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Geological and Paleontological Evidences for Biological Evolution; An Overview

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ABSTRACT

This study was carried out to examine the geological and paleontological evidence supporting the biological evolution of certain vertebrates and invertebrates. It also emphasises the importance of tracking the evolution process over the geologic time scale, particularly as recorded by the fossil record, as fossils are the primary source of information on the evolution of planet life. We would not be aware of extinct species like dinosaurs and trilobites without the information they offer. Furthermore, we wouldn't be able to directly determine when important biological events like the beginning of life, the formation of shells or skeletons, the colonisation of the land, the emergence of blooming plants and animals, the creation of flight, other significant incidents occurred of extinction. But according to this study, the invertebrate fossil scallop Chesapecten changed over a period of roughly 13 million years. The presence of legs, for example, distinguishes a class of vertebrate animals known as tetrapods, such as Temnospondyls, most of which had long, narrow bodies, large, fat skulls, and relatively short legs. Since the skeletons of Archaeopteryx and Compsognathus are so similar, several Archaeopteryx specimens were initially mistakenly categorised as Compsognathus. However, they are now considered to be directly descended from reptiles. The earliest reptiles had characteristics similar to those of mammals, and skull studies reveal how the ear area and jaw articulation changed as reptiles evolved into mammals. The cephalopods, also known as osteostracans, are the most well-known group of early jawless fishes that eventually evolved into jaw fishes. Horse evolution began with significant changes in size and morphology during the Eocene era, about 60 million years ago. The finding of hominid fossils and artifacts has accelerated during the last 20 years, and the human family tree is now considered to be much more branched and less linear than previously imagined.

الأدلة الجيولوجية والحفريات على التطور البيولوجي؛ نظرة عامة

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أُجري هذا البحث لفحص الأدلة الجيولوجية والحفريات التي تدعم التطور البيولوجي لبعض الفقاريات واللافقاريات .كما أنه يبرز أهمية تتبع عملية التطور على مقياس الزمن الجيولوجي، خاصة كما هو موثق في السجل الأحفوري، حيث أن الأحافير هي المصدر الرئيسي للمعلومات حول تطور الحياة على كوكب الأرض .لن نكون على دراية بالأنواع المنقرضة مثل الديناصورات والترايلوبتات بدون المعلومات التي تقدمها .علاوة على ذلك، لن نكون قادرين على تحديد مباشرة متى حدثت أحداث بيولوجية هامة مثل بداية الحياة، وتكوين الأصداف أو الهياكل العظمية، واستعمار اليابسة، وظهور النباتات والحيوانات المزهرة، وخلق الطيران، وغيرها من الحوادث الهامة التي أدت إلى الانقراض .لكن وفقًا لهذه الدراسة، تغيرت المحار اللافقاري المنقرض Chesapecten على مدى فترة تقارب 13 مليون سنة .وجود الأرجل، على سبيل المثال، يميز فئة من الحيوانات الفقارية المعروفة باسم رباعيات الأطراف، مثل تمناسونديلز، التي كان معظمها يمتلك أجسامًا طويلة وضيقة، وجماجم كبيرة وسمينة، وأرجلًا قصيرة نسبيًا .نظرًا لأن

هياكل Archaeopteryx و Compsognathusمتشابهة جدًا، فقد تم تصنيف العديد من عينات Archaeopteryxبشكل خاطئ في البداية على أنها .Compsognathus ومع ذلك، يُعتبرون الآن منحدرين مباشرة من الزواحف .كانت الزواحف الأولى تتمتع بخصائص مشابهة لتلك الموجودة في الثدييات، وتكشف دراسات الجمجمة كيف تغيرت منطقة الأذن وتركيب الفك مع تطور الزواحف إلى ثدييات .الرخويات، المعروفة أيضًا باسم الأوستيوستراكان، هي المجموعة الأكثر شهرة من الأسماك البدائية عديمة الفكوك التي تطورت في النهاية إلى أسماك ذات فكوك .بدأ تطور الخيول بتغيرات كبيرة في الحجم والشكل خلال عصر الإيوسين، قبل حوالي 60 مليون سنة .لقد تسارعت اكتشافات الحفريات والأدوات البشرية خلال العشرين عامًا الماضية، ويُعتبر الآن أن شجرة العائلة البشرية أكثر تفرعًا وأقل خطية مما كان يُعتقد سابقًا.

INTRODUCTION

Evolution is one of the basic ideas that underpin modern science. This compelling argument explains things like the fossil record's record of life, the physical, molecular, and genetic similarities and differences across creatures, and the geographic distribution of living things both now and in the past. In fact, data from a wide range of scientific fields supports the idea that evolution is the basis of contemporary biology and palaeontology. In the viewpoint of the general people, evolution is also one of the most disputed and misinterpreted ideas. This circumstance is regrettable as there is no need for the evolution debate. One reason people oppose evolution is because they don't grasp how science differs from religion. Different approaches to understanding the Earth are offered by science and religion. And universe. Scientists are limited to natural, testable explanations because they test hypotheses. By definition, science cannot prove or disprove the existence or activity of a Creator; such issues are outside its purview.

Consequently, evolution as a scientific theory cannot allude to a Creator. Although numerous religious groups have released declarations endorsing evolution, many religious individuals, including scientists, do not see any conflict between evolution and their faith. Science and religion don't have to clash. There are several lines of evidence that demonstrate how life has evolved over time. The most plausible scientific explanation for this development is evolution. This paper summarises the processes involved in fossilisation and evolution and presents a limited amount of the data supporting this transition, particularly as recorded by the fossil record. There are still many intriguing unanswered questions about the origins of life and its evolutionary path.Charles Darwin described biological evolution as "descent with modification," or the alteration of organisms in subsequent generations.

This can also be stated as "species of organisms originate as modified descendants of other species"(Hurry, 2001). The process by which previously existing species give rise to new ones throughout time is known as biological evolution. The fundamental idea that unifies natural history is evolution, which also serves as the basis for all of contemporary biology and palaeontology.

For knowledge on the evolution of life on Earth, fossils are the primary source. We wouldn't know about extinct species like trilobites and dinosaurs without the information they provide us, and we could only learn about the creation and evolutionary relationships of the current flora and fauna from the living things themselves. Furthermore, we wouldn't be able to directly determine when important biological events like the beginning of life, the formation of shells or skeletons, the colonisation of land, the emergence of flowering plants and animals, the development of flight, and significant extinction crises occurred (Hurry, 2001).

Modes of Fossilization

Fossil preservations come in two primary varieties:

1. Modification of preservation

2. Preservation through direct means

The most prevalent is the change of fossil preservation. This is a partial to complete transformation of the original biological substance into new stuff. But Figure 1 shows the several ways to preserve fossils (Hurry, 2001).

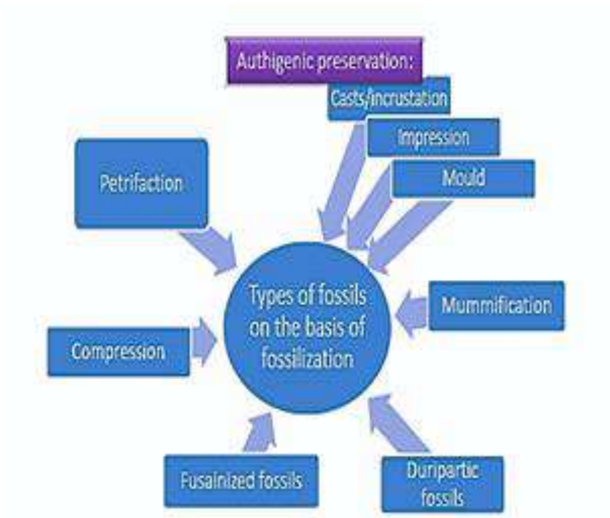

Fig. 1 Fossils preservation types

1. Fossils: are the naturally preserved remnants of a creature from a previous geologic epoch, as seen in Figure 2.

Fossils Evidences for Life Evolution

Fig. 2 Fossils preservation

2. Impression: An impression is a fossil showing the negative imprint of parts of an organism in rocks. No organic matter is present, but the line of external features of the parts of the organism is discernable (Figure 3).

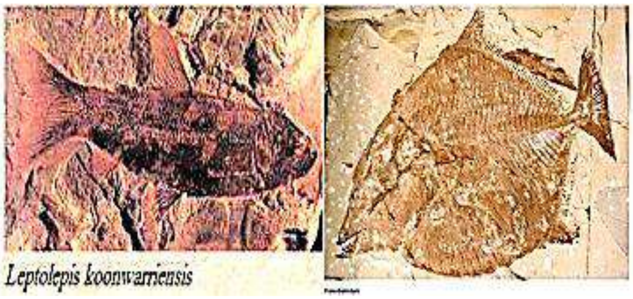

Fig. 3 Fossils impression on hard rock

3. Compression: As seen in Figure 4, the fossil is a compacted opaque black carbonaceous film that has been preserved in the rock while maintaining the organism's original outward characteristics and contour.

Fig. 4 Fossils compression on the rock

4. Mould: is a bad representation of a three-dimensional organ or creature that is imprisoned in a rigid material, losing its biological content and leaving a hollow in its shape.

External mould ***Internal mould***

Fig. 4.Fossils compression on the rock

5. Cast is an in-mold cast, which is a positive three-dimensional reproduction of the organic remnants of the original organism or organ created when mud, sand, or mineral stuff fills the mold's chamber and then solidifies (Figure 5).

Fig. 5 Fossils preserved as cast

STUDY OBJECTIVES

The following are the primary goals of this study:

1. To differentiate between the importance of studying the geological and paleontological sciences in order to identify biological evolution.
2. To acknowledge the biological evolution across geologic eras of some invertebrate and vertebrate animals.
3. Showcase the value of fossil records as primary sources of information about the development of life on Earth.

METHODOLOGY

The material used in this review study was gathered from a variety of sources, including published research studies, papers, articles, and textbooks, as well as from the geological, paleontological, and biological Literature Review Databases.

EVOLUTION PROCESS

Evolution is the process by which something gradually changes, particularly from simple to more complex forms. The methods via which various living organism types are believed to have evolved and diverged from previous forms throughout Earth's history are referred to as evolution in the biological sciences.

Changes in heritable genetic features within biological populations over the course of multiple generations are another aspect of biological evolution (originally identified by Gregor Johann Mendel in 1865). Numerous scales, including as the molecular, cell, organism, species, and environmental community levels, are involved in evolution (1).

1. Evolution and Fossil Record

There are several uses for the fossil record.

1. It offers concrete proof of evolution.
2. Illustrates the evolution and diversification of lineages across time.
3. Provides details regarding the modes of development.
4. Provides data about evolution's rate.

2. Geologic Time Scale

was first created prior to the development of radiometric dating and the overwhelming support for evolution.

The five eras that make up the Geologic Time Scale are further subdivided into periods according to the following shifts in the kinds of fossils discovered:

1. Arachaen: started 3.6 bya ago, with mainly prokaryotic organisms and mostly reduced sediments (no oxygen available). At the conclusion of the era, at 2.5 bya ago (billion years ago), oxygen-producing photosynthesis was first observed, most likely from some bluegreen algae.
2. Proterozoic: first eukaryotes appeared 2.5 bya, followed by multicellular creatures 2.0 bya. The earliest identifiable members of current phyla (such as Cnidaria, Annelida, and Arthropoda) appeared around 650 million years ago, or 1 bya. This period is known as the pre-Cambrian period.
3. Paleozoic: split into six eras, starting 540 million years ago
4. Mesozoic: split into three eras, starting 250 million years ago
5. Centennial: started 65 million years ago and split into two periods

The following is a detailed description of the previous three eras:

1. Paleozoic 540 Mya era, which is separated into six phases
   1. Cambrian: Marine life became more diverse, the majority of contemporary animal phyla emerged quickly, and the earliest vertebrates (agnathans)
   2. The Ordovician, 500 million years ago, saw the diversification of several animal phyla and the cessation of catastrophic extinction.
   3. The Silurian period (440 million years ago) saw the emergence of several agnathans, the first jawed fishes, including bony fishes, insects, and terrestrial vascular plants.
   4. Devonian 410 mya, often known as the "Age of Fishes," saw a huge extinction at the conclusion of the era and a tremendous variety of fish species, including sharks, bony fishes, amphibians, ferns, and seed plants.
   5. Carboniferous - 360 mya - first flying insects, first reptiles, and first forests of early ferns, seed plants, etc. (plant remnants from this time formed many coal deposits).
   6. Permian, 300 mya; further diversity; first reptiles resembling mammals; cataclysmic extinction of the majority of marine life at the end of period
2. Mesozoic division of the era (250 mya) into three phases
   1. Triassic: first continental split, Pangean division, diversity of marine and terrestrial life, including the first animals and dinosaurs
   2. The Jurassic Period (200 Mya, or the "Age of Dinosaurs") saw the diversification of several reptilian groups, the earliest birds and mammals, but the majority of species were tiny, and the dominance of gymnosperms in plant life.
   3. Cretaceous: 145 million years ago, the greatest extinction occurred, the continents completely separated, dinosaurs, birds, and mammals continued to diversify, and flowering plants became more diverse. This period is known as the "Cretaceous-Tertiary boundary."
3. Cenozoic era with two eras (65 mya)
   1. Tertiary: 65 million years ago, continents reached their current locations. Mammals diversified and occupied niches that had previously been occupied by reptiles, as well as a variety of blooming plants and pollinating insects and teleost (spiny-finned) fishes.
   2. Quaternary: two million years ago; several glaciations, the extinction of great animals, the development of modern people, and agriculture

The five epochs that make up the Tertiary Period are the Paleocene, Eocene, Oligocene, Miocene, and Pliocene.

There are two distinct epochs within the Quaternary Period: Pleistocene and Holocene. The present epoch is the Holocene (2).

The timing and relationships between events that have happened in the geologic record are related using the geological time scale. Radioactive dating, the existence of plant and animal fossils, and the relationships between rock types and strata have all been utilised by geologists and earth scientists to piece together a timeline of historical events that have taken place across geologic time. A unique kind of rock system is generated during each of the four major geologic time periods known as Aeons: Hadean, Archean, Periods, and others. Certain periods are separated into epochs that are not depicted in Figure 6 or Chart 7.

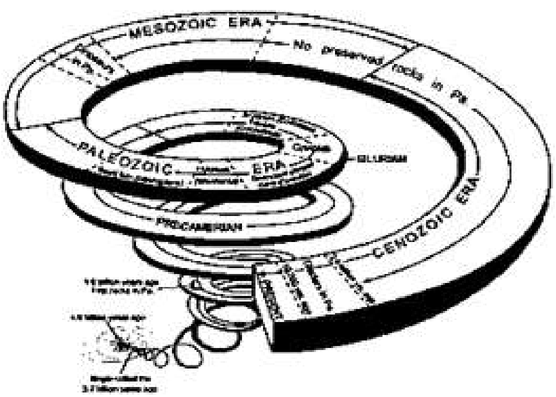

Fig. 6 Geological time scale

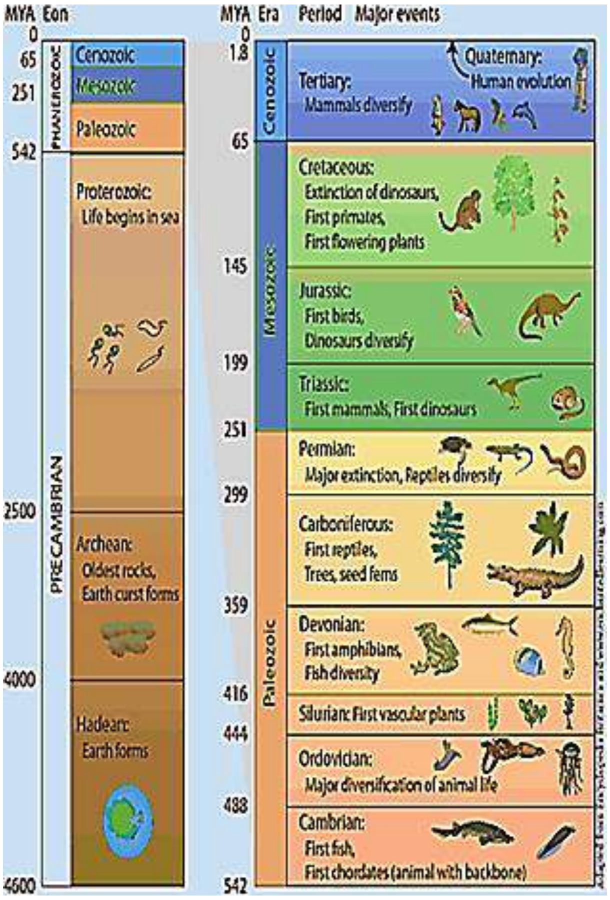

Fig. 7 Chart of geologic time scale with biological distribution (William, 2019)

EXAMPLES OF EVOLUTION

Numerous well-documented instances of species transitions and the emergence of novel physical traits may be found in the fossil record.

Because it offers a temporal perspective for comprehending the development of life on Earth, evidence from the fossil record is special. Other scientific disciplines and databases that facilitate the study of evolution do not offer this viewpoint.

Examples of evolution from the extraordinarily rich and amazing fossil record of life on Earth are discussed in this section. The main reason we picked vertebrates—animals with backbones—as examples is because most of us can more readily relate to this group. Nonetheless, there are other studies of evolutionary changes observed in extinct plants, invertebrates, and creatures without backbones that we may have selected as the Chesapecten scallops.

1. Evolution of Invertebrate

Variations in the ribs on the shell and the "ear" on the upper right of each shell (see arrows) are two examples of how the fossil scallop Chesapecten changed during a period of around 13 million years (John et al., 2020). as seen in Figure 8.

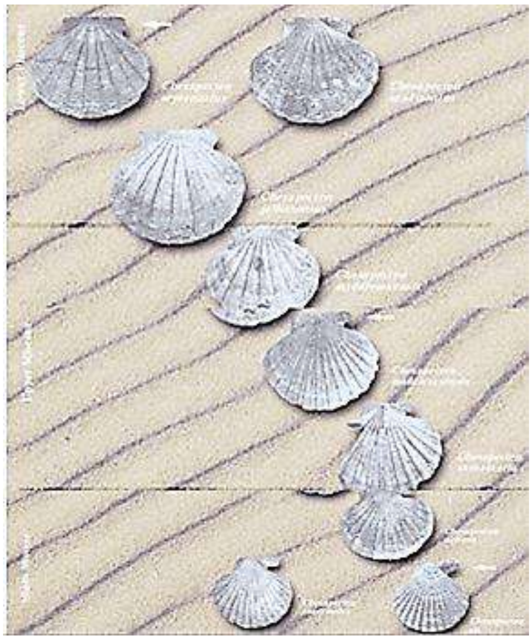

Fig. 8 Changes in the fossil scallop *Chesapecten* (John et al., 2020)

2. Evolution of Vertebrate

A category of vertebrate creatures known as tetrapods differ from fishes, which have fins as an appendage, in that they have legs. Most fish are referred to as "ray-finned" because of the way their thin bony fin supports are placed, which resembles a fan's rays. Among the live ray-fins are bass, trout, and perch (Betancur et al., 2013).

Some fish are referred to be "lobe-finned" due to the robust, bone supports in their appendages. Around 377 million years ago, in the early Late Devonian period, lobe-finned fish made their first appearance in the fossil record. Some lobe-finned fishes have bony supports that are arranged similarly to the bones in tetrapods' forelimbs and hindlimbs: one upper bone, two lower bones, and numerous small bones that are the ancestors of wrist and ankle bones, hand and foot bones, and fingers and toe bones that were first identified in Late Devonian amphibian-like animals around 364 million years ago. They were the original tetrapods. Additionally, there are many parallels between amphibian-like tetrapods and Devonian lobe-finned fishes in terms of skull bones and other skeletal components. The distinction between what constitutes a fish and what constitutes a tetrapod is actually in dispute because of how similar certain fossils are to one another (Betancur et al., 2013). The temnospondyls are the biggest and most varied group of these late Paleozoic-early Mesozoic tetrapods. Previously known as "labyrinthodonts," the majority of them possessed short legs, long, narrow bodies, and huge, fat heads. Some of the significant early tetrapods are shown by specimens in Figure 9. (A) A gigantic contemporary salamander skeleton is in the foreground, surrounded by the massive temnospondyl Eryops from the Lower Permian strata of north Texas. Figure 9 (B) shows the skeleton of the huge, fat-headed Triassic temnospondyl Anaschisma (formerly known as Buettneria and Koskinodon (Clarke and Friedman, 2018).

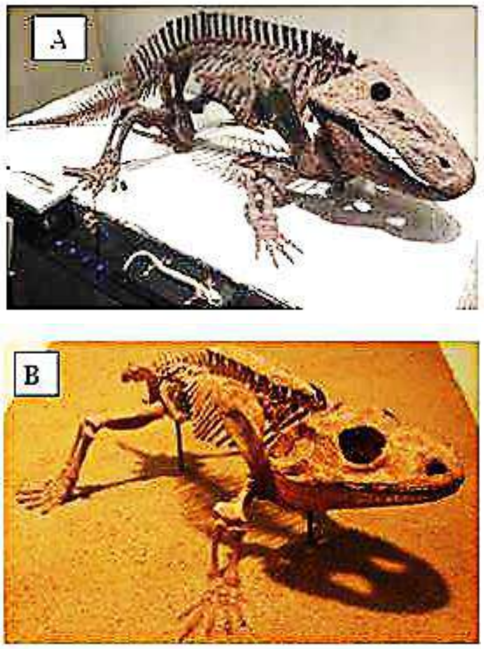

Fig. 9 Early tetrapods from the Lower Permian and Triassic

Central Pennsylvania's Upper Devonian rocks, which date back around 370 million years, were used to describe a lobe-finned fish in 1998 (Daeschler and Shubin, 1998). The arrangement of the bones of this fish's forelimb is almost exactly the same as that of some tetrapods that resembled amphibians in the Late Devonian. A single upper arm bone (humerus), two forearm bones (radius and ulna), and several small bones joined by joints to the forearm bones at the locations of the wrist and finger bones are all part of the pattern. But instead of resembling the tetrapods' really jointed finger bones, the finger-like bones resemble unjointed fin rays. Is the creature a tetrapod or a fish? I can't say. The animal may be categorised as a fish based on the bones of its fingers, yet it may be categorised as a tetrapod based on the huge limb bones.

3. Evolution of Birds

The majority of palaeontologists believe that birds are the direct ancestors of some dinosaurs rather than descended from another group of reptiles. For many years, zoologists and palaeontologists have acknowledged the kinship between birds and reptiles. numerous skeletal characteristics, shelled egg laying, and scale possession—though in birds, scales are restricted to the legs—are among the numerous characteristics that the two groups have in common. Even the earliest birds have primitive fingers on their wings. Large, movable claws on the first and second digits of the wings of a juvenile South American hoatzin, Opisthocomus hoazin, are unique to this contemporary species. These claws are used to hold branches by the juvenile bird. Thomas Henry Huxley, a well-known advocate of Darwin and his theories, originally suggested that birds descended from dinosaurs in the late 1860s. The discovery of the first almost complete skeleton of Archaeopteryx lithographica in Upper Jurassic limestones, which are approximately 150 million years old, at Solenhofen, Germany, in 1861 provided fossil evidence for the reptilian-avian connection. Archaeopteryx's skeleton is unmistakably dinosaurian. It has a mouth full of fangs, three claws on each wing, and a long, bony tail. The fact that this species possessed feathers, including feathers on its long bony tail, was something that had never been observed in a reptile before. Huxley's theory on the connection between birds and dinosaurs was founded on his thorough examination of the skeleton of Archaeopteryx. One of the foremost experts on the link between birds and dinosaurs is Yale University's John Ostrom, who has compiled all the information regarding the skeletal resemblances between Archaeopteryx and tiny, bipedal Jurassic dinosaurs like Compsognathus. Compsognathus is one of the dinosaurs that Ostrom referred to as the "ultimate killing machine," along with Deinonychus and the well-known Velociraptor from Jurassic Park. Some specimens of Archaeopteryx were initially mistakenly categorised as Compsognathus because to the fact that their skeletons are so similar. Archaeopteryx was considered by Ostrom to be directly descended from reptiles by birds (Figure 10) (Ostrom and John, 1975).The middle Eocene lake shales are home to the earliest bat fossils that have been preserved, as seen in Figure 11 (Ostrom and John, 1994a).

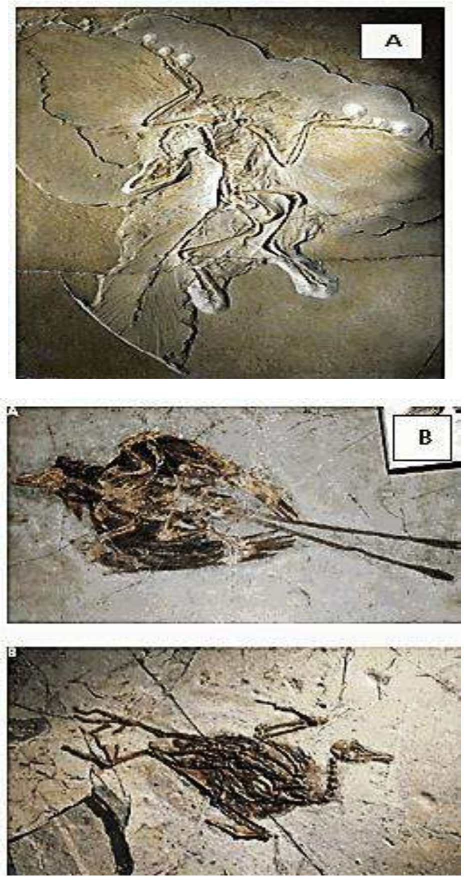

Fig. 10 Fossils of some Cretaceous birds. (A) *Archaeopteryx*, (B) *Confuciusornis*

Fig. 11 Well-preserved bat fossils come from the middle Eocene

The graphic in Figure 12 compares the anatomical similarities and differences between a tiny theropod (A), an archaeopteryx (B), and a bird (C) (Ostrom and John, 1994b.)

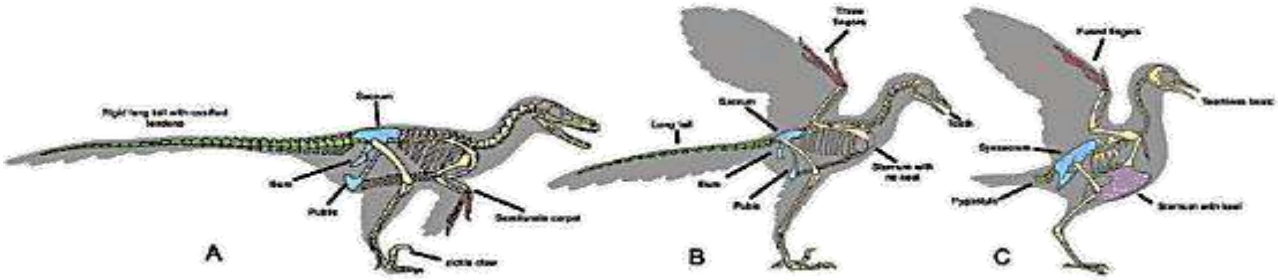

Fig. 12 A comparison of te anatomic similarities (Modified from (Ostrom and John, 1975)**)**

4. Evolution of Mammals

The earliest mammal-like reptiles, known as synapsids, are found in Pennsylvanian-aged rocks that date back around 305 million years. But it wasn't until the Late Triassic period, some 210 million years ago, that the earliest mammals were recorded in the fossil record. "The transition from basal amniotes [egg-laying tetrapods except amphibians] to basal mammals is represented by the most complete and continuous fossil record among all the great transitions between major structural grades within vertebrates," stated Hopson (Hopson, 1994).

Numerous studies have examined the structural development of certain functional systems, most notably the middle ear and feeding mechanism, and they have shown how gradually these significant adaptive changes occur. The way the lower and upper jaws articulate or connect is an often used definition of mammals. Reptiles have three bones in each half of the lower jaw, but mammals have a single bone termed the dentary in each half (Hopson, 1994).

Diagrammatic skulls that illustrate how the ear area and jaw articulation changed as mammals evolved from reptiles (Figure 13). There is just one ear bone, the stapes, on each side of the lower jaw, which is composed of many bones on each side in reptiles. Only one bone on each side makes up the lower jaw in mammals, while the other jaw bones have acquired new roles in the middle ear. The quadrate bone of the reptile jaw becomes the incus bone of the middle ear of mammals, whereas the reptilian articular

bone becomes the malleus bone. There is no longer any angular bone.

5.5. Evolution of Jaws in Fish

The oldest fish, which date from the Ordovician and Silurian periods, had mouth openings that occasionally had teeth instead of jaws. About 400 million years ago, during the Devonian Period, fish with jaws first developed. The modified gill arches the bones supporting fish's breathing organs, or gills were the ancestors of their jaws. Although contemporary jawless fish, such as lampreys and hagfish, suck the blood of other fish, it is believed that jawless fish originally nourished by sucking food from the ocean floor. Fish with jaws were able to live in a variety of ways that jawless animals could not. During the Devonian, the diversity of jawed fish species increased dramatically due to the emergence of jaws. Meanwhile, the majority of the jawless fish species disappeared (Donoghue and Purnell, 2009).

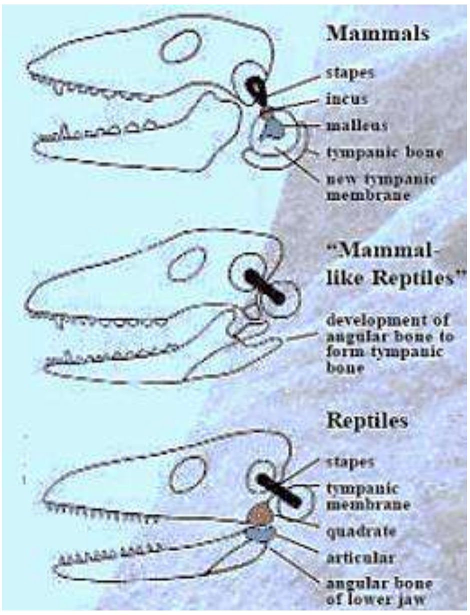

Fig. 13 Evolution from reptile to mammals (Modified from Savage and Long, 1986).

Figure 14: Images of significant synapsid (or "pelycosaur") fossils, such as (A) Casea and (B) Cotylorhynchus (Angielczyk et al., 2013 ; Liu et al., 2009).

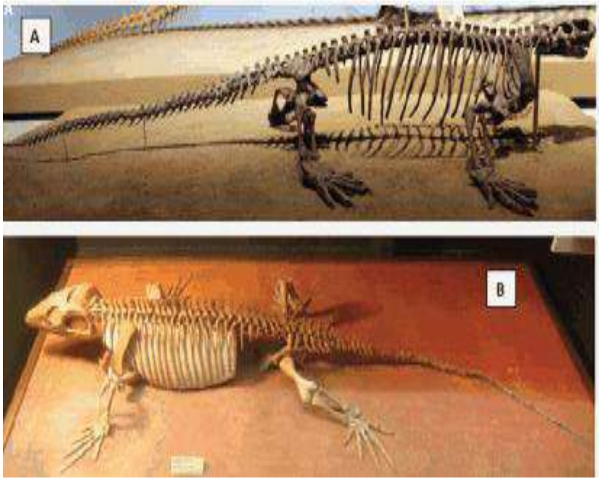

Fig. 14 Examples of synapsid fossils (Angielczyk et al., 2013 ; Liu et al., 2009).

Cephalaspids, also known as osteostracans, are the most well-known group of early jawless fishes. They usually possessed a massive, fattened skull shield (Figure 15). They were originally known as "ostracoderms," however that term is no longer relevant because it was once applied to all armoured jawless fsh. A single bone plate with several polygonal components fused together makes up the skull shield of the majority of species (Long, 2010).

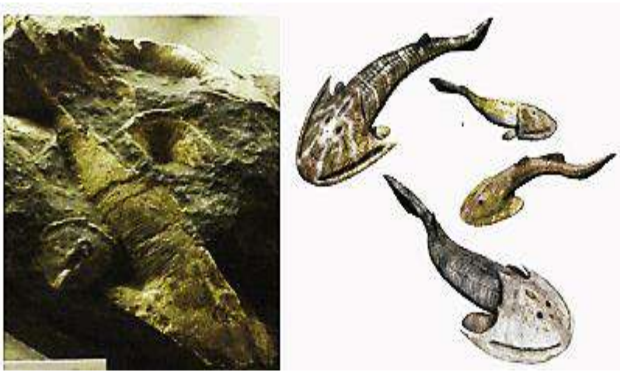

Fig. 15 A range of different kinds of osteostracan *Hemicyclaspis*

6. Evolution of the Horse

About 60 million years ago, during the Eocene era, horses began to evolve. Horses, the animal family with arguably the greatest fossil record, provide an example of how fossils have been used to interpret connections between creatures. The size of the body, the form of the teeth, and the structure of the hooves are only a few of the morphological alterations that show how the contemporary horse evolved from its earliest species. These morphological alterations are a reflection of shifting food and environment. Grazing on harsh grasses on open plains replaced browsing on soft leaves in woods. About 50 million years ago, in the early Eocene, the earliest horse ever discovered was Hyracotherium. It was a canine-sized animal with short-crowned teeth and front and rear feet with four and three toes, respectively. There was a little hoof on each toe. The body size of Hyracotherium's ancestors gradually increased until it reached the size of a modern horse. The number of toes on both the front and rear feet gradually decreased to one, and the teeth became lengthy crowns with intricate enamel ridges for crushing hard grasses. The phases of horse development across geologic eras are shown in Figure 16 (Taylor and Francis, 2022).

7. Human Evolution

The placental group of mammals, which includes all apes, humans, and monkeys, is referred to as the taxonomic order Primates. A set of anatomical characteristics common to arboreal life—that is, life connected with trees—is shared by primates. Collectively, they have a propensity for sitting, standing, and jumping that causes upper body erectness. The shoulder joint is made flexible by the clavicle, or collarbone. The thumb and big toe (apart from Homo) are opposable to other fingers, and the five digits on the hands and feet are typically well-developed for gripping. Instead of claws, fingers have nails. They have good hand-eye coordination and forward-facing eyes with well-developed, frequently stereoscopic vision. Primates exhibit very sophisticated social behaviours, well-developed parental care, and comparatively big brains. Lemurs, orangutans, gorillas, chimpanzees, and humans are all members of the Anthropoids suborder of primates. Larger brains, small jaws that result in flat faces, four upper and lower incisors, fully opposable thumbs, and no tail are some traits they have in common with other primates.

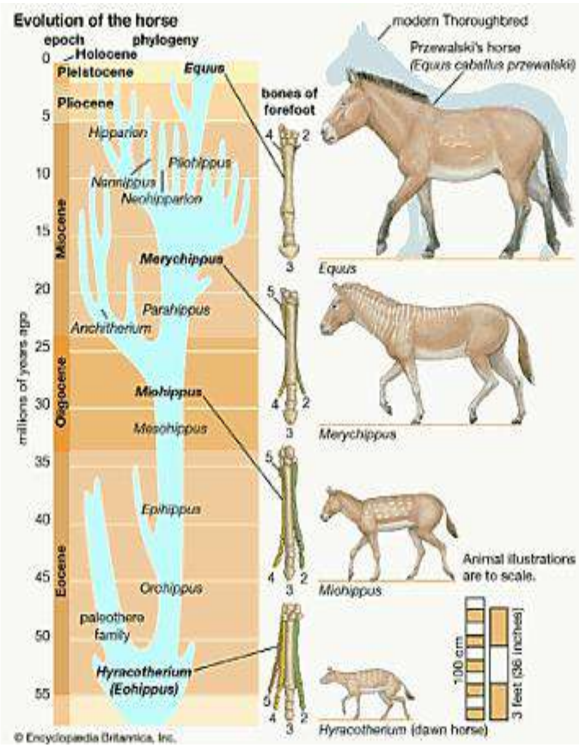

Fig. 16 Horse evolution through geologic ages (Taylor and Francis, 2022)

A group of Anthropoids known as hominids are more closely related to humans than to any other extant species, such as gorillas or chimpanzees. All hominid species that follow the last common ancestor of humans and great apes are often referred to by this term. Numerous hominid species appear to have lived at some point since then, according to fossil evidence. Some of these extinct species seem to have coexisted with one another, while others seem to have lived simultaneously. The only extant hominid species is the human (Homo sapiens) (Taylor and Francis, 2022). Over the past ten years, a growing amount of fossil material has been found, and new developments in DNA analysis, protein comparison studies, and dating methods have fundamentally altered our understanding of the branching pattern of Anthropoids. The evolutionary divergence maps of hominids and other primates have been updated using the "clock-like" characteristics of DNA, where accumulating mutations indicate elapsed periods of time.

Using the DNA clock, current estimates indicate that:

1. Gorillas diverged approximately 10 million years ago;
2. Chimpanzees and early hominids split somewhere between 5 and 7 million years ago; and
3. Orangutans (the Pongo lineage) split and evolved from the common ancestor of Great Apes approximately 15 million years ago.

The finding of hominid fossils and artefacts has accelerated significantly during the last 20 years, and the human family tree is now regarded to be much more branched and less linear than previously imagined. According to the recently developed theory of hominid evolution, several distinct species adaptations and divergent hominid branches are the consequence of multiple adaptive radiations that have happened at various points in time. Bipedalism, greater dexterity, and even a larger brain are some of the morphological traits that we often think define our human ancestry. According to this concept, these traits may have been gained and lost in several species during an adaptive radiation (Behrensmeyer, 2015). One important piece of evidence supporting evolution is the fossil record. Scientists have been able to examine the various genotypes in order to provide light on the course of human evolution because to the vast collections of ancient human bones. Based on observable shared and derived features, scientists utilise cladistics to create hierarchical groupings of human ancestors. The order Primates is depicted in the cladistical diagram (Figure 17). Gorillas, old world monkeys, and all large apes are members of this order. For instance, the Hominini tribe has a clade that includes both Pan and Homo.

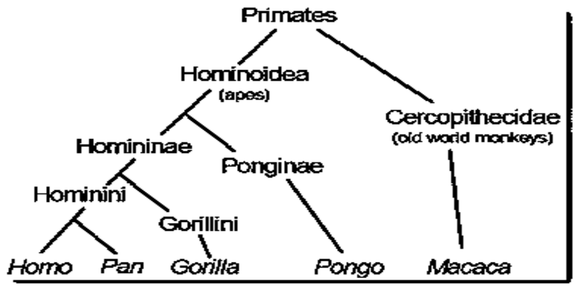

Fig. 17 Orders of primates (Behrensmeyer, 2015)

7.1. Hominoidea (Apes and Humans)

The apes and humans (today classified in the family Hominidae) are also considered catarrhines, along with Old World monkeys (Figure 18). In contrast to monkeys, apes are able to swing between branches hand over hand (brachiation) because they have lost their tails and typically have a higher range of motion in their shoulder joints (Taylor and Francis, 2022).

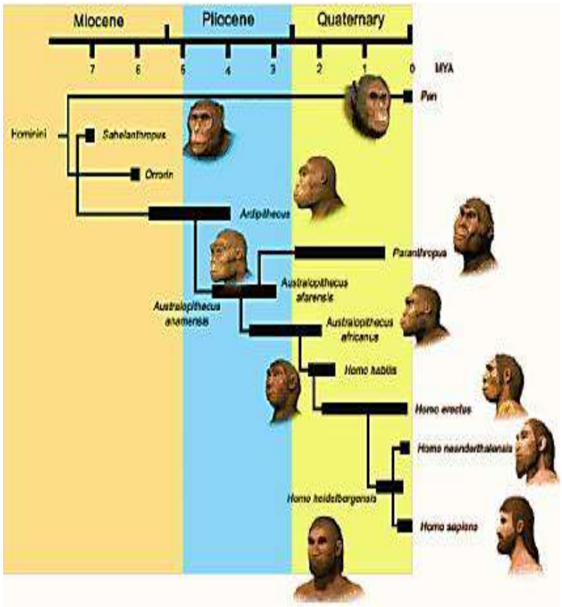

Fig. 18 Family tree of the major species of humans (tribe Hominini) and their nearest relatives(Taylor and Francis, 2022).

The only people who can still deny the existence of human evolution are those who refuse to consider the facts. About 15 years ago, the oldest fossil that can be accurately identified as belonging to our own tribe the Hominini, or "hominins" was found and described. Although its discoverers called it "Toumai," Sahelanthropus tchadensis is its official scientific name. A practically complete cranium from rocks that are between 6 and 7 million years old is the greatest example (Figure 19) (Asher et al., 2008 ; Janis et al., 2008).

Fig. 19 A complete skull about 6–7 million years ago

Examples of the more complete hominid fossils are shown in Figure 20. In contrast to (A) the well-known "Taung child" skull of Australopithecus africanus, which has a small ape-like brain exposed in the back and a relatively fat face with small brow ridges, characteristic of more evolved hominins, the oldest fossil in the human lineage comes from the distorted skull of Sahelanthropus, which was found in beds in Chad around 6–7 Ma. Late Pliocene hominid displays are shown in (B) and (C). Skulls of the robust genus Paranthropus, including the primitive P (left to right), are shown in the middle row. *The sturdy "Nutcracker Man," P. boisei, aethiopicus (the "Black Skull"), and the original species of the genus Paranthropus, P. robustus, are seen on the right. Given that the crowns were pulverised fat from a gritty diet, the lower jaws in the bottom row demonstrate how large and unusual their lower molars were. Australopithecus africanus, which is more graceful, is in* the top row (Taylor and Francis, 2022).

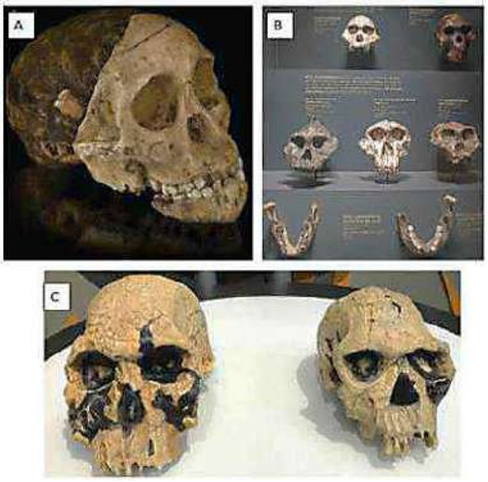

Fig. 20 Examples of the more complete hominin fossils

7.2. Hominin Fossil Record

Conversely, Figure 21 shows the fossil record of hominins over the different geologic periods (Foley and Lewin, 2013 ; Harris, 2015).

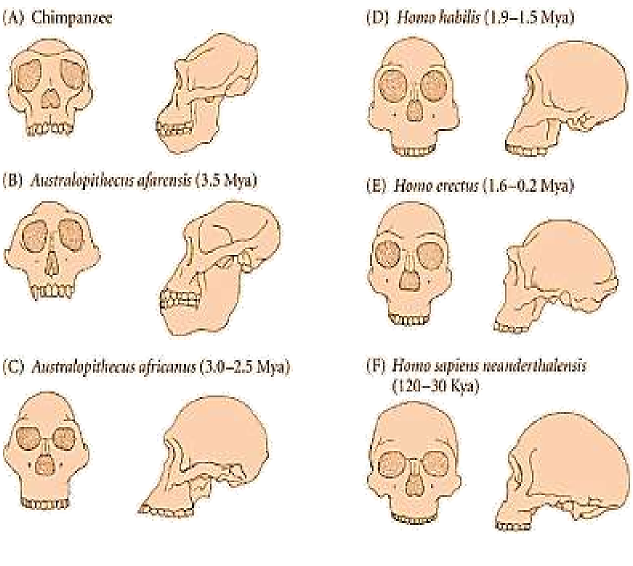

Fig. 21 Hominin fossil record and their ages

6. EVIDENCES OF EVOLUTION

The types of species that existed when rock formed are revealed by fossils. Scientists found proof that living species have evolved throughout time by studying fossils and rock strata. This process is known as evolution, and it involves the slow creation of new creatures from old ones. Charles Darwin's hypothesis from 1859 states that natural selection is the cause of this. The similarities in animal skeletons, as seen in Figure 22, is evidence of evolution. However, despite the fact that these creatures' front limbs are employed in various ways, their bones are comparable. A shared ancestor is indicated by similar structures (Taylor and Francis, 2022).

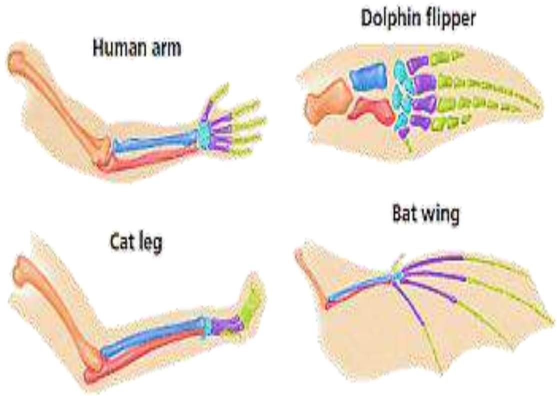

Fig. 22 The similarity of bones structure and their functions in animals

Nonetheless, the following is an expression of the evidence for evolution:

Recent Fossil Discoveries: Since Darwin, fossils have been found that record transitional phases in the evolution of animals like whales. The fossil record isn't comprehensive, though.

Comparing Anatomy: Figure 23 illustrates the fundamental bone structure shared by all vertebrate limbs.

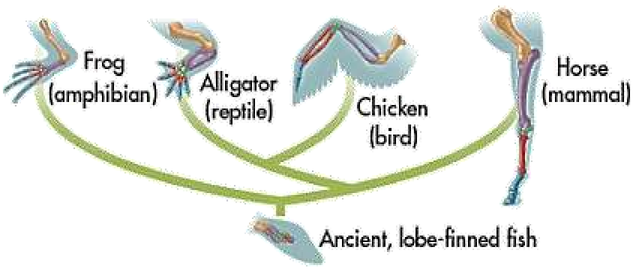

Fig. 23 Comparing vertebrate limbs bone structure

Homologous Structures: Inherited from a common ancestor, homologous structures are shared by related species.

Determining how recently species shared an ancestor is aided by the similarities and contrasts between homologous structures.

Analogous Structures: Such as the wing of a bee and the wing of a bird, these body parts have a similar function but a different structure.

The whale pelvis and the bones of the hind limbs are examples of vestigial features, which are inherited from ancestors but have lost most or all of their original function.

Embryology: Many animals have a similar appearance in their early developing phases.
Genetics and Molecular Biology: The universal genetic code and homologous molecules demonstrate shared ancestry at the molecular level.
Homologous Molecules: For example, genes can coexist. Hoxgenes aid in determining the body's axis throughout development and guide limb growth.
Proteins that are homologous share structural and chemical characteristics, such as cytochromec, which is present in practically all living cells.

Causes of Extinction

The following are the main causes of extinction:

1. Natural factors have been responsible for the extinction of significant groupings of creatures throughout Earth's recorded history.
2. Almost 60% of the kinds that were present at the conclusion of the Paleozoic Era's Permian epoch were extinct.
3. By the conclusion of the Mesozoic epoch, comparable large-scale extinctions had been documented. as seen in Figure 24.

However, a well-known cartoon that illustrates human evolution is seen in Figure 25. Without making significant adjustments to the way we utilise the planet's finite resources, many people concur that humans are significantly changing our global ecosystem, perhaps leading to disastrous outcomes. In order to prevent disaster, we must learn how to maintain and manage the natural resources of our planet and control our population in whatever manner (Taylor and Francis, 2022).

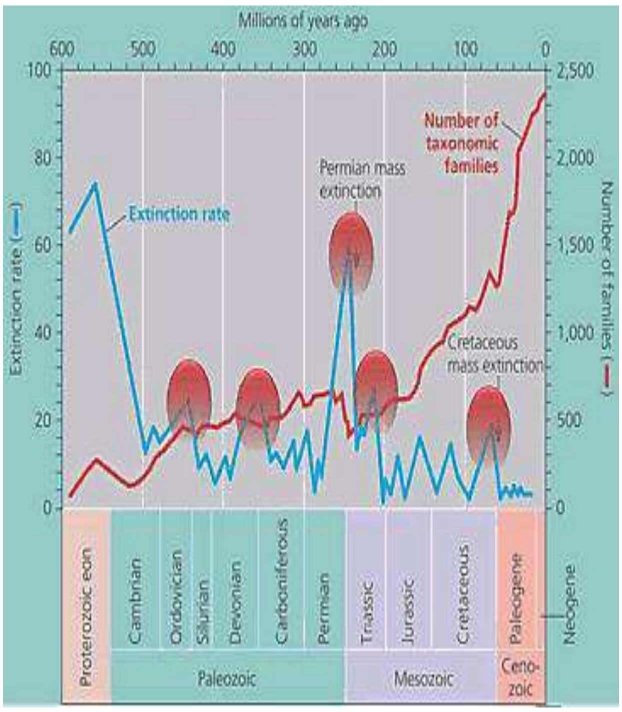

Fig. 24 Extinction through geologic ages

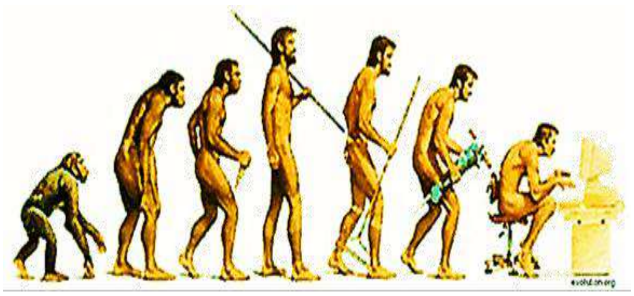

Fig. 25 Stages of human evolution through time

CONCLUSION

Based on the findings of the earlier study, the following conclusions may be made:

1. To differentiate biological evolution, the study concentrated on geological and paleontological data.
2. The evolution of both vertebrates and invertebrates throughout Earth's history is highlighted in this paper, along with their modifications and advancements.
3. Since fossils are the primary source of knowledge on the history of life on Earth, fossil records are essential for tracking the evolution process.
4. The record of fossils is also highly important for classifying geologic time scales as relative ages.
5. We wouldn't know about ancient creatures like dinosaurs and trilobites if it weren't for the information that fossils provide.
6. Direct knowledge of the chronology of important biological events, including the emergence of life, the formation of shells or skeletons, the colonisation of land, the emergence of flowering plants and animals, the evolution of flight, and significant extinction occurrences, is provided by fossil records.
7. According to this study, the invertebrate fossil scallop Chesapecten has changed during the past 13 million years.
8. The majority of the tetrapods, a group of vertebrates that includes Temnospondyls, had long, narrow bodies, huge, fat heads, and relatively short legs.
9. In birds, Archaeopteryx and Compsognathus share such a similar skeleton that certain Archaeopteryx specimens were initially mistakenly classed as Compsognathus, but are now considered to be directly descended from reptiles.
10. Research on skulls demonstrates how the jaw articulation and the ear area changed as reptiles evolved into mammals, and the earliest reptiles have traits similar to those of mammals.
11. The most well-known class of early fishes without jaws is the cephalaspids, also known as osteostracans, which eventually evolved into jaw fishes.
12. Due to significant variations in size and shape, horses have evolved since the Eocene era, about 60 million years ago.
13. In terms of human evolution, the rate at which hominid fossils and artefacts have been found has accelerated over the last 20 years, and the human family tree is now considered to be far more branched and less linear than previously imagined.

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