SUBJECT- ENVIRONMENTAL SCIENCE

SEMESTER – 4TH SEMESTER (CC8)

TEACHER- SHRAMANA ROY BARMAN

TOPIC- HISTORICAL BIOGEOGRAPHY

History of Earth

The earth was formed approximately 4.5 billion years ago via accumulation of particle. cosmic dust lumped together to form particulates, particulates became gravel, gravel became ball then tiny planets and finally, dust became the size of the moon and ultimately planets were formed. This process is known as accretion.

Large bodies slamming into the planet produced immense heat in its interior, melting the cosmic dust found there. The resulting furnace--situated some 200 to 400 km underground and called a magma ocean--was active for millions of years, giving rise to volcanic eruptions.

When Earth was young, heat at the surface caused by volcanism and lava flows from the interior was intensified by the constant bombardment of huge objects. No life was possible during this period.

At that time--4.44 billion to 4.41 billion years ago--Earth began to retain its atmosphere and create its core.

As the earth cooled, there was no atmosphere to trap the heat. The surface cooled off fast due to the cold temperature of space (like how the top of coffee cools off when exposed to the air). This created a layer of cooled rock that solidified into the crust. Differences in magma created two types of the lithosphere, oceanic and continental, characterized by the **basalt** in oceans and **granite** in the continents.

There are two types of lithosphere: oceanic lithosphere and continental lithosphere. Oceanic lithosphere is associated with oceanic crust, and is slightly denser than continental lithosphere.

Plate Tectonics

The most well-known feature associated with Earth's lithosphere is tectonic activity. Tectonic activity describes the interaction of the huge slabs of lithosphere called tectonic plates.

The earth's crust consists of several large dynamic tectonic plates. These tectonic plates moves slowly but continuously at an average rate of around 10 cm. Considering this, there was no Atlantic Ocean, and North America and Europe together were one continent 180 million years ago. The Atlantic Ocean came into being because of the drafting apart of the Eurasian and North America plates.

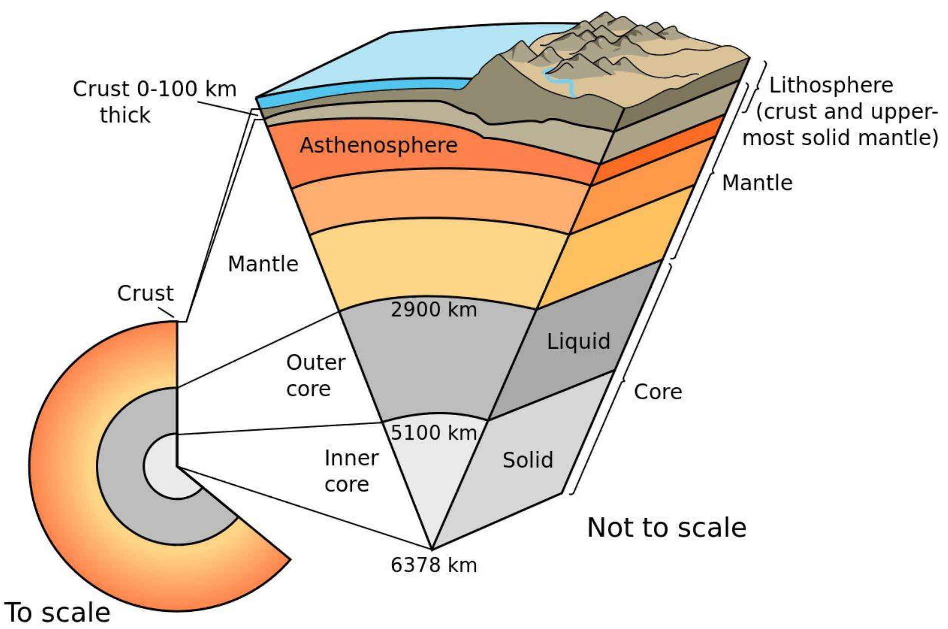
Most tectonic activity takes place at the boundaries of these plates, where they may collide, tear apart, or slide against each other. The movement of tectonic plates is made possible by thermal energy (heat) from the mantle part of the lithosphere. Thermal energy makes the rocks of the lithosphere more elastic.

Tectonic activity is responsible for some of Earth's most dramatic geologic events: earthquakes, volcanoes, orogeny (mountain-building), and deep ocean trenches can all be formed by tectonic activity in the lithosphere. Tectonic activity can shape the lithosphere itself.

Mantel convection (leading to tectonic activity)

Heat flows in two different ways within the Earth: conduction and convection. Conduction is defined as the heat transfer that occurs through rapid collisions of atoms, which can only happen if the material is solid. Heat flows from warmer to cooler places until all are the same temperature. The mantle is hot mostly because of heat conducted from the core. Convection is the process of a material that can move and flow may develop convection currents. Convection in the mantle is the same as convection in a pot of water on a stove. Convection currents within Earth's mantle form as material near the core heats up. As the core heats the bottom layer of mantle material, particles move more rapidly, decreasing its density and causing it to rise. The rising material begins the convection current. When the warm material reaches the surface, it spreads horizontally. The material cools because it is no longer near the core. It eventually becomes cool and dense enough to sink back down into the mantle. At the bottom of the mantle, the material travels horizontally and is heated by the core. It reaches the location where warm mantle material rises, and the mantle convection cell is complete.

Convection in the mantle is the same as convection in a pot of water on a stove. Convection currents within Earth's mantle form as material near the core heats up. As the core heats the bottom layer of mantle material, particles move more rapidly, decreasing its density and causing it to rise. The rising material begins the convection current. When the warm material reaches the surface, it spreads horizontally. The material cools because it is no longer near the core. It eventually becomes cool and dense enough to sink back down into the mantle. At the bottom of the mantle, the material travels horizontally and is heated by the core. It reaches the location where warm mantle material rises and the mantle convection cell is complete.



Early Earth would have been very different and inhospitable compared to the Earth today.It was very hot due to- Primordial heat, decay of short-lived radioactive elements

Consequences - Constant volcanism, surface temperature too high for liquid water or life as we know it, molten surface or thin, unstable basaltic crust. Early atmosphere was probably completely different in composition (H_2, He)

Then cooling took place

- Primordial heat dissipated to space
- Condensation of water (rain), accumulation of surface water.
- Accumulation of new atmosphere due to volcanic out gassing
- Conditions appropriate for evolution of life

First Atmosphere

- Composition - Probably H_2, He
- These gases are relatively rare on Earth compared to other places in the universe and were probably lost to space early in Earth's history because
  - Earth's gravity is not strong enough to hold lighter gases
  - Earth still did not have a differentiated core (solid inner/liquid outer core) which creates Earth's magnetic field (magnetosphere = Van Allen Belt) which deflects solar winds.
- Once the core differentiated the heavier gases could be retained

Second Atmosphere
Produced by *volcanic out gassing*.

- Gases produced were probably similar to those created by modern volcanoes (H_2O, CO_2, SO_2, CO, S_2, Cl_2, N_2, H_2) and NH_3 (ammonia) and CH_4 (methane)
- No free O_2 at this time (not found in volcanic gases).

- *Ocean Formation* - As the Earth cooled, H_2O produced by out gassing could exist as liquid in the Early Archean, allowing oceans to form.

Addition of O_2 to the Atmosphere
Today, the atmosphere is ~21% free oxygen. How did oxygen reach these levels in the atmosphere?

Oxygen Production

- **Photochemical dissociation** - breakup of water molecules by ultraviolet

        - Produced O_2 levels approx. 1-2% current levels
        - At these levels O_3 (Ozone) can form to shield Earth surface from UV
- **Photosynthesis** - $CO_2 + H_2O$ + sunlight = organic compounds + O_2 - produced by cyanobacteria, and eventually higher plants - supplied the rest of O_2 to atmosphere.
- **Oxygen Consumers**
    - **Chemical Weathering** - through oxidation of surface materials (early consumer)
    - **Animal Respiration** (much later)
    - **Burning of Fossil Fuels** (much, much later)

Throughout the Archean eon there was little to no free oxygen in the atmosphere (<1% of presence levels). What little was produced by cyanobacteria, was probably consumed by the weathering process. Once rocks at the surface were sufficiently oxidized, more oxygen could remain free in the atmosphere.

During the Proterozoic eon the amount of free O_2 in the atmosphere rose from 1 - 10 %. Most of this was released by cyanobacteria, which increase in abundance in the fossil record 2.3 Ga (giga annumor A **billion years** (10^9 **years**)). Present levels of O_2 were probably not achieved until ~400 Ma(mega annum)

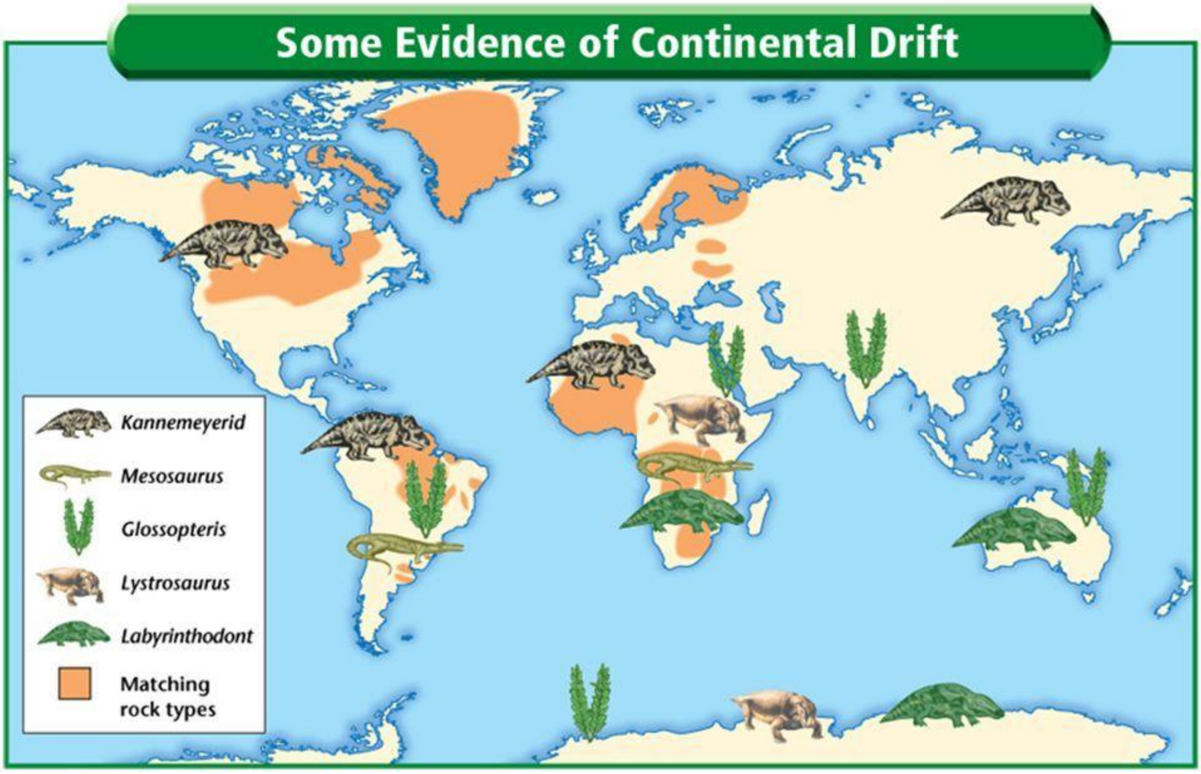
Continental Drift

Wegener developed an idea that he called **continental drift,** which proposed that Earth's continents had once been joined as a single landmass that broke apart and sent the continents adrift. He called this supercontinent **Pangaea**, a Greek word thatmeans *all the earth*, and suggested that Pangaea began to break apart about 200 mya. Since that time, he reasoned, the continents have continued to slowly move to their present positions.

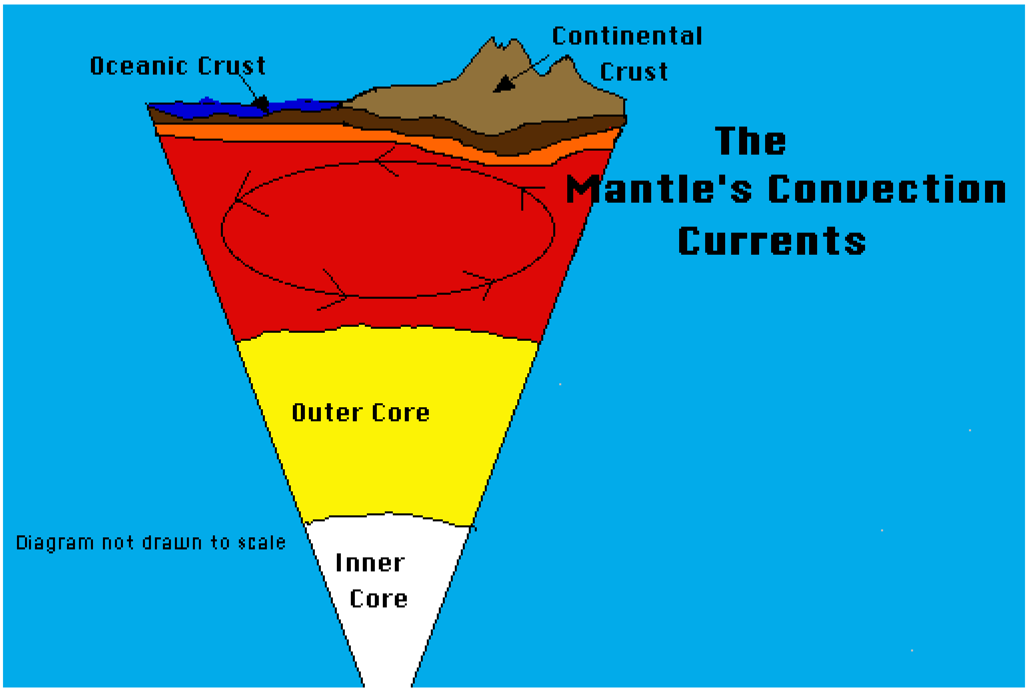
Evidence from rock formations: Wegener reasoned that when Pangaea began to break apart, large geologic structures, such as mountain ranges, fractured as the continents separated. Using this reasoning, Wegener thought that there should be areas of similar rock types on opposite sides of the Atlantic Ocean. He observed that many layers of rocks in the Appalachian Mountains in the United States were identical to layers of rocks in similar mountains in Greenland and Europe. These similar groups of rocks, older than 200 million years, supported Wegener's idea that the continents had once been joined.

Evidence from fossils: Wegener also gathered evidence of the existence of Pangaea from fossils. Similar fossils of several different animals and plants that once lived on or near land had been found on widely separated continents.

Evidence from Fossils and Rock Formations



The Earth is a *dynamic* or constantly changing planet. The thin, fragile plates slide very slowly on the *mantle*'s upper layer. This sliding of the plates is caused by the mantle's convection currents slowly turning over and over. This overturn is like a conveyor belt that moves the plates of the crust.



These plates are in constant motion causing earthquakes, mountain building, volcanism, the production of "new" crust and the destruction of "old" crust. The following cards will teach you more about the Earth's plates.

The Earth's crust is broken into many pieces. These pieces are called ***plates***. There are twelve main plates on the Earth's surface. The red lines on this map of the world represent the largest plate boundaries. A plate boundary occurs where two plates come together. There are three kinds of plate boundaries:

1. ***Convergent boundary*** -where two plates collide to form mountains or a *subduction zone*.

2. ***Divergent boundary*** -where two plates are moving in opposite directions as in a mid-ocean ridge.

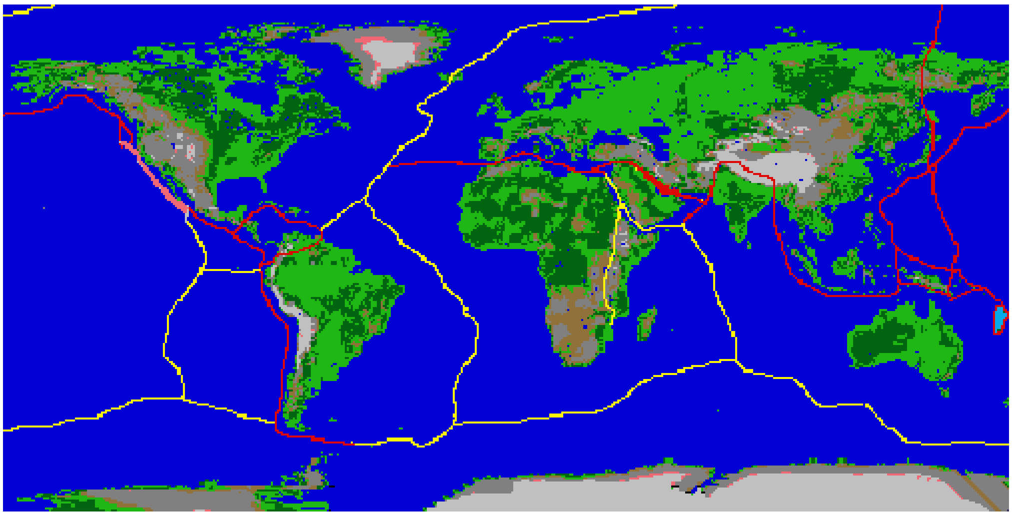
3. ***Transform boundary*** -where two plates are sliding past each other as in the San Andreas fault of California.

The Earth's plates are in constant, but very, very slow motion. They move at only 1/2 to 4 inches (1.3 to 10 cm) per year!! This does not seem like much, but over millions of years it adds up to great distances of movement.

The ***[Continental Drift](#)*** ***Theory*** states that the continents have moved and are still moving today. In 1912 ***Alfred Wegener*** introduced this theory, but he did not fully understand what caused the plates to move. A ***theory*** is an explanation of a scientific process that has been successfully tested by many different methods.

The motion of the Earth's plates help scientists to understand why earthquakes, volcanoes, and mountain building occur.

Scientists believe these plates have been moving for millions of years. In fact, 250 millions years ago the Earth's seven continents were all grouped together into a supercontinent called **Pangea.**

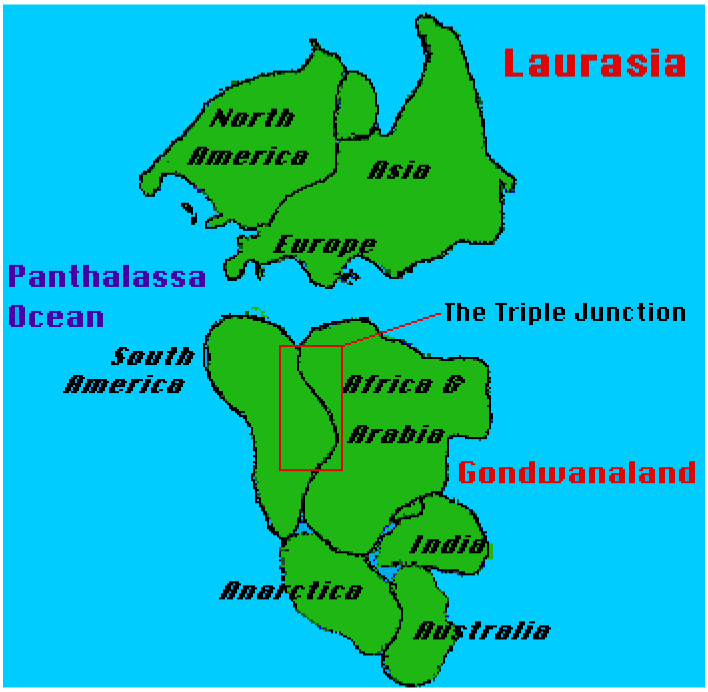


Just before the days of the dinosaurs the Earth's continents were all connected into one huge landmass called ***Pangaea*** . This huge supercontinent was surrounded by one gigantic ocean called ***Panthalassa.***

Notice the postion of the continents of Antarctica (Far north of its current position), Australia (flipped sideways and far west of its current position) and the subcontinent of India (Hundreds of miles from Asia).

Scientists believe that the North American continent was located much farther south and east of it's position today. In fact, much of North America was in or near the tropics!! How do scientists know this?? They have found fossils from this period of time. These fossils are of tropical plants and animals. The fossils have been found in cold regions like North Dakota and Greenland!!!

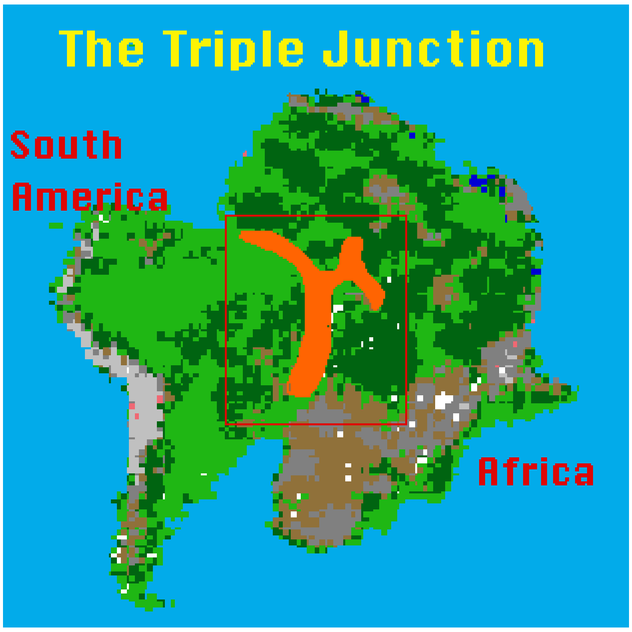
180 Million Years Ago



About 180 million years ago the supercontinent Pangea began to break up. Scientists believe that Pangea broke apart for the same reason that the plates are moving today. The movement is caused by the convection currents that roll over in the upper zone of the mantle. This movement in the mantle causes the plates to move slowly across the surface of the Earth. About 200 million years ago Pangaea broke into two new continents Laurasia and Gondwanaland. ***Laurasia*** was made of the present day continents of North America (Greenland), Europe, and Asia. ***Gondwanaland*** was made of the present day continents of Antarctica, Australia, South America. The subcontinent of India was also part of Gondwanaland. Notice that at this time India was not connected to Asia. The huge ocean of Panthalassa remained but the Atlantic Ocean was going to be born soon with the splitting of North America from the Eurasian Plate.

How do we know that South America was attached to Africa and not to North America 180 million years ago?

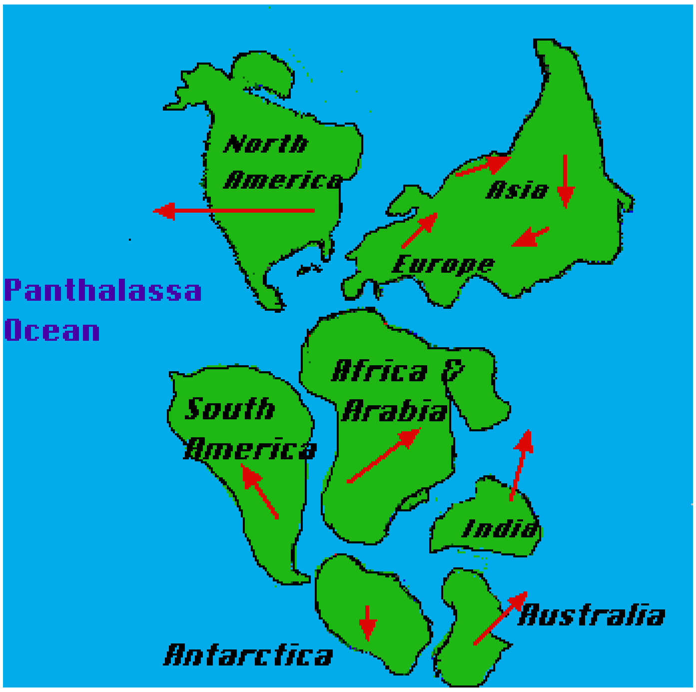
Scientists today can read the history of the rock record by studying the age and mineral content of the rocks in a certain area.



The ***Triple Junction*** was formed because of a three-way split in the crust allowing massive lava flows. The split was caused by an upwelling of *magma* that broke the crust in three directions and poured out *lava* over hundreds of square miles of Africa and South America.

The rocks of the triple junction, which today is the west central portion of Africa and the east central portion of South America, are identical matches for age and mineral make up. In other words the rocks in these areas of the two continents were produced at the same time and in the same place. This tells us that South America and Africa were connected at one time. Today these two continents are separated by the Atlantic Ocean which is over 2000 miles wide!

135 Million Years Ago



About 135 million years ago Laurasia was still moving, and as it moved it broke up into the continents of North America, Europe and Asia (Eurasian plate). Gondwanaland also continued to spread apart and it broke up into the continents of Africa, Antarctica, Australia, South America, and the subcontinent of India. Arabia started to separate from Africa as the Red Sea opened up. The red arrows indicate the direction of the continental movements. Notice how far the Indian subcontinent has to move to get to its present postion connected to Asia.

The Atlantic, Indian, Arctic, and Pacific Oceans are all beginning to take shape as the continents move toward their present positions.

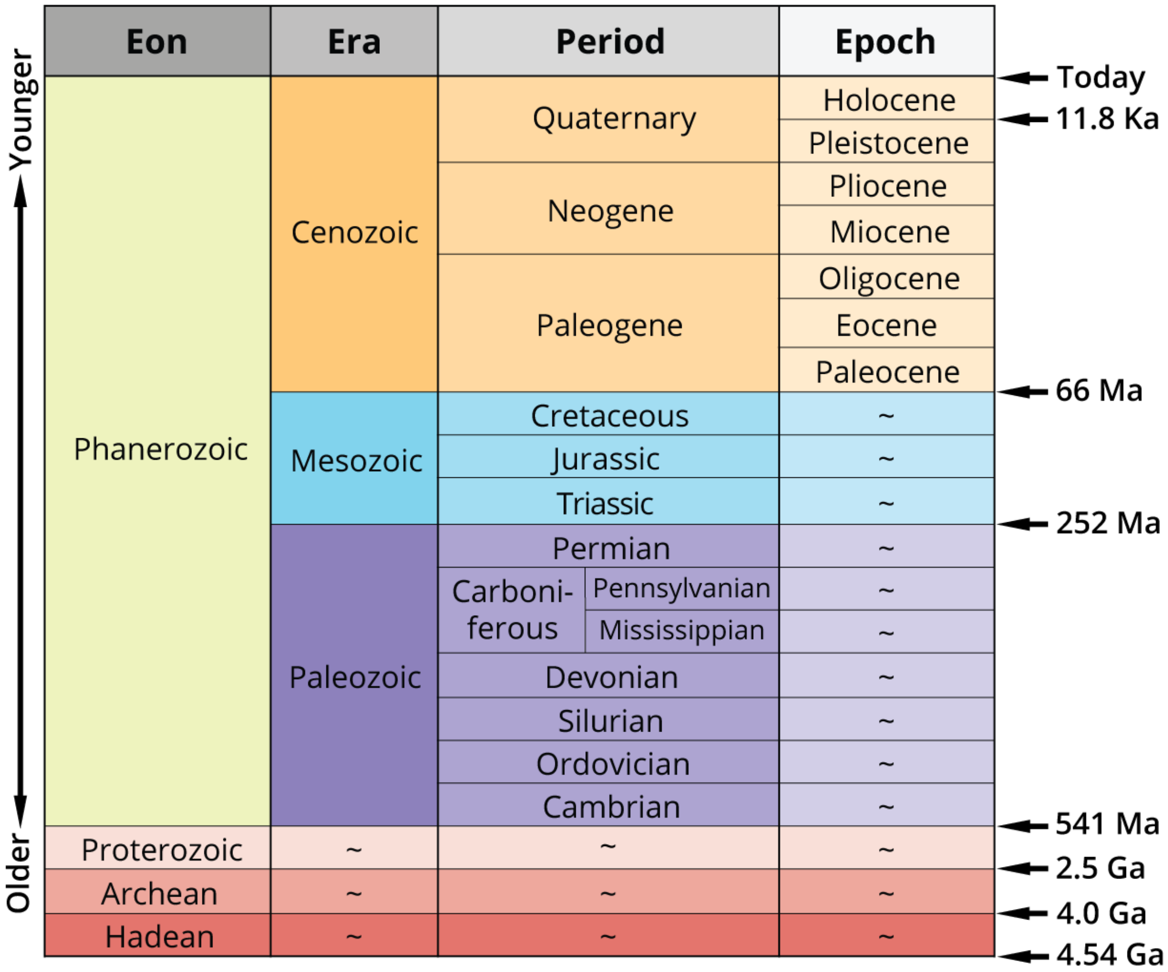
The plates are still moving today making the Atlantic Ocean larger and the Pacific Ocean smaller. The yellow arrows on the world map indicate the direction of plates movements today.

Notice the position of the Indian Subcontinent today. It moved hundreds of miles in 135 million years at a great speed (4 inches per year!!!) The Indian plate crashed into the Eurasian plate with such speed and force that it created the tallest mountain range on Earth, the Himalayas.

What is biogeography?

Biogeography is the study of the distribution of species and ecosystems in geographic space and through geological time.

Biogeography is a branch of geography that studies the past and present distribution of the world's many animal and plant species and is usually considered to be a part of physical geography as it often relates to the examination of the physical environment and how it affected species and shaped their distribution across the world.



The geological time scale

As such, biogeography also includes the study of the world's biomes and taxonomy—the naming of species—and has strong ties to biology, ecology, evolution studies, climatology, and soil science as they relate to animal populations and the factors that allow them to flourish in particular regions of the globe.

The field of biogeography can further be broken down into specific studies related to animal populations include historical, ecological, and conservation biogeography and include both phytogeography (the past and present distribution of plants) and zoogeography (the past and present distribution of animal species).

History of Biogeography

The study of biogeography gained popularity with the work of Alfred Russel Wallace in the mid-to-late 19th Century. Wallace, originally from England, was a naturalist, explorer, geographer, anthropologist, and biologist who first extensively studied the Amazon River and then the Malay Archipelago (the islands located between the mainland of Southeast Asia and Australia)

During his time in the Malay Archipelago, Wallace examined the flora and fauna and came up with the Wallace Line—a line that divides the distribution of animals in Indonesia into different regions according to the climates and conditions of those regions and their inhabitants' proximity to Asian and Australian wildlife. Those closer to Asia were said to be more related to Asian animals while those close to Australia were more related to the Australian animals. Because of his extensive early research, Wallace is often called the "Father of Biogeography."

Following Wallace were a number of other biogeographers who also studied the distribution of species, and most of those researchers looked at history for explanations, thus making it a descriptive field. In 1967 though, Robert MacArthur and E.O. Wilson published "The Theory of Island Biogeography." Their book changed the way biogeographers looked at species and made the study of the environmental features of that time important to understanding their spatial patterns.

As a result, island biogeography and the fragmentation of habitats caused by islands became popular fields of study as it was easier to explain plant and animal patterns on the microcosms developed on isolated islands. The study of habitat fragmentation in biogeography then led to the development of conservation biology and landscape ecology.

Historical Biography

Today, biogeography is broken into three main fields of study: historical biogeography, ecological biogeography, and conservation biogeography. Each field, however, looks at phytogeography (the past and present distribution of plants) and zoogeography (the past and present distribution of animals).

Historical biogeography is called paleobiogeography and studies the past distributions of species. It looks at their evolutionary history and things like past climate change to determine why a certain species may have developed in a particular area. For example, the historical approach would say there are more species in the tropics than at high latitudes because the tropics experienced less severe climate change during glacial periods which led to fewer extinctions and more stable populations over time.

The branch of historical biogeography is called paleobiogeography because it often includes paleogeographic ideas—most notably plate tectonics. This type of research uses fossils to show the movement of species across space via moving continental plates. Paleobiogeography also takes varying climate as a result of the physical land being in different places into account for the presence of different plants and animals.

Ecological Biogeography

Ecological biogeography looks at the current factors responsible for the distribution of plants and animals, and the most common fields of research within ecological biogeography are climatic equability, primary productivity, and habitat heterogeneity.

Climatic equability looks at the variation between daily and annual temperatures as it is harder to survive in areas with high variation between day and night and seasonal temperatures. Because of this, there are fewer species at high latitudes because more adaptations are needed to be able to survive there. In contrast, the tropics have a steadier climate with fewer variations in temperature. This means plants do not need to spend their energy on being dormant and then regenerating their leaves or flowers, they don't need a flowering season, and they do not need to adapt to extreme hot or cold conditions.

Primary productivity looks at the evapotranspiration rates of plants. Where evapotranspiration is high and so is plant growth. Therefore, areas like the tropics that are warm and moist foster plant transpiration allowing more plants to grow there. In high latitudes, it is simply too cold for the atmosphere to hold enough water vapor to produce high rates of evapotranspiration and there are fewer plants present.

Conservation Biogeography

In recent years, scientists and nature enthusiasts alike have further expanded the field of biogeography to include conservation biogeography—the protection or restoration of nature and its flora and fauna, whose devastation is often caused by human interference in the natural cycle.

Scientists in the field of conservation biogeography study ways in which humans can help restore the natural order of plant and animal life in a region. Often times this includes reintegration of species into areas zoned for commercial and residential use by establishing public parks and nature preserves at the edges of cities.

Biogeography is important as a branch of geography that sheds light on the natural habitats around the world. It is also essential in understanding why species are in their present locations and in developing protecting the world's natural habitats.

A **land bridge**, in biogeography, is an isthmus or wider land connection between otherwise separate areas, over which animals and plants are able to cross and colonise new lands.