The Origin of Man

Beginning of Time – The Big Bang.

In the beginning was the Word, and the Word was God, and God said “Let there be Light”!

That was 13.5 Billion years ago when the void was filled by an almighty explosion – the Big Bang – the beginning of everything. Before the Big Bang, so we are told, there was absolutely nothing; no time, no space, no matter, no energy in fact no nothing. Hard to imagine or understand. Definitely!

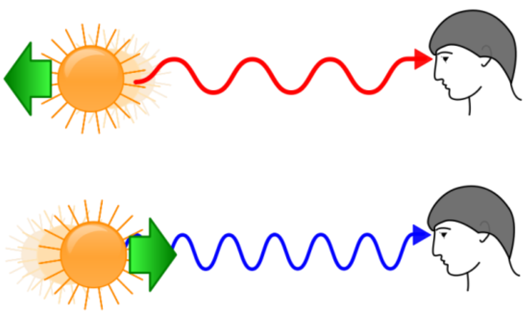
Why and how did the Big Bang occur? In fact, how do we know if there actually was a Big Bang?

The story of the of the Big Bang starts with the discovery by Edwin Hubble in 1929 at the Mount Wilson observatory that most if not all of the observable galaxies in the universe were moving away from each other. This made scientists realise that if everything was moving away from everything else, then sometime in the past everything must have been much, much closer together. If this was taken to its logical conclusion then sometime in the past, everything must have come from a single point or as it has sometimes been called the “primordial atom”.

You may well ask how Hubble could know that all galaxies were moving apart. The answers lies in a phenomenon we have all experienced but mostly have never thought about. It is known as the Doppler Effect. Even as a child you will have noticed that the sound of a siren from an approaching fire engine or police car seems to drop in pitch just as it passes you.

Sound is composed of waves of alternating air pressure radiating outwards in all directions from a source, a bit like an expanding bubble. If, the source were moving, the waves in front of the source would be compressed and would sound higher pitched than those lagging behind which would be stretched out and therefore sound lower in pitch. This is the Doppler Effect.

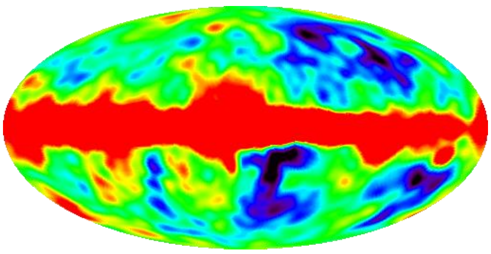
Well, this effect doesn’t only happen with sound waves in air, it also happens with light emitted or reflected from a moving object, such as a torch, a planet, a sun or a galaxy. In this case the light coming from a receding body is stretched or shifted nearer to the red or long wave end of the visible spectrum while the light of an approaching object is squeezed to the shorter or blue end of the spectrum, the faster the velocity the bigger the effect. Of course this effect only becomes obvious at seriously fast velocities. Unfortunately the human eye is not that good at detecting this effect but scientist using telescopes and special devices called spectroscopes are able to measure exactly how far light from receding galaxies is stretched and from this they can work out how fast they are moving away from us.

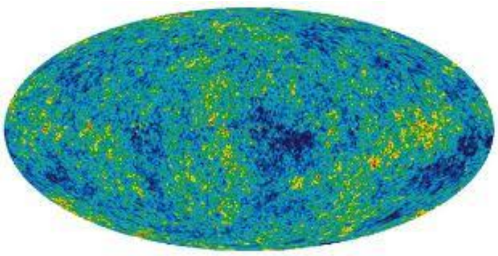


We now know how it was discovered that galaxies were moving apart from each other, and at what speeds, but how do we know when the Big Bang actually happened.

This is mainly down to a discovery made by two scientists, working for Bell Labs in New Jersey in 1964, Arno Penzias and Robert Wilson.

Penzias and Wilson were doing research into satellite communication but were continually getting interference from unknown radio sources during their experiments. It did not seem to matter where they pointed their antenna, which was big and shaped like a horn (see above picture), they always got the same interference. At first they thought the radio noise must be coming from some local terrestrial sources then maybe from satellites. They even thought that it might be emanating from within their own equipment or antenna, so they tried all sorts of fixes to eliminate the problem, but nothing seemed to work. Eventually, however they had no option but to conclude that the noise was extra-terrestrial in origin. And as luck would have it they discovered that at around the same time they were experiencing these problems some other scientists had actually predicted that such a background noise should be detectable from outer space. This radio noise became known as the microwave Background Radiation (MBR).





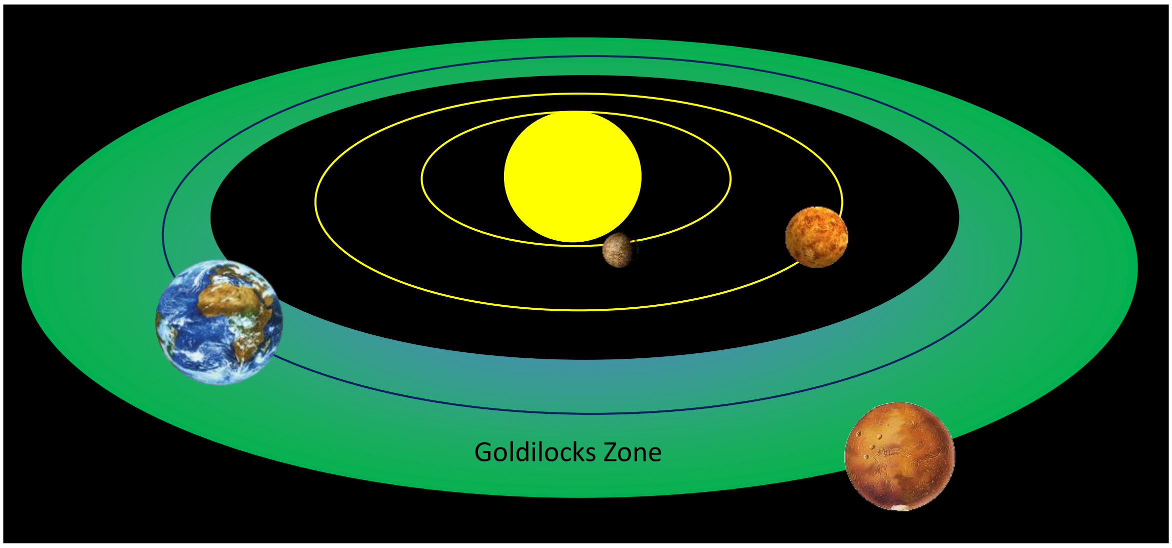
The MBR is considered to be the remnants of the radiation produced at the time of the Big Bang, and by knowing exactly how strong it is and comparing this to how strong they thought it would have been at the time of the Big Bang, scientists were able to calculate the approximate age of the universe – clever chaps these scientists!

Creation of the Earth

Jumping forward 9.5 Billion years to 4 Billion years ago, our universe has already been around for some time and our sun is burning brightly. Around the sun are a number of rings, rather like those of Saturn. These were composed of loose rock and debris produced during the creation of our galaxy. The planets surrounding the sun were formed by a process of accretion, under the influence of gravity the matter in these rings collided and sometimes fused, thus the planets were formed. Earth was a molten ball of rock filled with erupting volcanoes, lava fields as big as Africa and very little liquid water present on the surface. It was also under continuous attack from meteorites and asteroids which at that time seemed to be in abundance. The Moon had recently been formed by one of the larger of these collisions and the atmosphere would have killed the likes of you and me almost instantly. This was known as the Hadean (or hellish) Era, a time when the Solar System was being formed.

Some scientists have speculated that life could have begun during the early Hadean period, as far back as 4.4 billion years ago, surviving heavy meteoric bombardment in hydrothermal vents below the Earth's surface.

A number of important coincidences have allowed the Earth to become the warm and life friendly place it is today. For one, the Earth is in exactly the right place for liquid water to exist over most of its surface; sometimes called the Goldilocks zone – not too hot and not too cold but just right. Another coincidence, the Moon once in place acted as a partial shield, protecting the early Earth from serious impact damage. A further lucky break was that the Earth was surrounded by a strong magnetic field, which protected our forming atmosphere from being blown away by the solar wind. The magnetic field also protected life once formed from the worst of the radiation bombarding us from outer space.

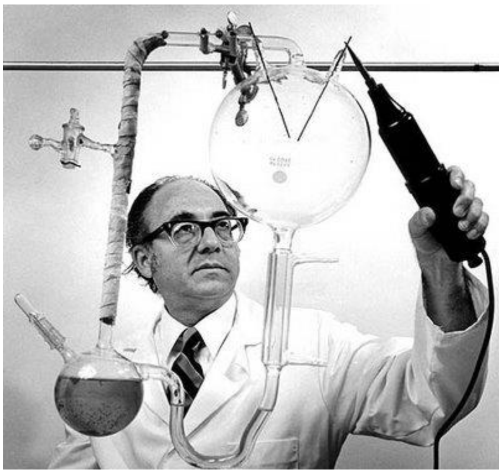


The Primordial Soup

This was an idea first put forward by English Geneticist J.B.S. Haldane and independently by Russian Chemist A.I. Oparin around the same time in 1920.

It was during the Archaean era between 3.5 and 2 billion years ago, that the Primordial Soup was considered to provide the most favourable conditions for the genesis of Life. All the necessary ingredients were here, gases such as Methane, and Ammonia filled the atmosphere with poisonous fumes. Some of our oldest fossils date back roughly to the beginning of this period, and consist of bacterial microfossils.

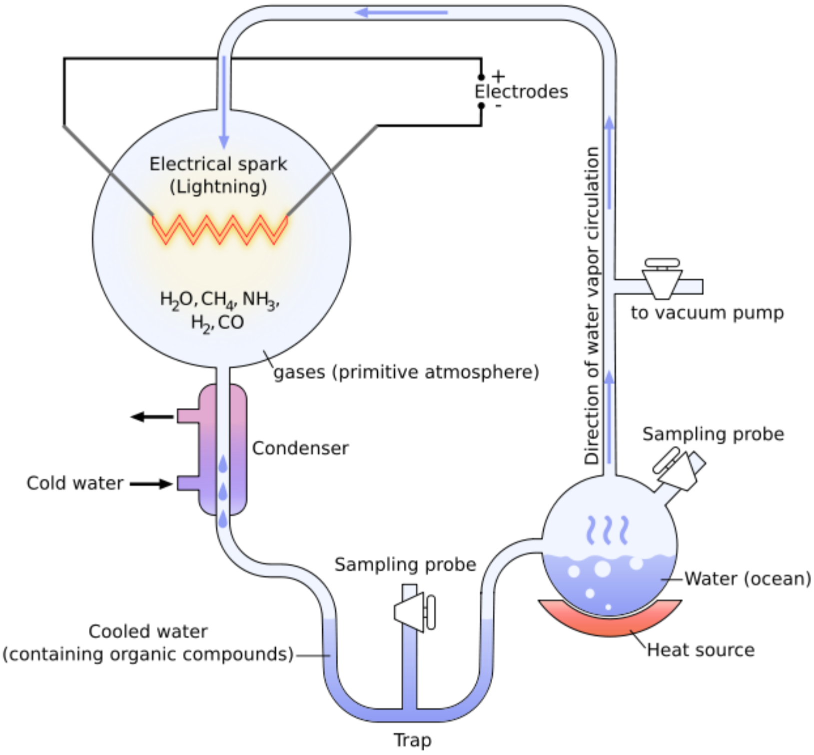
Stromatolites, colonies of photosynthetic bacteria have been found as fossils in Archaean rocks from South Africa and Western Australia. Also during this time, the Earth's crust cooled enough for rocks and continental plates to form.



To try and show how it would be possible for Life to arise from the Primordial Soup, two scientists Stanley Miller and Harold Urey in 1952 devised an experiment where they tried to recreate the formation of life in the primordial soup.

Miller took gasses which were believed to represent the major components of the early Earth's atmosphere and put them into a closed system.

The gases they used were methane (CH^4), ammonia (NH^3), hydrogen (H^2), and also included water (H^2O). Next, he ran a continuous electric current through the system, to simulate lightning storms believed to be common on the early earth. Analysis of the experiment was done by chromatography. At the end of one week, Miller observed that as much as 10-15% of the carbon was now in the form of organic compounds. Two per cent of the carbon had formed some of the amino acids which are used to make proteins. Perhaps most importantly, Miller's experiment showed that organic compounds such as amino acids, which are essential to cellular life, could be made easily under the conditions that scientists believed to be present on the early earth. This enormous finding inspired a multitude of further experiments.



In 1961, Juan Oro found that amino acids could be made from hydrogen cyanide (HCN) and ammonia in an aqueous solution. He also found that his experiment produced an amazing amount of the nucleotide base, adenine. Adenine is of tremendous biological significance as an organic compound because it is one of the four bases in RNA and DNA. It is also a component of adenosine triphosphate, or ATP, which is a major energy releasing molecule in cells. Experiments conducted later showed that the other RNA and DNA bases could be obtained through simulated prebiotic chemistry with a reducing atmosphere (no oxygen present).

These discoveries created a stir within the science community. Scientists became very optimistic that the questions about the origin of life would be solved within a few decades. This has not been the case, however. Instead, the investigation into life's origins seems only to have just begun.

There has been a recent wave of scepticism concerning Miller's experiment because it is now believed that the early earth's atmosphere did not contain predominantly reductant molecules. Another objection is that this experiment required a tremendous amount of energy. While it is believed lightning storms were extremely common on the primitive Earth, they were not continuous as the Miller/Urey experiment portrayed. Thus it has been argued that while amino acids and other organic compounds may have been formed, they would not have been formed in the amounts which this experiment produced.

Many of the compounds made in the Miller/Urey experiment are known to exist in outer space. On September 28, 1969, a meteorite fell over Murchison, Australia. While only 100 kilograms were recovered, analysis of the meteorite has shown that it is rich with amino acids. Over 90 amino acids have been identified by researchers to date. Nineteen of these amino acids are found on Earth. The early Earth is believed to be similar to many of the asteroids and comets still roaming the galaxy. If amino acids are able to survive in outer space under extreme conditions, then this might suggest that amino acids were present when the Earth was formed. More importantly, the Murchison meteorite has demonstrated that the Earth may have acquired some of its amino acids and other organic compounds by planetary infall.

If these compounds were not created in a reducing atmosphere here on Earth as Miller suggested, then where did they come from? New theories have recently been offered as alternative sites for the origin of life. These include ones where life initially started on Mars.

First Life

If you could take a look at all life on Earth as it currently is, down to the microscopic level, one thing will become obvious, that there appears to be a great similarity between all living cells.

They all have some sort of cell membrane; they all have (except in some specific exceptions) very similar internal structures containing a number of organelles such as a Nucleus, Mitochondria etc. And they all possess the molecule of life itself, Deoxyribonucleic Acid or DNA.

DNA contains the basic instructions for the cell to reproduce and create other cells just like it. Taken to its ultimate conclusion, all living cells today owe their existence to a single “Adam” cell which was formed around the Archaean or possibly even during the Hadean era.

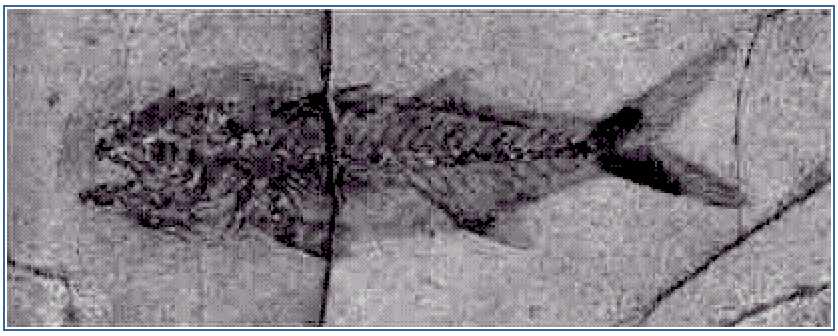
How did this first cell form? No one really knows. However there are a number of possible theories which may offer answers. One of these postulates that bubbles composed of fatty acids similar to soap bubbles were formed in hydrothermal vents and may have enclosed a number of amino acids on their inner surface, somehow giving rise to formation of the first proteins and possibly even to the first Ribonucleic Acid or RNA fragment. RNA is very similar to DNA and is an integral part of cell reproduction. Another suggests as in the Bible, the ingredients for the first living cells were formed on the surface of crystalline clay also within hydrothermal vents, in time evolving into RNA.

OK, so this is mostly in the realms of speculation but you have to start from somewhere. These ideas may be wrong but they may lead to the correct theory being formulated, given time.

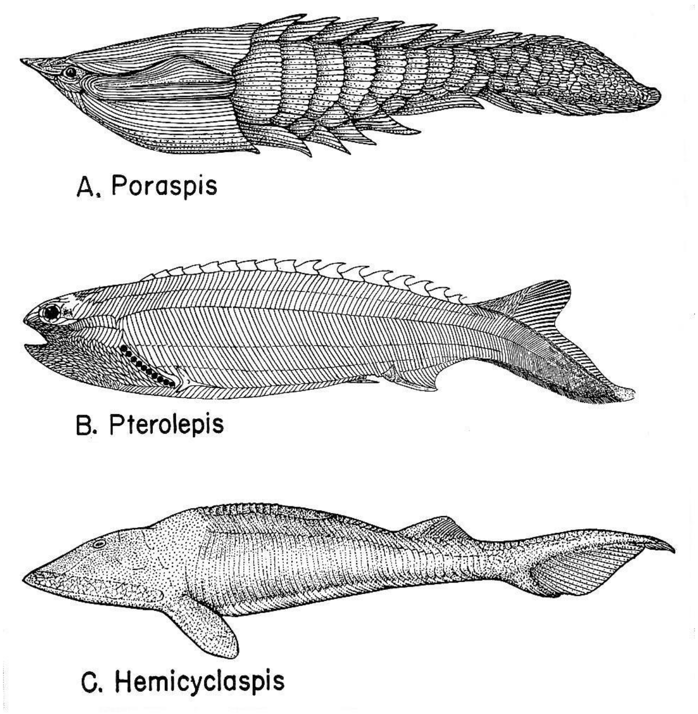
In the last few years John Sutherland at Manchester University has been able to produce a couple of essential RNA bases by simply applying heating and cooling to water and some basic gasses in a cyclical process.

Of course once the first cells and life was formed, Darwin’s Law of Evolution kicked in. This ensured that through the process of combination, mutation and diversification cells were able to grow and adapt to their changing surroundings, producing ever more complex forms. Some of these would have become more like algae and eventually went on to produce the first plant life, while others tended to become more like bacteria and organisms showing similarities to modern day animal cells. These would have been the precursor to the first fish to swim in the early oceans.

The First Fish



The first fish appeared on the earth about 500 million years ago. These fish are called ostracoderms. They were slow, bottom-dwelling animals that were covered from head to tail with heavy armour of thick bony plates and scales. Like today's lampreys and hagfish, ostracoderms had no jaws and had poorly formed fins. For this reason, scientists group lampreys, hagfish, and ostracoderms together.



Ostracoderms were not only the first fish, but also they were the first animals to have a backbone. Most scientists believe that the history of all other vertebrates can be traced back to the ostracoderms. The ostracoderms gave rise to jawed fish with backbones, and they in turn gave rise to amphibians (vertebrates that have legs and live both on land and in water). The amphibians became the ancestors of all land vertebrates.

Ostracoderms probably reached the peak of their development about 400 million years ago. About the same time, two other groups of fish were developing - acanthodians and placoderms. The acanthodians became the first known jawed fish. The placoderms were the largest fish up to that time. Some members of the placoderm group called Dinichthys grew up to 30 feet (9 meters) long and had powerful jaws and sharp bony plates that served as teeth.

The Age of Fishes

The Age of Fishes was a period in the earth's history when fish developed remarkably. Scientists call this age the Devonian Period. It began about 410 million years ago and lasted about 50 million years. During much of this time, dinichthys and other large placoderms ruled the seas.

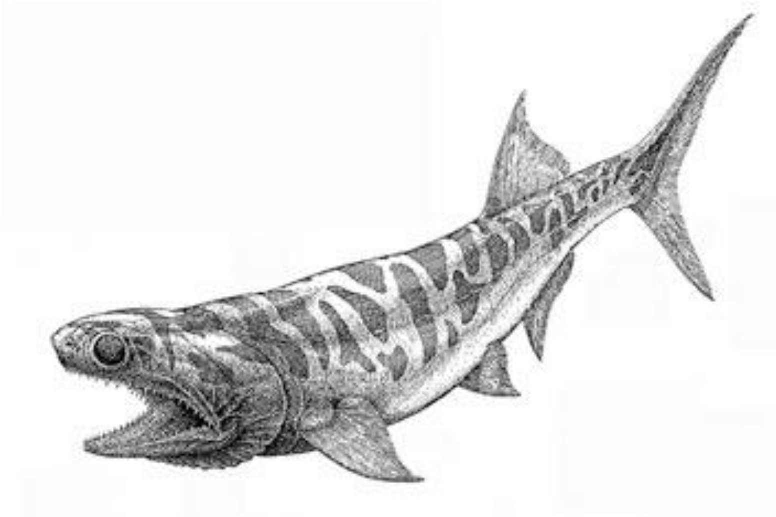
The First Bony Fish

The first bony fish appeared early in the Devonian period. They were mostly small or medium-sized and, like all fish of that time, were heavily armoured. These early bony fish belonged to two main groups - sarcopterygians and actinopterygians.

Coelacanth

Lungfish

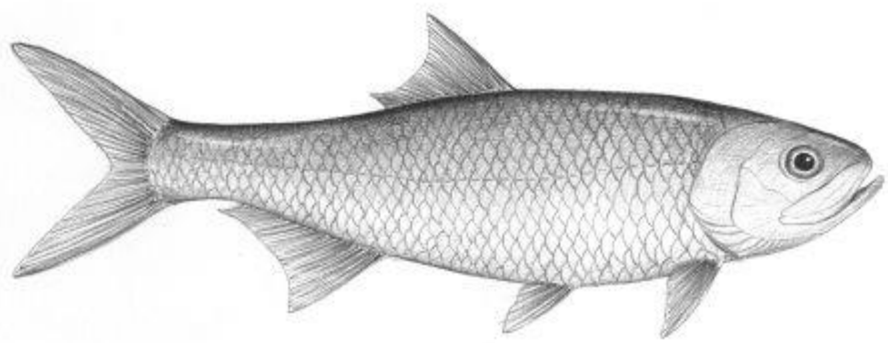
The sarcopterygians had fleshy or lobed fins. Few fish today are even distantly related to this group. The coelacanth and the lungfish are the only surviving sarcopterygians. In addition, certain scientists include the African bichir in this group. Some scientists believe that among fish, lungfish are the nearest living relatives of land vertebrates. The actinopterygians had rayed fins without fleshy lobes at the base. Among the first actinopterygians were the chondrosteans, which differed in many ways from modern ray-finned fish. The chondrosteans were the ancestors of today's ray-finned fish, which make up about 95 per cent of all fish species. The paddlefish and sturgeons are the only surviving chondrosteans, and most scientists believe the bichirs are their nearest relatives.



Nematoptychius, a ray-finned (actinopterygian) fish

The first sharks appeared during the Devonian Period. They looked much like certain sharks that exist today. The first rays appeared about 200 million years after the first sharks. By the end of the Devonian Period, nearly all jawless fish had become extinct. The only exceptions were the ancestors of today's lampreys and hagfish. Some acanthodians and placoderms remained through the Devonian Period, but these fish also died out in time.

The first modern fish, or teleosts, appeared during the Triassic Period, which began about 240 million years ago. The chondrosteans of the Devonian Period had given rise to another group of primitive bony fish, the holosteans. The holosteans, in turn, became the ancestors of the teleosts. The only surviving holosteans are the bowfin and freshwater gars.



Teleost fish, *Flindersichthys denmeadi*

The teleosts lost the heavy armour that covered the bodies of most earlier fish. At first, all teleosts had soft-rayed fins. These fish gave rise to present-day catfish, minnows, and other soft-finned fish. The first spiny-finned fish appeared during the Cretaceous Period, which began about 138 million years ago. These fish were the ancestors of such highly developed present-day fish as perch and tuna. Since the Cretaceous Period, teleosts have been by far the most important group of fish.

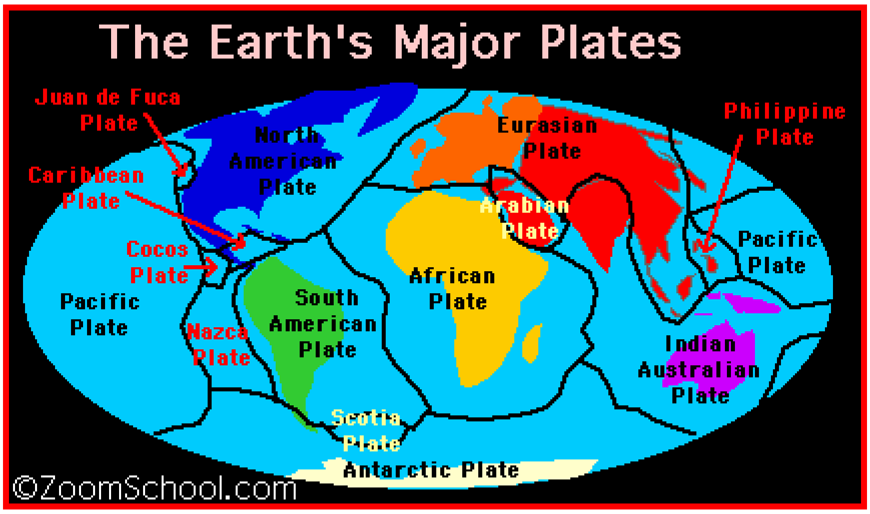
Where did the Land come from?

The Earth's rocky outer crust solidified billions of years ago, soon after the Earth formed. This crust is not a solid shell; it is broken up into huge, thick plates that drift atop the soft, underlying mantle.

The plates are made of rock and drift all over the globe; they move both horizontally (sideways) and vertically (up and down). Over long periods of time, the plates also change in size as their margins are added to, crushed together, or pushed back into the Earth's mantle. These plates are from 50 to 250 miles (80 to 400 km) thick.

The map of the Earth is always changing; not only are the underlying plates moving, but the plates change in size. Also, the sea level changes over time as the temperature on Earth varies and the poles melt or freeze to varied extents, covering or exposing different amounts of crust.

Earth's Major Plates:



The current continental and oceanic plates include: the Eurasian plate, Australian-Indian plate, Philippine plate, Pacific plate, Juan de Fuca plate, Nazca plate, Cocos plate, North American plate, Caribbean plate, South American plate, African plate, Arabian plate, the Antarctic plate, and the Scotia plate. These plates consist of smaller sub-plates.

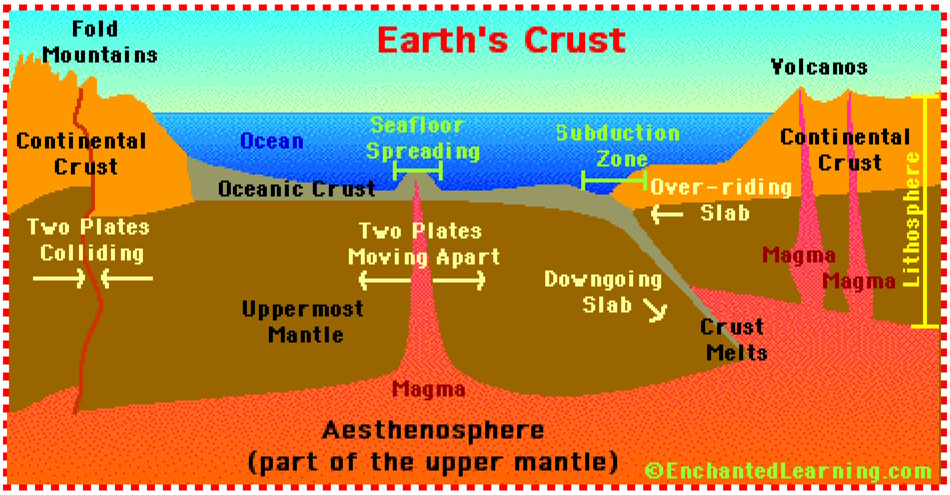
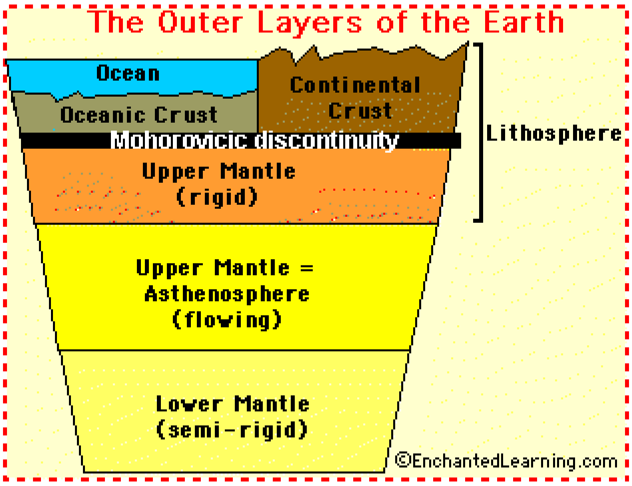


Plate Tectonics

The theory of plate tectonics (meaning "plate structure") was developed in the 1960's. This theory explains the movement of the Earth's plates (which has since been documented scientifically) and also explains the cause of earthquakes, volcanoes, oceanic trenches, mountain range formation, and many other geologic phenomenon.

The plates are moving at a speed that has been estimated at 1 to 10 cm per year. Most of the Earth's seismic activity (volcanoes and earthquakes) occurs at the plate boundaries as they interact.

Type of Crust	Average Thickness	Average Age	Major Component
Continental Crust	20-80 kilometers	3 billion years	Granite
Oceanic Crust	10 kilometers	Generally 70 to 100 million years old	Basalt



The top layer of the Earth's surface is called the crust (it lies on top of the plates). Oceanic crust (the thin crust under the oceans) is thinner and denser than continental crust. Crust is constantly being created and destroyed; oceanic crust is more active than continental crust.

Under the crust is the rocky mantle, which is composed of silicon, oxygen, magnesium, iron, aluminum, and calcium. The upper mantle is rigid and is part of the lithosphere (together with the crust). The lower mantle flows slowly, at a rate of a few centimeters per year. The asthenosphere is a part of the upper mantle that exhibits plastic properties. It is located below the lithosphere (the crust and upper mantle), between about 100 and 250 kilometers deep.

Dating the Past