Most people are aware that fossils (preserved life in historic rocks) are remains of the animals and plants that once lived on the Earth. But, few know that fossils are crucial keys that reveal our relation to that primitive cell, which most likely formed near about 3.5 billion years ago. Life as it exists today, evolved from that first mother cell.

The Earth was formed about 4.5 billion years ago and life began on the Earth over 3.5 billion years ago. Since the beginning, life has achieved three major steps in its evolution. The first was appearance of prokaryote organisms (single cell, cells devoid of nucleus, and DNA not arranged), then came eukaryotes (highly organized single cell, with nucleus within which reside the chromosome with arranged DNA) and finally multicellular organisms (combination of eukaryote cells). This evolution mainly occurred in the Precambrian time of the Earth’s history.

The entire geological time scale is mainly divided in two parts, Precambrian and Phanerozoic. The Precambrian is known as the age of “microscopic life” and Phanerozoic for “megascopic life”. The Cambrian time has great relevance in the Earth’s history because this was the time when crust was formed on the Earth’s surface ~ 4.0 billion years ago. Since Archean time, rocks have preserved history of evolution of life. At present, the world’s oldest fossils are known from the 3.3 to 3.6 billion years old Warrawoona Group rocks of Western Australia. Stromatolite and tiny filamentous fossils have been reported from these rocks.

Skeletalisation event was the key to the evolution of life from the early Cambrian arthropods to the giant dinosaurs and then on to humans.

Appearance of Prokaryotes

The most significant feature of Archean time is arrival of life. Scientists are agreed that both the essentials for the origin of life were present during this time: first, elements suitable for life and secondly energy source that could synthesize organic molecules. It is perceived that organisms are mainly composed of carbon, hydrogen, nitrogen and oxygen. These components were present in the early atmosphere of the Earth in the form of CO$_2$, H$_2$O, CH$_4$ and NH$_3$. The term ‘monomers’ is used for a combination of simple organic molecules containing mainly C, H, N, and O. Experimental evidence for the formation of monomers has been shown by Miller in 1953 who synthesized several amino acids through the mixture of some gases that existed in the early atmosphere of the Earth.
So, the earliest organic molecules might have been synthesized from atmospheric gases of the early Archean and subsequently the first cell (without nucleus) might have been formed. But this explanation of origin of life has been questioned by some workers, who propose that life originated via hydrothermal vent systems on the seafloor. According to this hypothesis, ocean water that contained large quantities of dissolved minerals percolated inside the rocks through cracks and fissures, and was heated by hot magma, and then again came to the surface through hydrothermal vents in a complex form including organic molecules.

As per general understanding, elements and energy are required for the synthesis of molecules; the hydrothermal vent system fulfills both requirements. Even amino acids have been discovered in modern hydrothermal vent systems on the seafloor. Through this complex process protocell would have been formed in the Archean.

The earliest living organisms on the Earth were undoubtedly prokaryotes and primitive prokaryotes were bacteria and cyanobacteria (blue-green algae). The filamentous forms have been reported from the Warrawoona Group rocks of Australia, which is considered to be 3.5 billion years old. This fossil record is considered as the oldest evidence of prokaryote type of life. However, their presence in the Archean was scarce but they thrived during the Paleoproterozoic (2500-1600 Ma). Well-preserved prokaryotes have been documented from the 2 billion years old Gunflint chert of Precambrian Iron Formation of Canada.

Concepts of evolutionary trend within the prokaryotes have also been proposed by some workers mainly by the J. W. Schopf of California University. In evolution of bacteria, anaerobic bacteria came first than aerobic bacteria and this evolutionary change happened in between 3.5 to 2.5 billion years ago (mainly in Archean time). Since it has been revealed by some studies that primitive atmosphere had less O₂ or may be totally absent, therefore, anaerobic bacteria may have appeared before the aerobic bacteria.

Appearance of Eukaryotes

All living organisms, other than prokaryotes, are eukaryotic. Eukaryotic cells are higher in organization than prokaryotic cells. Present paleobiological studies indicate that they evolved during the Proterozoic time. Cyanobacteria (aerobic) increased oxygen level in the primitive atmosphere through the process of photosynthesis and it is thought that this presence of free oxygen in the atmosphere triggered the evolution of eukaryotes.

Multicellular Organisms

In the evolutionary fossil records of eukaryotes, it is very difficult to distinguish between the appearance time of single and multicellular eukaryotes. However, some metaphytes (multicellular algae) have been documented from the 1.7 billion year old Tuanshazi rock of the Jixian area of North China. Accordingly, we can assume that the first unicellular eukaryotic organisms evolved ~2 billion years ago followed by multicellular eukaryotes ~1700 million years ago. Multicellular organisms are composed of many cells of eukaryotes. Accordingly, in the evolutionary order of life we can propose that unicellular eukaryotes gave rise to multicellular organisms.

Multicellularity evolved among unicellular organisms because: i) multicellularity increased the size, due to which less number of cells are exposed to the external environment, ii) process of
records is documented from rocks younger than 600 million years.

**Explosion of Life**

Animal life achieved its multicellularity ~ 600 million years ago, but at that time life was very simple and only soft bodied worm-like creatures were present. The Ediacaran period (635-542 Ma) in which this soft bodied life existed, closed ~ 542 million years ago. The Precambrian era also ended with the Ediacaran time, and the Phanerozoic era started from here.

The major criterion that is used to distinguish both the time frames is abrupt presence of life from Cambrian onwards. The sudden appearance of major animal phyla in fossil records is known as “Cambrian explosion”. This life explosion brought calcareous algae, sponges, molluscs and echinoderms etc. on the Earth, most of them extant up to the present. So, the major animal phyla on Earth appeared ~ 542 million years ago.

Now, what happened on the Earth in the Cambrian time due to which life exploded and diversified? There are lots of explanations and hypotheses.

During transition time between Ediacaran and early Cambrian (635-542 Ma), the existing atmosphere was also in an evolutionary stage. The significant change was build-up of free oxygen in the atmosphere as a result of photosynthesis process, which finally attained a level sufficient to support fast evolutionary process, resulting in the bloom in animal life.

Marine transgression (rise of sea level), which happened immediately after the latest Neoproterozoic (635 Ma) glaciation (ice sheet) event due to warming of climate, opened new shallow water ecological niches (life favorable environment) near the shelf zones of continents. Accordingly the availability of food increased.

Due to this marine transgression, phosphorous accumulated in the deep sea was brought up near the shelves thus also increasing the nutrient level. Phosphorus is essential for life and this event triggered the sudden diversification of animal life. Accordingly the deposits of the phosphorite along the Precambrian-Cambrian boundary are recorded the world over. Phosphorite deposits in the Lesser Himalaya region (mainly in and around Mussoorie township of Uttarakhand) of India also correspond with this great historical event.

**Appearance of Hard Skeleton**

At what time did life get its skeletal part, and what were the reasons behind it? Interestingly, the diversification of life and its skeletonisation were both a simultaneous event. Skeletonisation event has also been dated ~542 million years ago. The only minor difference in both events is that life diversified highly during 530-520 million years ago, but obtained skeletonisation a little earlier, ~ 548-542 million years ago. We can assume that the skeleton gave protection to life and due to this life diversified later.

Some studies show that eukaryotic cells are able to produce protein substances, capable of mineralization. Another view regarding skeletalisation is that, the calcareous or phosphatic material originated as an excretory product, which was accumulated over the skin and hardened it. Some organisms have mechanical tendency to make their own envelope through available surrounding material, called agglutination; this also served as the primary skeleton.

Shells (hard armour) of Cambrian animals were mainly composed of calcium phosphate and calcium carbonate, and so large accumulation of both substances along the Precambrian-Cambrian boundary was a possible factor leading to hardening of animal shells. It is also suggested that the phosphate excreting process was developed in animals at the time of high phosphate availability in the ocean. Some studies indicate that oxygen level that was increasing during Precambrian-Cambrian transition enhanced the producing power of skeletal mineral (organic) and protein.

Once the hard part developed, organisms used it as protection, support, friction against surrounding hard things, and increasing muscle power. Finally, skeletonisation event was the key to the evolution of life from the early Cambrian arthropods to the giant dinosaurs and then on to humans.