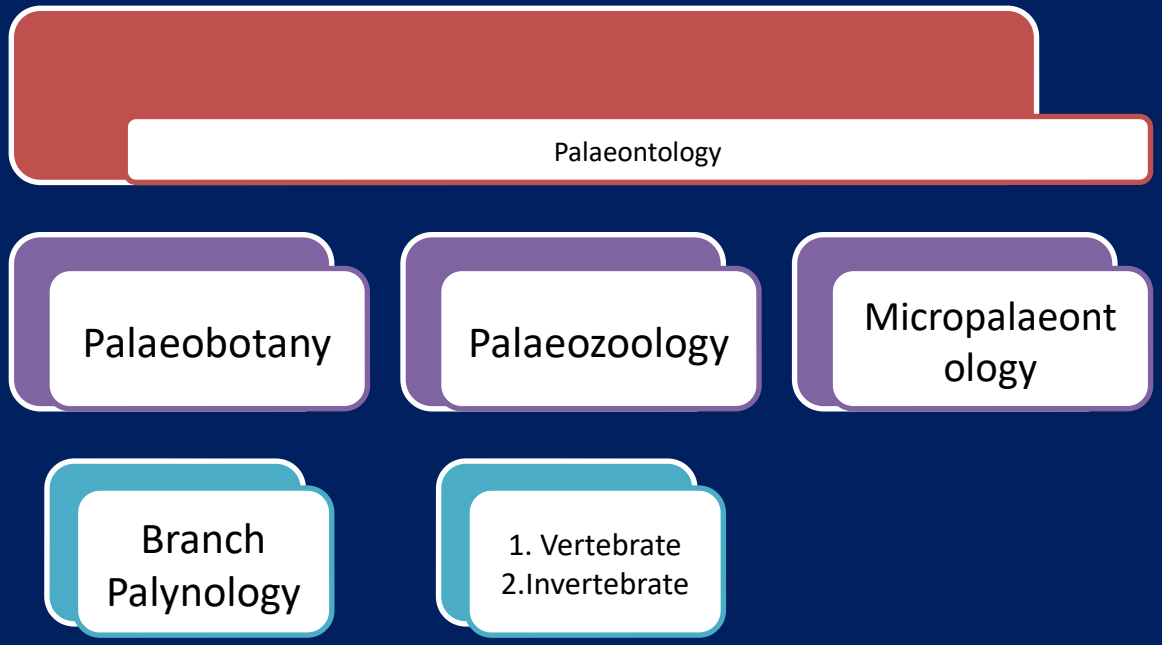
PALAEONTOLOGY
or
PALEONTOLOGY

Unit 1

The study of fossils

What is Paleontology?

Paleontology is the study of plant and animal's fossils of ancient time or geologic past.


Palaeontology
Palaeobotany
Palaeozoology
Micropalaeontology
Branch Palynology
1. Vertebrate
2.Invertebrate

Paleontology is divided in to Paleobotany, Paleozoology, Palynology and Micro Paleontology.

Paleobotany: Study of fossil plants; traditionally includes the study of fossil algae and fungi in addition to land plants.

Paleozoology: Study of fossil animals

Palynology: Study of fossil pollen and spores

- **Invertebrate Paleontology:** Study of invertebrate animal fossils, such as mollusks, echinoderms, and others. (animals without a vertebral column)
- **Vertebrate Paleontology:** Study of vertebrate fossils, from primitive fishes to mammals. (animals with a vertebral column)
- **Human Paleontology (Paleoanthropology):** The study of prehistoric human and proto-human fossils.

Micropaleontology:

- Study of generally microscopic fossils, regardless of the group to which they belong.
- Microfossils have many applications to petroleum geology.
- The two most common uses are: biostratigraphy and paleoenvironmental analyses.
- Biostratigraphy is the differentiation of rock units based upon the fossils which they contain.

- Paleoenvironmental analysis is the interpretation of the depositional environment in which the rock unit formed. paleoclimatology, biogeography, and thermal maturation.
-

Taphonomy: Study of the processes of decay, preservation, and the formation of fossils in general.

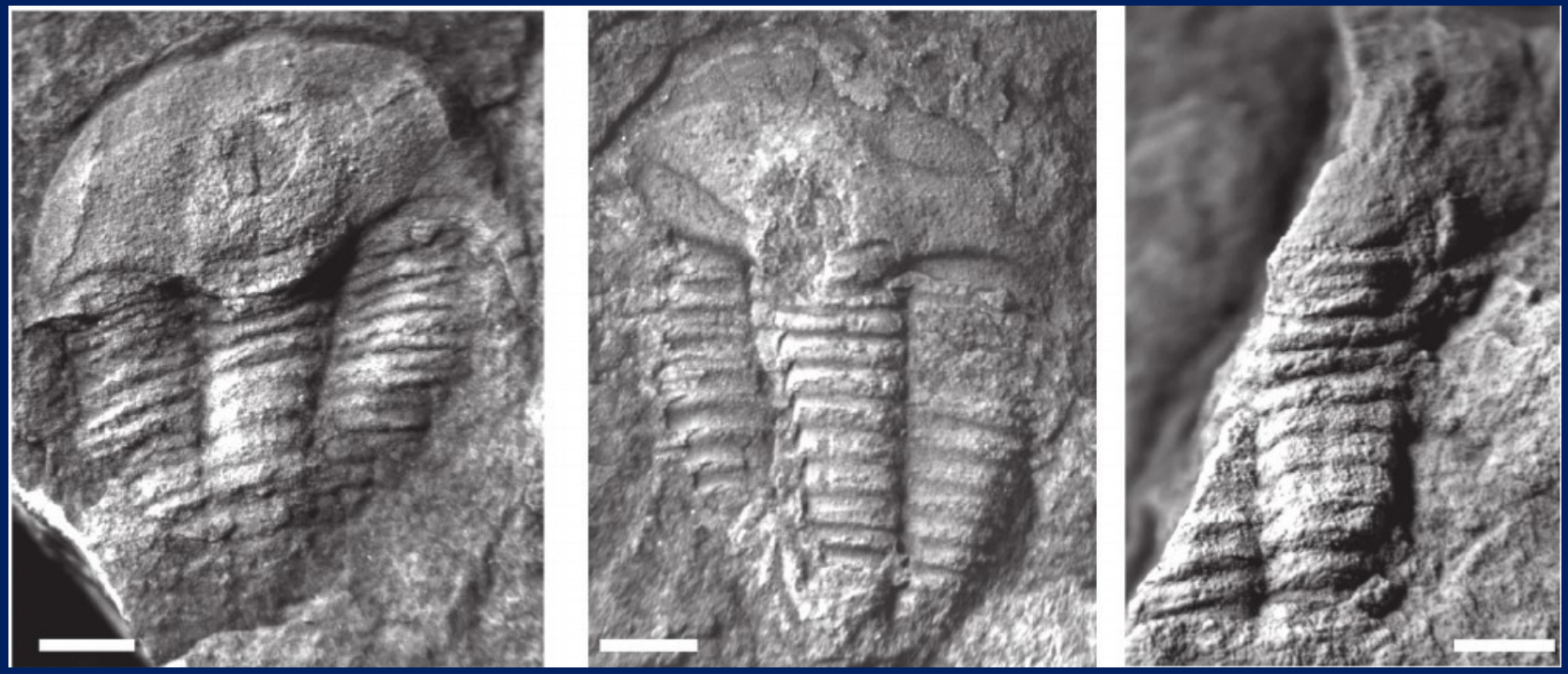
Paleontology in India

- In India, the fossiliferous horizons are mainly found in the formations of Kashmir, Spiti valley of Himachal Pradesh, formations of Kutch, Narmada valley, Tiruchirappalli, and Jaisalmar in Rajasthan.
- Vertebrate fossils were recorded all along the foot hills of Himalaya in Siwalik formations,
- Gondwana formations in Bihar, M.P, Maharashtra , A.P and T.N contains lot of flora and reptilian fauna.

Paleontology in India

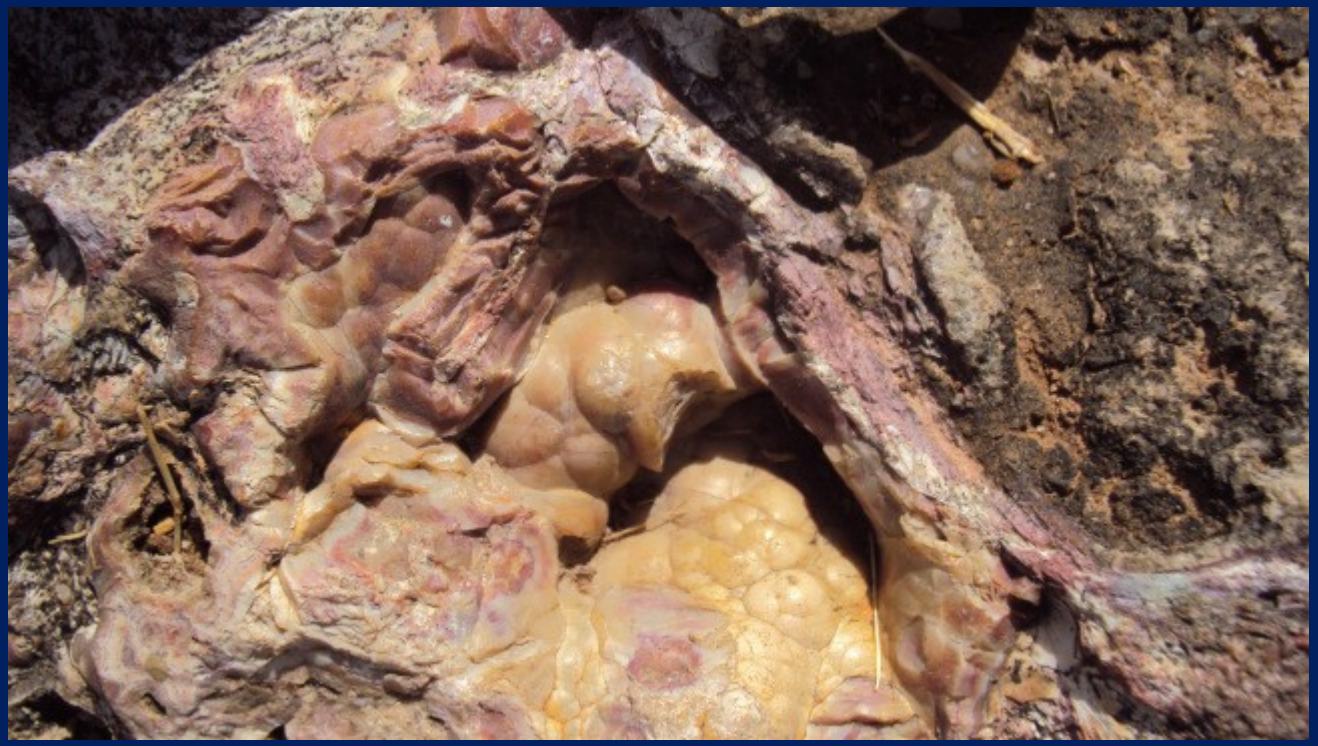
- In 1810 an Army officer. J. Warren found a petrified wood near village Treevikera in Karnataka.
- In 1819, the first animal fossil was discovered by a surveyor, H.W. Voysey in basaltic rocks of Melconda of Deccan.
- Systematic and organized study of fossils began with the setting up of Geological Survey of India in 1851.

The world's most diverse marine animals – Zanskar Valley, Kashmir



Dinosaur fossil site in India with flora, fauna intact – Waddham, Maharashtra

India’s first unique dinosaur species – Balasinor, Gujarat



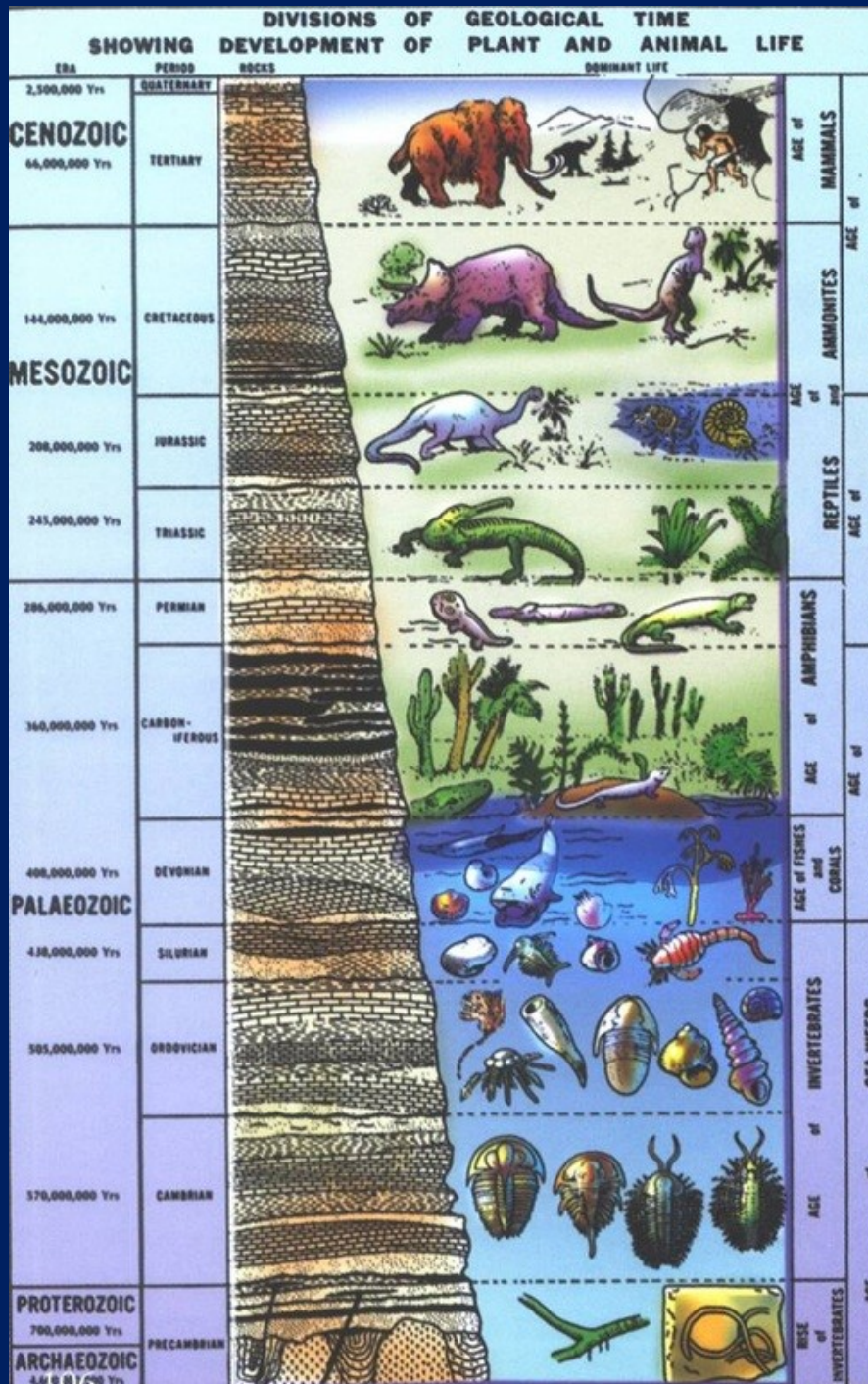
Perfectly preserved ancient trees (wood fossil) – Thiruvakkarai, Tamil Nadu

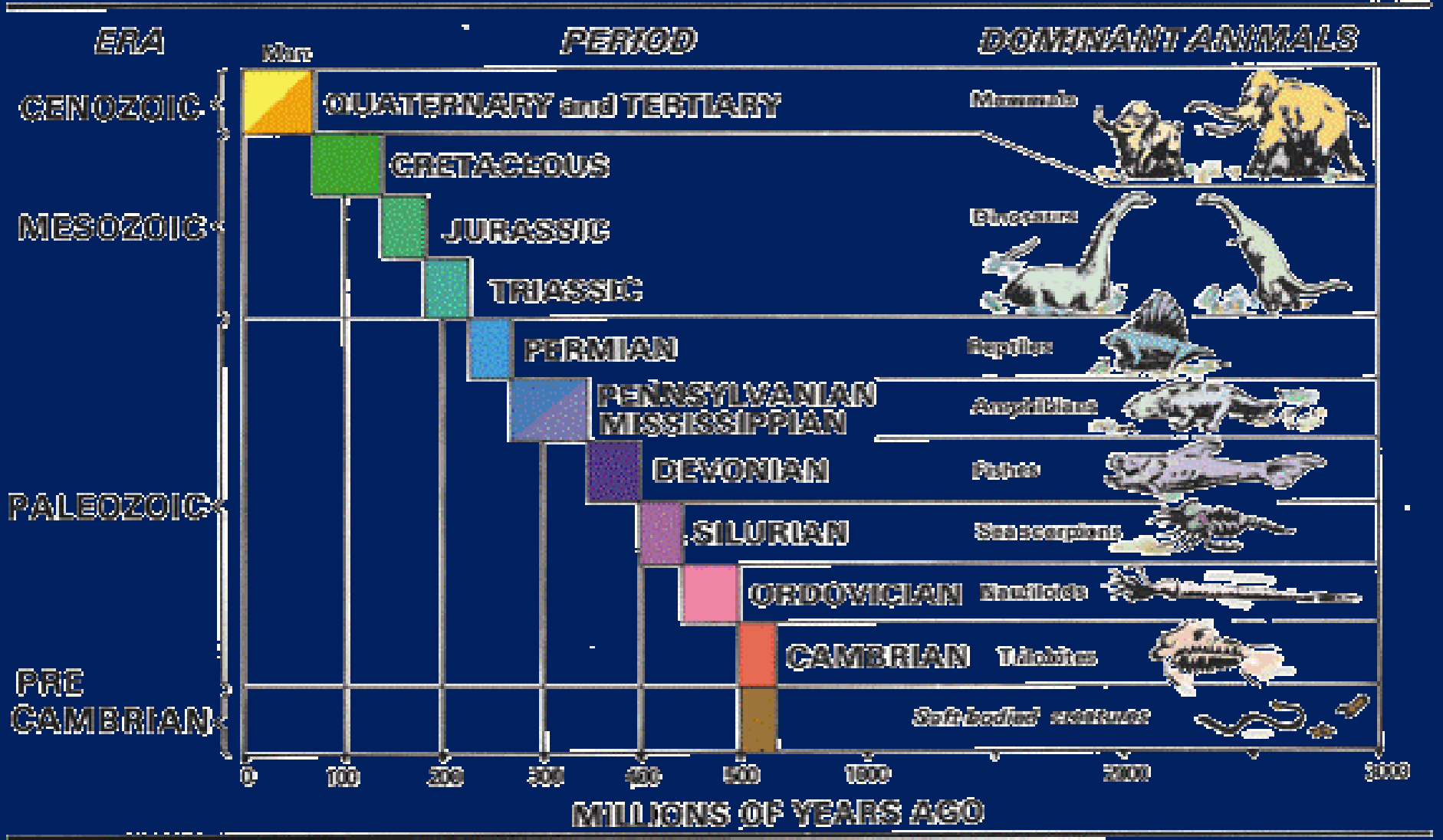
- **Paleontology in Tamil Nadu**
- **GSI located rich site of fossil around Tiruchirappalli.**
- **The secod treasure of Indian fossils of cretaceous age.**
- **Gondwana flora was recorded around Karai, Therani near Tiruchirappalli.**
- **Plant fossils are found near Sathanur (Ariyalur) and Tiruvakkarai (Pondicherry).**
- **Manganese and Phophatic nodules are found near Uttatur.**

Geologic Time Scale

- The geologic time scale is used by geologists and other scientists to map the **timing and relationships between events** that have occurred during the history of the Earth.
- Based on radiometric dating techniques, the Earth is estimated to be about 4,570 million years (4570 "Ma") old.
- The geological time scale is a means of mapping the history of the earth.
- It combines estimates of the age of geological formations as provided by radiometric dating techniques with the direct evidence of sequences and events in the rock record as assembled by geologists

Eon	Era	Period	Epoch	m.y.
Phanerozoic	Cenozoic	Quaternary	Holocene	
			Pleistocene	1.5
		Neogene	Pliocene	
			Miocene	23
		Paleogene	Oligocene	
			Eocene	
			Paleocene	65
	Mesozoic	Cretaceous		
		Jurassic		
		Triassic		250
	Paleozoic	Permian		
		Carboniferous: Pennsylvanian		
		Carboniferous: Mississippian		
		Devonian		
		Silurian		
		Ordovician		
		Cambrian		540
Precambrian		Proterozoic		2500
		Archean		3800
		Hadean		4600





Major divisions of geologic time.

Objectives of the paleontologist

1) Identification
2) Determine Form (= Morphology) and Function
3) Association of plants and animals and environmental reconstruction (paleoecology)
4) Evolution in Various Organisms
5) Dispersal and distribution of plants and animals through space and time
6) Correlation and Dating Rocks
7) Studies of Geochemistry - especially changes in ocean chemistry due to actions of organisms

What is Fossil?

The remains of animals and plants of past ages preserved in the rocks are know as fossils, the study of which forms the subject of *Paleontology*.

The word "fossil" is derived from the Latin fossils, something dug up

What is Fossilization?

Fossilization is the process by which the body of an organism is converted into fossil. The process involved in the fossilization are petrification, carbonization, mummification etc.

The process of preservation or burial occurred by some natural agencies either by water or wind borne sediments or being engulfed in bog or quick sand.

Physico- Chemical conditions required for Fossilization

1. Environmental Conditions
2. Chemical Conditions
    1. Organic substance
    2. Mineral Substance
        1. Petrification or Permineralisation
        2. Replacement of mineralisation
        3. Recrystalisation
        4. Carbonisation or Distillation

Environmental Conditions

- The body must be rapidly isolated from oxygenated environment,
- Immediate burial by fine grained sediments
- The subsequent deposition of large quantities of sediments load which leads to prevent of oxidation
- The expulsion of water and compaction
- Best sediments for Good Preservation:
  - ***1. Water borne 2. wind borne sediments***
- Water borne sediments derived from argillaceous and calcareous are good for fossil preservation
- Wind borne sediments like loess and volcanic ashes yielded fossils in terrestrial organisms.
- Geographic, topographic and climatic conditions also influence preservation.
- Colonizing, gregarious and borrowing animals are more easily preserved than those which live in isolation.

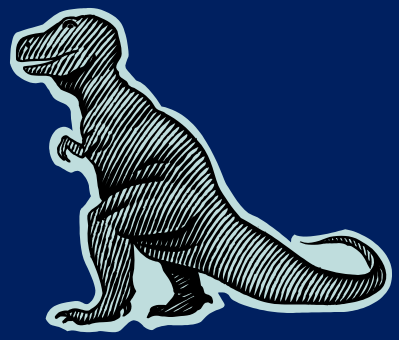
1. Chemical Conditions
    1. Organic substance

    Soon after death the soft part of the organism undergo decomposition by the activity of bacteria rendering these initially hard parts become porous and brittle.

    2. Mineral Substance
        1. Petrification or Permineralisation
        2. Replacement of mineralisation
        3. Recrystalisation
        4. Carbonisation or Distillation

When the organism dies . . .

- The soft parts that are exposed to air decompose quickly.

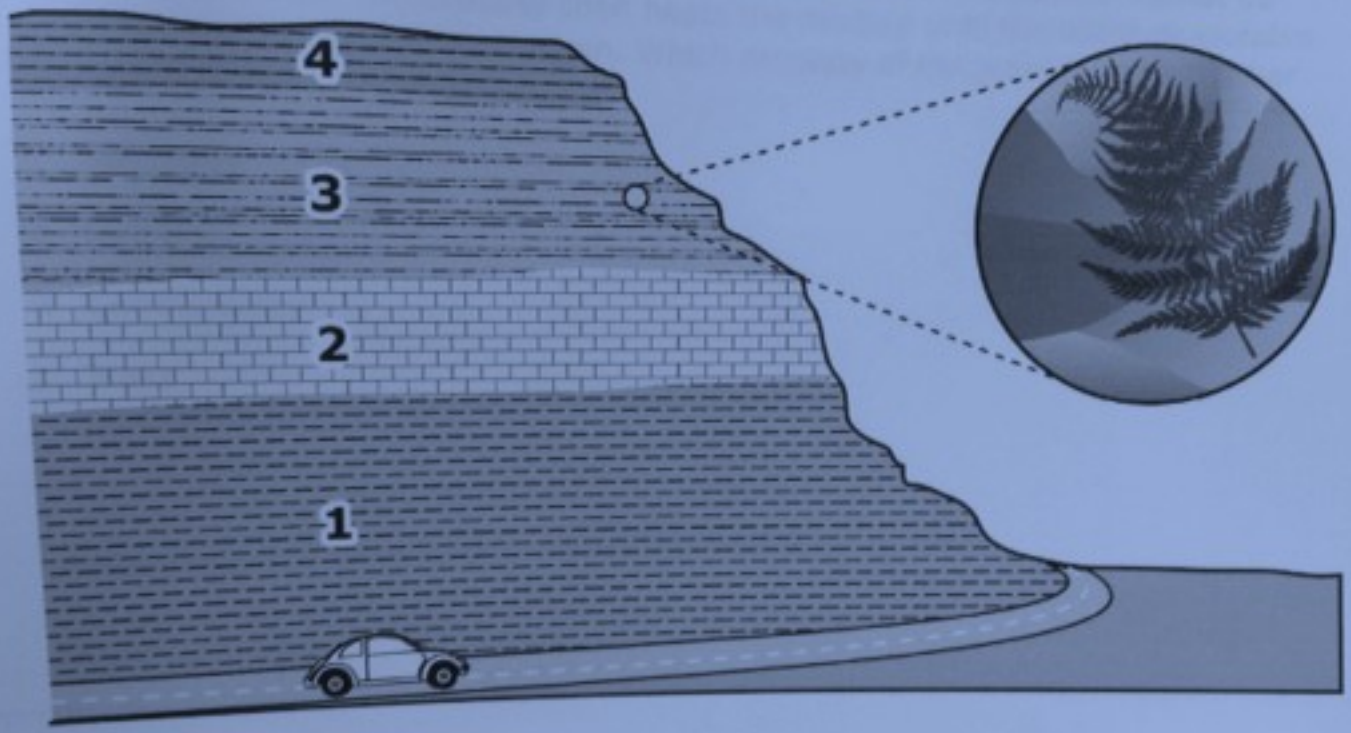


- Hard parts like bones, shells, or wood, don't decompose as quickly. They have the greatest chance of becoming a fossil.

The organism may be buried in layers deep in the earth. These layers might be composed of mud, lava or water.

- Fossils are formed under very special conditions.
- They give us clues about what life was like long ago.
- Fossils also give us clues about the environment from a long time ago.
- They help us understand that plant and animal species change over time.

9 The diagram below shows rock layers next to a road.



Layer 3 contains many plant fossils. Layer 3 most likely formed in which of these environments?

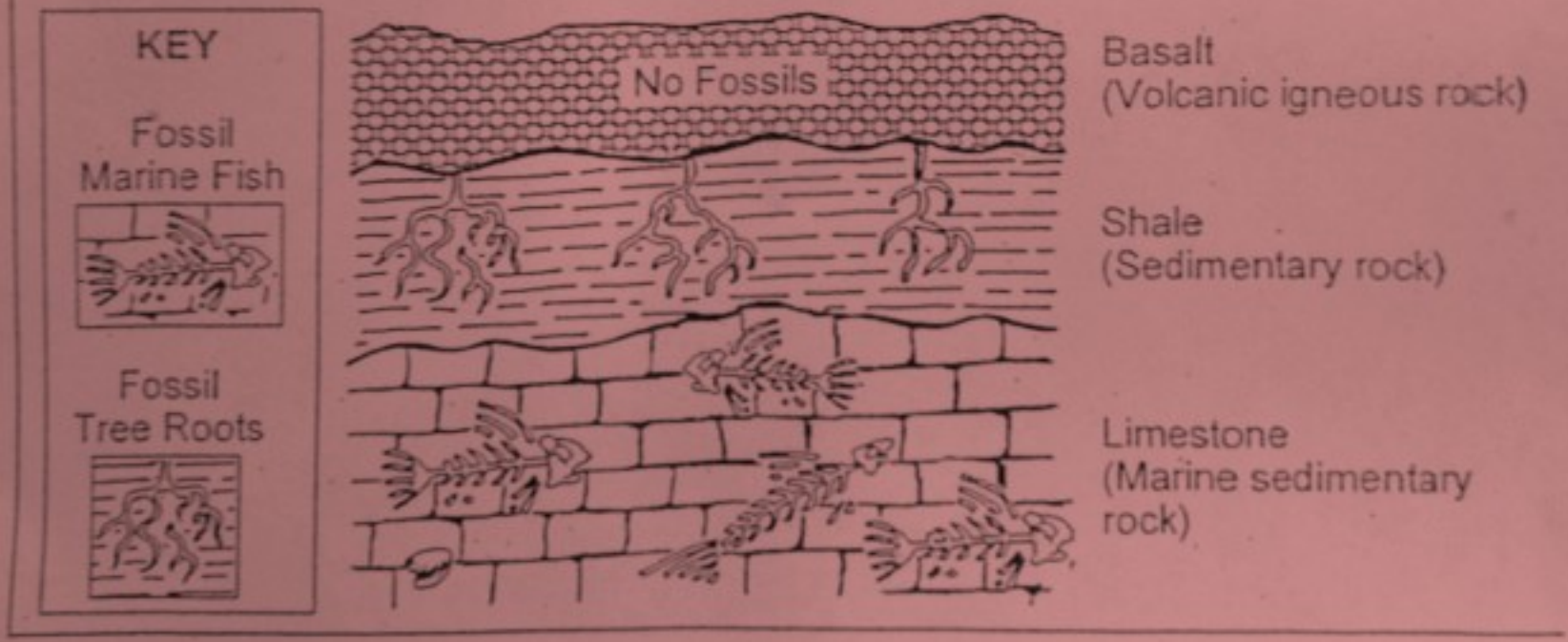
A Desert

B Forest

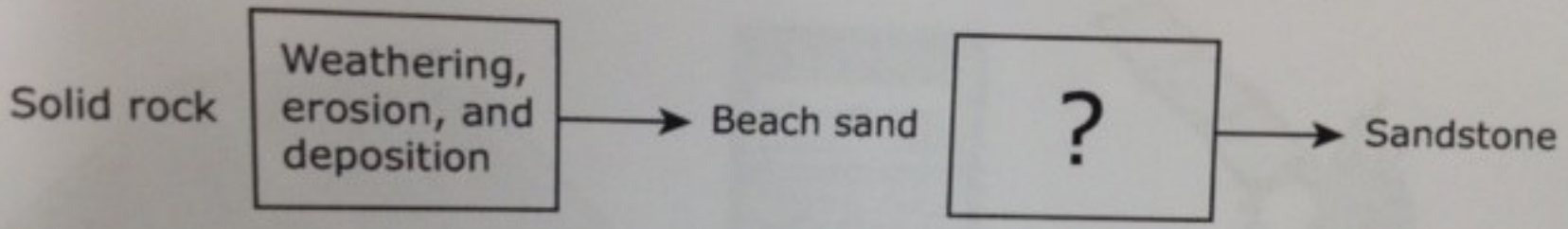
C Ocean

D Tundra

A geologist examined the cross-section of rock shown below to determine the history of the area.



1 The diagram below shows the sequence of the processes that turn solid rock into sandstone.



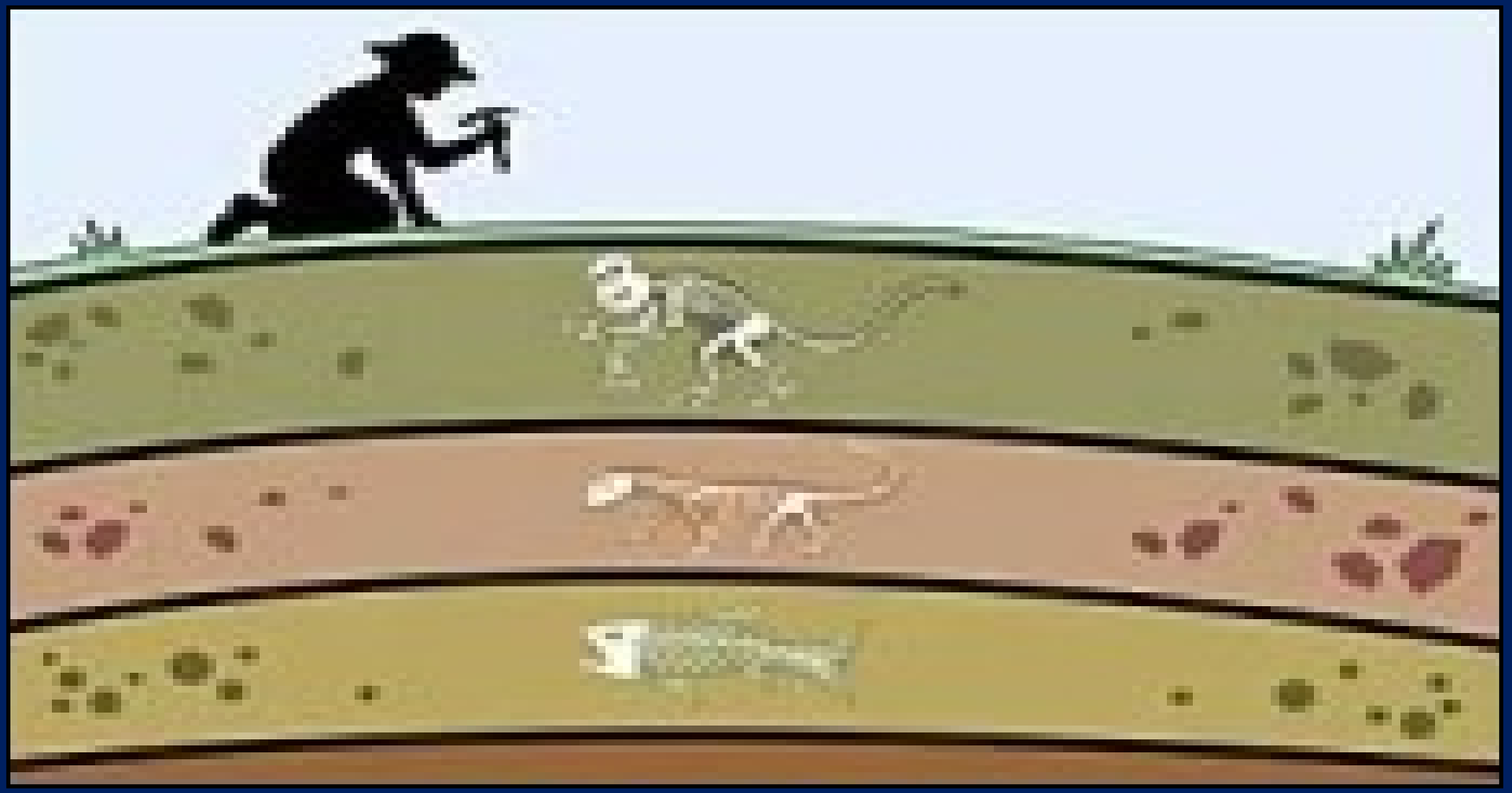
Which two processes best complete this diagram?

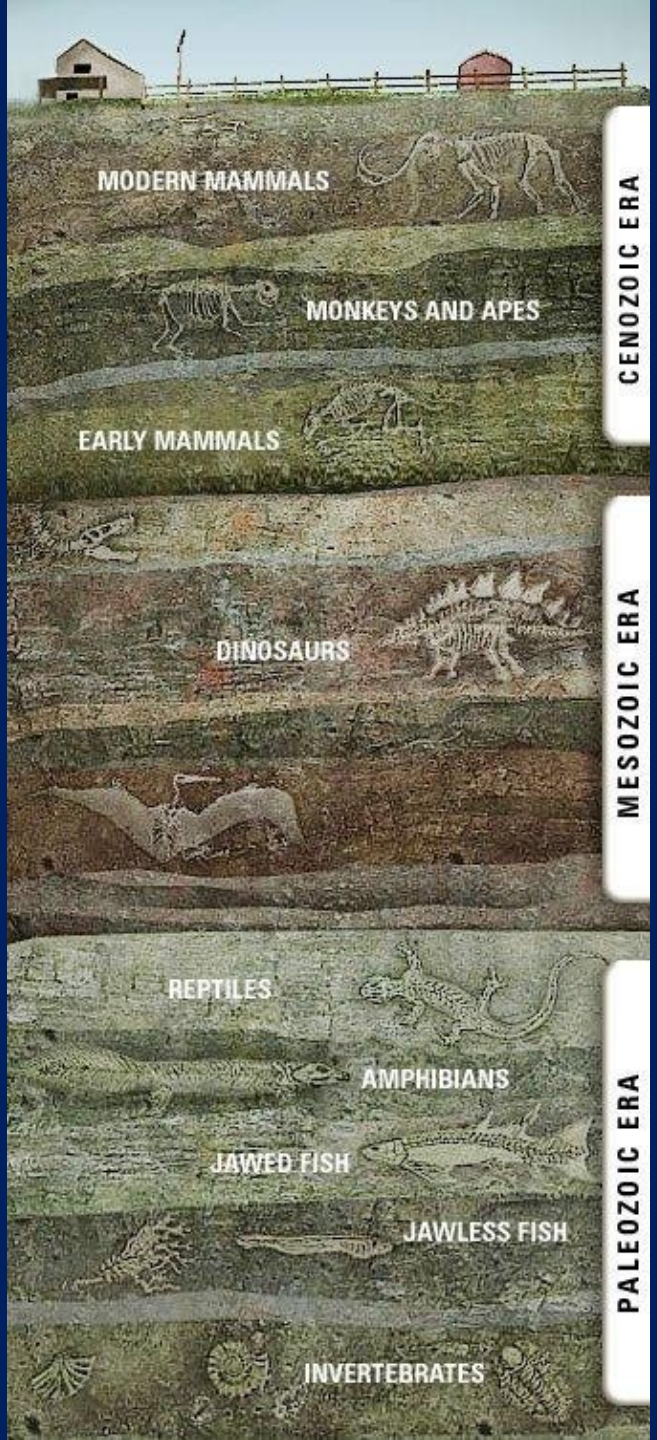
A Melting and cooling

B Erosion and compaction

C Compaction and cementation

D Evaporation and dissolving




MODERN MAMMALS
MONKEYS AND APES
EARLY MAMMALS
DINOSAURS
REPTILES
AMPHIBIANS
JAWED FISH
JAWLESS FISH
INVERTEBRATES
CENOZOIC ERA
MESOZOIC ERA
PALEOZOIC ERA

Mode of Preservation

1. Preservation of soft parts
2. Preservation of unaltered hard parts
3. Moulds and Cast
4. Imprints and Traces of biological activities

Preservation of Soft Parts

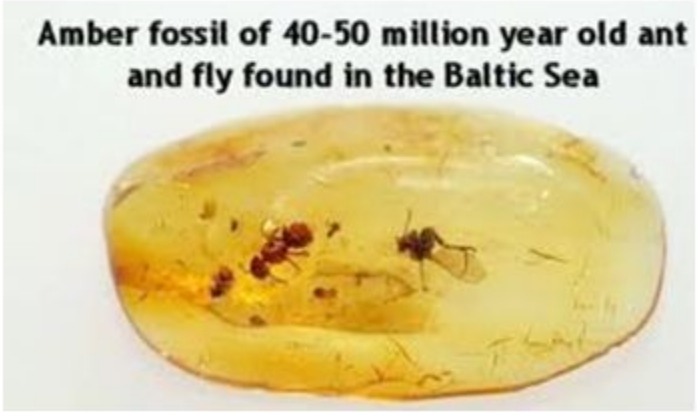
- Animal remains with all original substances intact, are found frozen in the Paleocrystic ice or in the soil itself.
- Rare preservation of animals were also found in Amber, a fossil resin from pines. Later through the evaporation of more volatile portions, they become hardened and finally changed to amber without slightest injury to the insects anatomy.
- Miring in bogs and quicksand with its combined death and burial.
- Crude asphatic oil (Tar) is the another most remarkable death trap in the world
- Mummification in arid region

Kinds of Fossils

1. **Preservation of Organisms** - Usually only the hard parts of organisms fossilize; in rare cases, the whole organism is preserved...

a. Mummification - drying

b. Amber – tree sap



c. Tar Beds – large variety

d. Freezing

- ***Desiccation, also known as Mummification***, is a very unique and rare form of fossilization.
- Desiccated/mummified fossils are next in quality to the frozen fossils.
- Bones and tissues of these desiccated organisms of the desert are preserved.
- In the desiccated fossils, the skin and hair retain their original color.
- For example, a fossil "mummy" of Anatosaurus was air-dried before natural burial and when fossilized.
- Desiccation results when organic material is found in conditions void of moisture, where dehydration results and material can be preserved for thousands of years.
- Obviously, one of the favorable environments where desiccation occurs is in the arid regions. Another type of environment where desiccation also occurs is dry caves.

Preservation of unaltered Hard Parts

- The hard parts are composed of minerals like calcite, aragonite, silica, chitin and chitinophosphate.
- Shells of Mullusca, Braciopoda and bones and teeths of vertibrates are found preserved unaltered under most adverse conditions.
- Preservation generally concerns only those hard parts can be mineralized.
- The shells and bones get replaces by secondary minerals.

Molds and casts

Organisms buried in sediment may decay or dissolve away leaving a cavity or **mold**. If the space is subsequently filled with sediment, an external **cast** can be made. **Molds and casts** are three dimensional and preserve the surface contours of the organism.

Moulds and casts

- A Mould is the impression of an organism or an organic structure in the surrounding sediments.
- ***Imprints of soft parts***: Entire soft body or organs become slightly hardened due to presence of chitin or lignin to form imprints. Eg. Feathers of Archeopteryx in the Jurassic limestone
- ***Imprints of hard parts****:* Imprints were developed before the chemical alteration and dissolution of hard parts.
- This external moulds tell about the ornamentation of the shells and tests.
- The quality of the imprints related to the fineness of the sediment grain size.
- Fossil ammonoids are the best example for the Moulds and Cast.


Fossil mold and cast
mold
cast
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Traces of biological activities and rain prints

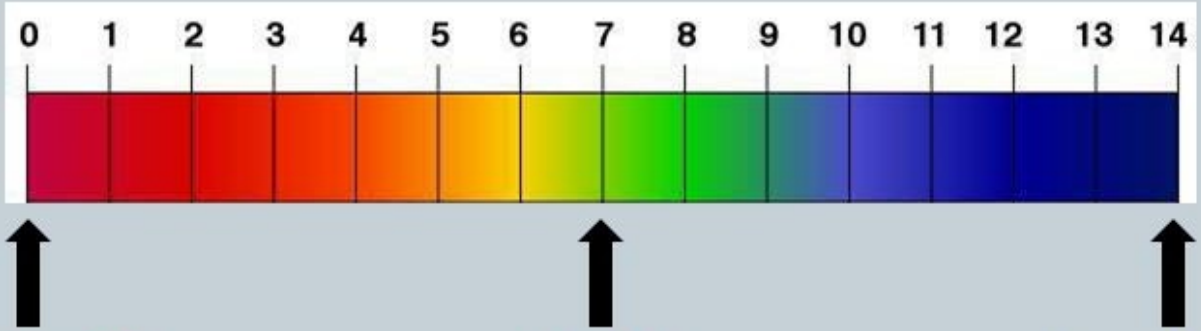
Chemical Conditions

- ***Organic Substance***: After death, soft part of the organisms undergo decomposition by the activity of bacteria.
- Similarly proteinaceos associated with shells, bones and test are often disappears, rendering these initially hard parts porous and brittle.
- Recent study broughtout that amino acids and proteins being perfectly preserved in sediments.
- ***Mineral Substance:*** Mineralised part of organisms may be preserved without any notable change but generally, recrystallization, permineralization and carbonization occurs.

Petrifaction

- Long ago, dead logs were washed into a river and buried in the sand.
- Water with alkaline and dissolved silica went down through the sediments, and contacted the logs.
- The logs decayed, releasing carbon dioxide, which dissolved in the water and formed carbonic acid.
- The alkaline water was then neutralized, and the silica precipitated out of the solution.
- Very slowly, the cellulose of the wood is replaced, molecule by molecule, by the silica.
- Eventually, the wood is replaced in perfect detail by minerals.

pH Scale



- Shows whether a solution is acidic, neutral or alkaline.
- pH < 7
- pH = 7
- pH > 7

Carbonization

- The soft parts of the organism were compressed and heated, driving off all the volatiles (H, N, O).
- A carbon film is left behind.
- Most common in plants, soft-bodied organisms, organisms with phosphate skeletons, organisms with chitin skeletons, and sometimes fish (under the right environmental conditions).
- Each organism here had a proteinaceous skeleton or framework.
- During lithification, pressure and high temperatures volatilized the N, H and O of the protein, leaving behind a black carbon film.

Replacement:

- Original mineral has been dissolved away and replaced by a different mineral.
- Usually the original mineral was aragonite or calcite, and it has been replaced by silica (in oxidizing and acidic conditions) or pyrite (in reducing conditions, in the absence of oxygen).
- Under some conditions, replacement happens on an atom-by-atom basis, and the fine structure of the fossil is preserved in the new mineral.

Replacement: Pyritization
(replacement by pyrite)

Pyritized brachiopod

Original calcitic brachiopod

Recrystallization:

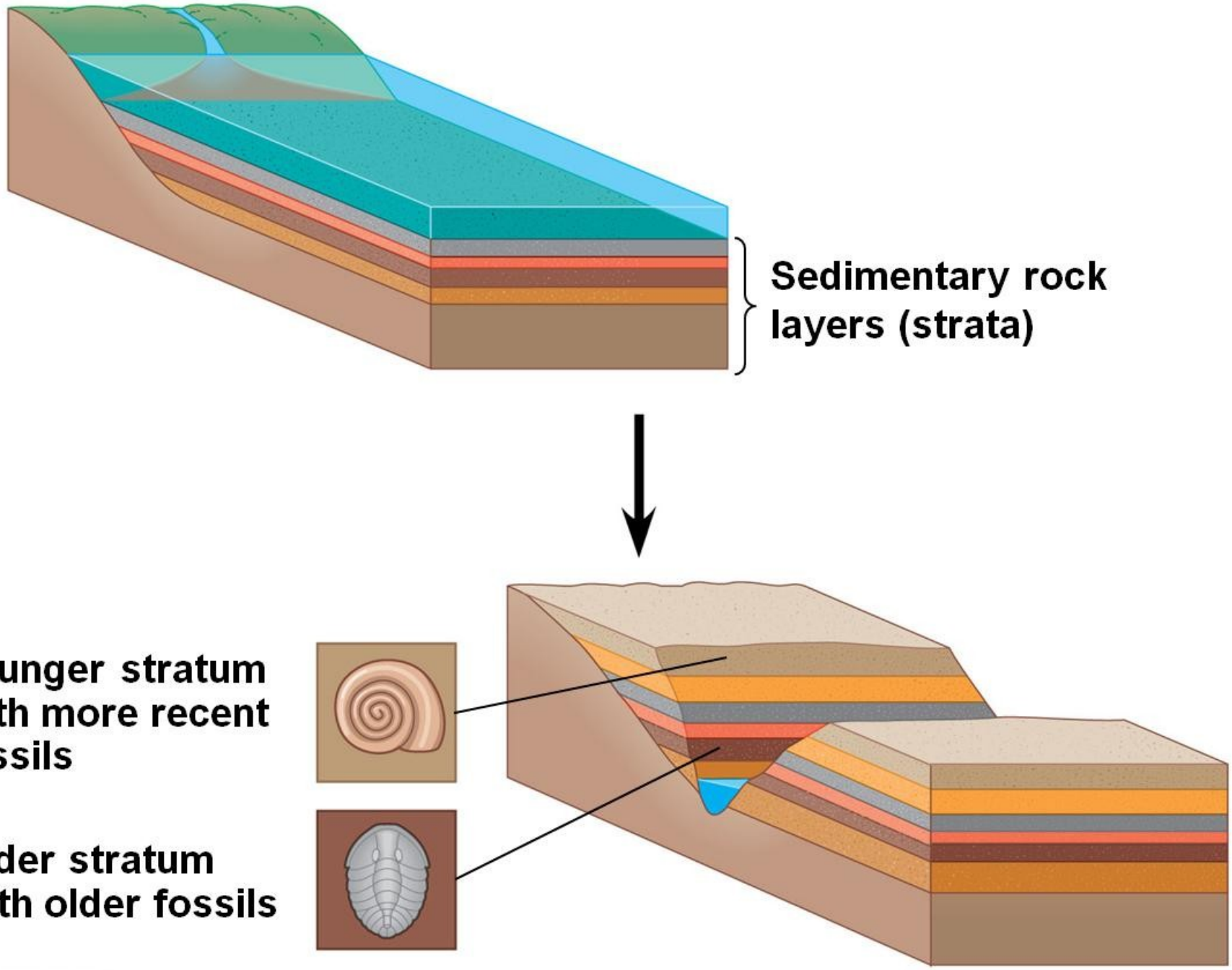
The original skeletal material has grown into new crystals.

The process may be aragonite crystallizing to calcite, as in fossil snails, or it may be the growth of larger crystals of an existing mineral such as the large calcite crystals in the algae.

Molds and casts

Organisms buried in sediment may decay or dissolve away leaving a cavity or **mold**. If the space is subsequently filled with sediment, an external **cast** can be made. **Molds and casts** are three dimensional and preserve the surface contours of the organism.

Figure 22.3



Type of Fossil

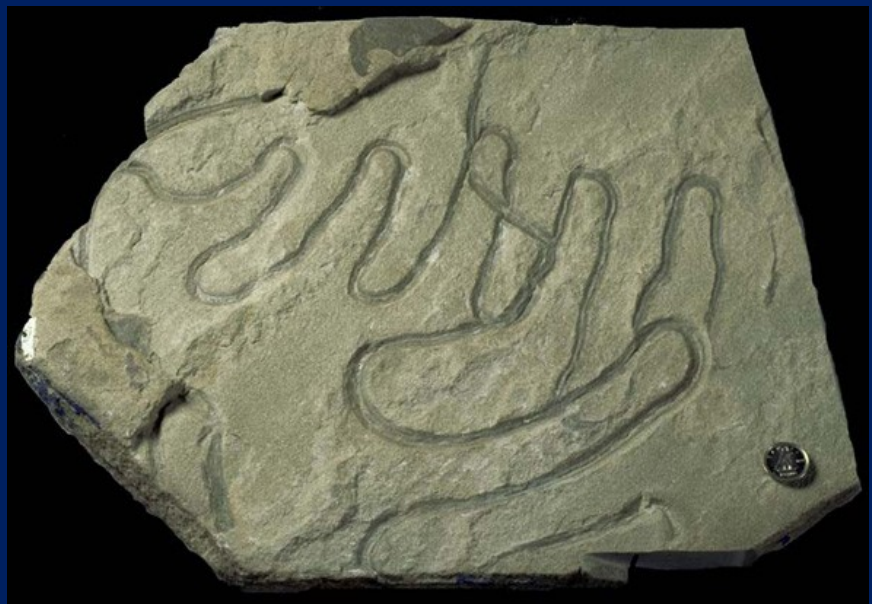
- ✓ Body Fossil
- ✓ Trace Fossil
- ✓ Derived fossils or Reworked Fossil
- ✓ Living Fossil
- ✓ Pseudo fossil
- ✓ Index Fossil or Guide Fossil or Marker Fossil

Body Fossil

- Well preserved entire organism, altered and unaltered hard parts and naturally formed moulds and cast are classed as body fossils.

Trace Fossil

- Foot prints, trails, burrows and fossilize eggs are termed as trace fossil.
- It is also known as Ichnofossil



Derived Fossil

- Fossils whose original home was in some older bed which was transported to younger beds called derived fossils or reworked fossils.

Living Fossil

- Fossils which range from ancient time to the present day without any change in their primitive characters are known as living fossils
- an organism such as a horseshoe crab or a ginkgo tree that has remained essentially unchanged from earlier geologic times and whose close relatives are usually extinct.

Pseudo Fossil

- Certain structures of sedimentary or tectonic origin which resemble fossilized organic remains are termed as pseudo fossil.

Examples:

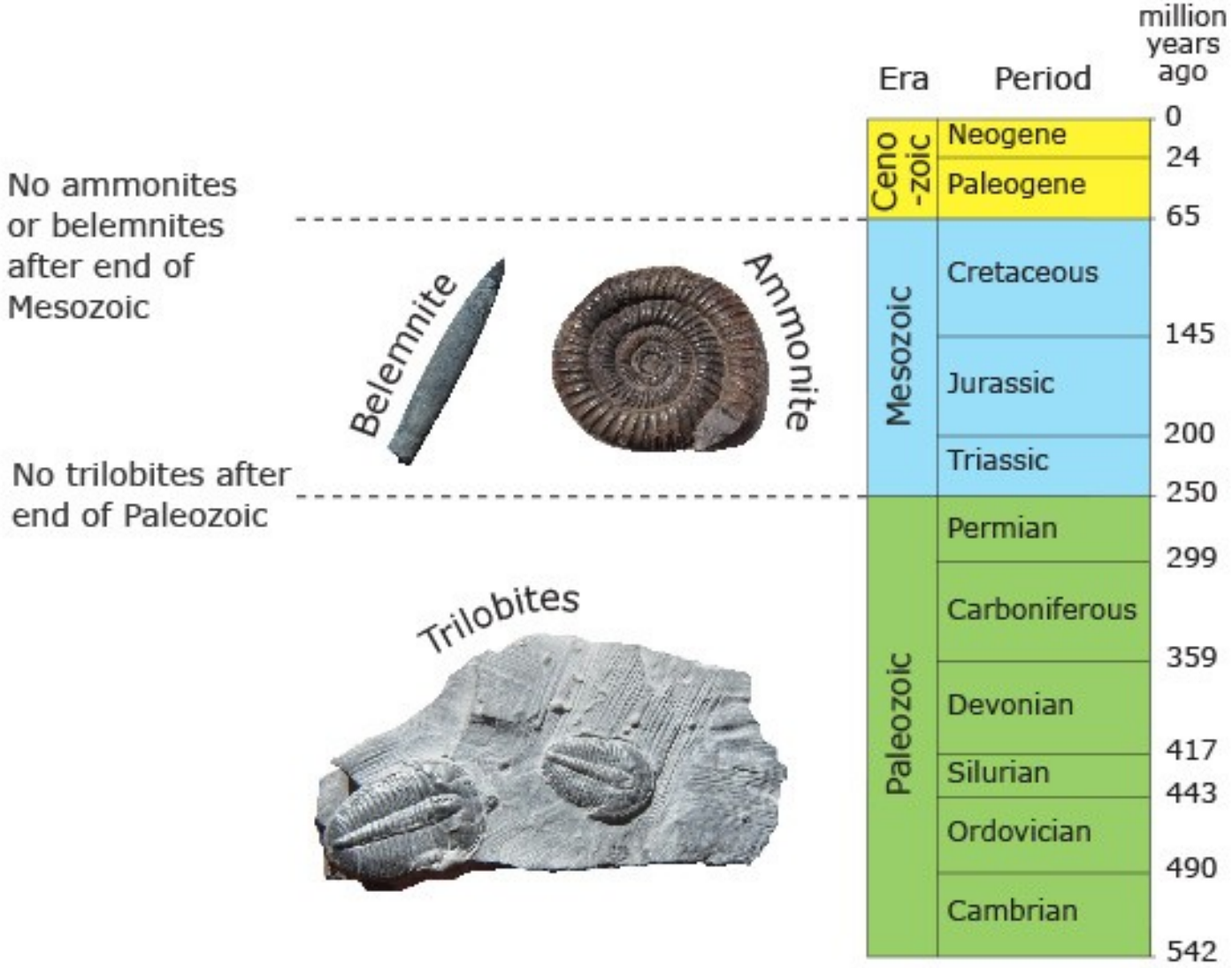
I. Plant like dendritic structure developed from manganese hydroxide markings.

II. Concretions with dinosaur's egg

Index Fossil

- Certain animals or plants remain are so characteristic of certain geological horizons that they are called index fossil or guide fossil or marker fossils

Index Fossil



Uses of Fossils

Fossils provide evidence of evolution and migration:

- The fossils of most primitive animals and plants are preserved in the rocks, which were formed during the early part of the geological period of the earth.

- A variety of organisms, though have been extinct since long from a particular region, newer and more developed.

- Along with their evolution the animals and plants have migrated from place to place on the surface of the globe.

- The geological history of present day horses and their primitive ancestors may be taken as an example.

- The primitive horses originated in North America and in course of their evolution they migrated to India, through Central Asia.
- This type of scientific conclusion is possible because of systemic research on the available fossil records.

- Fossils help in establishing the geological age and order of superposition of a sedimentary formation along with their correlation with the formations of one area with the other.

- The fossil assemblage of a rock bed is different from the bed above and below it.

- The rock-beds formed during different geological periods should contain fossil remains of those organisms which were flourishing during that particular geological period.

- Hence, it is possible to establish the geological age of a particular bed and the chronological order of the sedimentary formation and correlate the same with other sediment formation formed elsewhere on the surface of the earth with the help of fossils.

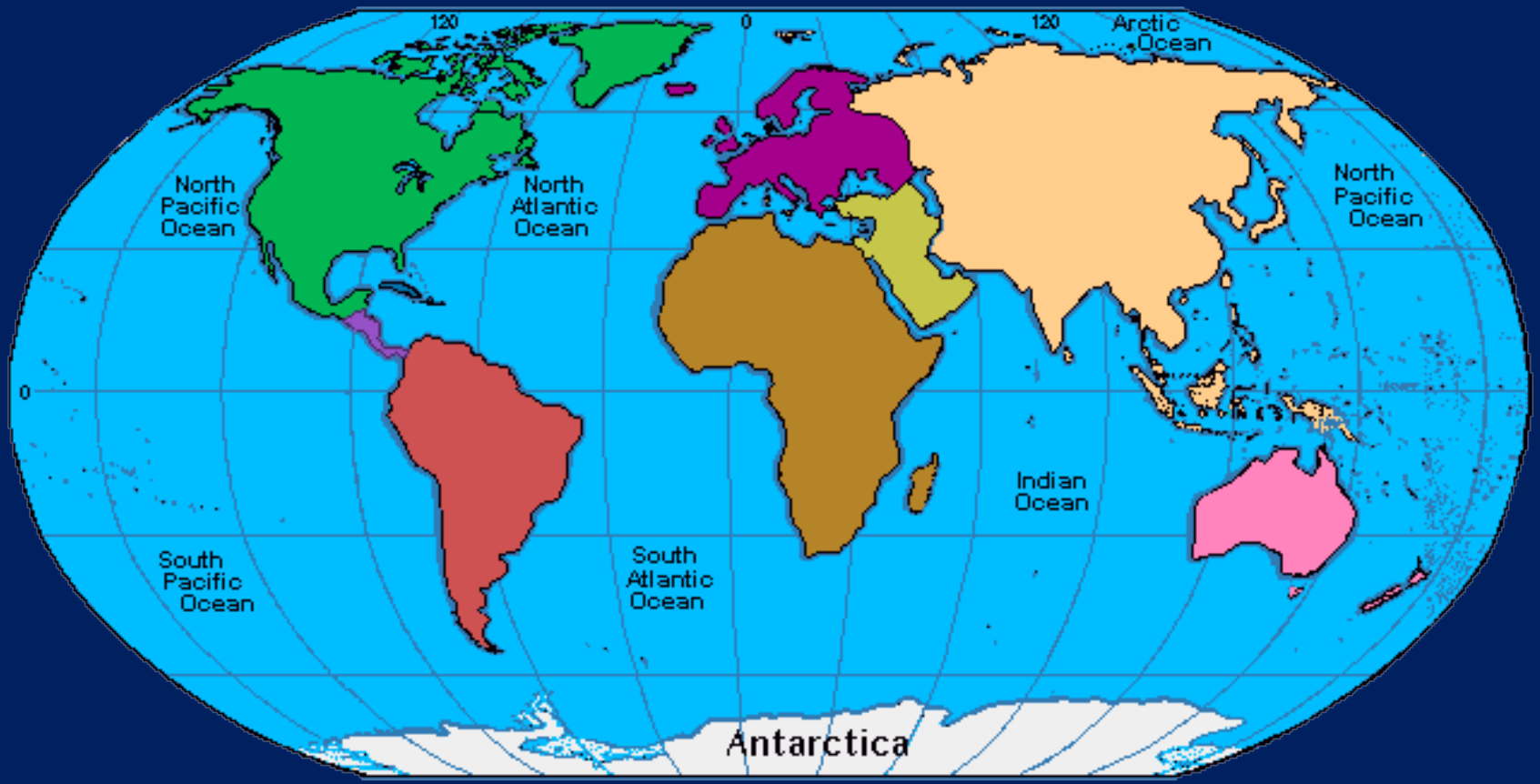
Study of ancient geography:

Distinct differences are found among aquatic and land animals and plants.

Shallow and deep water organisms differ from each other in many respects.

The ancient organic world can be visualized in the light of their present day representatives.

By examining the fossils and the rocks in which they are preserved, the rock beds formed under different climatic conditions and environments can be differentiated from each other.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120
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North Pacific Ocean
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Indian Ocean
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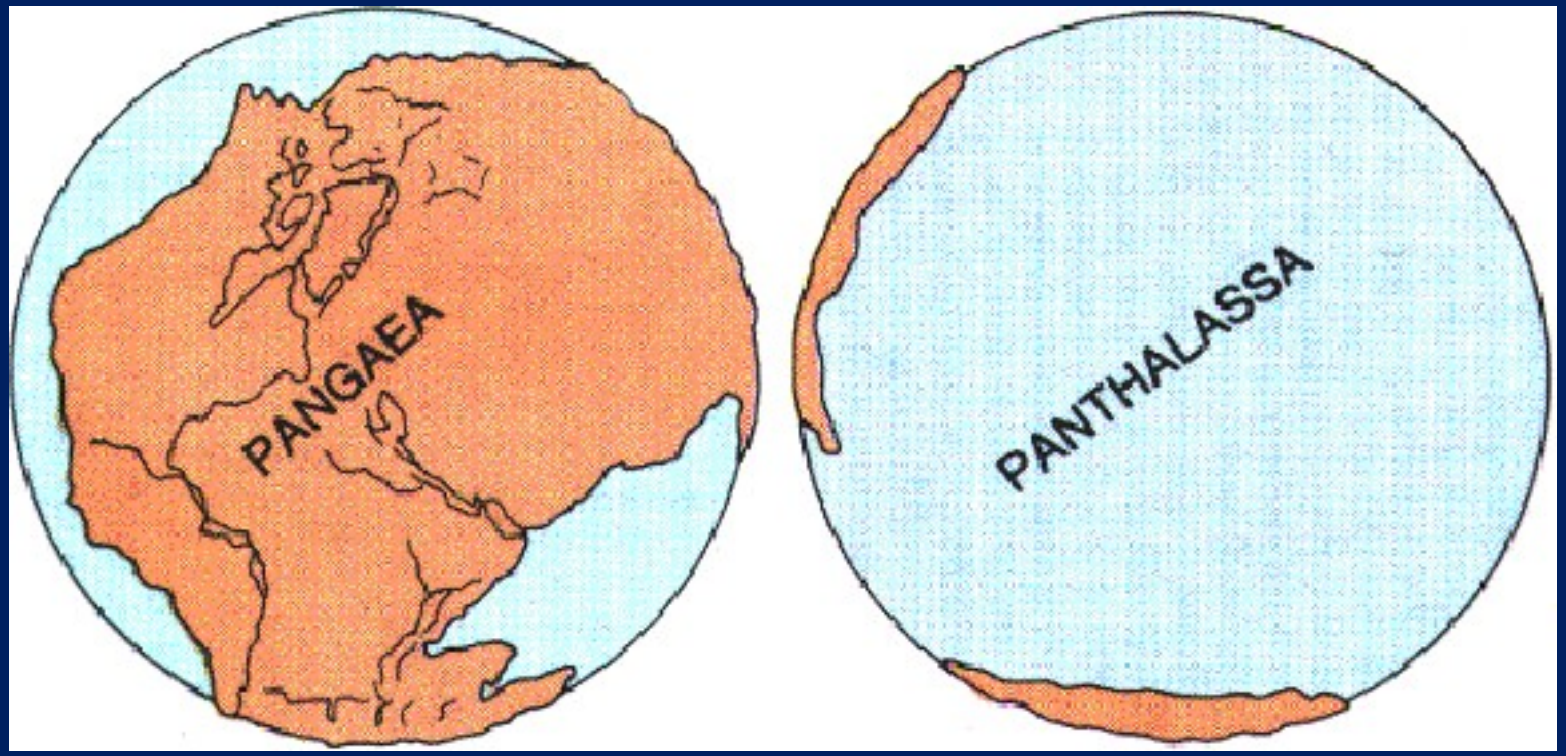
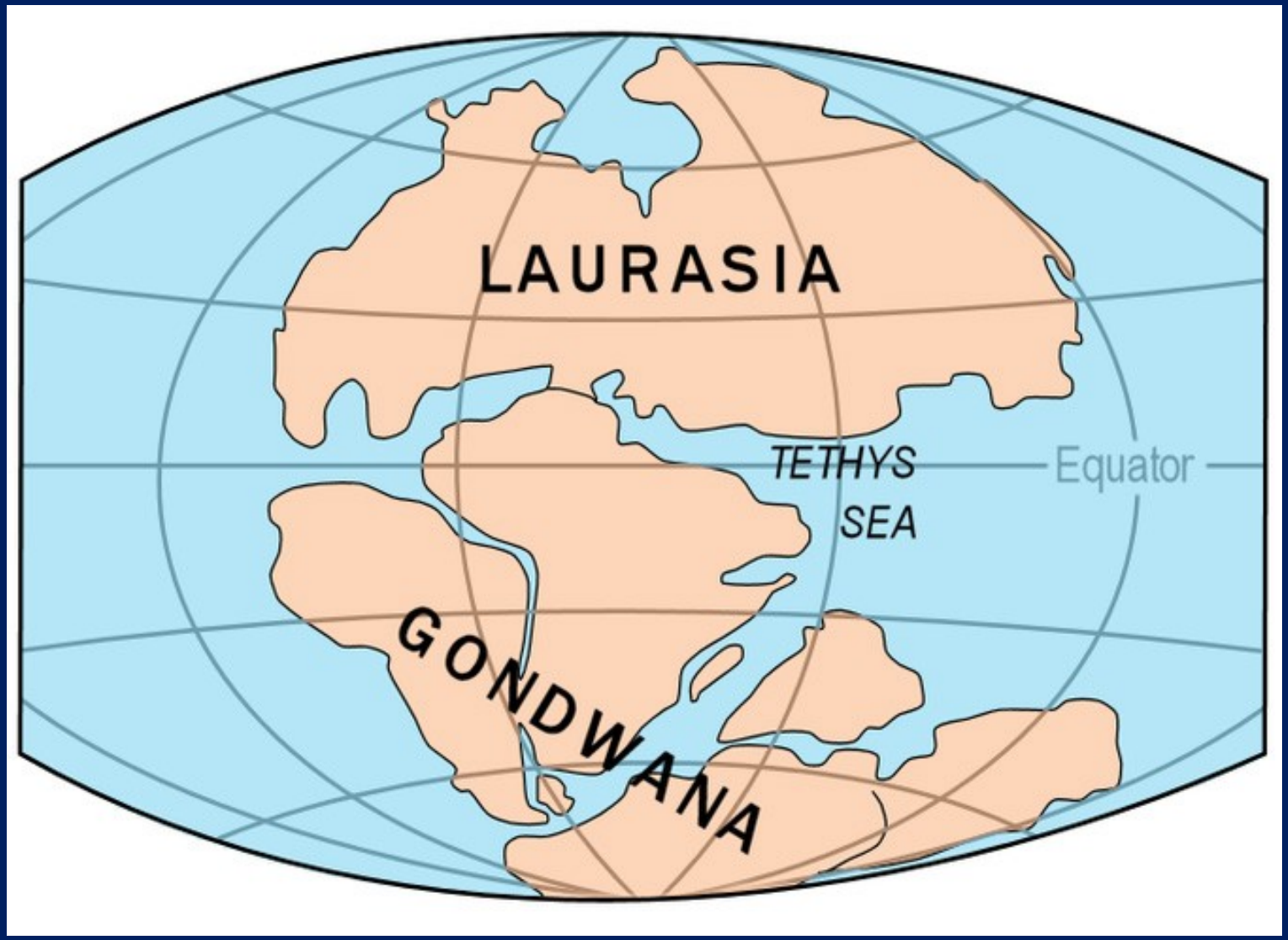
South Atlantic Ocean
Antarctica


PANGAEA
PANTHALASSA


LAURASIA
TETHYS
SEA
Equator
GONDWANA


ARCTIC OCEAN
Greenland
Svalbard (Nor.)
ARCTIC OCEAN
United States of America
Canada
Iceland
Norway
Sweden
Finland
Russia
United Kingdom
Denmark
Ireland
Neth.
Ger.
Pol.
Estonia
Latvia
Belarus
Ukraine
Kazakhstan
Mongolia
France
Italy
Rom.
Georgia
Bulgaria
Azer.
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Kyrgyzstan
Tajikistan
Turkm.
Portugal
Spain
Turkey
Greece
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Syria
Iraq
Iran
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Pakistan
China
N. Korea
S. Korea
Japan
Nepal
Bhutan
India
Laos
Taiwan
Burma
Bangl.
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Philippines
Thailand
Cambodia
Sri Lanka
Malaysia
Indonesia
Papua New Guinea
Solomon Islands
Fiji
Australia
New Zealand
United States of America
ATLANTIC OCEAN
PACIFIC OCEAN
Morocco
Algeria
Libya
Egypt
Israel
Jordan
Kuwait
Saudi Arabia
U.A.E.
Oman
Yemen
Western Sahara
Mauritania
Mali
Niger
Chad
Eritrea
Djibouti
Sudan
Senegal
Guinea-Bissau
Sierra Leone
Liberia
Cote d' Ivoire
Ghana
Togo
Nigeria
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C.A.R.
Ethiopia
Somalia
Gabon
Dem. Rep of Congo
Uganda
Kenya
Tanzania
Rep. of the Congo
Angola
Zambia
Malawi
Namibia
Zimbabwe
Mozambique
Botswana
Swaziland
Lesotho
South Africa
Madagascar
INDIAN OCEAN
Mexico
Guatemala
Honduras
Nicaragua
Costa Rica
Panama
Colombia
Ecuador
Ven.
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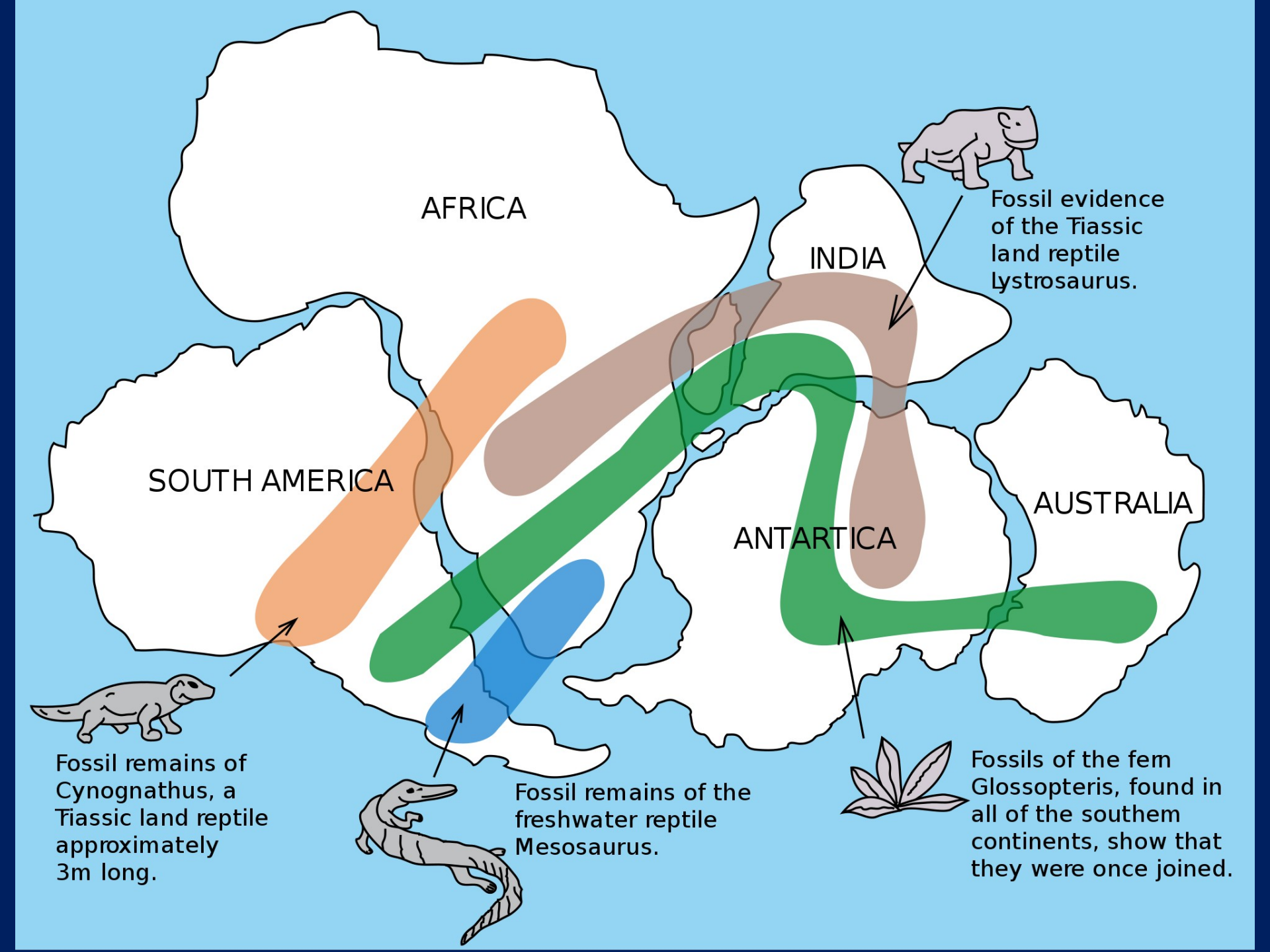
Pangea – 250 million years ago

PANGEA


EURASIA
NORTH AMERICA
PACIFIC
AFRICA
SOUTH AMERICA
INDIA
PACIFIC
EAST ANTARCTICA
AUSTRALIA


AFRICA
INDIA
SOUTH AMERICA
ANTARTICA
AUSTRALIA
Fossil evidence of the Tiassic land reptile Lystrosaurus.
Fossil remains of Cynognathus, a Tiassic land reptile approximately 3m long.
Fossil remains of the freshwater reptile Mesosaurus.
Fossils of the fern Glossopteris, found in all of the southern continents, show that they were once joined.

- Fossils of marine animals are found to be preserved in the rocks of the Himalayas indicating the presence of a sea in the region where the Himalayas is found today.

- Hence, by systematic study of the fossils the distribution of land and sea, changes in climatic conditions and such other ancient geographical features on the surface of the earth can be well established.

The search for new deposits of coal and petroleum:

- The fossil fuel deposits are always associated with the ancient organic world.
- Most of the large deposits of coal are associated with the sedimentary rocks deposited in lake-basins during Permian period.
- On the other hand, petroleum deposits are commonly formed within marine sediments of Tertiary period.
- With the help of fossils, a geologist while establishing the age of the rocks of the area can locate fresh deposits of coal, petroleum and other useful rocks and minerals.

- Amber with ancient insects is used as jewelry

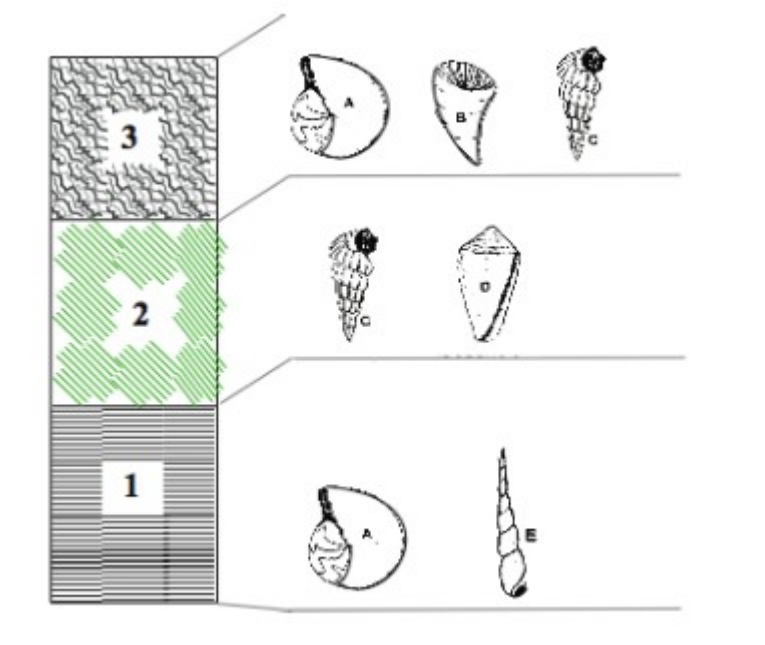
- Apart from the above, the fossils are helpful in finding missing links of the animal and plant kingdom.

- It is used to establishing a full picture of the organic evolution, fixing their geological age and working out a correct classification of the organic world and a standard geological time-scale.

Dating Layers of the Earth

- Fossils aren't used only to understand individual organisms. Geologists also use fossils for what is called biostratigraphic correlation, which allows researchers to match layers of rock in different locations by age based on how similar the fossils in each rock layer are.
- This information can be used to help understand when different layers of rock were formed even when large distances separate them

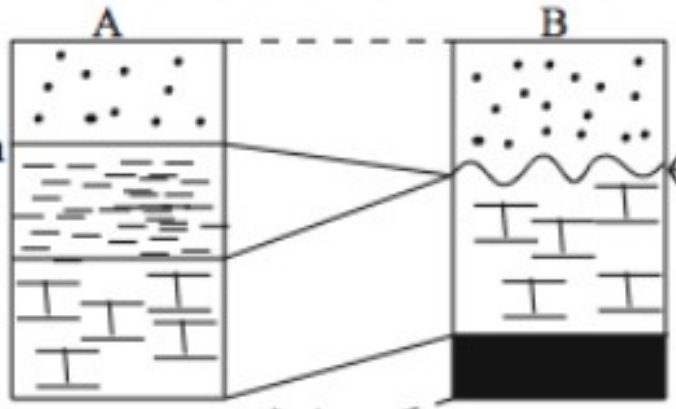
Biostratigraphy is the correlation of stratigraphic units based on fossil content



Rock beds can be correlated one of two ways: **lithologic correlation** uses lithology (rock type) to match like rock units, while **biostratigraphic correlation** uses age (via index fossils and fossil assemblages) to match like rock units.

The formations may be of different thickness from one column to the next due to erosion or other processes. Sometimes rock beds **pinch out, or kind of taper off in** thickness as it approaches the edges of its lateral depositional area, and will not be found in other sections.

LITHOLOGIC CORRELATION

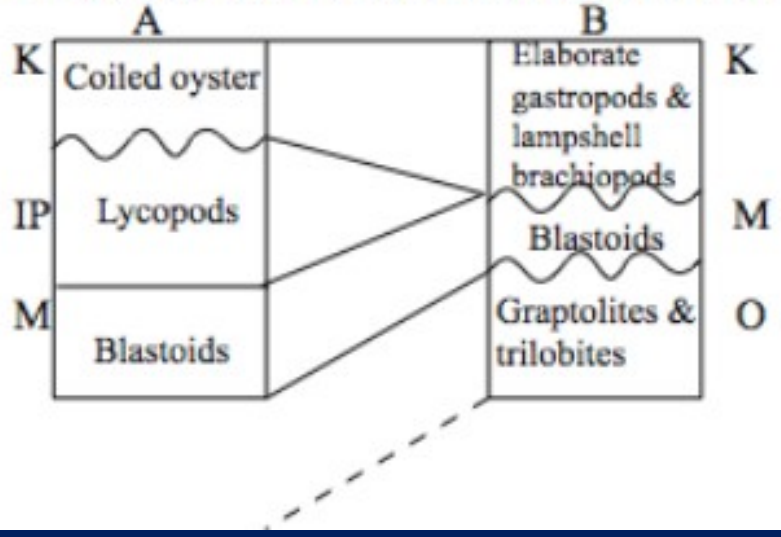


Notice that the pinch out automatically points to an unconformity

Always mark any unconformitites with a wavy line

The dotted line implies there is not enough information to determine if there is a corresponding formation at Location A. Either it is not exposed, or the geologist did not investigate down that far.

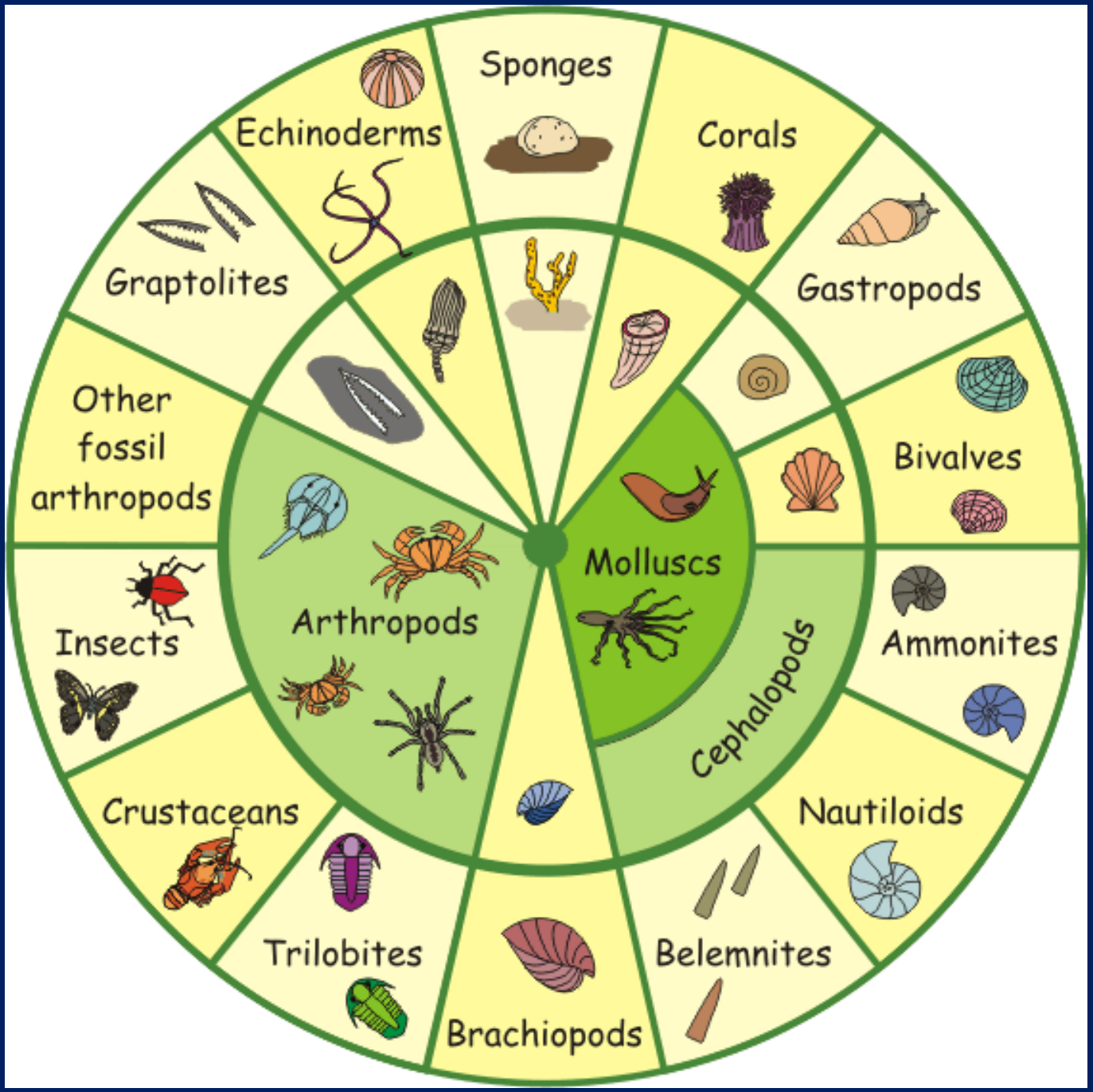
BIOSTRATIGRAPHIC CORRELATION



Fossils reveal much useful information. Among the most important uses of fossils are:

- Tracing the development of the plants and animals of our planet earth.
- For purposes of correlation to determine the distribution of geologic units of similar age
- By studying fossils, paleontologists can tell us more about the lives of ancient plants and creatures, and thus provide information about modern types of life forms.
- Fossils reveal information about ancient environments and climates.

- Fossils can give the age of certain rocks. This allows geologists to match up or correlate rock layers from all over the world, often leading to the discovery of new mineral deposits of economic importance.
- Fossils are used to make geological maps. They help the geologists to work out the correct sequence of deposition of the sedimentary rocks, i.e., which rock layers are oldest and which are youngest.
- There are other types of fossils known as fossil fuels, such as oil and coal, which are used every day. Coal is formed from ancient plant remains, and is used to generate power. Oil is formed from the bodies of millions of tiny sea creatures which have been compressed over millions of years to form oil.


Sponges
Corals
Echinoderms
Gastropods
Graptolites
Bivalves
Other fossil arthropods
Molluscs
Arthropods
Insects
Ammonites
Cephalopods
Crustaceans
Nautiloids
Trilobites
Belemnites
Brachiopods