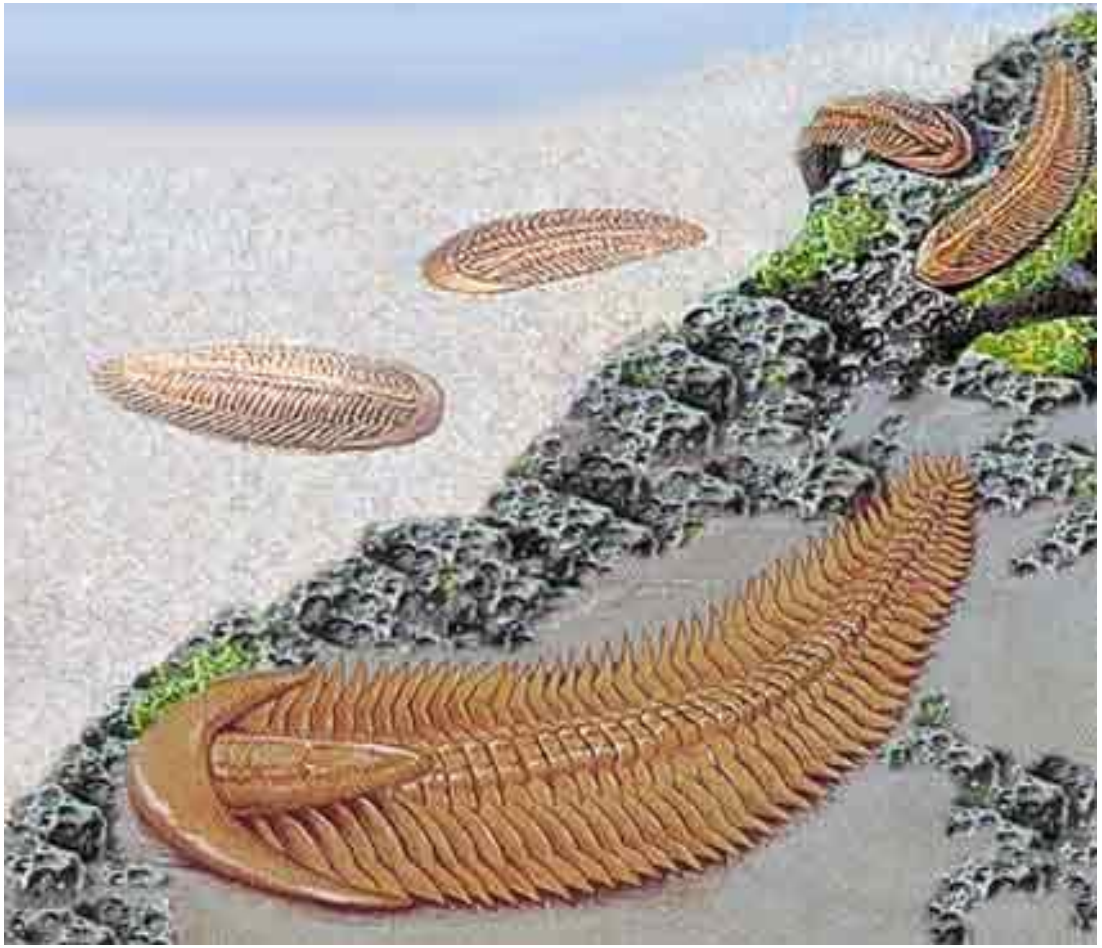
Kimberella is believed to be an early predecessor of snails and clams. Kimberella left fossil evidence in sandstone

Dikinsonia

1.like a flat sheet on the sea bottom.
2.absorbed nutrients directly from the water.
3.It couldn't swim. Or maybe even crawl.
4.no modern relatives."

It grew to a length of as much as two feet (60 cm)

***Spriggina*,**

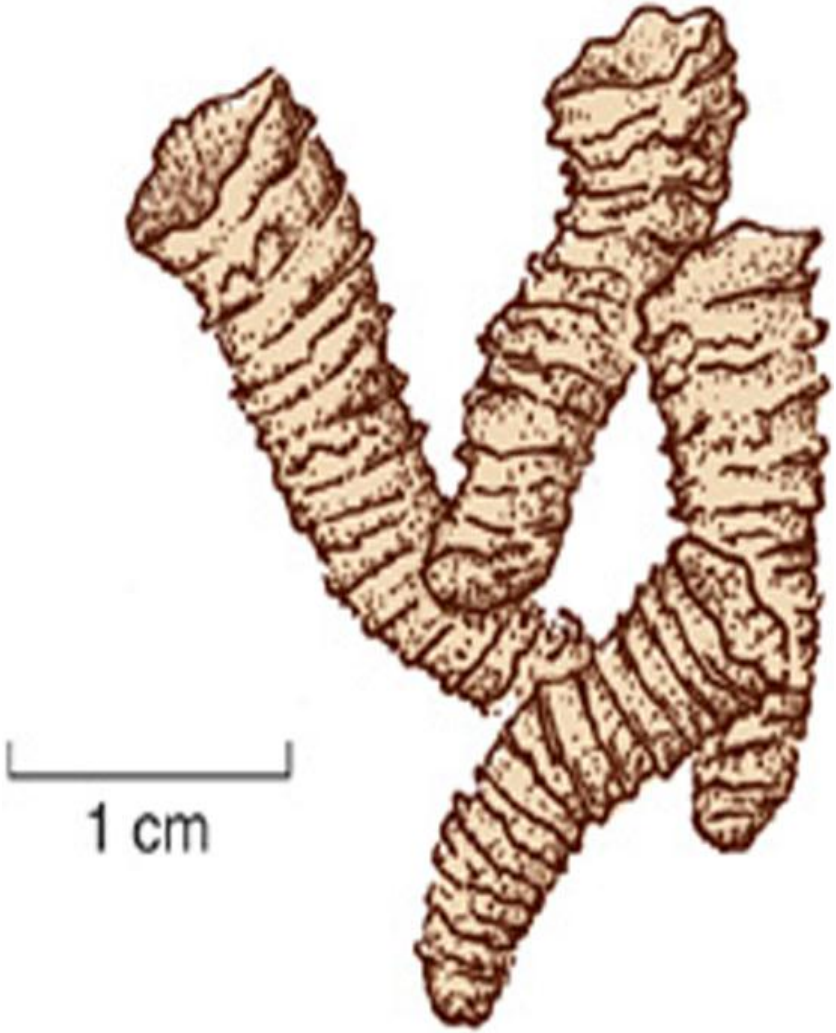


Classified as a relative of the modern earthworm

We see no legs, no mouths, no digestive tracts, nothing to suggest they were animals.

Due to the soft-bodied structures, the majority left no fossil evidence.

Cloudina



- Earliest known shell bearing fossil

A tube-dwelling worm

Trace Fossils

- Made by a mollusk as it crawled across the sea floor bottom

Many strange forms were present, some of which still do not have any parallels in modern times.

The appearance of the life represented by these fossils, set the stage for the rise of larger animals.

Due to the soft-bodied structures, the majority left no fossil evidence.

What stimulated the appearance of these animals?

- May be related to the accumulation of sufficient oxygen in the atmosphere to support an oxygen-based metabolism. .
- Life may have evolved gradually from earlier forms that did not leave a fossil record.

Proterozoic Glaciation - Earth's First Ice Age?

- A Proterozoic ice age is recorded in rocks north of Lake Huron in southern Canada (called the **Huronian glaciation**).

Causes of the first Ice Age

The Great Oxygenation Event
More life emerged, Changes in the atmospheric make up- less Carbon Dioxide=the earth began to cool and ice sheets began to form and spread

Major events

1. Major mountain building as land masses collided
2. Earth's first glaciation
3. Widespread volcanism
4. Rise in atmospheric oxygen (great oxidation event- Red banding)
5. Active plate tectonics
6. Formation of a super continent- Rodina, and its break up
7. More complex life forms- Eukaryotes(cells with a nucleus)

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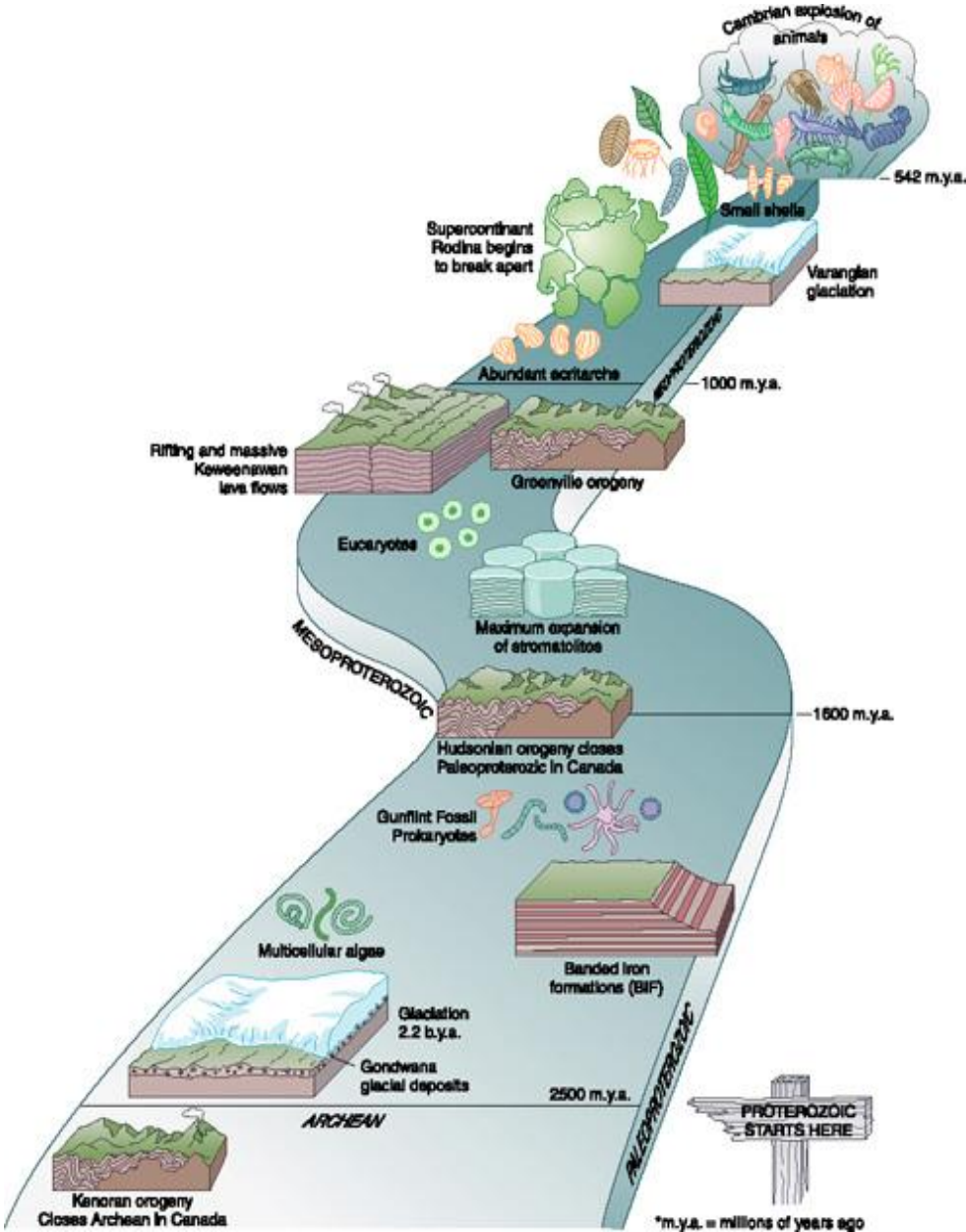


Precambrian Oil

Traces of oil and gas in Australia and South Africa which date around 2 billion years old. (oil and gas are a bi-product of decay of tiny marine life forms, = their presence implies the earth was well-populated with active microbes, more than previously assumed.

Paleozoic Era

The Paleozoic Era can be divided into:

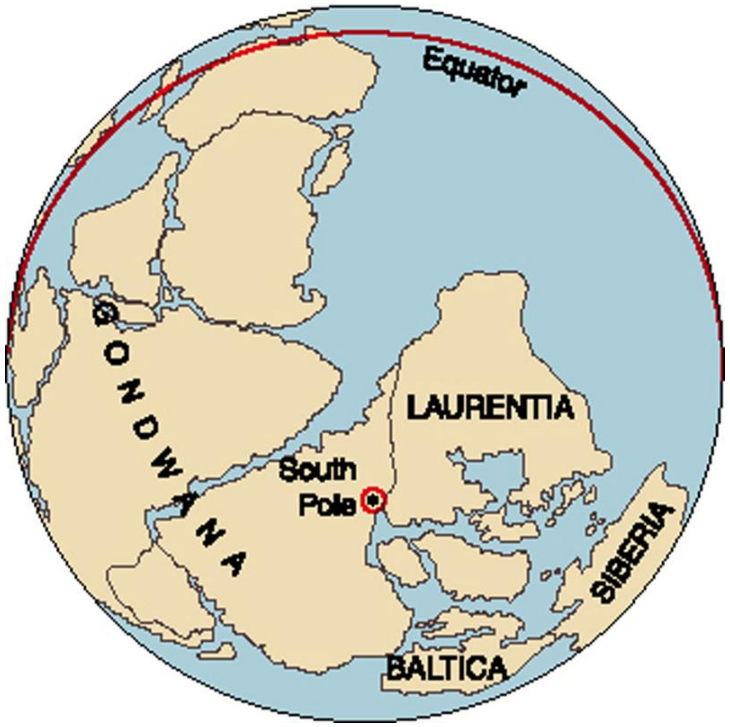
- Early Paleozoic = Cambrian, Ordovician and Silurian
- Late Paleozoic = Devonian, Mississippian, Pennsylvanian, and Permian

The Paleozoic Era

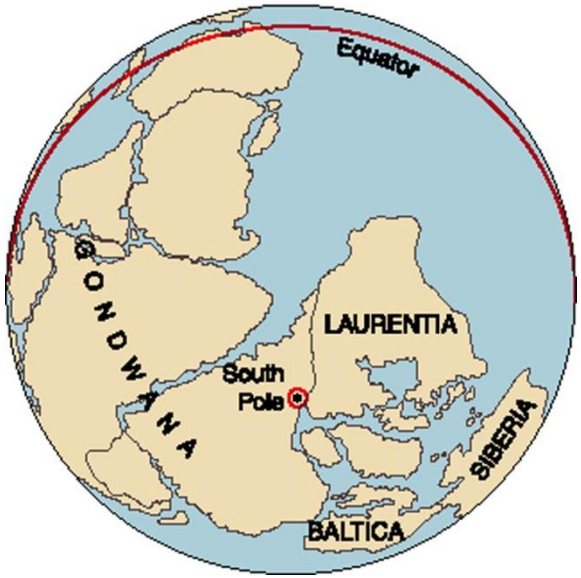
The Paleozoic is characterized by long periods of sedimentation punctuated by mountain building (Orogeny)

Late Precambrian Paleogeography

Just before the Paleozoic began, the Precambrian supercontinent, **Rodinia**, had rifted apart to form six large continents and several smaller continents.



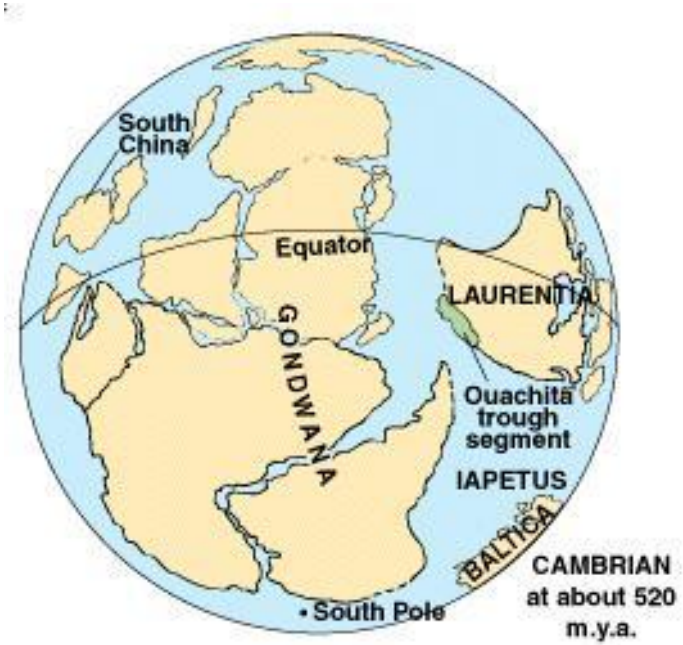
The Continents

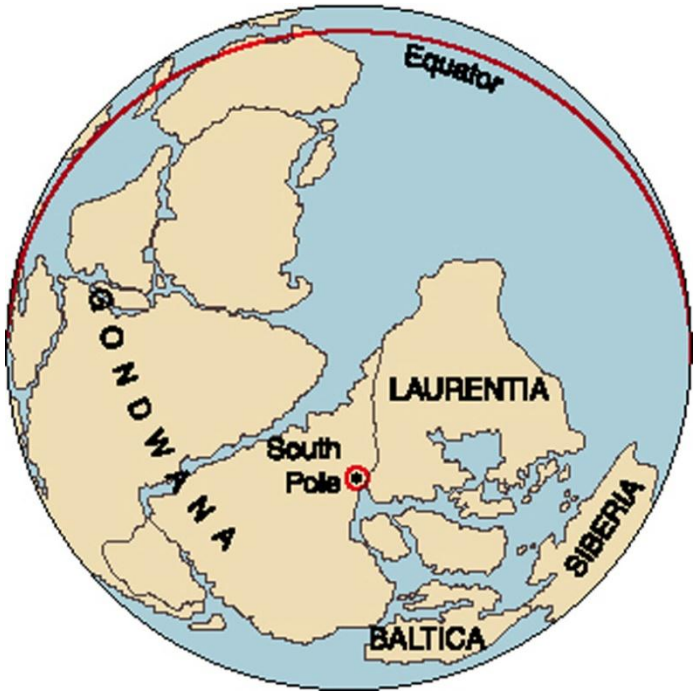


1. **Laurentia** (North America, Greenland, Ireland, and Scotland)
2. **Baltica** (Northern Europe and western Russia)
3. **Kazakhstania** (between the Caspian Sea and China)
4. **Siberia** (Russia east of the Ural Mtns and north of Mongolia)
5. **China** (China, Indochina, and the Malay Peninsula)
6. **Gondwana** (Africa, South America, India, Australia, Antarctica)

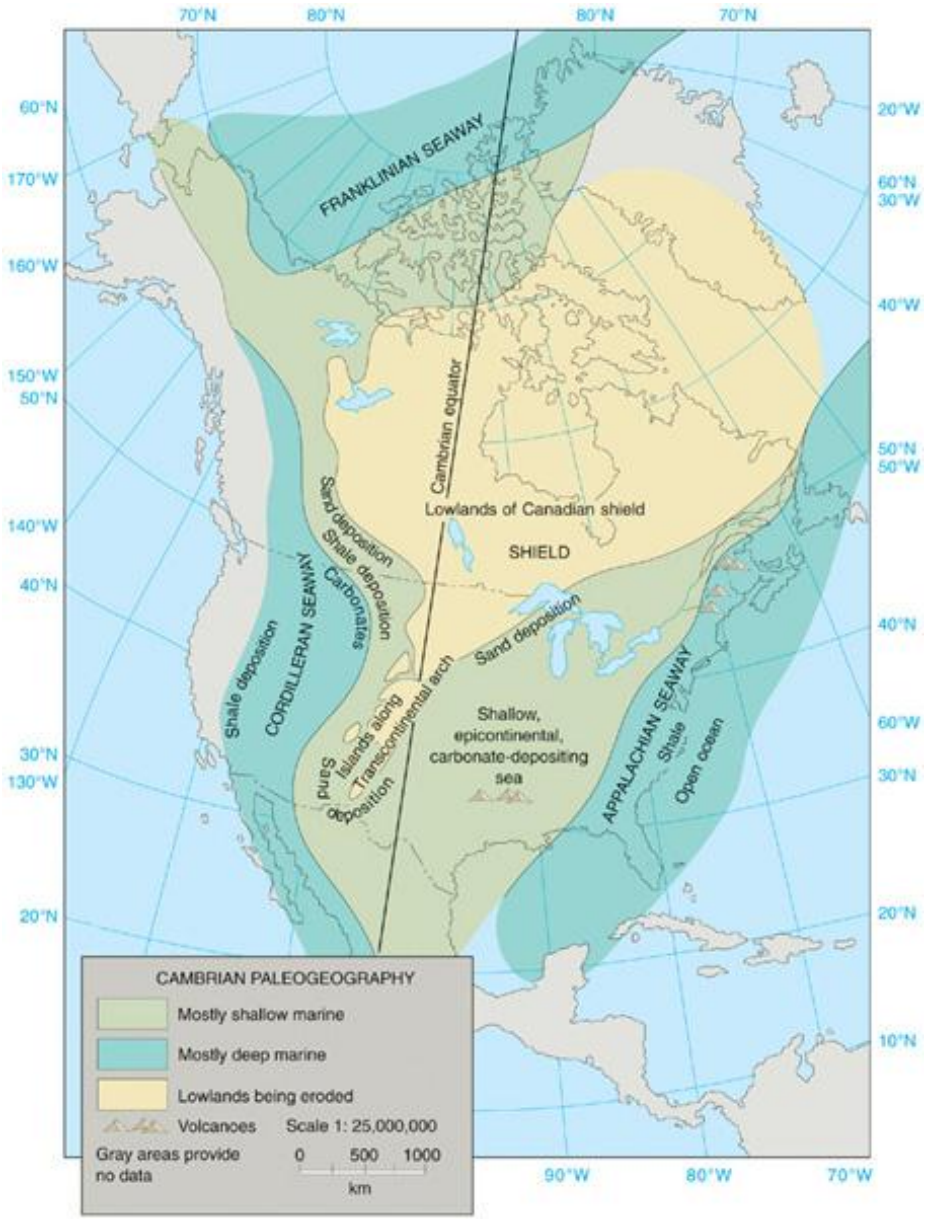
By the Cambrian Period, the continents moved off the pole. Some continents lie on the equator.

Glaciers melted, sea levels rose, and shallow **inland seas** flooded the continents.





CAMBRIAN
at about 520
m.y.a.



Paleogeography

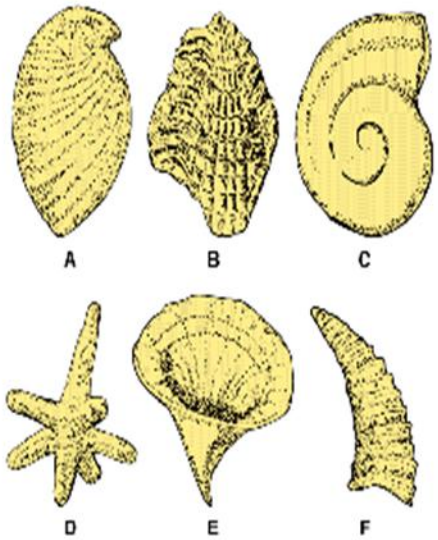
- Laurentia =nearly covered by shallow epicontinental (inland) seas.
- on the equator, so water is warm.
- Water deepens toward edges of continent, where shale is deposited

Life in the Cambrian

Big Bang of Life or Cambrian Explosion

Begins with small shelly organisms

The small shelly fauna includes
sponge spicules,
brachiopods,
mollusks, and others



Millimeters in size

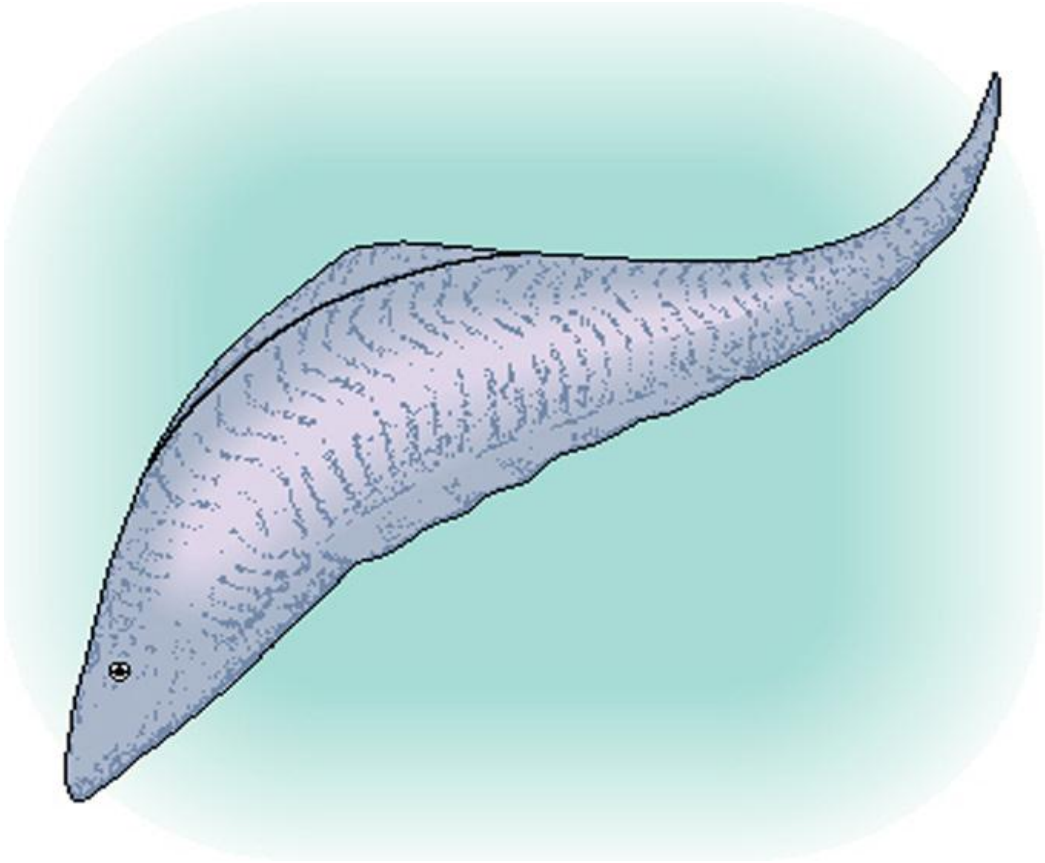
Paleozoic Fossil Record

The Paleozoic = abundant fossils of multicellular organisms with shells. As a result, the fossil record improves dramatically at the beginning of the Paleozoic Era.

Exceptional Preservation

- Fossil sites containing abundant fossils with extraordinary preservation are called lagerstatten.
- Both the Burgess Shale fauna = large accumulation of fossils with soft body parts

Jawless Fish

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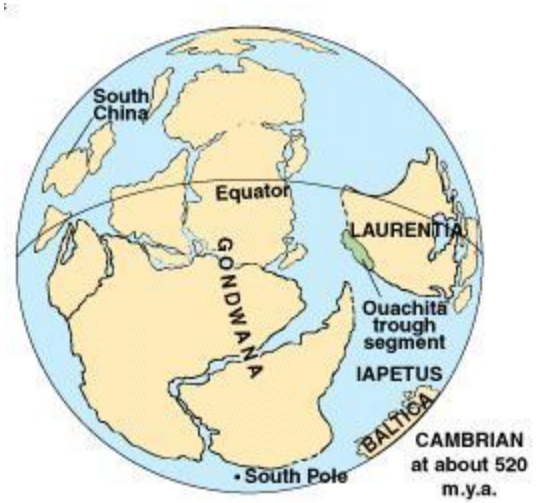
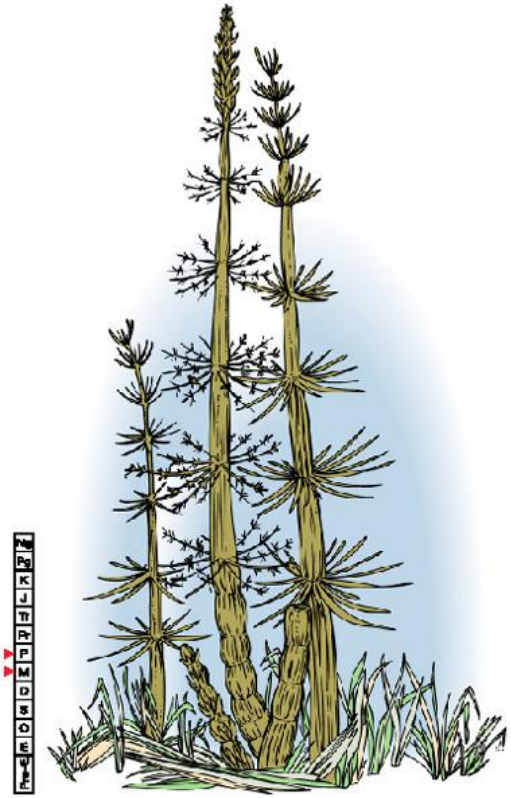
The small shelly organisms disappeared at the end of the Cambrian, and larger ones became abundant, such as trilobites and brachiopods, as well as soft bodied organisms

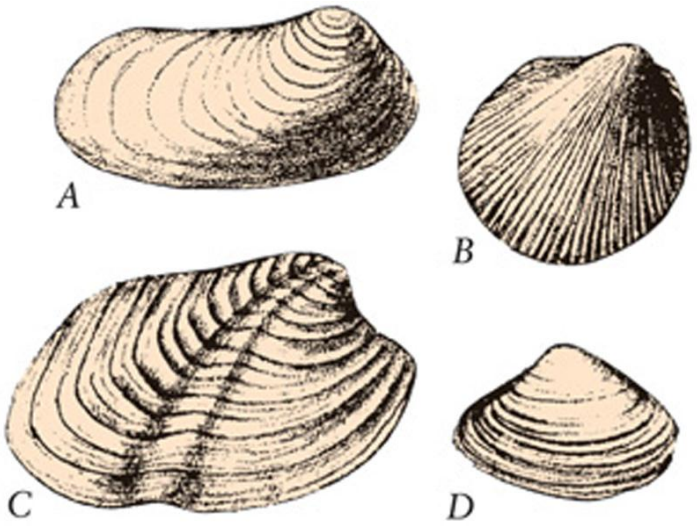
Ordovician=Continents on the move



Primitive plants appear- spores not seeds



Many more shelled organisms



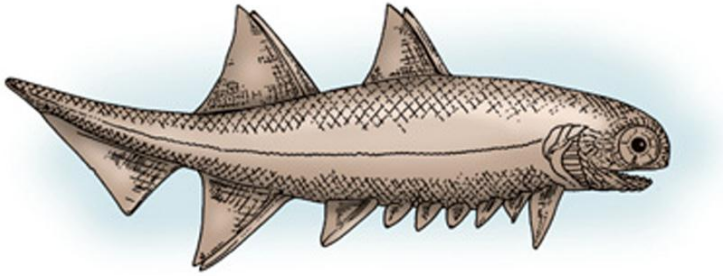
As Gondwana moves toward the south pole= glaciation and a drop in sea level=

A TIME OF EXTINCTION

This led to an abrupt decline in diversity.

Silurian=Gondwanaland =on the south pole, Laurentia =centered on the equator

The first fish to have jaws



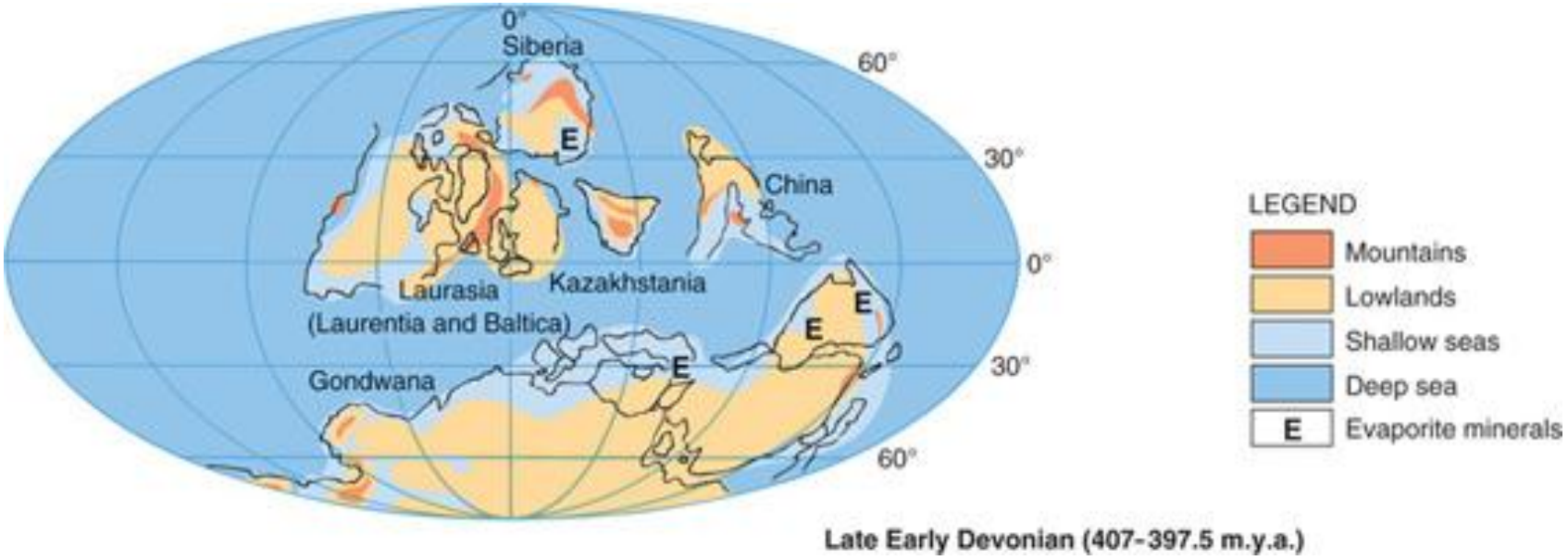
Placoderms or "plate-skinned" fishes.

Silurian Iron Ore

- **iron ore deposits** accumulated during the Silurian in the southern Appalachians, particularly around Birmingham, Alabama.

- Niagara Falls is formed

Devonian



Late Early Devonian (407-397.5 m.y.a.)

Carboniferous =

Mississippian and Pennsylvanian

The Mississippian is Early Carboniferous.
The Pennsylvanian is Late Carboniferous

Mississippian

- The sedimentary deposits of the Mississippian Period =limestone with fossils of crinoids, blastoids, bryozoans, and foraminifera.

Late paleozoic

- The Mississippian and Pennsylvanian = Carboniferous period.

- Accumulation of plant remains in swamps produced the vast coal deposits for which the Carboniferous was named.

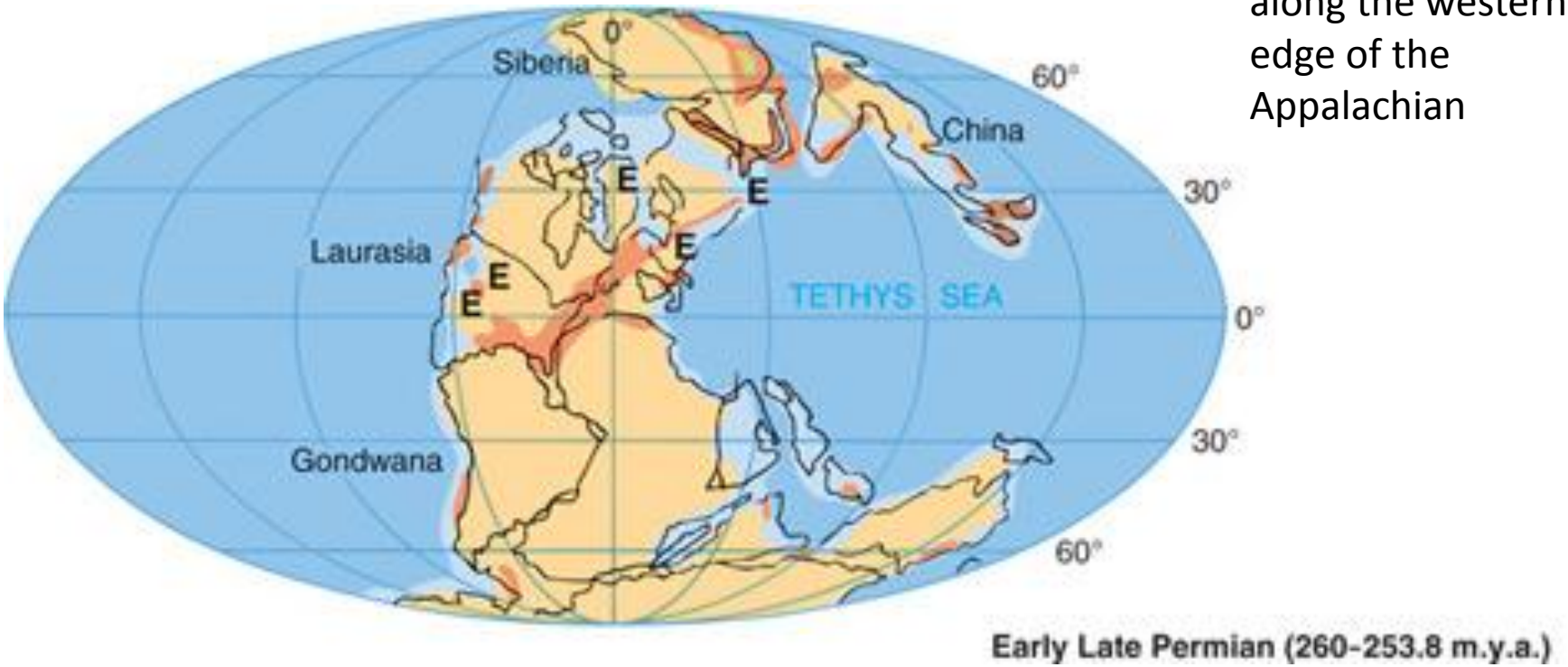
Crinoids

Coal and Plant Fossils

- Pennsylvanian coal deposits are mined extensively in the Appalachian area, the Illinois basin, and in Europe.
- They are commonly associated with rocks containing plant fossils.

Permian

Coal swamps formed along the western edge of the Appalachian



Early Late Permian (260-253.8 m.y.a.)

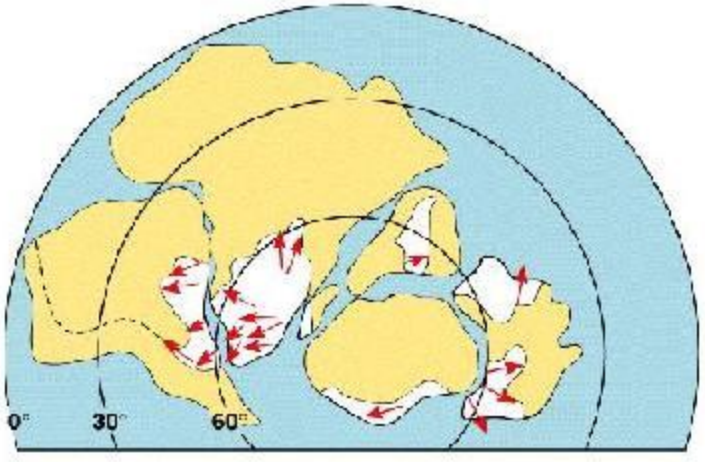
The oceanic area east of Pangea, and between Africa and Europe was called the Tethys Sea. (Sediments deposited in the Tethys Sea formed the Himalaya Mountains when the Tethys closed, much later.)

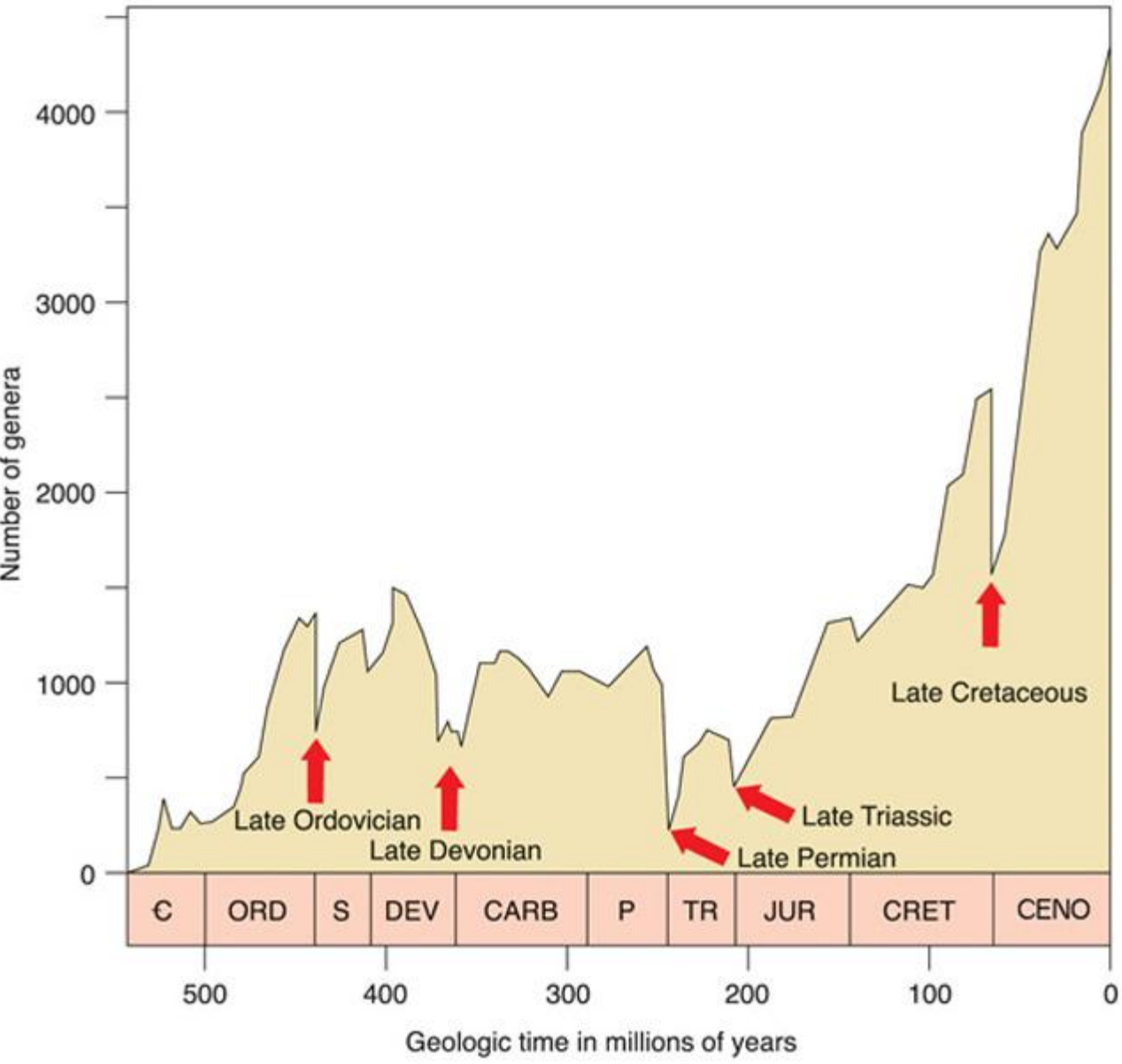
During the Permian, all of the continents had collided and joined to form the supercontinent, Pangea

Pangea was surrounded by a huge ocean

The Late Permian = Sea levels were low worldwide. The vast seas that once covered North America and parts of other continents were gone.

The Gondwana part of Pangea continued to sit on the South Pole, and glaciation continued.





Permian extinction was the most severe =

considered to be the most catastrophic mass extinction in the history of life

Late Ordovician Extinction

Related to global cooling and the growth of glaciers in Gondwanaland

Late Devonian Extinctions

Bacteria breaking down large quantities of dead algae uses up all of the oxygen in the water, causing anoxic conditions (= "without oxygen"). DEADZONES

Late Permian Extinction Event

A catastrophic extinction event = the total disappearance of many animal groups.

This was the largest extinction event in the history of life

More than 90% of all marine species that existed in the Permian disappeared .

The following marine organisms were extinct by the end of the Permian:

Some species of corals
Blastoids
Trilobites

Other groups of organisms were severely reduced in diversity, with some surviving species:

Brachiopods
Crinoids
Bryozoa
Ammonoids

Organisms which inhabited warm waters shifted their distributions toward the equator. Cool conditions prevented construction of reefs and the formation of limestones

Permian mass extinction was due to:

Climatic change
Glaciation at both north and south ends of Pangea
= (habitat loss) as sea level dropped

Unusually active volcanism releasing CO_2 leading to global warming

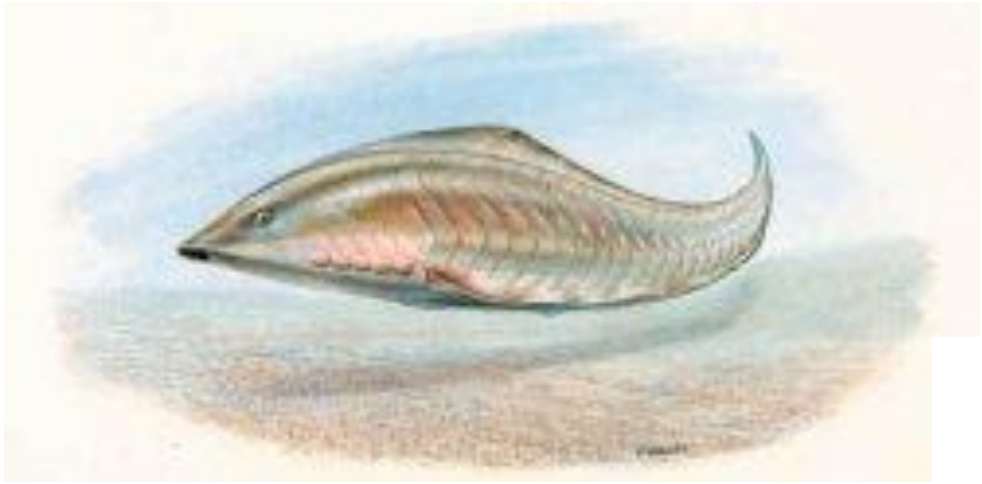
Possibility of an extraterrestrial impact

Permian basins in west Texas and New Mexico

- The ancient reef forms the steep El Capitan in the Guadalupe Mountains.
-

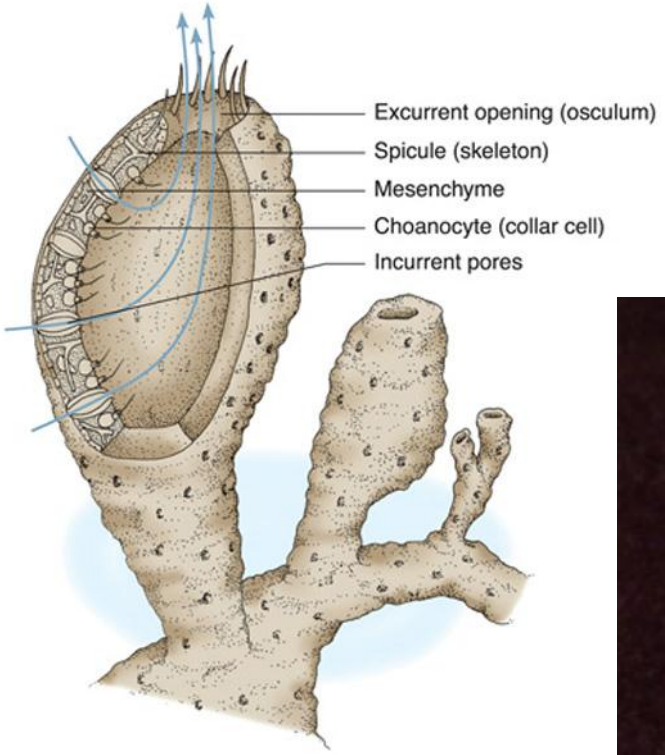
Near El Paso, Texas - Sediment was deposited - indicating it was covered with water

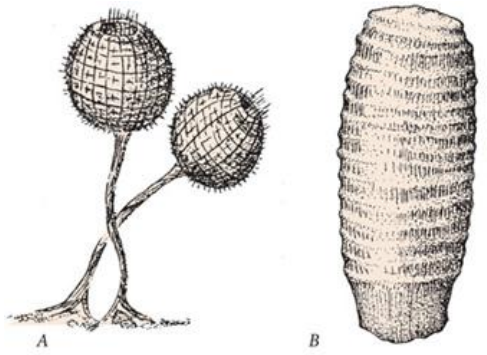
Early Fish = Jawless



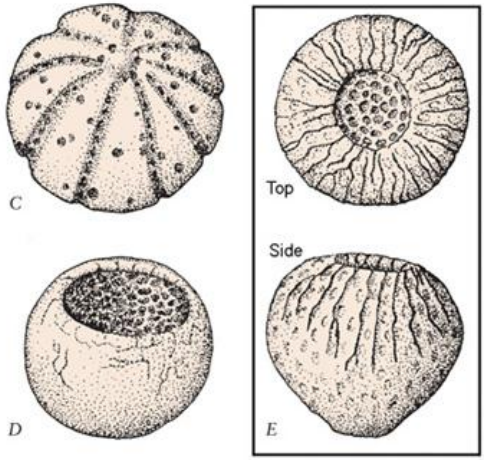
Phylum Porifera - The Sponges

Name means "pore-bearing". Covered by tiny pores.





www.fossiel.net © Robert Mensink

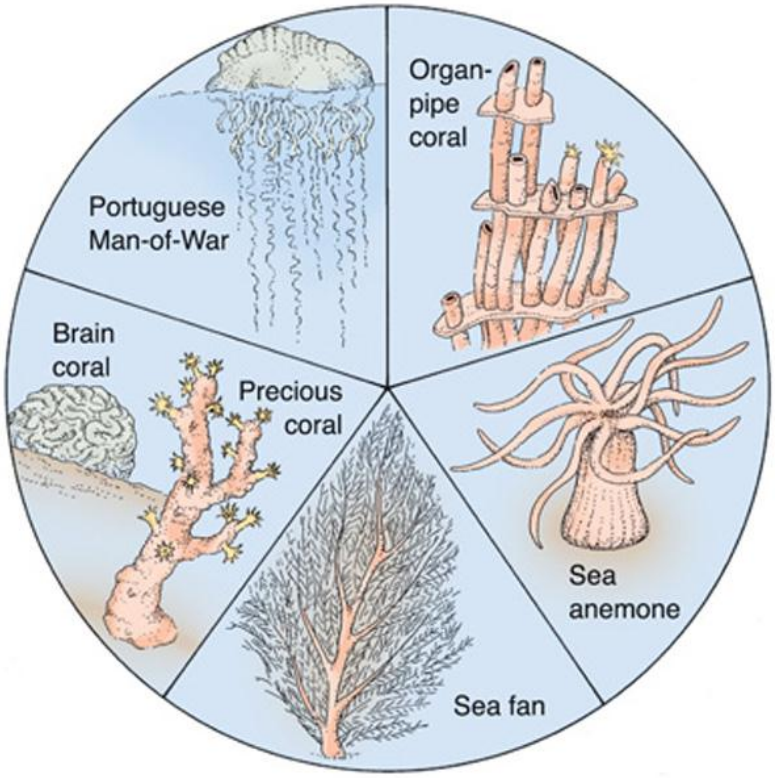


Bryozoans- resemble trees

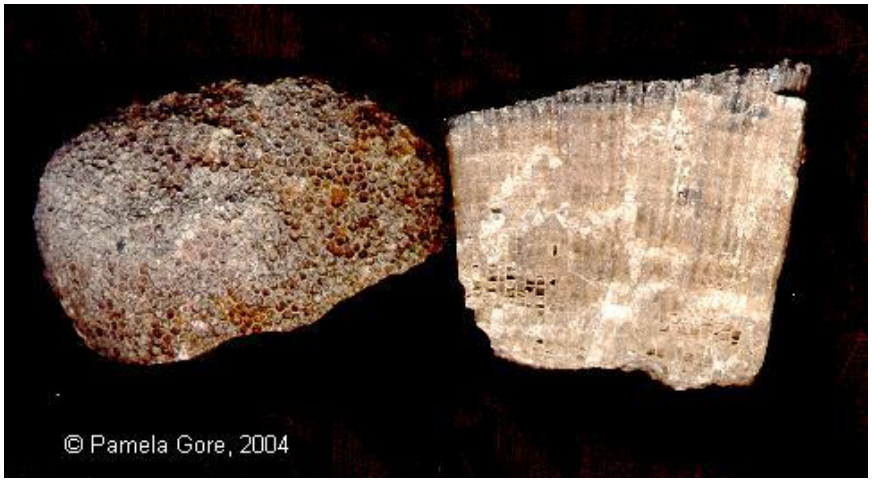
PHYLUM CNIDARIA

Corals, sea fans, jellyfish, and sea anemones.

Name: Cnidaria are named for stinging cells



Tabulate Corals



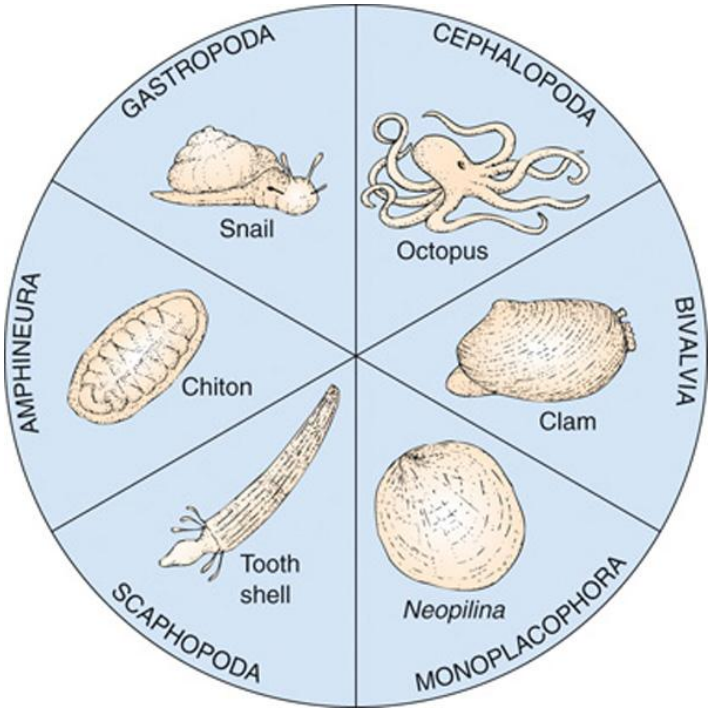
Brachiopods

Symmetrical formation of brachiopods

- Early Brachiopod.

Phylum Mollusca

- Clams, oysters, snails, slugs, *Nautilus*, squid, octopus, cuttlefish
- *Name*: Mollusca means " soft bodied".

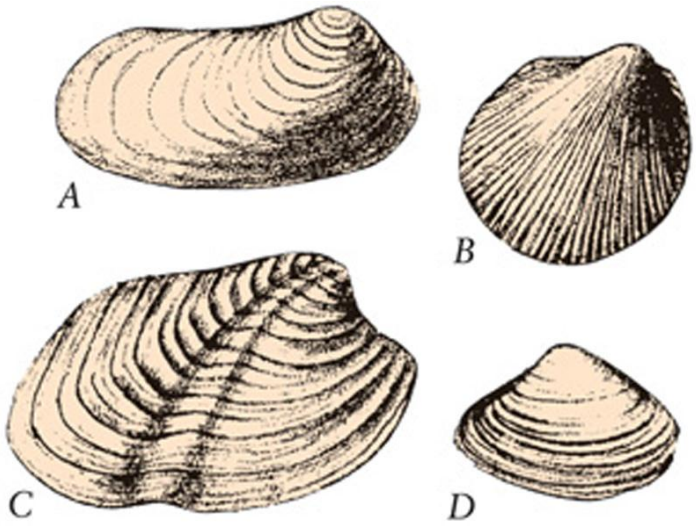


Class Bivalvia

Name: Bivalvia means " two" (bi) + " shells" (valves).

- Clams, oysters, scallops, mussels, rudists

- *Chief characteristics*:
  - Skeleton consists of two valves connected by a hinge.



Ammonites

Scaphopoda

- Tusk shells or tooth shells
- *Chief characteristics*: Curved tubular shells open at both ends.
- *Geologic range*: Ordovician to Recent.
- *Mode of life*: Marine.

Class Gastropoda

- Snails and slugs
- *Chief characteristics*:
  - Asymmetrical, spiral-coiled calcareous shell.
- *Name*: means "stomach" (gastro) + "foot" (pod).
- *Geologic range*: Early Cambrian to Recent.
- *Mode of life*: Marine, freshwater or terrestrial.

Phylum Arthropoda

- Insects, spiders, shrimp, crabs, lobsters, barnacles,, trilobites
- *Name*: means "jointed" (arthro) + "foot" (pod).
- *Chief characteristics*:
  - Segmented body with a hard exterior skeleton composed of chitin (organic material).
  - Paired, jointed legs.
  - Highly developed nervous system and sensory organs.

trilobite

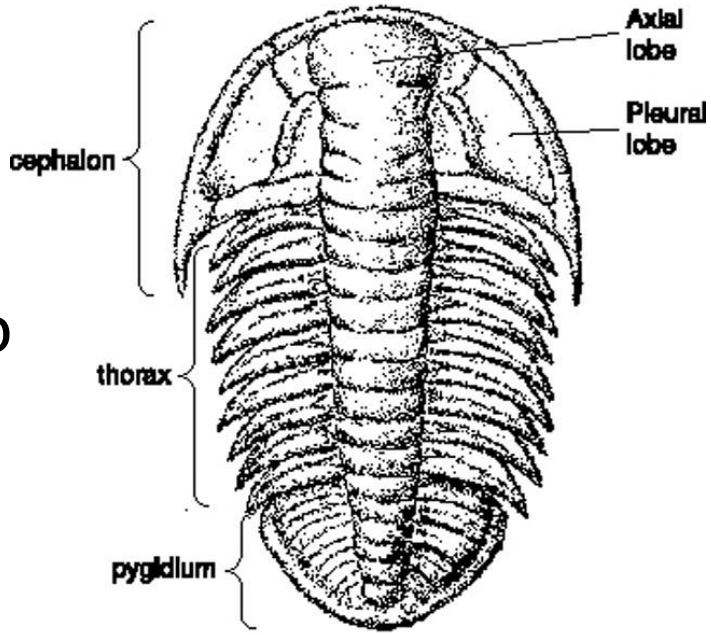
Trilobite

trilobite

trilobites

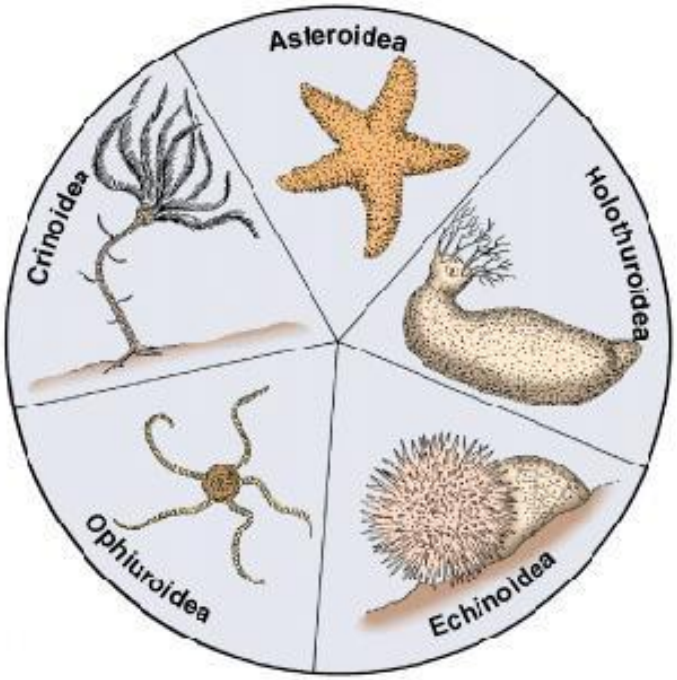
Trilobites

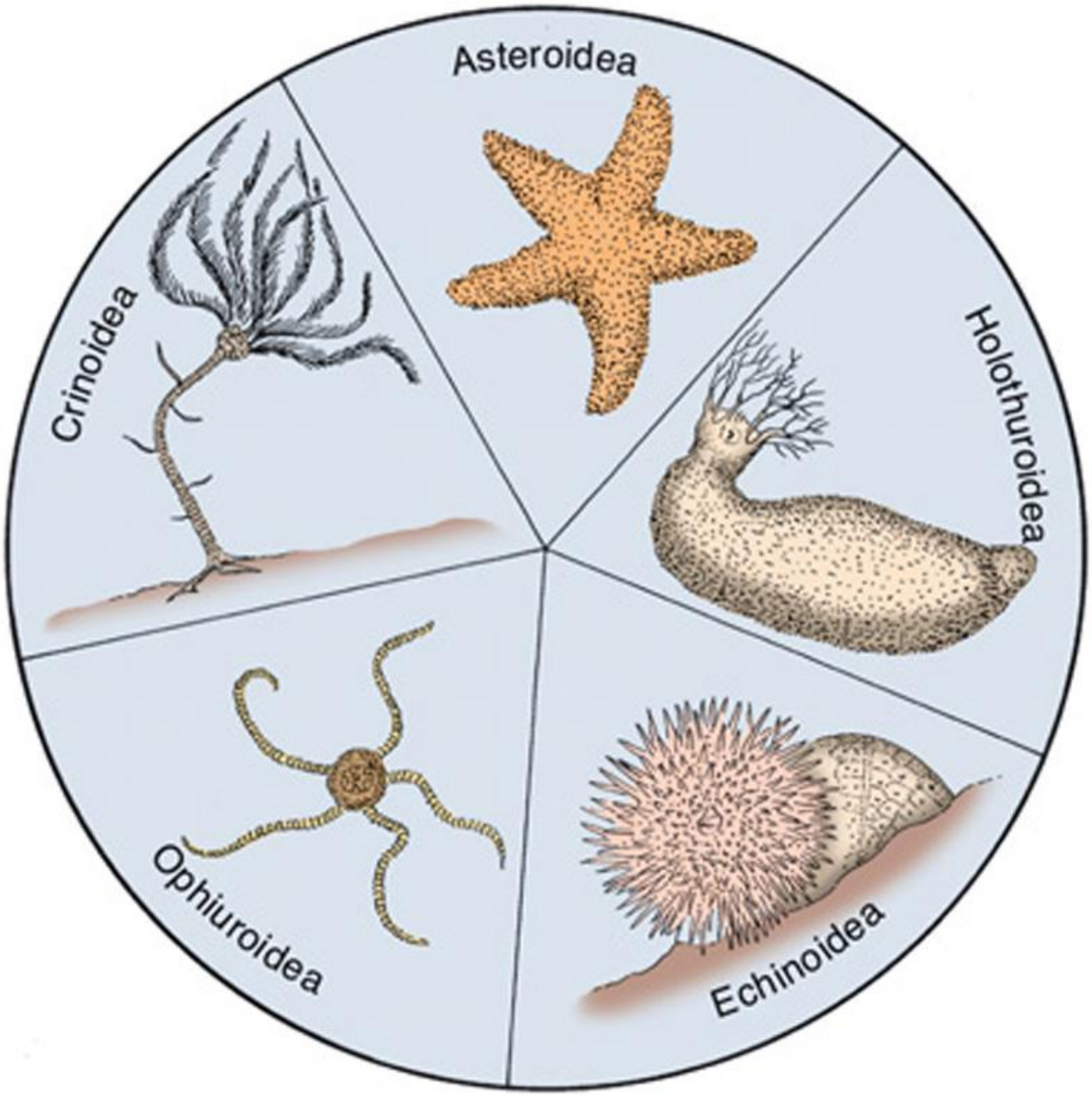
- *Chief characteristics*:
  - Body has three-lobes
  - Bottom Dweller-Shallow Water
  - Body is divided into three segments:
    - Rigid head segment -
    - Jointed, flexible middle sectio
    - Rigid tail piece



Phylum Echinodermata

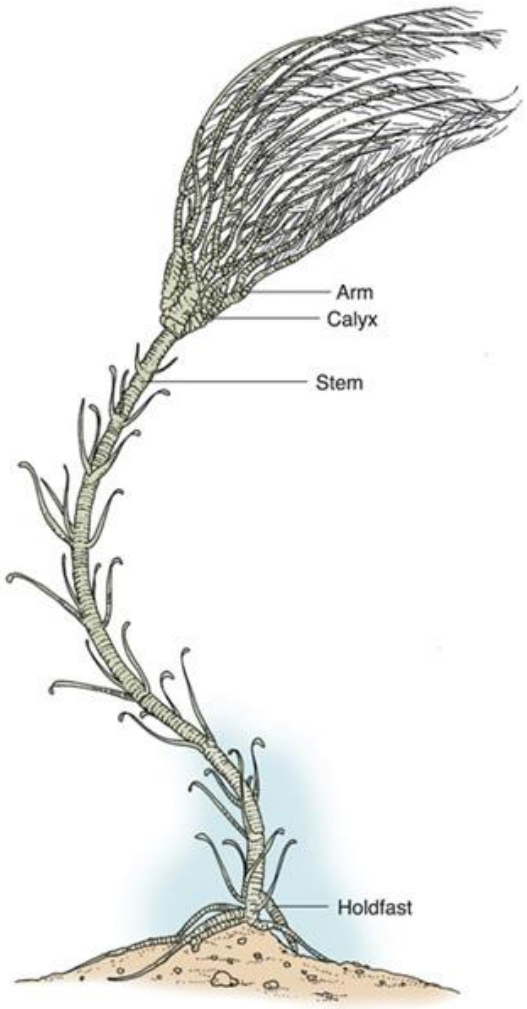
- Starfish, sea urchins, sand dollars, crinoids, blastoids, and others
- *Name*: Echinodermata means "spiny" (echinos) + "skin" (derma).





Phylum-
Echinoderms

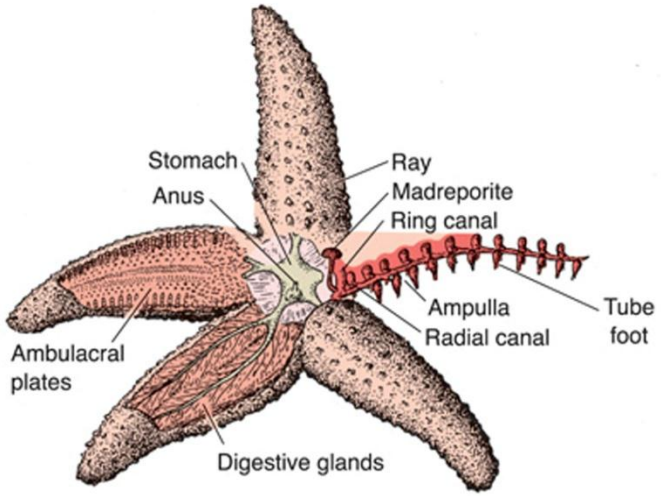
Class Crinoidea - Crinoids



- Crinoids are **animals** which resemble flowers.
- The crinoid is attached to the sea floor by root-like holdfasts.
- Over 1000 genera are known.

Starfish

- Starfish are star-shaped echinoderms with five arms.
- About 430 genera are known.
- *Geologic range*: Ordovician to Recent.

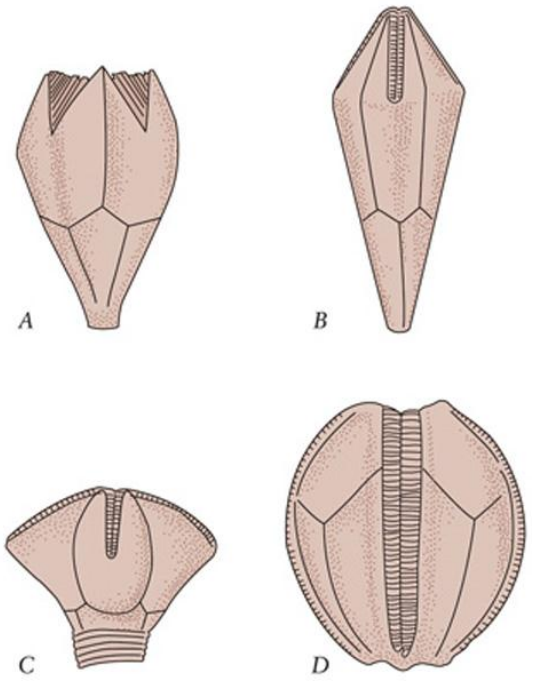


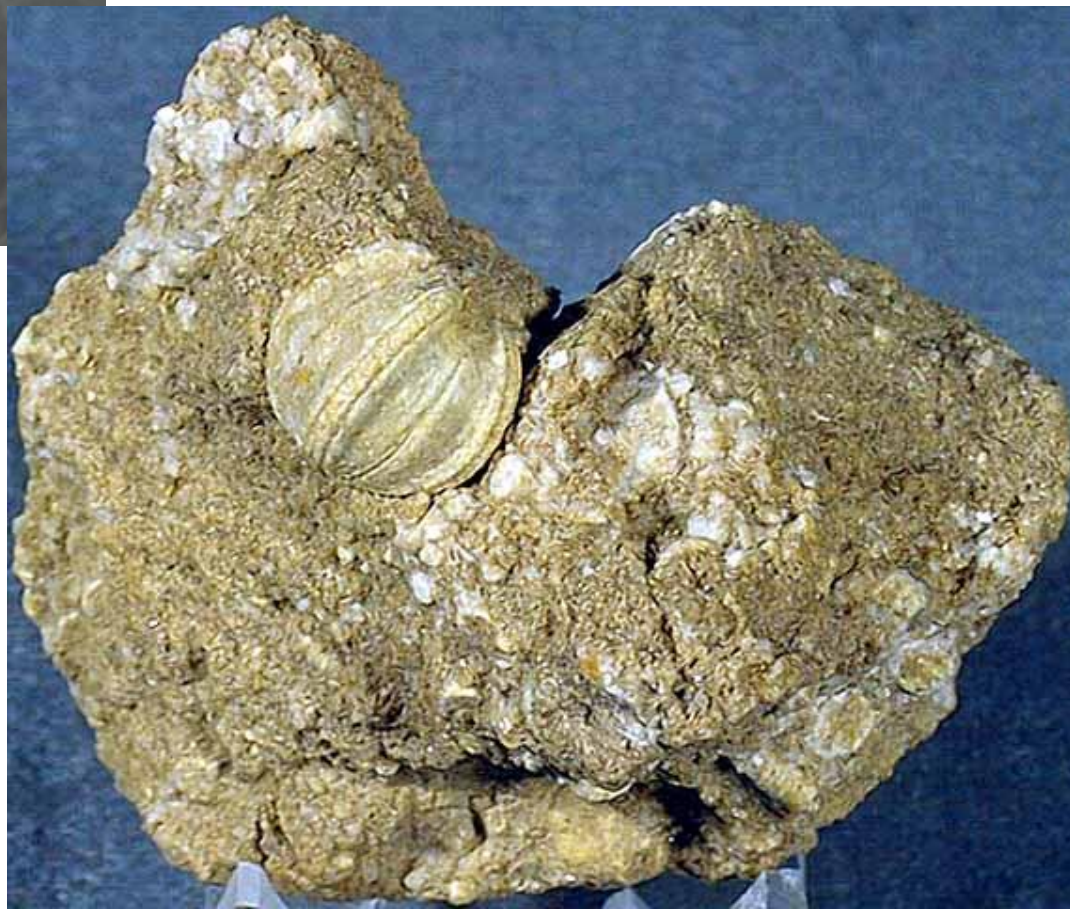

Pamela Gore, 1998


Pamela Gore, 1998

Blastoids

- Blastoids are extinct animals with an armless bud-like calyx on a stem.
- About 95 genera are known.
- All extinct.



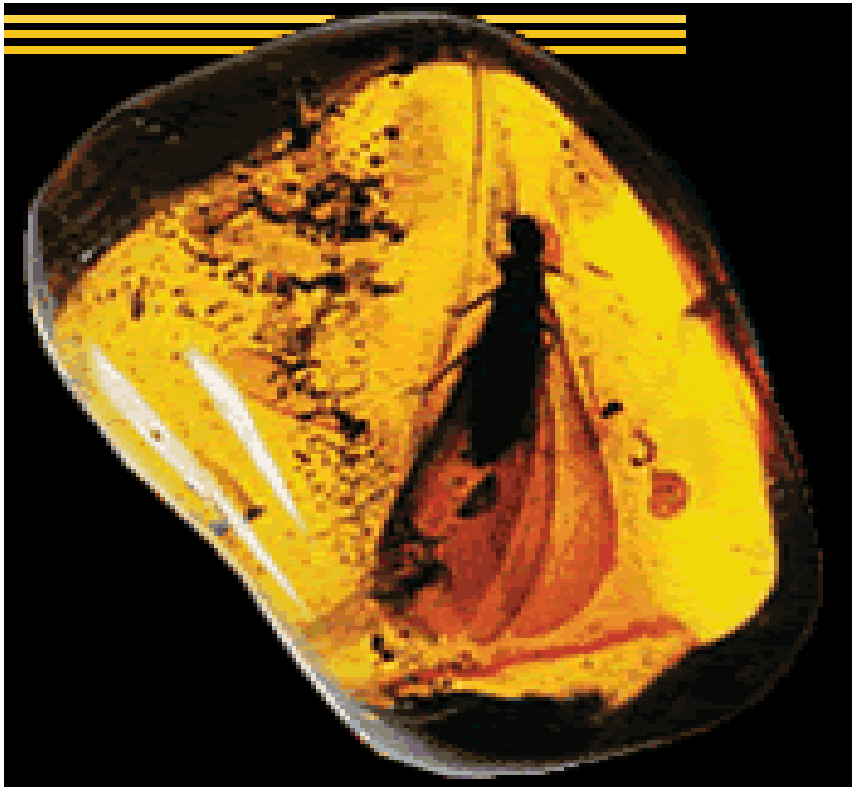


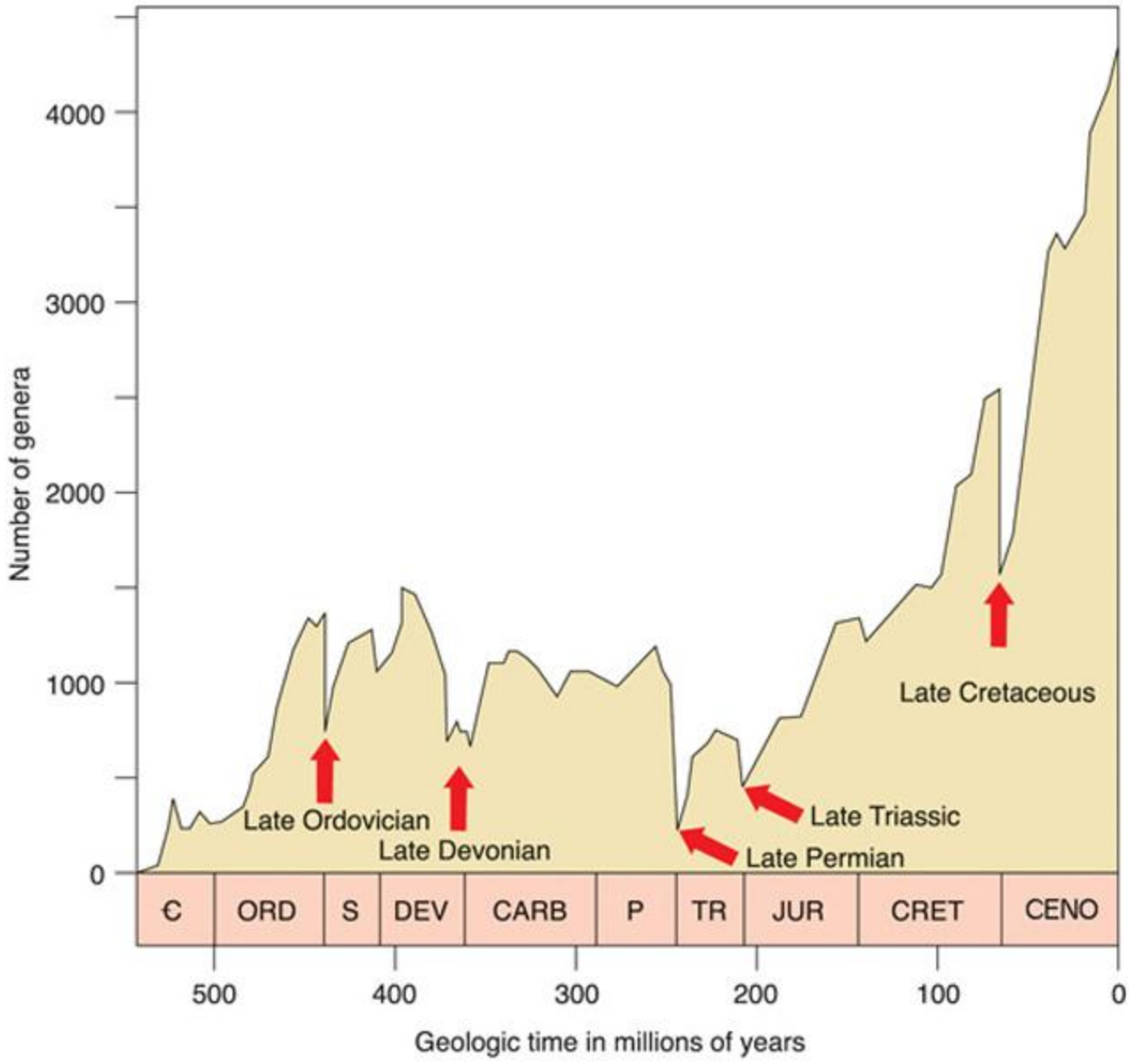
Other Fossil Info

Coprolites = Fossilized Dung

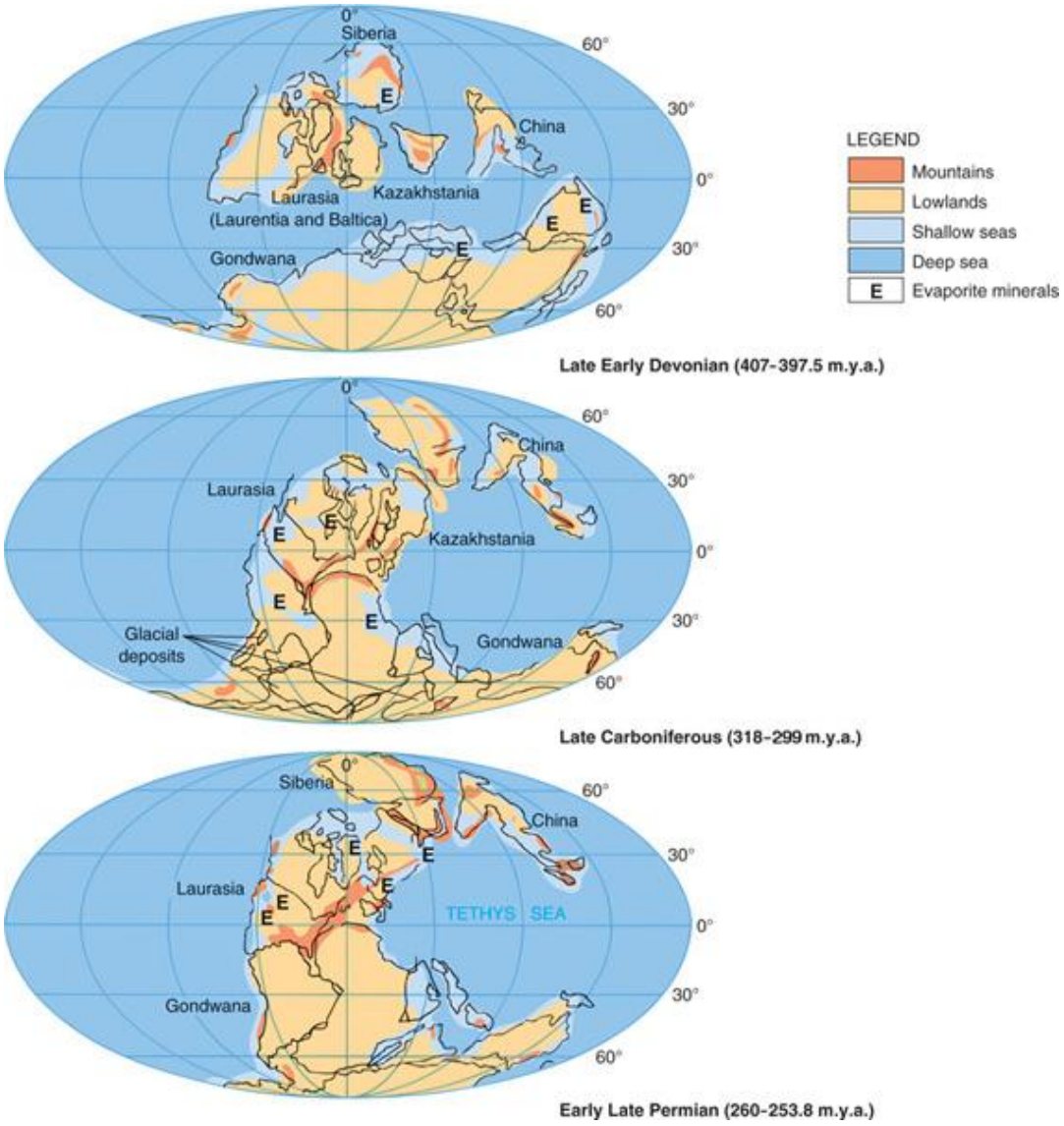
Amber

- Preserved in tree sap




4000
3000
2000
1000
0
Number of genera
Late Ordovician
Late Devonian
Late Permian
Late Triassic
Late Cretaceous
Є
ORD
S
DEV
CARB
P
TR
JUR
CRET
CENO
500
400
300
200
100
0
Geologic time in millions of years

Late Paleozoic Tectonic Setting



- The supercontinent **Pangea** assembled as the continents collided during the Late Paleozoic.
- Larger continents grew by addition of island arcs and microcontinents around their edges.

STOP

What are fossils?

- **Fossils** are the remains or traces of prehistoric life
- **Index Fossils-**(also known as guide fossils) are used to define and identify geologic periods

  The best index fossils are common, distinctive (easy-to-identify), abundant, and have a broad distribution,

Index Fossils tell us

- 1.What plant or animal life lived and died
  (Became Extinct)
- 2.The climates of the past
  example- a fern fossil indicates a warm
  climate
- 3.They help in dating other fossils found in the same sedimentary layer.

To Become a Fossil

These characteristics are favorable for fossil preservation:

- 1.Rapid burial with sediment to prevent destruction of the dead organism by scavenging or bacterial decay.
- 2.Presence of hard materials,= Preservable Parts like bones, teeth, or shell.
- 3.Escape from destruction by a chemical or physical force (decompose, eaten)

Trace fossils,

- Trace fossils may be impressions by an organism: Example, burrows, borings footprints and feeding marks, and root cavities.or organic material produced by an organism - for example coprolites (fossilized droppings)
- Trace fossils contrast with body fossils, which are the fossilised remains of parts of organisms' bodies, usually altered by later chemical activity or mineralisation.
- **Trace fossils represent the activities of ancient animals.**

Graptolites

- The name graptolite comes from the Greek *graptos*, meaning "written“

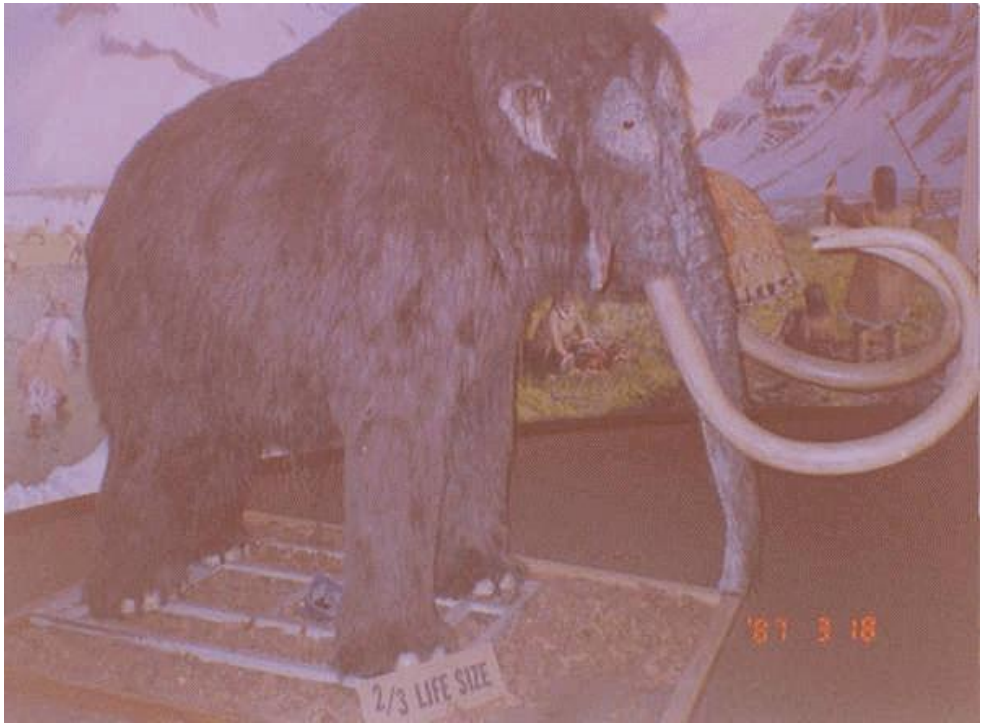
  and *lithos*, meaning "rock", as many graptolite fossils resemble hieroglyphs written on the rock.

Ways that fossils are preserved

- Freezing, as in glacial ice
- 40,000-year-old baby mammoth, perfectly encased in ice.

Tar pits

1. Preservation in oily, tar-like asphalt. (Example: Mammals preserved in the LaBrea tar pits in Los Angeles, California).



Carbonization

- preserves soft tissues of plants or animals as a thin carbon film

Other ways to preserve a fossil

1.Replacement or Recrystalization

Substitution of a mineral different from the original material.

Example: Petrified wood

2.Molds and casts