



# Geological Time Scale & Application of Paleobotany

**Dr. Mrunalini N. Desai**  
Assisatant Professor  
Vivekanand College, Kolhapur  
(Autonomous)





# What is the Earth's time scale?

- The *Geological time scale* is a record of the life forms and geological events in Earth's history.
- Scientists developed the time scale by studying rock layers and fossils world wide.
- Radioactive dating helped determine the absolute divisions in the time scale.



# Geological Time Scale:

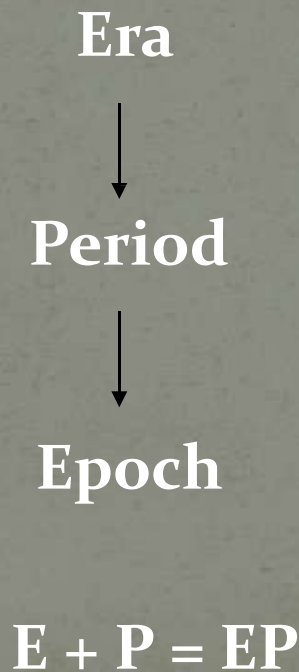
The Earth is believed to be about 5 billion years old.

The total period of about 5 billion years of the earth's history is divided into 4 major units called Eras.

1. Precambrian
2. Palaeozoic: Ancient life
4. Mesozoic: Middle age
5. Cenozoic: New life

# Divisions of Geological Time

- Eras are subdivided into periods...periods are subdivided into epochs.



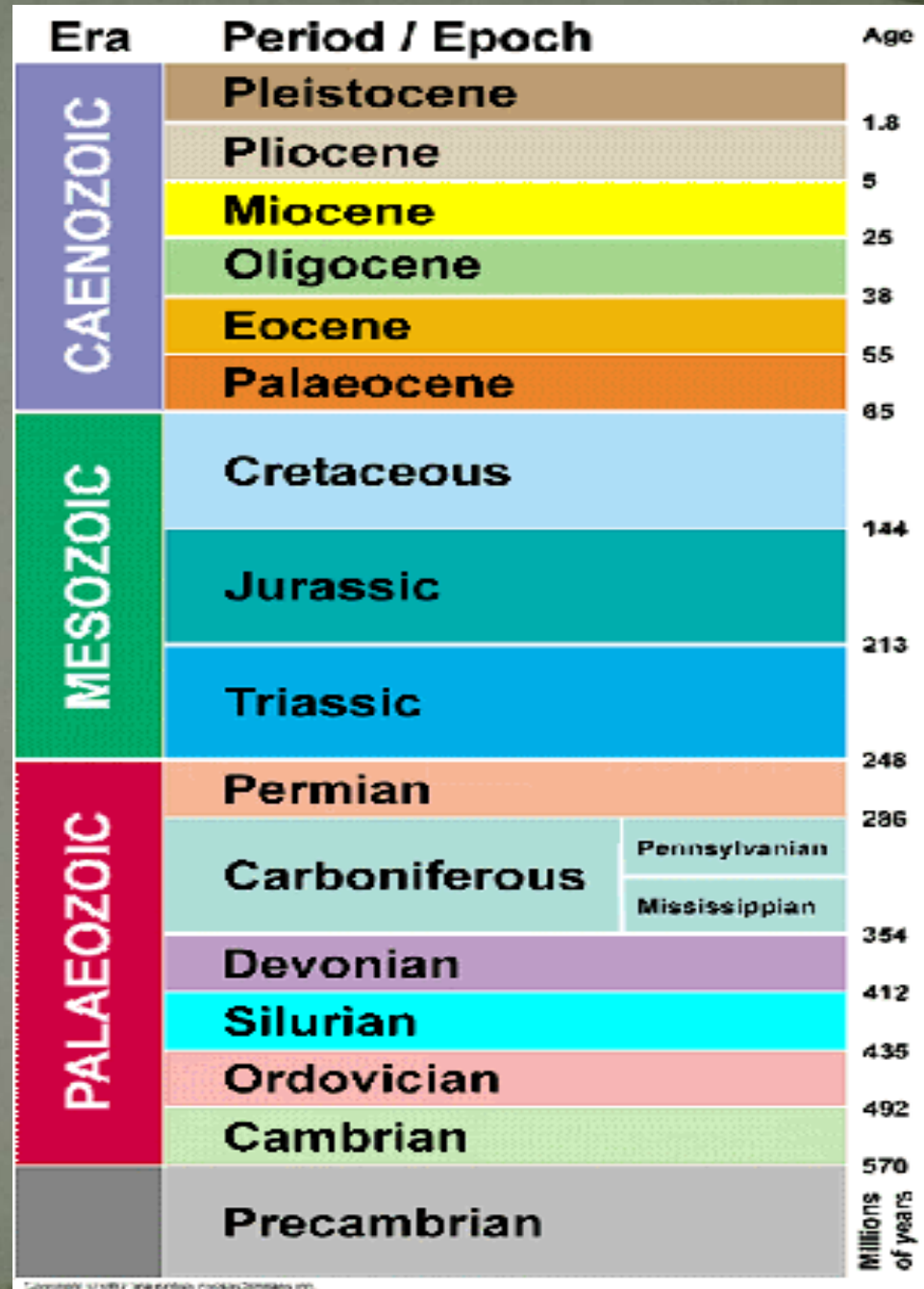
ERA	PERIOD	START OF EACH PERIOD (in millions of years)	FLORA & FAUNA
Cenozoic	Quaternary	1	Modern species of mammals, extinction of large forms, such as mammoth; dominance of human
	Tertiary	54	Rise of birds and placental mammals
Mesozoic	Cretaceous	65	Dominance of flowering plants; extinction of large reptiles and ammonites by end of period
	Jurassic	145	Reptiles dominant on land, sea and in air; first birds; archaic mammals
	Triassic	208	First dinosaurs, turtles, ichthyosaurs, plesiosaurs; cycads and conifers dominant
Paleozoic	Permian	245	Radiation of reptiles, which displace amphibians as dominant group; widespread glaciation
	Carboniferous	286	Ferns as dominant plant group; sharks and crinoids abundant; radiation of amphibians; first reptiles
	Devonian	360	Age of fishes (mostly freshwater); first trees and first amphibians
	Silurian	408	Invasion of the land by plants and arthropods; brachiopods; primitive jawless vertebrates
	Ordovician	438	Appearance of vertebrates (armoured fishes); brachiopods and cephalopods dominant
	Cambrian	505	Appearance of all invertebrate phyla and many classes; dominance of trilobites and brachiopods;



# Fossil Record

The dating of all fossils is included in the Geological Time Scale. This scale divides the time that the earth has existed into 4 eras.

Eras are then divided into periods based on common events in that time period.



Source: © 1997 The British Fossil Collection Ltd.

# FOUR Eras...

- **PRE-CAMBRIAN** – 88% of earth's history
- **Paleozoic (ancient life)**
  - 544 million years ago...lasted 300 million yrs
- **Mesozoic (middle life)**
  - 245 million years ago...lasted 180 million yrs
- **Cenozoic (recent life)**
  - 65 million years ago...continues through present day



# Today...

- Today we are in the Holocene Epoch of the Quaternary Period of the Cenozoic Era.



# Divisions of Geologic Time

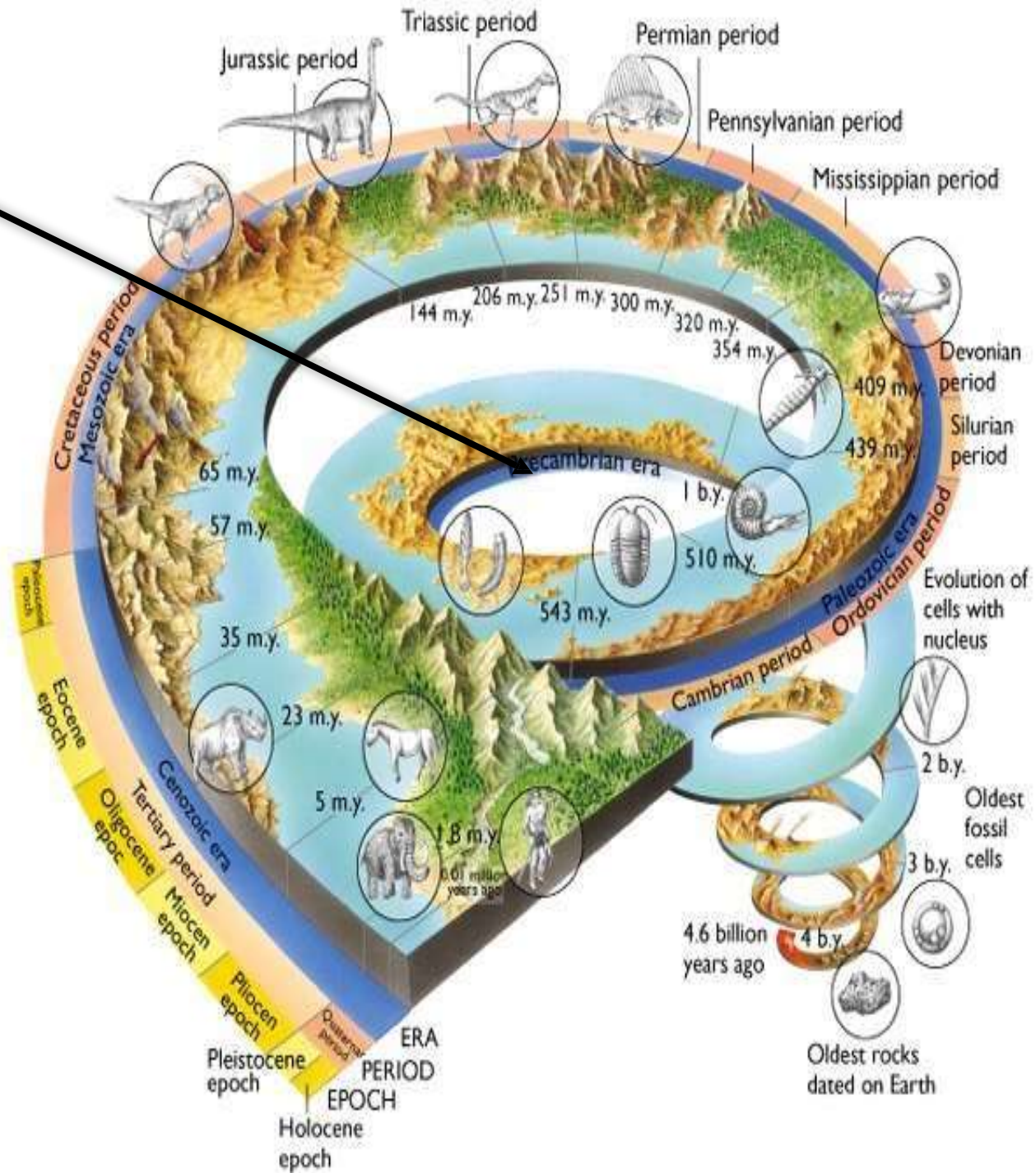
- Geological time begins with *Precambrian Time*. Precambrian time covers approximately **88%** of Earth's history.



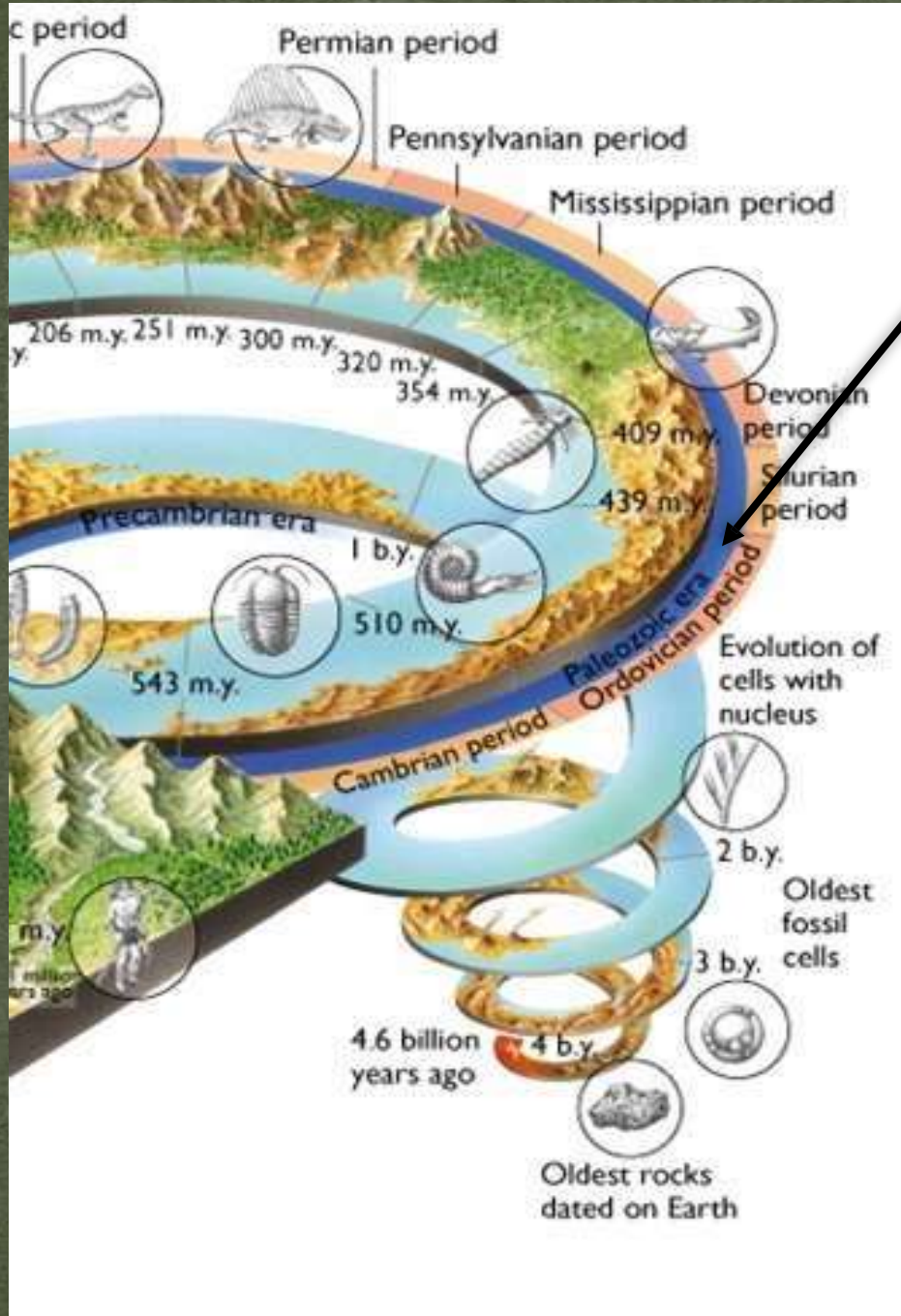


# Pre - Cambrian Era

- Began with the formation of the Earth 5-4.6 billion years ago.
- Bacteria appeared 3.5 billion years ago, followed by algae and fungi.



# Paleozoic Era



- Divided into 5 periods:
- **Cambrian period** - Sponges, snails, clams and worms evolve
- **Ordovician period** - First fishes evolved and other species become extinct
- **Silurian period** - Land plants, insects and spiders appear



# Paleozoic Era (Ancient Life)

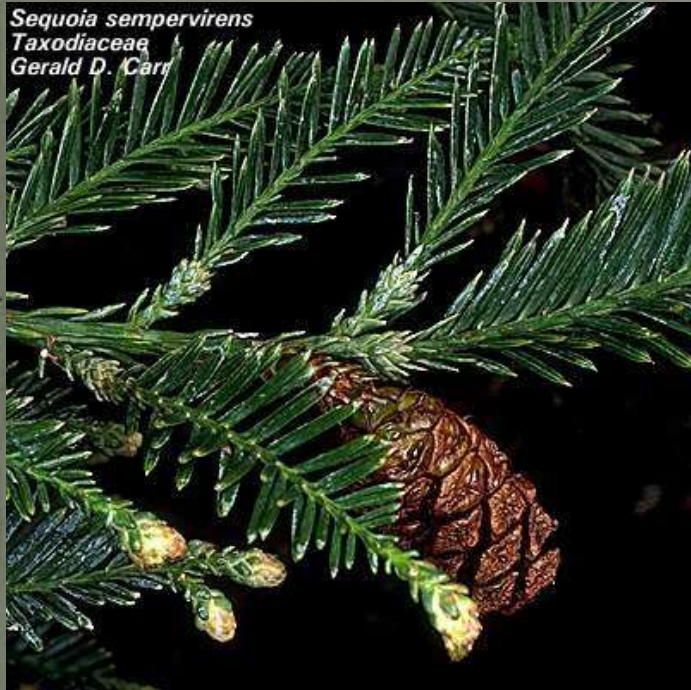
- The Cambrian period is the 1<sup>st</sup> period of the Paleozoic Era. “Age of the Trilobites”
- Explosion of life in the oceans began during this era.
- Most of the continents were covered in warm, shallow seas.
  - Invertebrates were dominate - Trilobites
  - Fish emerged during this time
  - Fish led to the arrival of amphibians
    - The end of the Paleozoic era is called the “Age of Amphibians”
  - Early land plants including mosses, ferns and cone-bearing plants.
  - The early coal forming forests were also formed during this time.

# Paleozoic Era

- At the end of the Paleozoic, the *largest mass extinction in history* wiped out approximately 90% of all marine animal species and 70% of land animals.
  - Possible causes of this Mass Extinction Event
    - Lowering of sea levels when the continents were rejoined as Pangaea (convergent boundary)
    - Increased volcanic activity (ash and dust)
    - Climate changes – cooler climate



# Early Land Plants



Cone bearing plants



Mosses



Ferns



- **Devonian period**

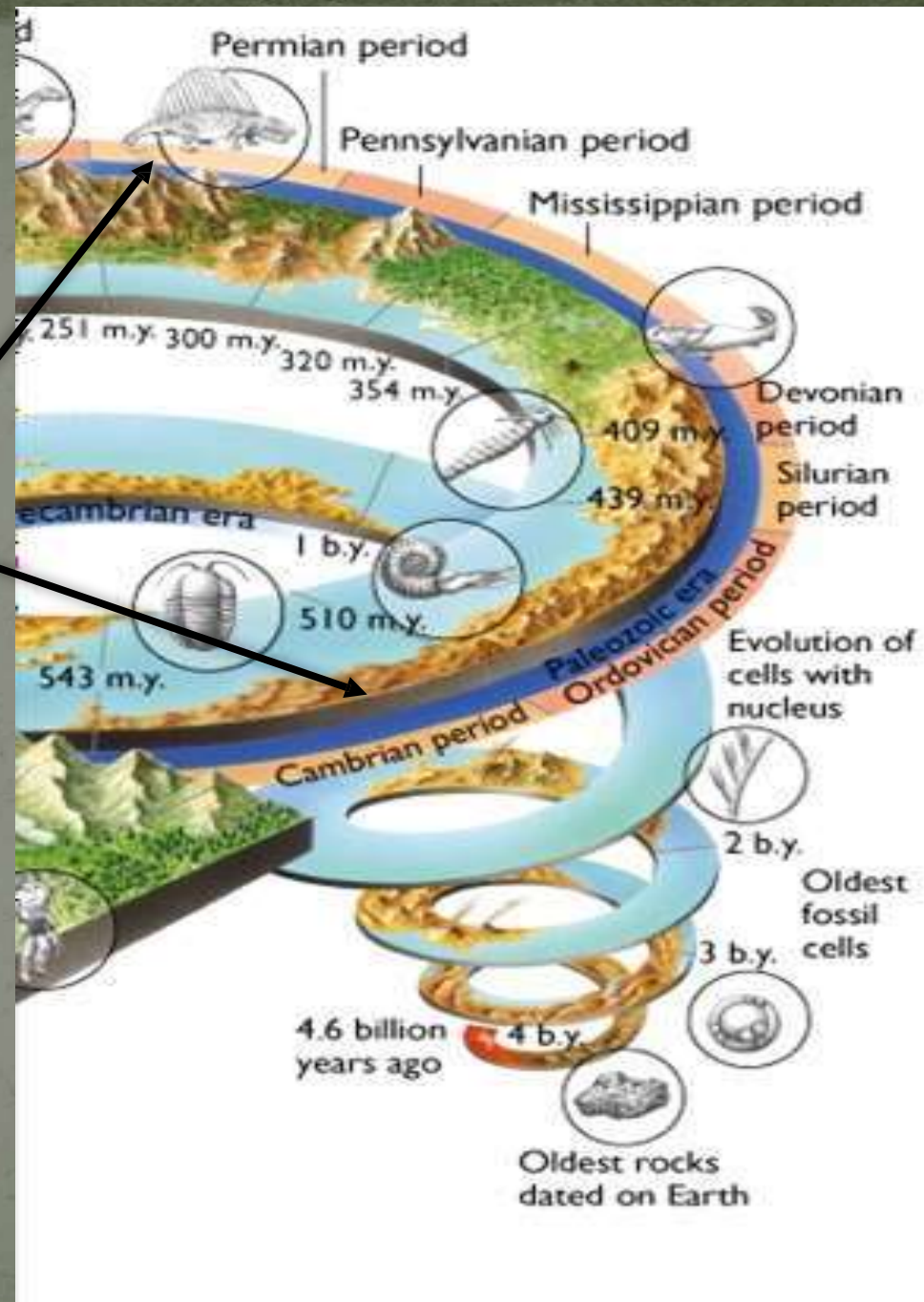
Amphibians evolve and cone-bearing plants start to appear.

- **Carboniferous period** -

Tropical forests appear and reptiles evolve.

- **Permian period** -

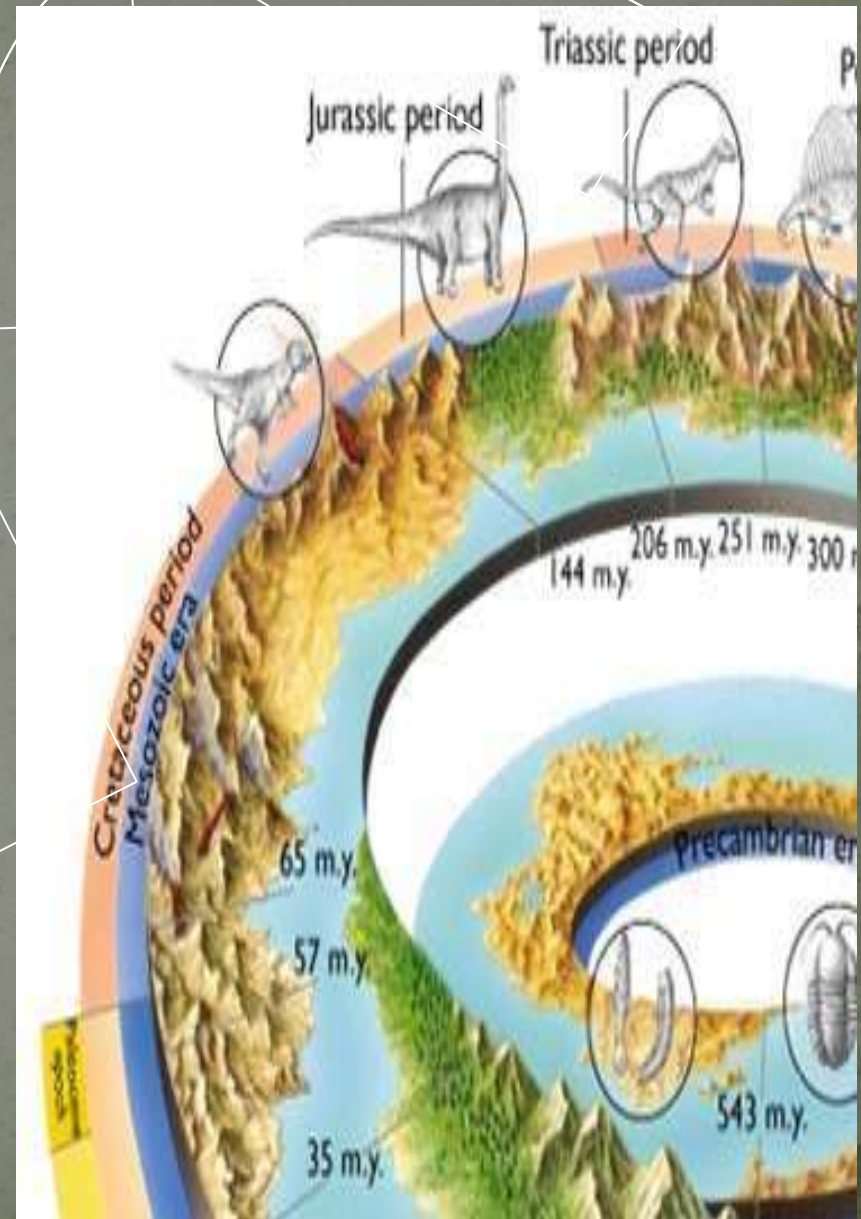
Seed plants become common and insects and reptiles become widespread. Sea animals and some amphibians begin to disappear.





# Mesozoic Era

- Divided into 3 periods:
- **Triassic period** - Turtles and crocodiles evolve and dinosaurs appear.
- **Jurassic period** - Large dinosaurs roam the world. First mammals and birds appear.
- **Cretaceous period** - Flowering plants appear, mammals become more common, dinosaurs become extinct.



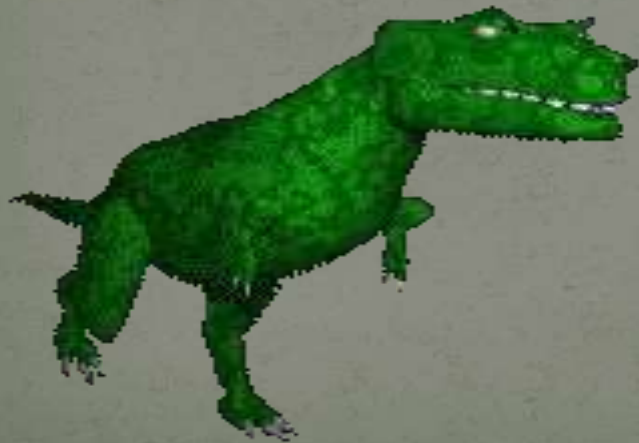
# Mesozoic Era – Middle Life

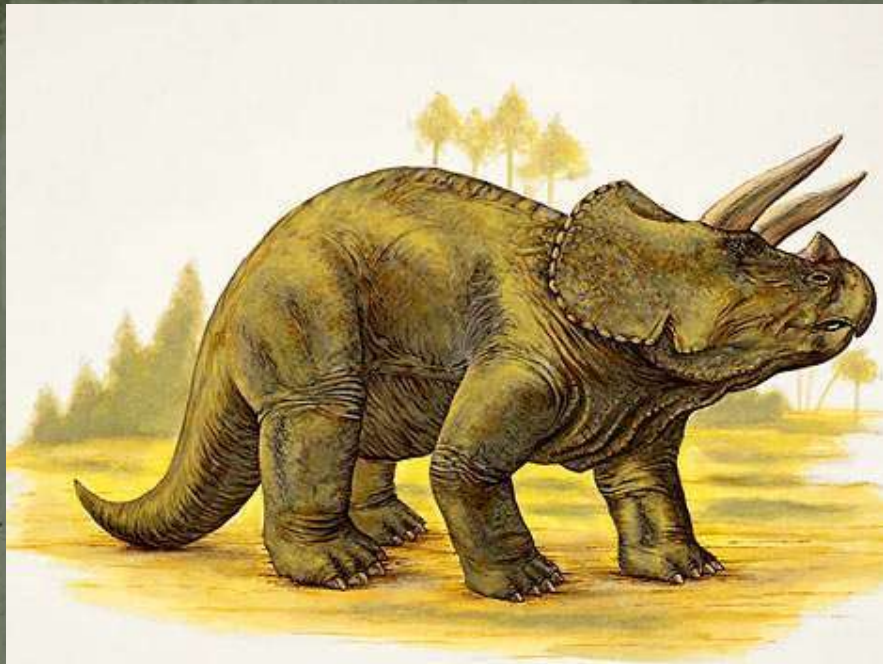
Reptiles became the most abundant animals because of their ability to adapt to the drier climate of the Mesozoic Era.

Skin maintains body fluids  
Embryos live in shells

- Dinosaurs were also very active in this era.
  - First small dinosaurs appeared in the Triassic Period.
  - Larger and more abundant dinosaurs appeared in the Jurassic Period.
- Small mammals and birds also appeared during this era.
  - The mammals were small, warm-blooded animals. Hair covering their bodies.
    - These characteristics help them survive in changing environments.









# Mesozoic Era

- The main plant life of this time were Gymnosperms or plants that produce seeds, but no flowers.
  - Pine Trees
- Flowering plants appeared during the END of this era.

# Mesozoic Era

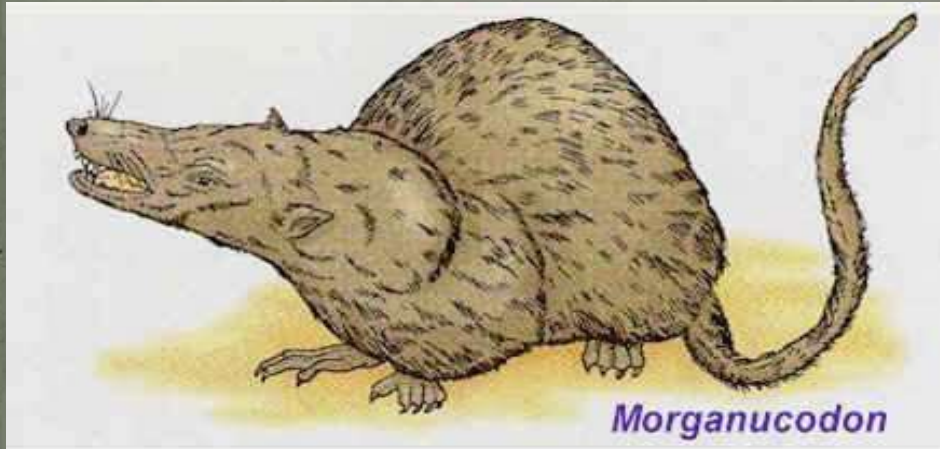
- This era ended with a mass extinction event about 65 million years ago.
  - Many groups of animals, including the dinosaurs disappeared suddenly at this time.
- Many scientists believe that this event was caused by a comet or asteroid colliding with the Earth.



# Mesozoic Era – Mass Extinction Event

- Asteroid or Comet collides with Earth.
  - Huge cloud of smoke and dust fills the air
  - Blocks out sunlight
  - Plants die
  - Animals that eat plants die
  - Animals that eat plant-eaters die.
- However, not all forms of life died during this event. Many animals that you see today are descendants from the survivors of this extinction event.

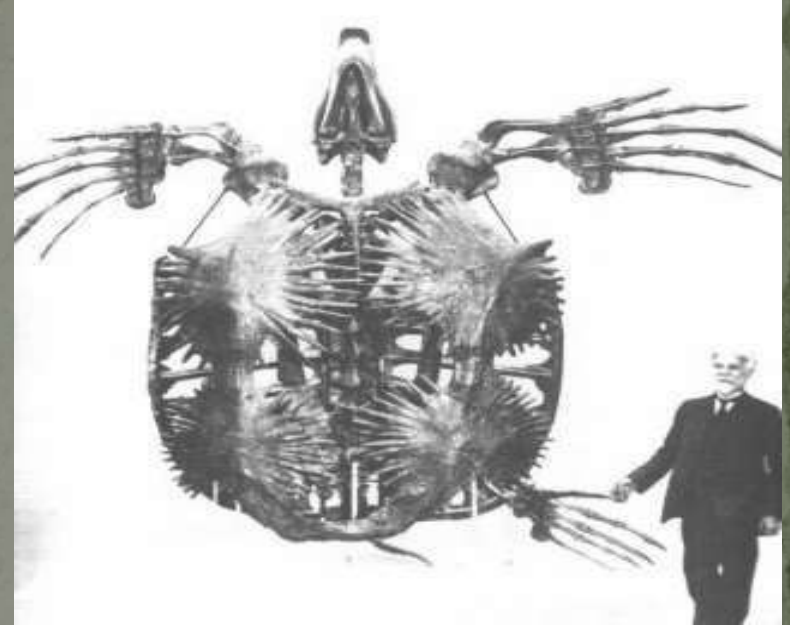
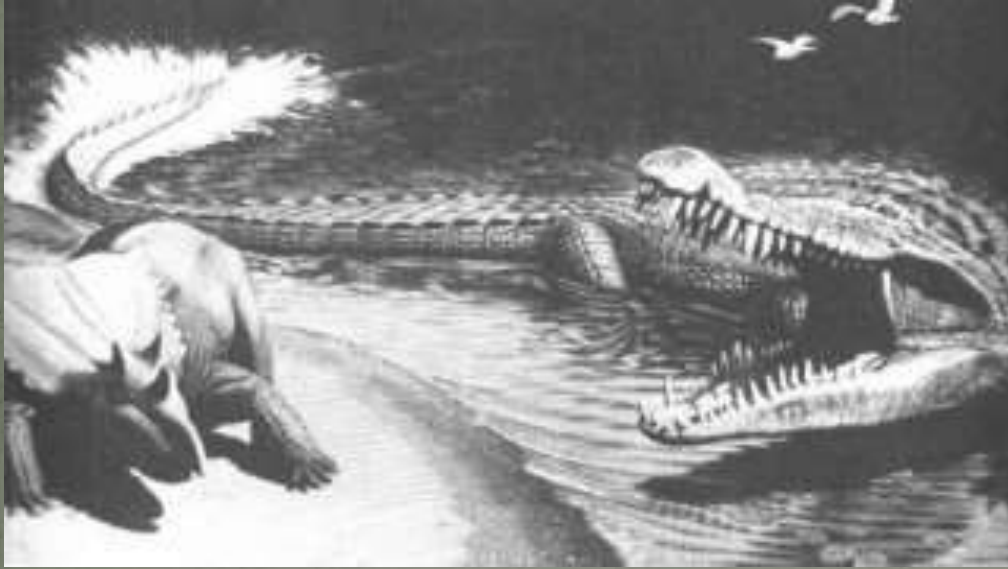
# Mesozoic Mammals



*Akidolestes ciferrii* reconstruction on fallen ginkgo branch.  
Illustrator: Mark A. Kingler / CMTet



# Mesozoic Reptiles





# Mesozoic Plants

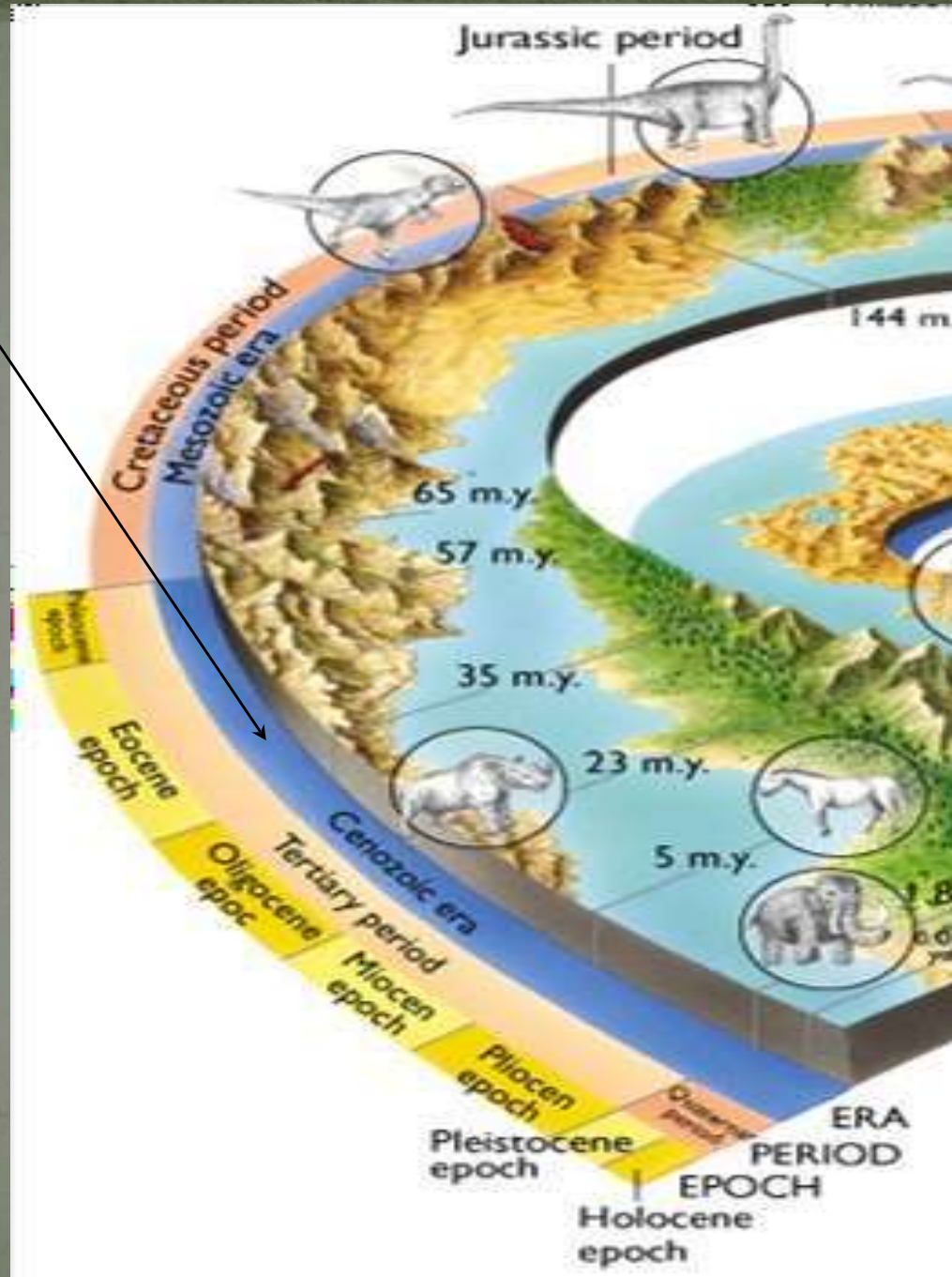
Flowering plants evolved towards the end of the Mesozoic Era.





# Cenozoic Era

- Divided into 2 periods:
- **Tertiary period** - First primates appear and flowering plants become the most common.
- **Quaternary period** - Humans evolve and large mammals like woolly mammoths become extinct.



# Cenozoic Era – Recent Life

- Began about 65 million years ago and *continues today!!!!*
  - Climate was warm and mild.
  - Marine animals such as whales and dolphins evolved.
- Mammals began to increase and evolve adaptations that allowed them to live in many different environments – land, air and the sea.
  - Grasses increased and provided a food source for grazing animals
- Many mountain ranges formed during the Cenozoic Era
  - Alps in Europe and Himalayas in India; Rocky Mountains in the USA



# Cenozoic Era

- Growth of these mountains may have helped to cool down the climate
  - Ice Ages occurred late in the Cenozoic Era (Quaternary Period).
- As the climate changed, the animals had to adapt to the rise and fall of the oceans caused by melting glaciers.
- This era is sometimes called the “Age of Mammals”



# Cenozoic Era

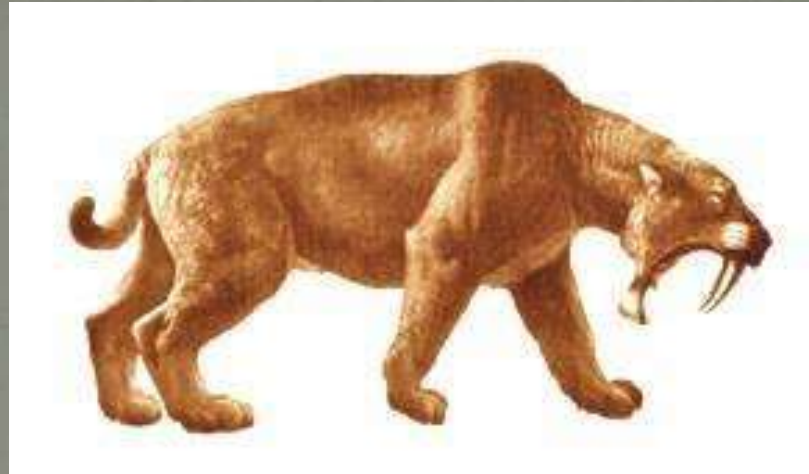


- Marine animal examples:
  - Algae, Mollusks, Fish and Mammals
- Land animal examples:
  - Bats, Cats, Dogs, Cattle and Humans
  - Humans are thought to have appeared around 3.5 million years ago (*during the most recent period – Quaternary*).
- Flowering plants were now the most common plant life.





# Cenozoic Mammals



# Flowering Plants were common during the Cenozoic Era







Applications of  
Paleobotany

# Nonrenewable vs. Renewable Resources

- Natural resources that can be replaced and reused by nature are termed as renewable.
- Natural resources that cannot be replaced are termed as nonrenewable.
  - Renewable resources are replaced through natural processes at a rate that is equal to or greater than the rate at which they are used, and depletion is usually not a worry. Some common examples include:
    - Air (wind)
    - Fresh water
    - Soil
    - Living organisms (trees)
    - Sunlight

Nonrenewable resources are exhaustible and are extracted faster than the rate at which they formed. Some common examples are:

- Fossil fuels (coal, oil, natural gas)
- Diamonds and other precious gems and minerals
- Types of metals and ores



**Trees: A renewable resource**



**Oil: A nonrenewable resource**



# Fossil Fuels

## 1. What is a Fossil Fuel?

Coal, oil, and natural gas formed from ancient organic matter, they are called fossil fuels.

**Coal** is actually a sedimentary rock that was originally formed from ancient plant matter through decomposition (decay) and millions of years of compaction. Coal, made of carbon, is by far the most abundant fossil fuel in the world. The eastern and Midwestern U.S. have abundant coal seams that formed during the Pennsylvanian Period.

**Petroleum:** A broad term that includes both crude oil and natural gas. **Crude oil** is a thick, black liquid mixture of naturally occurring hydrocarbons (compounds containing hydrogen and carbon) that forms from the buried remains of marine organisms. **Natural gas** forms under similar conditions but is in a gaseous state.

## **2. How do fossil fuels form?**

▪ Although we know that fossil fuels formed from the decomposed remains of past life over millions of years, large amounts of pressure and high temperatures are also necessary. As marine organisms, called plankton, die and fall to the seafloor, they are covered by sediment. After they are buried deeply enough, pressure and heat cause the dead plankton to change to oil and gas.

## **3. How can we find fossil fuel?**

There are specific but known conditions that must be met in order to find the oil and gas. Oil and gas are usually found within a permeable rock such as sandstone. Permeable simply means that the rock is porous, and liquids or gases can easily flow through it.



**Role Of Microfossils In  
Oil And  
Coal  
Exploration**



- ❖ Microfossils are nothing but the fossils of bacteria, diatoms, protista, fungi, pollen grains, spores, animals & plants.
- ❖ Microfossils are heterogeneous in nature. These are generally occurs in all kinds of sedimentary rocks in large number.
- ❖ On the basis of the presence of the types of microfossils the scientist confirms the presence of oil & coal in the particular region.
- ❖ If the occurrence of palynomorph microfossils is large in a particular area at that time it is to be confirmed that the presence of oil & coal in that region.



# Role of Microfossils in oil

- ❖ Oil is fossil fuel which formed over millions of year from the remains of plants and creatures.
- ❖ The oil exploration begins with search of a reservoir.
- ❖ The study of palynology gives relevant clues for oil exploration.
- ❖ The mega and microfossils throw light on evolutionary development.

❖ The organic matter occurring in the sediments from terrestrial and marine sources are as follows

❖ **Primary Source:-**

❖ Leave,Stems,Pollen,Spores etc.

❖ Planktonic freshwater algae

❖ **Marine Source:-**

❖ Organisms: Phytoplankton

❖ Benthos: Bacteria, algae, fungi.



# Generation of Oil

- Generation of oil involves a no. of geochemical and geological processes
- Generation of oil require five important features:
  - Total organic matter
  - Geological time
  - Temperature
  - Composition of source material
  - Extent of biogenic oxidation

# Exploration of Oil

- ❑ Exploration means:  
Investigation/ discovery.
- ❑ Edwin Laurentine Drake  
(Professionally a railroad  
conductor) drilled the first oil  
well on 27 Aug 1859 in  
U.S.A.

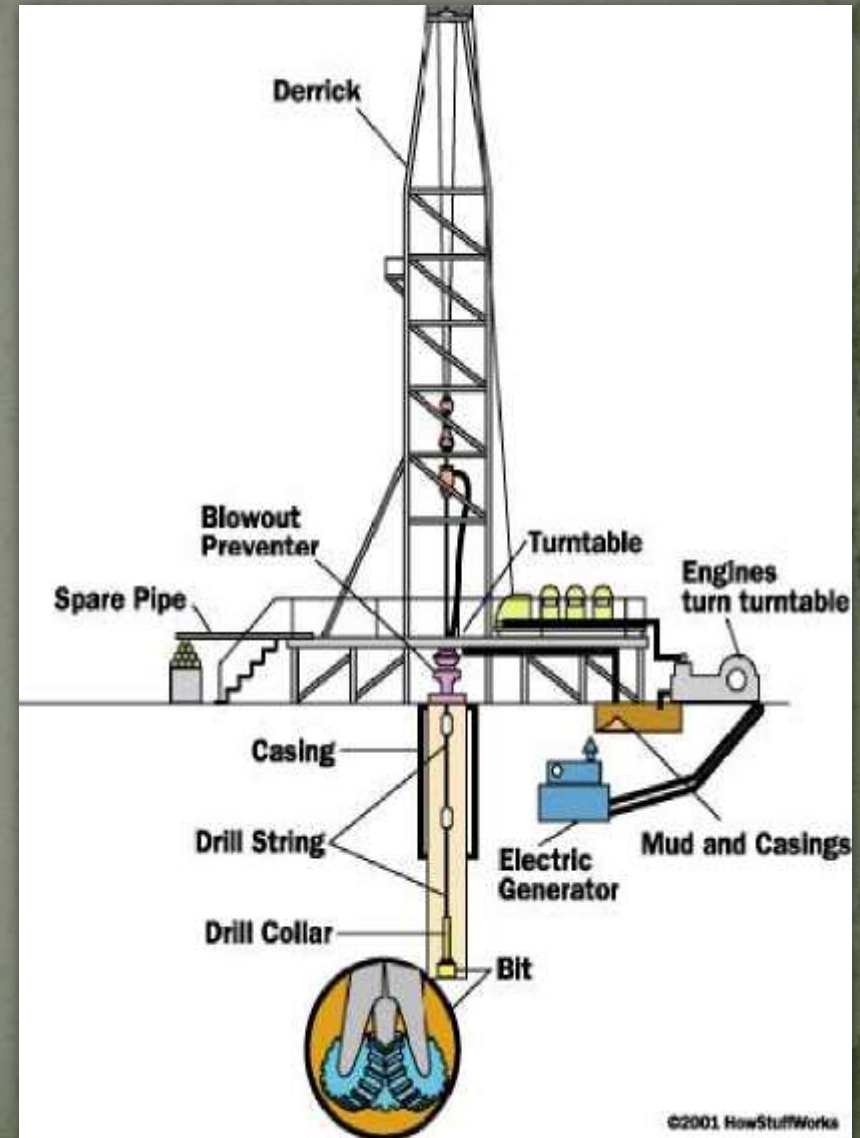


**E.L. Drake**  
**(1819-1880)**



# Exploration of Oil

- ❑ The palynological studies gives idea about oil deposition.
- ❑ The microfossil are removed with drilling machine.
- ❑ The oil wells are dome shaped useful for commercial production of petroleum.



# Extracting Earth's Resources: Oil

▪Once oil or gas is found beneath earth's surface by geologists, it must be extracted. Usually this is done by drilling through the rock to where the resource is trapped. When the well is completed, oil or gas can flow into the well and the resources are pumped up to the surface.

▪Oil companies drill for oil, and they employ geologists who usually identify the favorable areas that may have oil or gas. These geologists include stratigraphers, sedimentologists, and geophysicists. Many times, however, dry holes are drilled and geologists must move on to other locations.

▪In 2005, the United States produced an estimated 9 million barrels of crude oil per day and imported 13.21 million barrels per day from other countries. This oil gets refined into gasoline, kerosene, heating oil and other products. To keep up with our consumption, oil companies must constantly look for new sources of petroleum, as well as improve the production of existing wells.

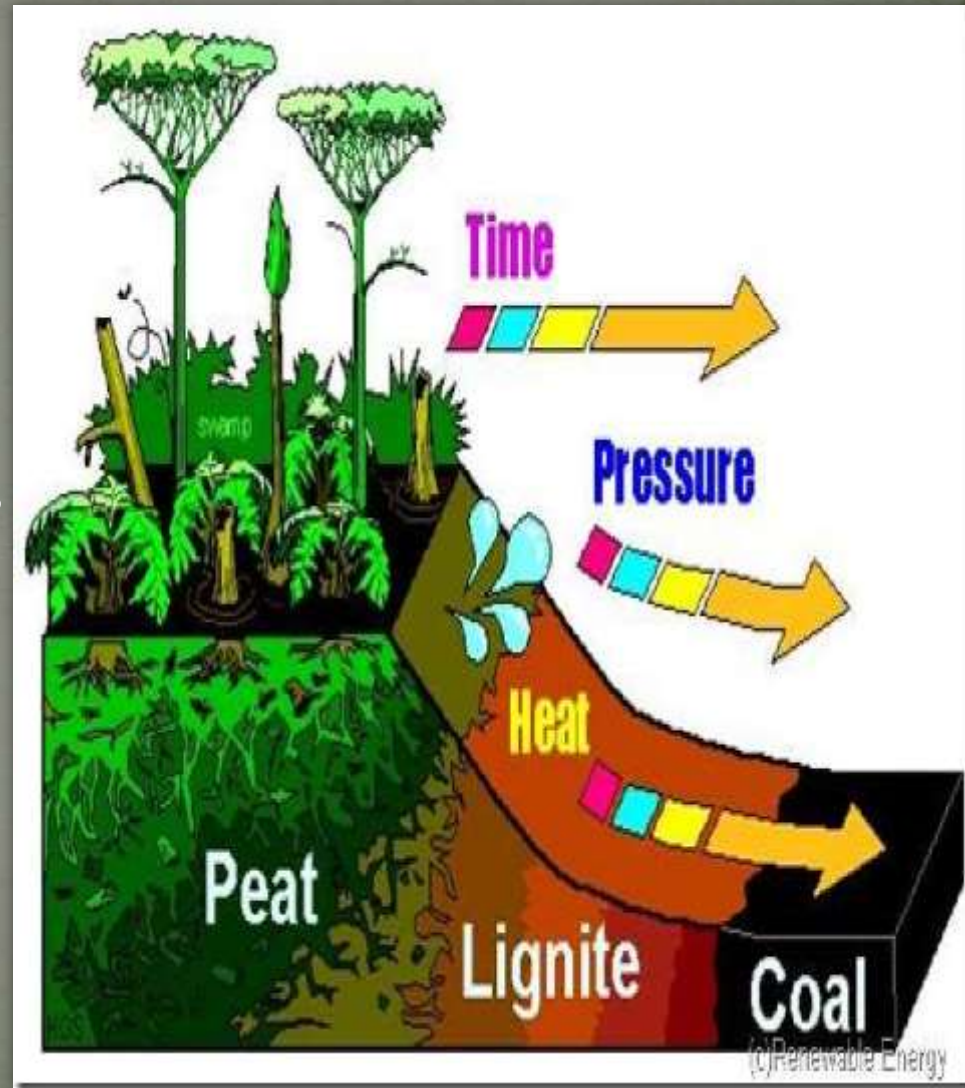


**Solitary oil rig pumping  
beneath the ground**



# Role of Microfossils in Coal exploration

- ❖ Paleo-Palynological studies in coal may be a tool to detect age of coal deposits
- ❖ Spores and pollen grains are present in coal deposits
- ❖ Megafossil occurring in various geological time help in establishing age of coal deposits
- ❖ Carboniferous strata often referred as coal age.



- ❖ Coal is derived from plants & organic matter.
- ❖ When the trees & other vegetation forms into the swamps & are covered by the soil, they undergo partial decomposition & become peat.
- ❖ The peat attacked by the bacteria & break up the organic compounds present in it.
- ❖ After breaking of the organic compounds the specific gases liberated & the peat converted into lignite.
- ❖ Then the lignite get converted into various grades of the coal.





# Extracting Earth's Resources: Coal

- While oil and gas is pumped from the earth, coal is removed through excavation (by digging). Two common methods are underground mining and strip mining, or open-pit mining.
- Underground mining requires tunneling (dug passage underground) into the ground in a process called drift mining or slope mining. This is a very dangerous process if done incorrectly or if the area is subject to earthquakes. In addition, toxic methane and carbon monoxide gases are associated with coal mining.
- Strip mining: This method is used when the deposits are close to the surface. Layers of rock and soil are dug up and the coal is removed, or stripped, before returning the rock and soil back to the earth. Trees are re-planted in a processes called “land reclamation (make waste land useable)” and, if possible, a natural habitat is re-introduced.



The Sago coal mine, Sago, West Virginia

# Exploration of Coal

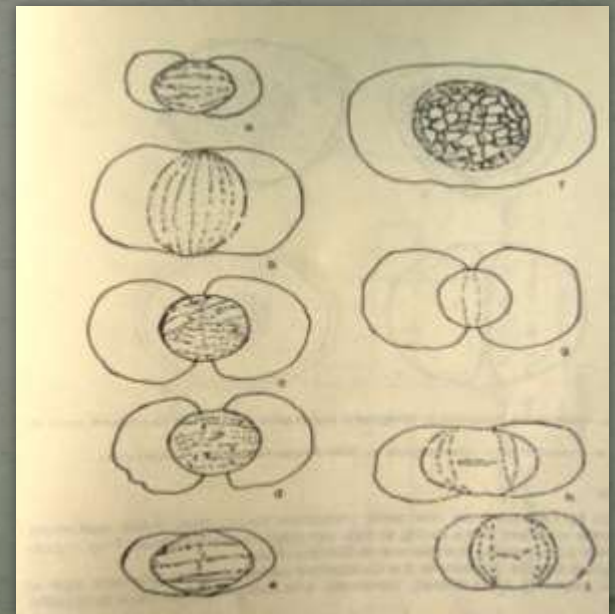
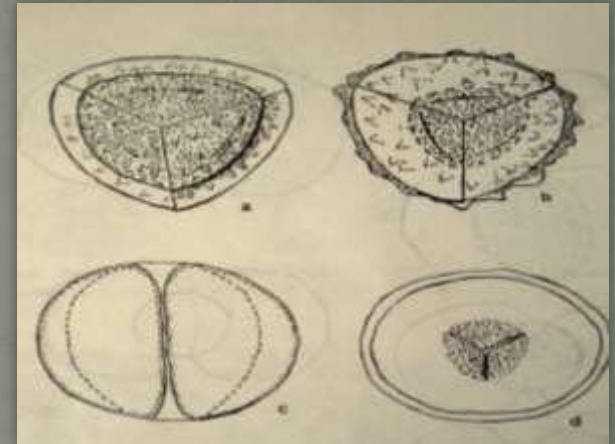
- Coal is an aggregation (combining several elements) of carbonized fossil plant material.
- Coal as a type of organic sedimentary rock formed due to sedimentation of plant debris with various minerals.
- In India Coal is preserved as distinct coal seams ranging from few centimeter to several meters thick.





# Role of Microfossils in coal Exploration

- ❖ **Microfossils:**
- ❖ Paleopalynological investigation of coal helpful in coal exploration.
- ❖ Pollen and spores are investigated from Lower Gondwana coal seams.  
e.g. Trilete, bisaccate and monosaccate spores.



- Coal is produced by the decay of organism that lived on the earth during the remote past.
- Coal is carbonized fossil plant material.
- Coal is a type of compression fossil.
- It is known as “**Black Diamond**”.
- It is very good source of thermal energy.





Thank You