"Early Geological and Biological History"

- Reconstructions of the geological and biological history of Earth are closely connected because of the central role of fossils in assigning ages to rock units. Major discontinuities in the rock record and in the corresponding fossil record are used as the dividing lines between geographical ages.

Within each age the pace of geological and biological change is modest; at the ends of ages, the changes are often profound. Because of the common use of distinctive biological markers (index fossils) to define the ages of ancient rocks, early geologists named the geological ages starting with the first in which fossil evidence of life was clear and unambiguous. The first few geological ages were named after their first-known and best-documented locales in Great Britain; the Cambrian, Ordovician, Silurian, and Devonian periods all were characterized and named at that time.

The later Mississippian and Pennsylvanian periods obviously were defined by type examples in the United States.

- The beginning of the oldest of these periods, the Cambrian, dates back to 570 MaBP (before the present). All rocks earlier than these, which were devoid of fossils that could be identified at that time, were lumped together as the Precambrian. Thus the vast span of time from 4.6 to 0.57 GaBP bore a single name, even though it accounts for some 88% of the age of our planet.

For convenience, the Precambrian is now subdivided into the Hadean era, > 3.9 GaBP, from which no rocks survive; the Archaean of Early Precambrian period 3.9 to 2.5 Ga ago, from which rocks but no fossils are known (also called the Azoic, or lifeless, Era); and the Proterozoic (first life) period from 2.5 to 0.57 GaBP, throughout which simple life forms populated Earth's oceans. The Proterozoic is for convenience further subdivided into the Middle Precambrian, 2.5 to 1.7 GaBP and the Late Precambrian, 1.7 to 0.57 GaBP.

- In recent years the latest Precambrian, especially in British Columbia and in Australia, has yielded fascinating glimpses of bizarre life forms that preceded the well-documented proliferation of fossil forms in the Cambrian Era.

- Geologists in the 18th century assembled enough information about the sequence of fossils in consecutive layers of sedimentary rocks to found both a science of fossils (paleontology) and a science of relative geological chronology (stratigraphy).

Absolute ages were then difficult to estimate, because radioactivity had not yet been discovered. Estimates of sedimentation rates derived from studies of modern processes were used by many geologists to suggest approximate times needed to produce the complete thickness of sediments in the marine geological record; estimates ranged from tens if millions of years upward.

Such estimates were severely attacked by the religious establishment, who based their official estimate of the age of Earth on the chronology published by Bishop James Ussher.

- The earliest evidence of life on Earth is the presence of biogenic organic matter in sedimentary rocks dating back to 3.8 GaBP.
- The earliest microfossils, the fossilized remains of bacteria and filamentous algae.
- The period from the oldest rocks to 2.5 GaBP is called the Archaean or Early Precambrian.

- The atmosphere at this early stage was certainly not strongly oxidizing (negligible free oxygen) and may have been a chemically reducing mixture of water vapor, lower hydrocarbons, and ammonia.
- It is possible that primitive unicellular life (or virus-like noncellular life) arose (in the Archaean Period) and was destroyed repeatedly until the surface environment became stable enough for life to persist.

In any event, the first cells were simple lipid membrane bags containing a soup of enzymes, proteins and DNA.

- The next benchmark in the development of life is the rise of autotrophic cells capable of synthesizing organic matter directly from inorganic gases and solar energy.

  (autotrophism: Literally self-feeding, a method of obtaining nutrients in which the principle carbon source is inorganic, usually carbondioxide)

- The earliest organisms to turn to actual oxygen gas production were probably prokaryotic blue-green algae.

  (prokaryote: A primitive type of unicellular organism lacking a nucleus and other cell organelles)

- The first appearance of blue-green algae around 3.2 GaBP.

- With the rise of oxygen came the photochemical production of ozone (o_3). Until oxygen was well established through photosynthesis, solar UV with wavelengths as short as 200 nm could penetrate to the surface. Such radiation destroys all of the chemicals essential to life, including DNA itself. The emergence of life onto land may have been enabled by the achievement of a critical ozone opacity or by the appearance of protective pigments and enzymes.

- In the middle and late Precambrian nucleated eukaryotic cells appeared and became very important. According to theoretical biologist Lynn Margulis of Boston University, these cells came about as a result of symbiosis of prokaryotic cells that produced mutually beneficial products. Colonies of such cells eventually gave way to mixed colonies of different types of cells, which came to function as "organs" in larger organisms, both plants and animals.

- The Cambrian period (570 to 500 MaBP) was marked by the emergence of a wide variety of molluscs with shells of calcium carbonate (bivalves, and snails) or of calcium phosphate (lamp shells). Creates morphologically similar to modern horseshoe crabs, the trilobites, abounded in the Cambrian seas, as did sponges, worms and anemones, echinoderms rather like modern sea cucumbers and early scorpion-like arachnids.

- The middle Cambrian was noteworthy for the extraordinary diversity and richness of life contained in it. The great success of animals at this time was surely related to the rise of oxygen, which made much more energetic modes of metabolism available. In places in western North America, Cambrian sediments attain a thickness of about 4 km.

- During the Ordovician period (500 to 430 MaBP) many species of trilobites, corals and colony-forming bryozoans flourished. Crinoids (sea lilies; echinoderms related to starfish, sand dollars, sea urchins and sea cucumbers) were common. The dominant life-forms of the time were large molluscs, including huge nautiloids with straight conical shells extending up to 4 m in length. The nautiloids and other cephalopods such as the squid and octopus were to remain very important until as recently as 65 MaBP.

- The Silurian period (430 to 395 MaBP) saw a continuing proliferation of the families and genera that were established in the Ordovician. Perhaps the most striking innovation of this period was the emergence of plants onto the land beginning in the latest Ordovician. Algal colonies, crinoids and corals flourished. Huge scorpion-like eurypterids, related to modern horseshoe crabs, grew to lengths of about 3 m and jawless (agnathan) fishes gained prominence.

- The Devonian period (395 to 345 MaBP) was distinguished of fishes, land plants and amphibians. It is at this time that animals first emerged onto the land. The agnathan fishes, plated fishes, bony fishes and prospered, culminating in the 10-m placoderm Dinichthys. The lobe-finned fishes gave rise to the first pioneering amphibians. Trilobites were driven to the verge of extinction.

- During the Mississippian period (345 to 320 MaBP) the proliferation of corals, crinoids and the closely similar blastoids, brachiopods and colonies of tiny bryozoans continued. On the land, forests continued to spread throughout all moist areas and the amphibians followed.

- The culmination of the spread of land planets in the Pennsylvanian period (320 to 280 MaBP) led to the formation of vast coal deposits. Forests of giant scale trees and seed ferns up to 50 m in height were widespread. Insects, including 30-cm cockroaches and protodragonflies with 90-cm wing-spreads, lived in these forests and left occasional fossil remains in the coal. Diversification of the amphibians led to the appearance of several types of primitive reptiles.

- The Permian period (280 to 225 MaBP) marked the transition from Pennsylvanian-type wet forests to primitive conifers, with an extension of the range of land plants to ever drier terrains. Insects, fishes and amphibians did well, and the reptiles proliferated wildly. Reptiles diversified into a variety of forms, most notably the squat Seymouria, which looked like a cross between a lizard and a frog , and the sail-backed carnivore Dimetrodon.

Some reptiles, such as the crocodile-like mosasaurs, found attractive niches in the sea. Unlike the early amphibians and reptiles, the theriodonts walked erect upon their legs, rather than sprawling on the ground. This mode of locomotion must have enhanced their agility and competitive success. The close of the Permian marks the greatest extinction event in the history of Earth and closes the pages of the Paleozoic ("ancient life") era.

This extinction event, which coincided with the beginning of the breakup of the Pangaea supercontinent, saw the disappearance of many families of foraminifera, crinoids, cephalopods, bryozoans, corals and brachiopods. The trilobites and blastoids utterly vanished.

- The Mesozoic (“middle life”) Era (225 to 65 MaPB) was the great age of the reptiles, when dinosaurs ruled the Earth unchallenged for 160 million years.

- The Triassic period (225 to 190 MaBP) saw the rise of the reptiles to dominance over the dry land and the emergence of the first dinosaurs. In the wake of massive extinctions in the sea, the coiled cephalopod “ammonites” rose rapidly in prominence and diversified and multiplied to an astonishing extent.

“Ichthyosaurs”, looking like toothy dolphins, ruled the seas and ate unwary ammonites. Modern looking corals, crinoids and arthropods resembling modern lobsters appeared in the sea. On land, cycads and conifers prospered in dry terrains, as did ferns and rushes in swamps.

- During the Jurassic (190 to 136 MaBP) the three main groups of dinosaurs reached their first culmination. The "sauropods", including Diplodocus and Apatosaurus (formerly called Brontosaurus), with very long necks and tails, elephantine legs and negligible intellects, were the largest and tallest herbivores. The "stegosaurs", with heavily armored and spiked backs and tails and 100-g brains, better adapted to grazing on low vegetation on dry land than to browsing, also failed to develop higher mathematics.

The "theropod" carnivores, such as Allosaurus ate the herbivores fir survival. The duck-billed herbivorous dinosaurs also appeared at this time. The first flying reptiles appeared. The rat-sized true mammals put in their first inauspicious appearance and the first true bird, Archaeopteryx, flew.

- The Cretaceous period (136 to 65 MaBP) was the last great age of the dinosaurs. The varied ranks of dinosaurs were joined by the “ceratopsians” (bone heads) such as Triceratops, tanklike “ankylosaurs”, and large duck-billed “ornithopods”. Huge plesiosaurs up to 13 m in length roamed the seas.

- The flowering plants (angiosperms) appeared in the lower Cretaceous and came to dominate the surface of the planet by the end of the Cretaceous period.

- Animals and insects adapted to the new sources of high-quality food provided by fruits, grains, nuts, berries and seeds.

- High-metabolic rate animals such as small mammals and birds were benefitted from these high-quality food.
- The entire rich tapestry of Cretaceous life was torn asunder by a giant impact event 65 Ma ago. An asteroidal body traveling roughly 20 km/s struck the continental shelf on the north slope of Mexico's Yucatan peninsula, driving tsunami waves deep into the interior of the continent

The sea surged back into the red-hot 180-km cavity left by the impact and boiled vigorously. Vaporized target rock rich in carbonates and sulfates fed a huge fireball with carbon dioxide and sulfur dioxide. Rock vapor in the fireball began to condense to a fine dust. Haiti, then much closer to the Yucatan than it is today, was battered by towering waves and buried under meters of crater ejecta. Rock ejected at near orbital speed from the impact crater flew all over the Earth, liberating so much energy upon reentry that the sky heated up to over 1000 °c.

The forests of Earth, grilled by several minutes of intense radiation, burst into flames, raising immense globe-girdling clouds of soot, and burned to the ground. The burning sky went black with dust and soot. Some 90% of the species on Earth were destroyed, including the last dinosaurs. Of all the wealth of animal life of the Cretaceous, only small burrowing animals massing less than about 20 kg survived to face a world permanently altered. Among them were our ancestors.

- Over the following months, acid rain charged with sulfuric, nitric and nitrous acids deluged the continents and poisoned the seas, washing vast amounts of iridium bearing asteroidal dust from the skies. Hugh amounts of nitrates and organic matter from decaying plants fecundated the oceans, sparking an explosive proliferation and diversification of life. And the lowly mammals, at last given an opportunity, became masters of the world.

- In the Cenozoic Era (recent life) the biosphere reestablished its dynamic balance with mammals at the top of the food chain.

- During the Tertiary period (65 to 2 MaBP) the whales replaced plesiosaurs; huge grazing mammals such as Megatherium, Titanltherium, and elephants replaced the sauropods; and the giant cats such as the saber-toothed tiger, Smilodon, replaced the theropods.

- The last 2 million years constitute the Quaternary period, within which humans became the dominant higher life form on Earth. The anthropoid apes, which had little influence on the world of 5 million years ago, produced one offshoot species called Homo sapeins sapiens.

"The Ascent of Man "

- Where did we come from?

- Who were our ancestor?

- The species of human is called *"Homo sapiens sapiens".*
- The genus "Homo" designates an anthropoid mammal that stands and walks upright on its hind limbs and has or had a cranial capacity greater than about 800 cubic centrimeters.

- The most advanced representatives of the genus "Homo" has a general range of brain capacity of 1,200 to 1,400 cm^3 (going as high as 1,800 cm^3 or rarely 2,200 cm^3 in large males).

- From many researches one reached the conclusions. First, man is a product of ordinary and universal evolutionary forces involving natural selection. Second, he is the descendant of creatures that, if not called apes, would have to be called ape-like. Finally, although closely related to them, he differs in significant ways from the apes.

- The Distinctive Features of *Homo sapiens sapiens*

- The paleontologist G.G. Simpson in a 1968 paper:
  1. Posture is normally upright.
  2. Legs are longer than arms.
  3. Toes are shot, the inner toes frequently longest and not divergent.
  4. The backbone makes a gentle S-shape curve.

5. The hands are prehensile, with a large opposable thumb.
6. Body hair is short, sparse, and inconspicuous compared with that of most other land mammals.
7. The neck joint is at the center of the skull base.
8. The brain is uniquely large in proportion to the body, the cerebrum being especially large and complex.

9. The face is short and flat, descending almost vertically below the front of the brain.
10. The jaws are short, with a rounded dental arch instead of a U-shaped one with parallel sides as the apes and lower anthropoids.
11. The canine teeth are usually no longer than the premolars, and gaps are not normally present in front of or behind the canines.

12. The first and second lower premolars are similar and the structure of the teeth is distinctive of the omnivorous feeding habit.

- But, what is man?
- Simpson's and Darwin's thought on the main features of humanness:

1. Man consciously and systematically both makes and uses tools in great variety, often combining more than one material and element for a single purpose.
2. Man's behavior is more flexible and responsive to changing externalities.
3. Man shares with other advanced animals the complex attributes of curiosity, attention, memory, and imitation, but he has developed them to higher levels.

4. Man reasons and adapts his behavior in rational and often far-sighted ways.
5. Man is above all a cultural and social animal that consciously and consistently bands together for mutual benefit and has developed culture and societies unique in complexity.
6. Man thinks abstractly and develops related vocalizations and symbolisms, chief among which are language and writing.