FOSSILS

Fossils are the preserved remains or traces of animals, plants and other organisms from the past. Fossils give valuable information about the past. There are different kinds of fossils.

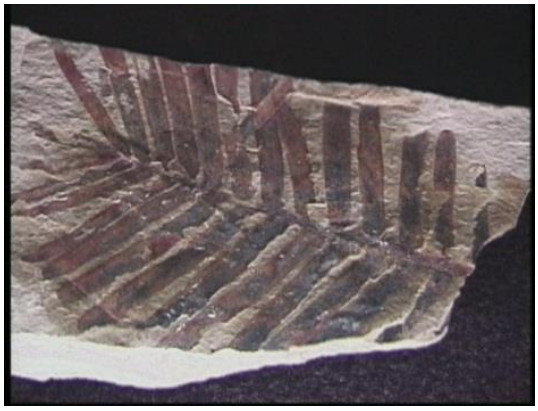
1. **Per mineralized Fossil** – This type of fossil contains pieces of an actual organism such as a fragment of the skeleton, skin, feathers or tissue. It can have the complete organism too. After an organism dies, the spaces in the hard parts get filled in by minerals from ground water. These fossils are carcasses, covered in mineral deposits, thus fossilizing the creature itself (or its parts)

2. **Mold fossil** – Mold and cast fossils are imprints of an organism, rather than actual remains or parts. As the name suggests, a mold fossil is a mold of the original plant/animal. A mold fossil contains a hollow impression of an organism in rock. For example, a creature may create an imprint of its outer shell in rock and this makes a mold fossil. A dinosaur footprint may create an imprint, which makes a mold fossil.

3. **Cast Fossil** – Mold and cast fossils are an imprint of an organism, rather than actual remains. For example, a prehistoric shell creates an imprint of its outer shell and this forms mold fossil. When the mold fossil is filled with minerals or sediments, the mold becomes a cast fossil. This is an actual replica of the living thing created within cast.

4. **Amber Fossils** – These are fossils made in a resin called amber. Amber fossils are found in trees, sedimentary rock. These fossils usually contain insects, plants, parts of animal skeleton, skin and feathers. These fossils usually preserve prehistoric life forms in their original appearance. Scientists who find amber fossils will be able to describe and display the physical appearance of the ancient life form in them very accurately.

5. **Imprint Fossils** – These fossils are created by an imprint, or an impression made by a living organism. These fossils do not contain any animal fragments or plant material, nor do they show the whole body of an organism like mold & cast fossils do. Instead they contain only traces of an organism like tracks, leaf or feather imprints or fossilized feaces. These fossils are usually found in fine grain clay or silt sediment. They allow scientists to research prehistoric ecosystems and the interactions and behaviors of organisms.



HOW FOSSILS FORM

For a fossil to form, there must be a way to preserve the dead remains of animals and plants so that they do not decay completely. The most common way, is on the bottom of a body of water. When an animal or plant dies and falls into water, it is gradually covered by sediment. The layers of sediment harden and form a protective covering. Over thousands of years, eventually the sediments harden into rock, the dead animal or plant decays, leaving an empty space behind. Mineral filter into this space, harden into rock and are called fossils. Occasionally no minerals filter down, and the space left is called an imprint.

Fossils can also be preserved in ice, amber (sticky sap from trees).

WHAT CLUES DO FOSSILS PROVIDE

Fossils can tell us many things about the past. We can see how life has changed through time. Fossils can be used to develop a history of the Earth and what types of species, the present life forms came from. It helps to identify the evolution and the extinction of species. Knowledge of extinction can help scientists protect species today. Fossils help to determine the age and the environment in which rocks were formed and this helps geologists to better search for mineral deposits. Similar fossils found on different continents were able to show us that the Earth was once a joined land mass.

PALEONTOLOGY

It is the study of fossils, fossil evidence of animals and plants on planet Earth. A person who studies fossils is called a paleontologist.

RECONSTRUCT

To rebuild or build something back up again. With fossils, it means trying to see what plant or animal, the fossil looks like.

AMMONITES

They are extinct fossils of marine animals. They are coiled, flat, fossil shells. Most ammonites have a shell that is a spiral, flat and coiled.

TRILOBITES

They are fossils of marine arthropods. Trilobites mean “3 lobes”. Trilobites usually have an elliptical skeleton with 3 lobes or 3 parts to their body: a head, a middle thorax with plates, and a tail shield. Most trilobites are found with the exoskeleton preserved. Many have spines.

HOW DID HUMANS EVOLVE

Paleoanthropology is the scientific study of human evolution. It is a subfield of anthropology which is the study of human culture, society and biology. Early human fossils and archeological remains offer the most important clues about the evolution of humans. These remains include bones, tools, footprints, hearths and more.

Humans have existed for only a tiny part of Earth's history. The Earth is about 4.5 billion years ago. The oldest fossils are about 3.5 billion years old. Human evolution started about 6 million years ago. The ability to walk on two feet (bipedalism) evolved over 4 million years ago. Other important characteristics like a large complex brain, the ability to make and use tools, language art and cultural diversity- emerged in the last 100,000 years. The species to which we belong (Homo sapiens) is only about 40,000 years old.

Humans first evolved in Africa. The fossils of early humans who lived between 6-2 million years ago come entirely from Africa. Early humans migrated from Africa into Asia about 2- 1.8 million years ago. They entered Europe somewhat later, about 1.5-1 million years ago. Species of modern humans spread to the rest of the world much later. For example, humans came to Australia about 60,000 years ago and to the Americas about 30,000 years ago. The beginning of agriculture and the rise of the first civilizations occurred within the past 12,000 years.

Humans are primates. They share a lot of similarities with apes. Humans, apes, chimpanzees and gorillas share a common ancestor that lived between 8-6 million years ago.

Australopithecines (6 million years ago)

An African apelike species evolved around 6 million years ago with two skeletal characteristics that set it apart from apes: small canine teeth (compared to the long canines found in other primates) and walking on two legs. Australopithecine means "southern ape," in reference to South Africa where the first known fossils were found.

6 million – 4 million years

The very early years of the transition from ape to human, about 6 million to 4 million years ago, is not well documented in the fossil record. The fossils that have been discovered show primitive combinations of ape and human features.

Australopiths (4 million – 2million years ago)

Fossils from early australopith species that lived between 4 million and 2 million years ago show the transition between ape and human much more clearly.

The best-known australopith specimen is Lucy, the partial skeleton of a female discovered in 1974 in Ethiopia. Lucy belongs to a species, Australopithicus afarensis, which lived in eastern Africa between 3.9 million and 3 million years ago. Lucy lived 3.2 million years ago. Another exciting find in Tanzania, was trails of bipedal human footprints preserved in hardened volcanic ash over 3 million years ago. The footprints provided evidence that australopiths regularly walked upright.

By about 2.7 million years ago, robust australopiths had evolved, with wide molars and premolars and a facial structure that indicate that these australopiths chewed their food. (mainly plants). The last australopiths died out about 1.4 million years ago.

Homo habilis (2.5 million – 1.6 million years ago)

This was the start of the genus Homo. The most significant difference between members of this genus and australopiths, with which they overlapped, was their significantly larger brains. Species of early Homo, among them Homo habilis, resembled australopiths in many distinct ways, but they had smaller teeth and jaws,

more modern-looking feet, and hands capable of making tools. They were the first true humans. They lived in Africa, made tools, were taller and had a larger brain.

Homo erectus (about 1.5 million years ago)

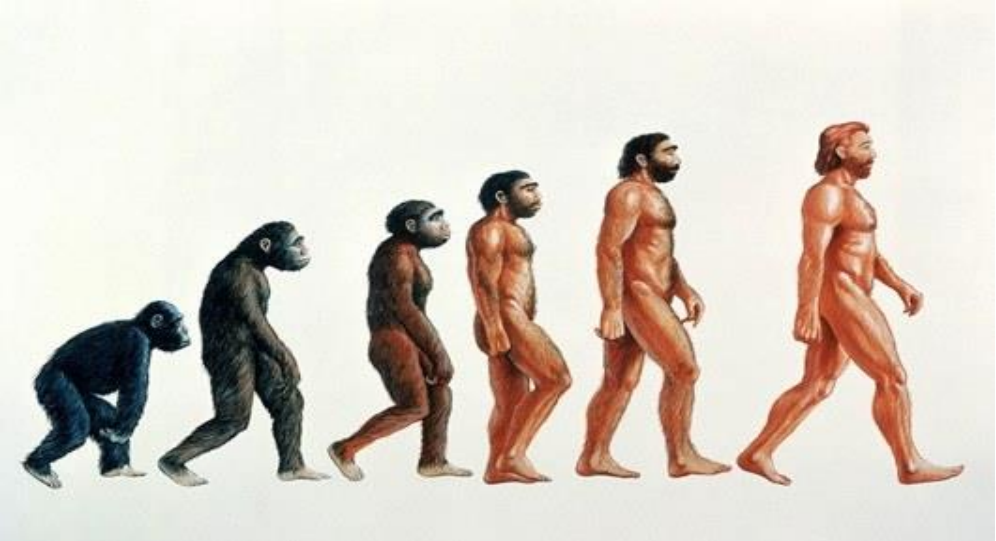
This was the middle Homo species. It was more similar to modern humans but their brains were relatively small compared. They probably overlapped with earlier Homo species and were a very successful species; fossils have been found throughout Africa, Europe, and much of Asia. They travelled from Africa and populated the other parts of the world. They were hunters and used fire.

Early Homo sapiens (500,000 years ago). Neanderthal man

They had large complex brains. They used stone-tipped spears, bone needles, bone fish hooks, sewed their clothes from animal skins, wore boots, and buried their dead with ceremony.

Modern Homo sapiens (25,000-10,000 years ago). Cromagnon man.

They used bow and arrows, well-constructed huts with central hearths for fires; necklaces & pendants, cave art, little statues made from ivory, bone; tools and weapons for hunting and fishing, oil lamps. Used honey to sweeten food. They lasted till the end of the last Ice Age about 10,000 years ago.



RELATIVE AGE AND ABSOLUTE AGE

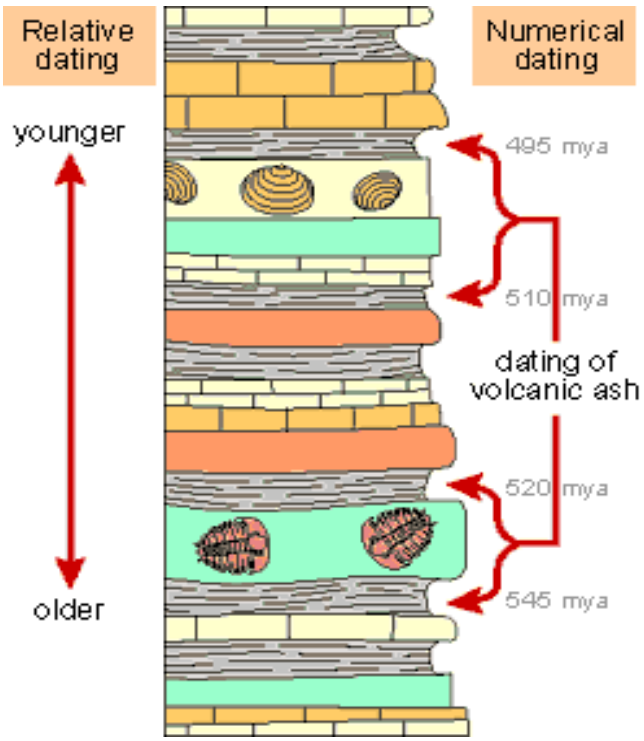
As geologists find and classify things that are found, it is important to understand the concepts of their time, and when they existed.

RELATIVE AGE

Relative means that we can determine if something is younger than or older than something else. It does not tell exactly how old something is, only the relative sequence of events. For example, in layers of sedimentary rock, we know that the layer that is at the bottom was deposited first and is the older layer. Therefore, the layers on top of it, are relatively younger. Relative age is the age of a rock or fossil relative to the rock layers around it.

ABSOLUTE AGE

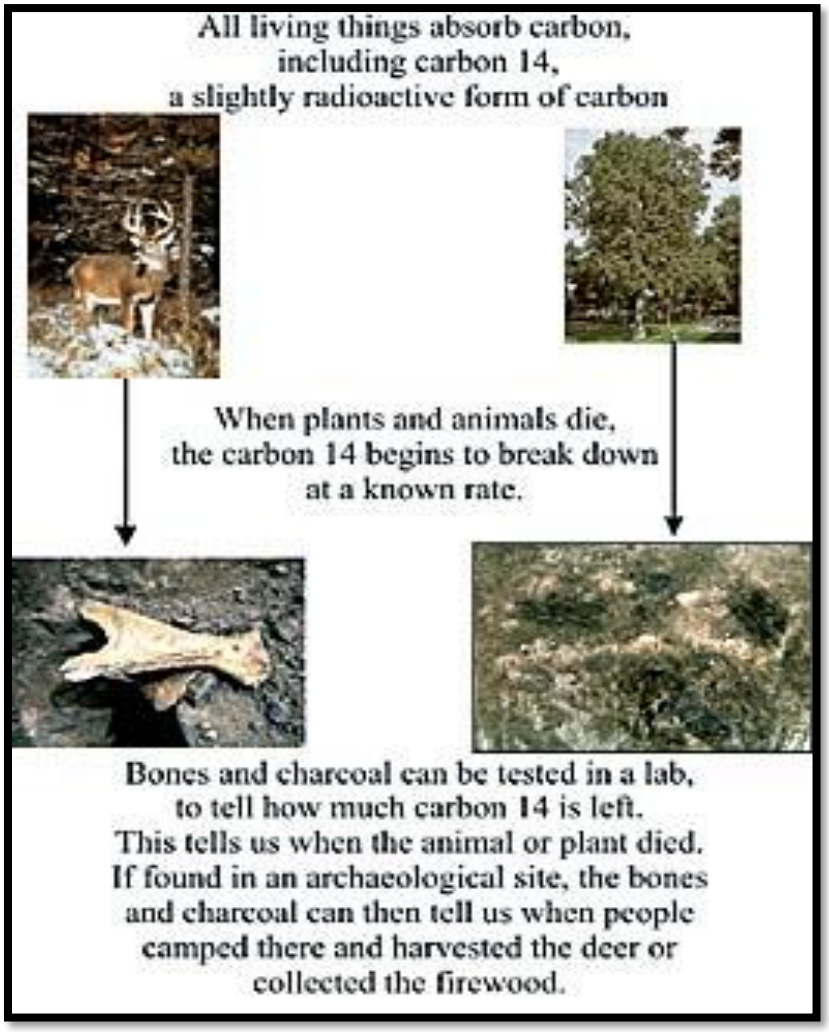
Absolute age means that we can tell "**exactly"** how old something is. An exact number (in years or some other time unit) can be assigned to the amount of time that has passed since the rock or fossil was formed.



HOW IS ABSOLUTE AGE DETERMINED

Absolute age can be calculated by radioactive/ radiometric dating or isotopic dating. All living things are made up of an element called carbon. When living things die, they stop taking in new carbon. The carbon in their bodies remains, and it breaks down at a known measurable rate. This allows scientists to look at the amount of breakdown of a fossil's radioactive carbon, and determine its exact age. C12 and C14 (Carbon12 and Carbon14) dating are used.

Other isotopes like uranium 238, uranium 235, potassium 40 are used because they have very long half-life compared to carbon. Carbon dating is only effective on samples that are 50,000 years old.



HOMOLOGOUS, ANALOGOUS AND VESTIGEAL STRUCTURES

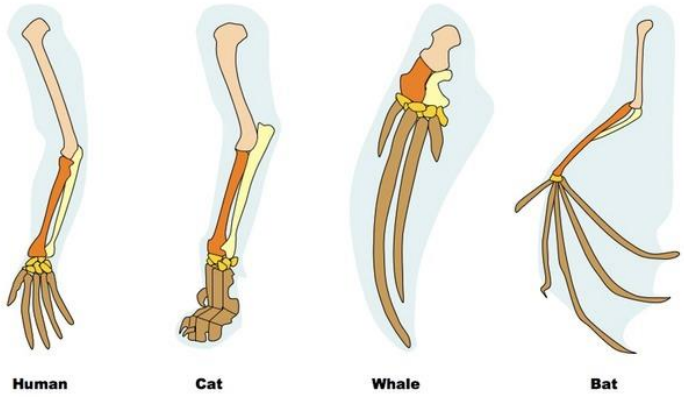
Evidence has indicated that living things have changed gradually during their natural history. The study of fossils provides evidence for evolution. Evolution is a very slow and gradual process. It is not possible to observe things change directly, since evolution happens over many thousands of years.

HOMOLOGOUS STRUCTURES

These are body parts that are alike because the species that have these structures have evolved from a common ancestor. These structures may either have the same or completely different functions. For example, the wing of a bird and the arm of a human have very different functions but are considered homologous structures because of the evolutionary relationship between birds and humans.

Examples of homologous structures

1. the coccyx in humans is homologous to the functional tail of other mammals.
2. the ear ossicles in humans are homologous to fish jaw bones.
3. Mammals have vertebrae in common. The giraffe (in spite of its height) has the same number of neck bones as a giant whale or a small human.
4. A dolphin flipper, birds wing, cats leg, and human arm are homologous structures.
5. Humans, dog and cats all have similar pelvises, which are homologous to a vestigial pair of bones that snakes have.

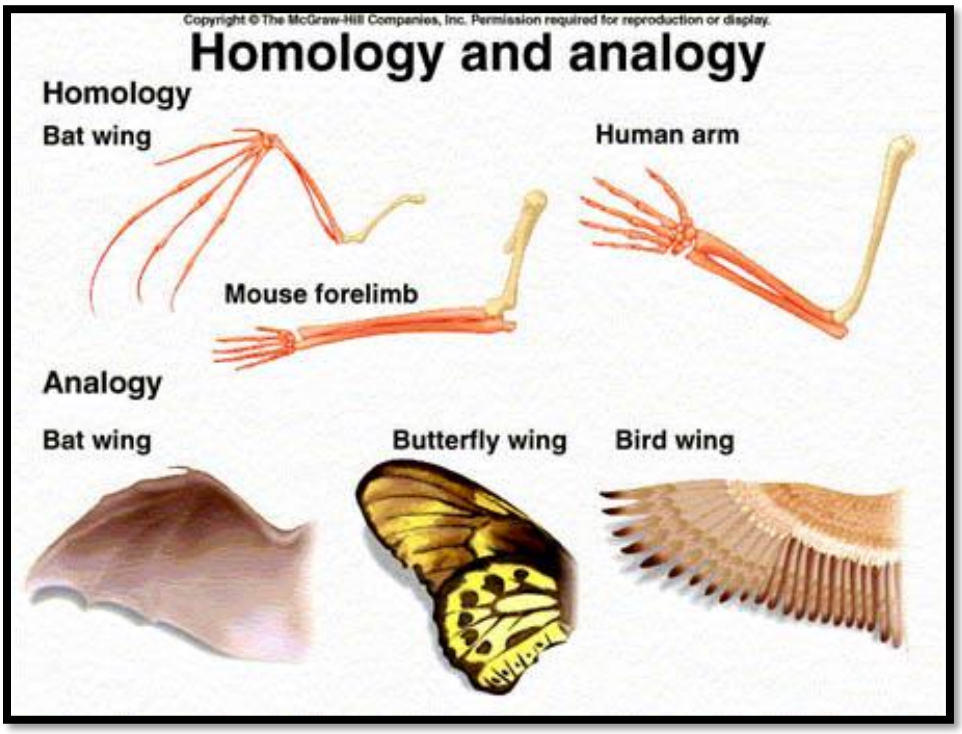


ANALOGOUS STRUCTURES

These are structures that look alike and may have similar function, but are in two unrelated species (species that have not evolved from a common ancestor). Analogous structures do the same thing but have evolved from completely different lines. For example, the human eye and the insect eye both do the same things, but they evolved completely separately. Similarly the dragonfly wing and the bat wing perform the same function but they evolved from completely different origins.

Examples of analogous structures

1. Shark fins versus dolphin fins
2. Moth wings, butterfly wings and bird wings are all analogous structures.
3. Octopus eye versus the human eye



VESTIGEAL STRUCTURES

This is a structure or an organ that has reduced in size or is of no usefulness in a species. This is due to evolution or it happens over a long period of time because the organ is not used anymore. The organ serves little to no use. Vestigial organs provide a clue about the evolutionary history of a species because they are remnants of structures found in the ancestral species.

Examples of vestigial structures

1. Whale legs. Scientists believe that whales evolved from ancestors that lived and walked on land. Their small leg bones are hidden at the back of their bodies now.
2. Ostrich wings are vestigial structures.
3. The human appendix.
4. Nipples in a human male.

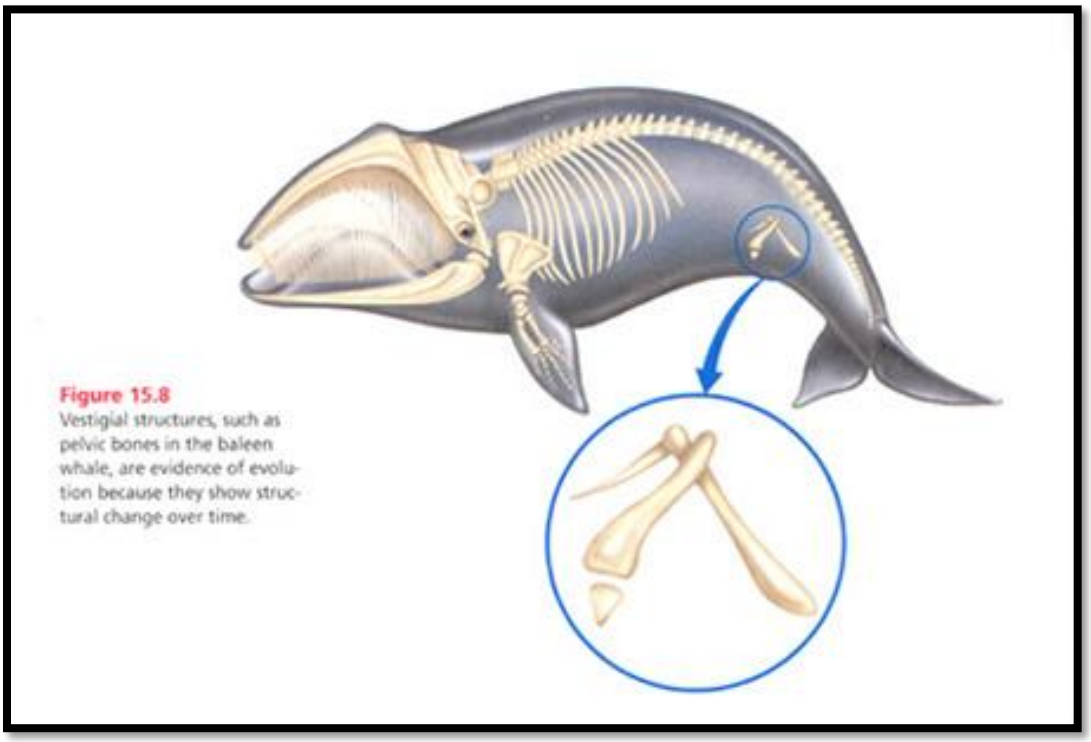


Figure 15.8
Vestigial structures, such as pelvic bones in the baleen whale, are evidence of evolution because they show structural change over time.

GRADUATED VERSUS PUNCTUATED EQUILIBRIUM

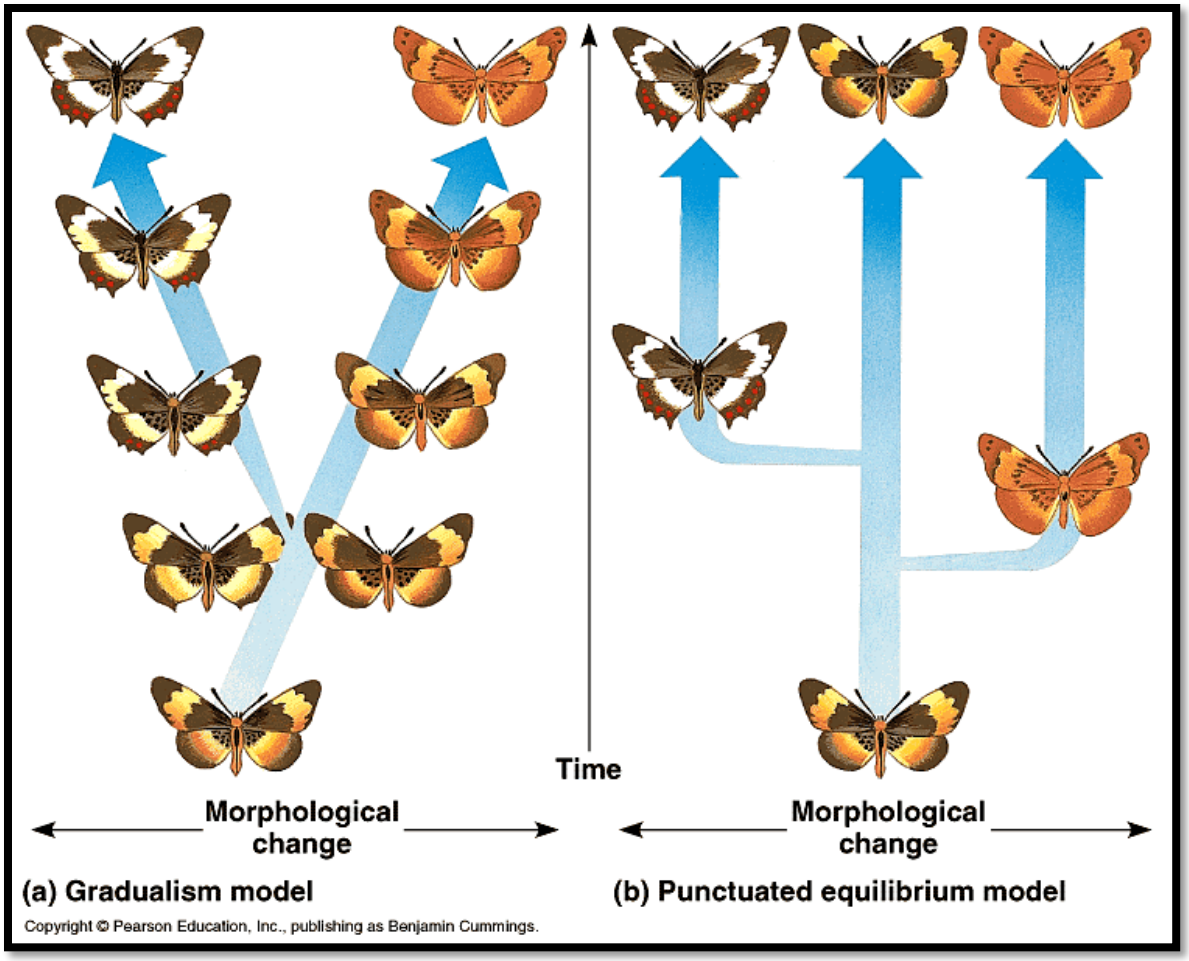
Graduated and punctuated equilibrium are two ways in which the evolution of a species can happen. A species can only evolve by one of these, or a combination of both. Scientists feel that species with a longer evolution evolved mostly by graduated equilibrium while those with shorter evolution evolved mostly by punctuated equilibrium.

GRADUATED EQUILIBRIUM

It is an evolution or a variation that happens more gradually. Over a short period of time, it is hard to notice. Small variations happen in an organism that help it to fit its environment slightly better. A few with less of that helpful trait die out. Very gradually, over a long period of time, the entire population changes. Change is slow, constant and continuous.

PUNCTUATED EQUILIBRIUM

In punctuated equilibrium, change comes in spurts. There is a period of very little change and then one or two huge changes occur. This may be because of a gene mutation. A mutation is a random change in the DNA of the genes, it changes the inherited information that is passed on. Though mutations are often harmful, sometimes the mutations that cause punctuated equilibrium are very helpful for the species to adapt. As a result, the species changes very rapidly over a few generations and then settles down to a period of no change. Punctuated equilibrium can also be due to other causes, such as a huge and sudden change in the environment, which causes a change in the organism because of a harsher natural selection.



ERA

An era is a commonly used word for a long period of time. When used in geology science, eras are clearly defined periods of time, and of well-defined length. For example, the Mesozoic era is limited by a start and end, from 250-60 million years ago. Each era is divided into smaller time segments called periods.

1. **Archaezoic**
2. **Precambrian** **3500-545 million years ago**
3. **Paleozoic**
    a. **Cambrian** **545-505**
    b. **Ordovician** **505-438**
    c. **Siliurian** **438-408**
    d. **Devonian** **408-360**
    e. **Mississippian** **360-286**
    f. **Pennsylvanian**
    g. **Permian** **286-248**
4. **Mesozoic**
    a. **Triassic** **248-208**
    b. **Jurassic** **208-144**
    c. **Cretaceous** **144-66**
5. **Cenozoic**
    a. **Tertiary** **66-1.6**
    b. **Quaternary** **1.6-present**

EARTH TIMELINE IN ERAS

1. **Archeozoic Era**: This is the first era to have record, (4500-1500 million years ago). The earth's surface changed from molten to rock and the continents formed and oceans formed. Basic cells were present, no nucleus.
2. **Proterozoic Or Precambrian Era: (2500-542 Million years ago):** Cells with nucleus and organelles were present. These organelles did special functions that were needed for the evolution of fungi, plants and animals. Earliest forms of life like bacteria and algae were present. At the end of this era, soft body organisms like jelly fish appeared. Few rocks from this era remain.
3. **Paleozoic Era**: (542-151 million years ago): This is the era where many changes happened. The first hard species like primitive fish, coral, plant life, vertebrate animals, wingless insects appeared. Fossils date back to this era.

At the end of the Paleozoic era, there was a great extinction that wiped out 95% of all life forms. It is called the **Permian period**. It is considered to be because when many continents formed 1 massive one called Pangaea, the earth became unstable, and many mass volcanoes appeared, destroying the oxygen level balance needed for life.

The continents were arranged as I super continent Pangaea. This broke apart and its pieces spread by a process of plate tectonics. Volcanoes, earthquakes, seafloor spreading are all part of plate tectonics and this process changed our earth.

4. **Mesozoic Era- (251-65 Million years ago)** This is the dinosaur age. Small mammals and birds appeared too. The climate became milder and reptiles appeared. The Mesozoic era is broken into 3 periods
   A. **Triassic**
   B. **Jurassic**
   C. **Cretaceous**.

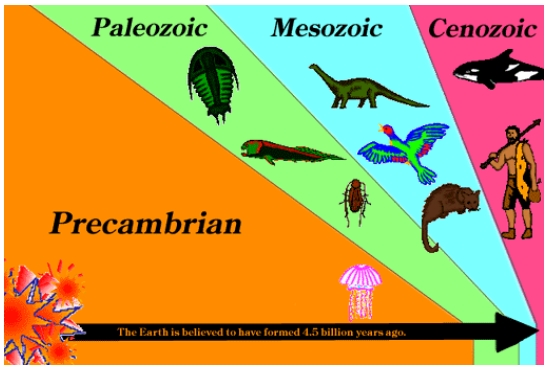
   A. **Triassic Period:** In this period, there were many primitive dinosaurs forming, and marine reptiles. Some of the 1st species were the Plesiosaurus, Euraptor, Herrerasaurus, Pisanousaurus, Saturnalia, and Staurikosaurus.
   B. **Jurassic Period-** In this period, dinosaurs had become much larger in size. The evolution of the long necked dinosaurs (sauro pods) was at its peak, Carnivore

dinosaur flourished. Reptiles with primitive albinos for flight like the archaeopteryx appeared but many ocean dwelling reptiles became extract.

C. **Cretaceous Period**- In this period, plated dinosaurs with defense body features like spikes appeared.

At the end of the Mesozoic Era, there was a large extinction situation and all the dinosaurs living on Earth were wiped out and became extinct. There are many theories why this happened.

5. **Cenozoic Era (65.5 Million years ago to today)-** The oldest known animals diversified and radiated across the continents. Mammals are the dominant life form, elephants, horses, other animals exist in this era.



Geologic Time Scale

Era	System & Period	Series & Epoch	Some Distinctive Features	Years Before Present
CENOZOIC	Quaternary	Recent	Modern man.	11,000
		Pleistocene	Early man; northern glaciation.	1/2 to 2 million
	Tertiary	Pliocene	Large carnivores.	13 + 1 million
		Miocene	First abundant grazing mammals.	25 + 1 million
		Oligocene	Large running mammals.	36 + 2 million
		Eocene	Many modern types of mammals.	58 + 2 million
		Paleocene	First placental mammals.	63 + 2 million
MESOZOIC	Cretaceous		First flowering plants; climax of dinosaurs and ammonites, followed by Cretaceous-Tertiary extinction.	135 + 5 million
	Jurassic		First birds, first mammals dinosaurs and ammonites abundant.	181 + 5 million
	Triassic		First dinosaurs. Abundant cycads and conifers.	230 + 10 million
PALEOZOIC	Permian		Extinction of most kinds of marine animals, including trilobites. Southern glaciation.	280 + 10 million
	Carboniferous	Pennsylvanian	Great coal forests, conifers. First reptiles.	310 + 10 million
		Mississippian	Sharks and amphibians abundant. Large and numerous scale trees and seed ferns.	345 + 10 million
	Devonian		First amphibians; ammonites; fishes abundant.	405 + 10 million
	Silurian		First terrestrial plants and animals.	425 + 10 million
	Ordovician		First fishes; invertebrates dominant.	500 + 10 million
	Cambrian		First abundant record of marine life; trilobites dominant.	600 + 50 million
	Precambrian		Fossils extremely rare, consisting of primitive aquatic plants. Evidence of glaciation. Oldest dated algae, over 2,600 million years; oldest dated meteorites 4,500 million years.	

DINOSAURS

Dinosaurs were a group of creatures that lived on land during the Mesozoic Era, about 250 million years ago. Dinosaurs existed about 250 million years ago and became extinct about 60 million years ago. They included large and small animals. They were both carnivorous (meat eating) or herbivorous (plant eating).

Dinosaurs have been classified into 2 major group based on the structure of their hip bones.

1. The first were **"lizard-hipped"** dinosaurs, which had hip bones similar to modern reptiles.
2.
3. Two were **"bird-hipped"** dinosaurs, which had pelvises or hip bones resembling birds.

FEATURES OF DINOSAURS

1. The hips, back legs and ankles were specialized, to allow the legs to move directly under the body, rather than extending on the side like modern lizards. They can be small or large.
2. Dinosaurs had strong leg muscles and bone structures to support a large body, to stand upright and for running.
3. The front legs were well adapted for holding prey.
4. They most often had a head and a tail, a neck that was long and curved, hinged jaws to open & close the mouth.
5. Dinosaurs walked on their toes, the ankle off the ground

NAMES OF SOME DINOSAURS

BRACHIOSAURUS	PTERODACTYLUS
BRONTOSAURUS	TRICERATOPS
ARCHAEOPTERYX	TYRANNOSAURUS
CENTROSAURUS	UITRASAURUS
EURAPTOR	VELOCIRAPTOR
IGOANODON	HADROSAURUS
MASOSPONDYLOS	POLACANTHUS

EXTINCT

Something that is no longer in existence, something has ended or died out.

WHY DINOSAURS BECAME EXTINCT

No one knows exactly why but these are some reasons

1. **Asteroid**: A large asteroid or comet hit the earth. This threw so much dust in the air and change in climate that the dinosaurs died. This is the most commonly accepted theory about why dinosaurs became extinct.
2. **Volcanoes**- A increase in volcanic activity pumped out so much ash that dinosaurs died.
3. **Ice Age**- A severe ice age change the temperature, froze a lot of the Earth's water. The dinosaurs could not live under these conditions.
4. **Disease**- Deadly diseases killed the dinosaurs
5. **Climatic changes**- The Earth gradually changed in climate; dinosaurs could not adapt and died out.

DID DINOSAURS LIVE TOGETHER AND AT THE SAME TIME?

No, they did not. Dinosaur communities were separated by time and geography. The Mesozoic Era (the dinosaur age) was divided into 3 consecutive time periods Triassic, Jurassic and Cretaceous. Different dinosaur species lived during each of these 3 periods.

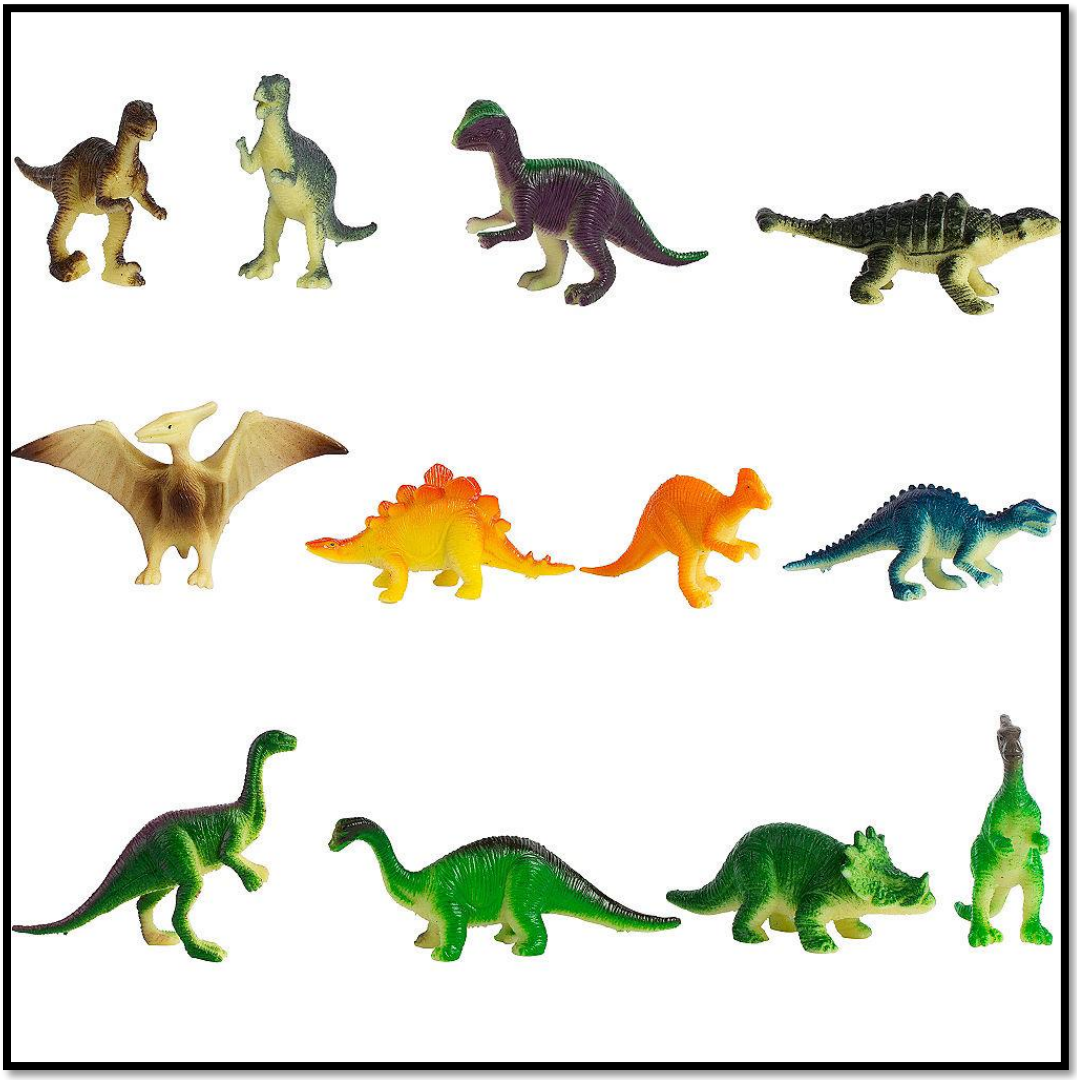
Also at the beginning of dinosaur history (Triassic Period), there was I super continent on earth Pangaea. Many dinosaur types were widespread across it However as Pangaea broke apart, dinosaurs scattered on separate continents and new types of dinosaurs evolved in each geographic area.

BIGGEST AND SMALLEST DINOSAURS

The biggest was the Brachiosaurus that we know of. The smallest dinosaur was about the size of a chicken called Compsognathus.

SPAN

Dinosaurs first appeared on earth about 230 million years ago. Older ones many yet be found. They became extinct about 65 million years ago. They lived on earth for about 165 million years. It is considered that a meteorite or asteroid impact was at least a partial cause of their extinction. Most dinosaurs hatched from eggs.



FOSSIL FUELS

Fossil fuels are natural substances made deep within the Earth from the remains of ancient plants and animals. Over time, heat and pressure turn these remains into fuels which release energy when burned. **Coal, oil and natural gas** are three main fossil fuels. Fossil fuels are the most commonly available source of power for our use but it is believed that the world is using fossil fuel at an unsustainable rate and alternate sources must be found. Also, fossil fuels must be burned to use their energy. This produces a lot of pollution in the environment. There are also dangers to the environment when mining for coal and drilling for oil is done as it causes damage to surrounding ecosystems.

COAL

It is a lumpy hard black substance. It started out millions of years ago as ferns, and as small trees & plants that grew in swamps. As the plants died, they got buried in water and acted on by bacteria. They formed peat. Over the years, heat and pressure changed it to coal. To get coal out of ground, it has to be mined (dug out of the ground). Coal is used to provide 27% of the world's energy and may only last another 200 years. It makes 40% of the world's electricity.

OIL

It is a dark, thick greasy liquid. It started out millions of years ago as tiny plants and animals called plankton that lived in lakes and seas. As plankton died, it was pressed between sand and mud into hard rock, and acted on by bacteria which changed it into dark ooze. Under heat and pressure, the dark ooze became crude oil. Today this oil is found between layers of rock and can be at different depths. Holes are drilled and the oil is pumped out of the ground. Most of the world's oil is found in the Middle East.

Crude oil is cleaned and separated in oil refineries, to make gasoline, diesel, kerosene, tar for roads, chemicals for plastic. Almost everything we use depends on oil and it gives 40% of world energy.

NATURAL GAS

It is a gas, made the same way as oil. It started out as tiny plants and animals (plankton) in lakes and seas. The plankton, sand and mud were acted on by bacteria, heat and pressure. Natural gas was formed. Like oil, it is drilled out our ground and is usually found where oil is found. Natural gas is made up of methane, butane, propane, and ethane. Before it can be used, it is sent to a factory to be cleaned. All the gases except methane are removed. Natural gas is mainly used for heating homes, water and cooking. It provides about 25% of world's energy.

It is becoming more popular since it is more efficient for making electricity as it burns hotter than coal or oil. Also, it produces less emission when burned, so it is better for the environment.