UNIT 1 INTRODUCING PALAEOANTHROPOLOGY*

Contents

Learning Objectives:

After reading this unit, you will be able to:

- understand the definition, aim and subject matter of Palaeoanthropology;
- comprehend the relationship of Palaeoanthropology with other disciplines; and
- know what are fossils, their process of preservation and fossilization and significance of fossils.

1.0 INTRODUCTION

Paleoanthropology emerged as a science during the late nineteenth century. The discovery of prehistoric artifacts in Pleistocene deposits soon led to the excavation of fossilized human bones. The archaeologists and geologists who unearthed these artifacts were primarily concerned with determining whether the human fossils and the artifacts found by them actually dated from the Pleistocene, thus offering evidence for the geological antiquity of humans. Prehistoric archaeologists reconstructed the way of life of prehistoric peoples through the artifacts found, while anthropologists examined the human fossils. They wanted primarily to identify the races of prehistoric humans. It was within this context that French anthropologists began to use the term *"pale´o-anthropologie"* to refer to a new scientific discipline devoted to the study of prehistoric human races and human paleontology.The field of paleoanthropology studies origin and development of early humans as an interdisciplinary branch of anthropology (Goodrum, 2014).

The field draws from and combines paleontology, biological anthropology, and cultural anthropology. As technologies and methods advance, genetics plays an ever-increasing role, in particular to examine and compare DNA structure as a vital tool of research of the evolutionary kinship lines of related species and genera.

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1.1 DEFINITION

The term paleoanthropology derives from Greek *palaiós* (παλαιὸς) "old, ancient", *ánthrôpos* (ἄνθρωπος) "man, human" and the suffix -logía (-λογια) "study of". Louis Lartet was one of the first to use the term "*pale΄o-anthropologie*." Paleoanthropology emerged within the context of the growing archaeological evidence from the late 1850s and early 1860s for the presence of humans in Europe during the Pleistocene. Thus as the name indicates, Palaeoanthropology is the study of man of ancient times. Now how do we study ancient man in current times, its evolution through the fossils of our early ancestors. Now what are fossils? It's a Latin word *Fodre* which means dig up.

Paleoanthropology is commonly considered as the study of human fossils and a descriptive and broadly narrative discipline that is dominated by poorly researched and media-friendly "findings" that cause changing views on the process of human evolution. Today's paleoanthropology or human palentology is a sub discipline of evolutionary biology that aims to describe, analyze, and interpret the process of human evolution mainly through a vast set of inductive approaches and deductive hypothesis testing. The palaeoanthropological approach helps to reconstruct our evolutionary history from the recovery and analysis of any relevant fossil evidence. Current palaeoanthropological research does not only ask what our forerunners looked like and when, where, and how they evolved but also specifically asks, for example, why humans evolved while other primate species died out. In paleoanthropology-as in other life sciences with a chronological perspective-the experiment is the historical process of nature itself(Henke and Tattersall, 2007).

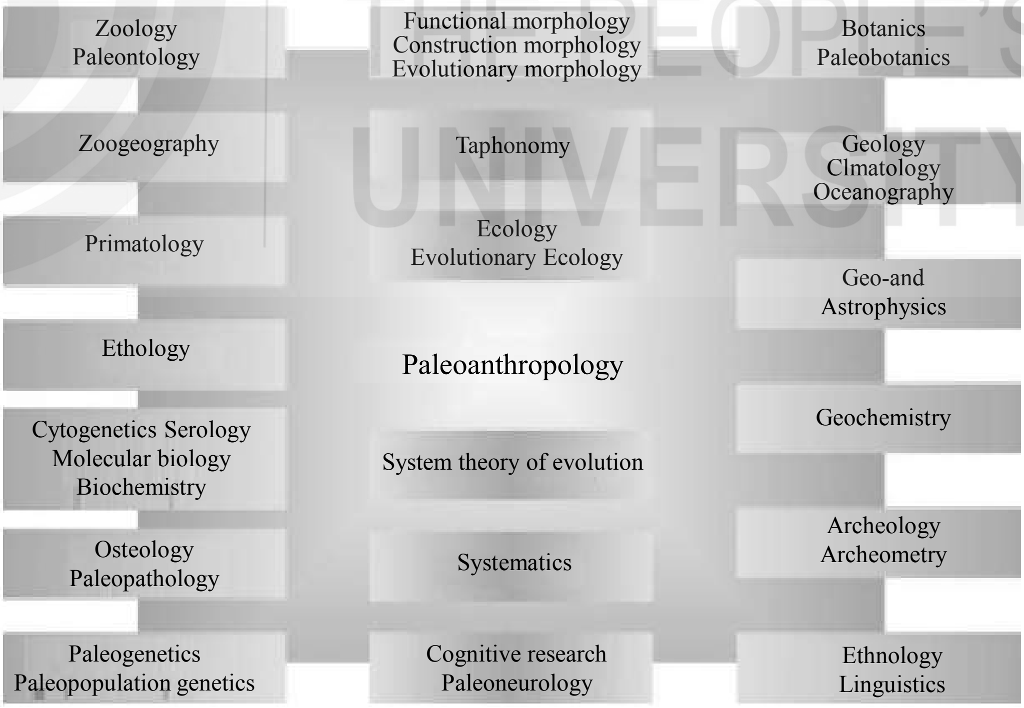

Fig. 1: Scientific disciplines that participate in the approach to reconstruct the process of human evolution (After Henke and Rothe, 1994)

In the early beginning of paleoanthropology, the main question was quite simple: is there a fossil record which proves the existence of our ancestors from ancient times? The protagonists of paleoanthropology soon recognized the need for a sophisticated empirical approach. The best basis for such a development existed in France, where Pierre Marcelin Boule (1861-1942), a qualified geologist, paleontologist, and archaeologist, unified *in persona* all necessary attributes to establish the Discipline of Paleoanthropology. His classical processing of the *Neandertal* skeletons from La Chapelle-aux-Saints (Boule 1911-1913) became a landmark in the history of human palentology. He aimed to understand the patterns of variation and the significance of anatomical differences. For this reason, Boule, invented special instruments for qualification(s) and simple statistical concepts to analyze the variation in human skeletons. Boule established a palentology of humans, later on called paleoanthropology, as a scientific discipline (Henke and Tattersall, 2007).

Check Your Progress

1) What is meant by Paleoanthropology?

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2) How does the field of Paleoanthropology reconstruct human past?

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1.2 AIM

Paleoanthropology is the study of human evolution and that of our closest living relatives, the other primates. Humans, of course are primates and paleoanthropologists recognize the importance of understanding primate evolution as a necessary condition in understanding human evolution. This is the reason primate evolution is most commonly considered a part of paleoanthropology as opposed to the larger field of vertebrate paleontology. Paleoanthropology also includes a variety of other fields that contributes to the study of various areas like human evolution and variation. These include primate biology, systematics, ecology, genetics and geology. And of course, since paleoanthropologists are interested in the behavior of fossil humans, and since many of these humans left material evidence of their behaviour in the fossil record, the analysis of this record. Paleolithic archeology is also a major part of paleoanthropology. Because the material evidence of the behavior of fossil humans is so ubiquitous, while it is essentially non-existent in other animals, paleoanthropology is unique among the historical sciences (Begun, 2013).

1.3 SCOPE OF PALEOANTHROPOLOGY

To adequately understand human bio-cultural evolution, we need a broad base of information. Paleoanthropologists recover and interpret all the clues left by early hominins. It is a diverse multidisciplinary pursuit that seeks to reconstruct every possible bit of information concerning the dating, anatomy, behaviour, and ecology of our hominin ancestors. In the past few decades, the study of early hominins has marshaled the specialized skills of many different kinds of scientists. This growing and exciting adventure includes, but is not limited to, geologists, vertebrate paleontologists, archeologists, physical anthropologists and paleoecologists.

Geologists, usually working with other paleoanthropologists, do the initial survey to locate potential early hominin sites. Many sophisticated techniques can contribute to this search, including aerial and satellite photography. Vertebrate paleontologists are also involved in this early survey work, for they can help find geological beds containing faunal remains where conditions are favorable for the preservation of bone from such species as ancient pigs or baboons, conditions may also be favorable for the preservation of hominin fossils. Paleontologists can also (through comparison with known faunal sequences) give quick and approximate ages of fossil sites in the field without having to wait for the expensive and time-consuming chronometric analyses.

Once identified, fossil beds likely to contain hominin finds become the focus for further extensive surveying. For some sites, generally those postdating 2.6 mya (the age of the oldest identified human artifacts), archaeologists take over in the search for hominin material traces. We don't necessarily have to find remains of early hominins themselves to know that they consistently occupied a particular area. Such material clues as artifacts inform us directly about early hominin activities. Modifying rocks according to a consistent plan or simply carrying them around from one place to another over fairly long distances (in a manner not easily explained by natural means, like steam or glaciers is characteristic of no other animal but hominins (Jurmain et al., 2011).

We have learnt that Palaeoanthropology being an offshoot of anthropology and archaeology focuses on the reconstructing the modern human on evolutionary lines working on biological indicators e.g.petrified skeletal remains, bone fragments, footprints and cultural information as stone tools, artifacts, and settlement localities. With such broad spectrum of this branch, palaeoanthropology is broadly of significance in educating about our past and that of nature and economic applications.

1.4 FOSSILS AND THEIR PRESERVATION

The term fossil (Lat. *Fossils* = to dig up), according to Lamarck, is defined as remains of plants and animals which have existed on the earth in prehistoric times and are found preserved within sedimentary rocks or superficial deposits of the earth, not only mostly as petrified structures of organisms but also whatever was directly connected with or produced by these organisms. Fossils provide some idea about the shape, size, appearance and activities of the organism (Jain and Anantharaman, 1996).

Much of what we know about the history of life comes from studying fossils. Fossils are traces of ancient organisms and can be formed in many ways. The oldest fossils found thus far date back to more than 3 billion years ago, because they are the remains of microorganisms, they are extremely small and are called *microfossils* (Jurmain et al., 2011).

Fossils are the most important link between our past and present, in fact it's around fossil only that we can trace our evolutionary history. Fossils occur in two forms: the actual remains of organisms, which are generally incomplete, including three-dimensional molds of their external body, and the remains of an animal's activity, such as trackways. The remains of an animal's activity are called trace fossils (Cachel, 2015). Fossils are assessed by the techniques of physical anthropology, comparative anatomy, and the theory of evolution.

Types of Preservation

The study of the formation and preservation of fossils is called *taphonomy*. There are several different types of preservation and several different approaches to classification. It is important to be able to understand the different ways that fossils can be formed in order to know what they can look like. It is also worth noting that a single fossil may fall into more than one of these categories.

Original preservation, preservation of the original chemical composition, is typically confined to geologically young fossils where the associated sediments have not yet undergone lithification. Examples of this type of preservation include *soft-tissue preservation* and *original hard part preservation*. Soft-tissue preservation, where organic materials such as organs, skin, and hair are preserved, only occurs under exceptional conditions. Forms of this type of preservation include *encasement* in *amber* and *mummification* via freezing, chemical reaction, lack of oxygen, extremely arid conditions, or dehydration and preservation in oily plant debris (as in the *Geiseltal* Formation in Germany) or tar (as in the *Rancho La Brea tar pits* in Los Angeles). This only occurs for geologically young specimens that date back at most a few million or tens of millions of years, beyond which time nothing but chemicals residues of organic matter will remain. Most well-known examples of this type of preservation are not technically considered fossils. Otzi, the Iceman is a famous example of soft-tissue preservation. Also in this category are finds of ice age mammals such as woolly mammoths, horses, caribou, and several other species in the Tundra of Siberia, Alaska, and the Canadian Yukon which presents the famous examples of soft-tissue preservation. They are sometimes mistaken for modern animals but break roughly into two groups, those aged 50,000-25,000 years old and those aged 15,000-10,000 years old.

Much more common is preservation of original hard parts. Sometimes, organic materials can be preserved intact or nearly intact, without any significant alteration. Teeth, bones, and shells may survive for many millions of years almost unchanged if they are incorporated into suitable, low-oxygen sediment. The enamel that coats teeth is very resistant, as is calcium carbonate and the calcium phosphate that forms bones. Pollen and some microfossils can also survive for long periods virtually unaltered from their original form. Geologically speaking, fossils in this state of preservation are still quite young. The longer a fossil is subjected to burial, compression, and differing chemical environments, the more likely the original material is to be changed.

The older the fossil, the more likely it is to be in a state of *altered preservation*. As sediments are buried deeper in the Earth and gradually lithify into rock, the associated fossils also undergo alteration to a greater or lesser extent. Examples of this type of preservation include permineralization, recrystallization, replacement, formation of casts and or molds, and carbonization. *Permineralization*, the most common form of alteration, is a process in which porous organic structures, such as wood and bone, have their microscopic pore spaces, left vacant by decay, filled by minerals precipitated from groundwater. The original hard parts remain but are encased in extra material that fills in the pores. The resulting fossil is heavier and denser than the original material. With this type of fossilization, the fine details of microscopic structure are generally preserved, occasionally even preserving details of cell structure. *Petrified wood* is a fairly common example of permineralization.

Recrystallization is a type of preservation where the crystalline minerals forming an organism's hard parts fuse to form larger, more stable crystals. The original chemical composition can sometimes be preserved, but in other cases, unstable minerals, such as aragonite, recrystallize into a more stable, chemically identical form, such as calcite. The original chemical composition remains, and much of the original shape of the fossil is preserved, but the texture difference is obvious under the microscope and much of the fine detail of the structure is lost.

Replacement is a process in which an organism's original hard parts are dissolved by chemical action and replaced by another mineral, such as calcite, silica, iron, or pyrite. The result is a chemically different replica of the original fossil. The replacement process takes on the name of the secondary mineral, for example *silicification*, which is the most common form, entails replacement of the original mineralogy by silica; *pyritization* is the replacement of calcite or softtissues with pyrite (like the sand dollars that you often see in stores); *phosphatization* usually involves replacement of low-phosphate apatite with high-phosphate apatite; and *dolomitization* is usually the incorporation of magnesium into hard parts that were originally calcite-forming dolomite. Growth of a replacement mineral occurs at the expense of the original mineral components, destroying fine detail while preserving the original size and shape of the fossil.

Sometimes the original material dissolves away completely, leaving a void in the surrounding sediment and leading to the formation of molds and/or casts. Molds are surface impressions created in the sediment surrounding the original material. Think, for example, of leaving a footprint in the sand. Molds can be found around extant fossils or, if the original material dissolved from the rock matrix, are left behind as impressions called external molds. If the original fossil material becomes filled with sediment internally, an impressions of the inside, called an internal mold, can also form. If a cavity in a fossil is completely filled in, it can form a nodular internal mold called a steinkern. A complete mold forms when internal and external mold surfaces are compacted together to produce impressions in the same layer of sediment.

Casts are formed when a mineral, sediment, or some other material fills in a mold and hardens to form a copy of the original structure. True casts are relatively rare in the fossil record, and internal molds (especially steinkerns) are often confused with them. A mold is a negative image of the original, while a cast is a positive image, or duplicate of the original. Since molds and casts occur as a result of the dissolution or destruction of the original material after the surrounding matrix of sediment has hardened, only a limited amount of fine detail is usually preserved.

Carbonization occurs when organic material is preserved through rapid burial in an anoxic (very low or no oxygen) environment. The organics do not decay. Instead, the volatile elements, such as hydrogen, oxygen, and nitrogen are driven off, leaving behind organic-rich hard parts and soft parts to be preserved as thin, black films of organic carbon. The fossil loses its three-dimensional shape, but this process often will preserve the outline of soft tissues, hair, or feathers, and can reveal fine details that would have been destroyed by other form of fossilization. Plants are also often preserved in this way. Some of the fantastic details of the 47-million-year-old fossil primate called Ida (incorrectly cited in the media as a missing link), such as the hair and skin shadow (an outline of an animal's soft tissue or flesh), are due to carbonization of the soft tissue around an animal's preserved bones. This combination gives an unprecedented amount of information about extinct organisms. Carbonized fossils are most commonly found on the bedding planes of sandstone and shale.

Different organisms have differing potential for fossilization. Organisms with hard parts are much more commonly preserved than organisms with no hard parts. The number and size of hard parts also affects preservation. Organisms with one or two large, robust shells are more likely to be preserved intact than organisms with lots of smaller, more delicate parts. The environment in which an organism lives also plays an important role in preservation. Organisms that live in environments where there is lots of chemical and physical weathering, and/or substantial erosion, such rapid burial and are preserved by lithification of the host sediments themselves, hopefully without significant distortion. Study of trace fossils (ichnofossils) is a specialized area of palentology called ichnology. Because trace fossils are very rarely found directly in contact with the organisms responsible for their creation, ichnologists have developed their own separate methods of classification.

1.5 PROCESS OF FOSSILIZATION

The very early traces of life are fragile and very rare. Most of our evidence comes later in time, and usually these fossils are pieces of shells, bones, or teeth, all of which, even in a living animal, were already partly made of mineral. After the organism died, these "hard" tissues were further impregnated with other minerals, being eventually transformed into a stone like composition. This process is mineralization (Jurmain et al., 2011).

Fossilization is the process by which the body of an organism is converted into a fossil by petrification or by gradual addition or replacement of organic material by inorganic substance. For the process of fossilization normally the organisms must have hard parts like skeleton, nail, tooth, bone etc. because the soft parts shall generally be decomposed. After the death of an organism, it must be immediately buried so that it does not get destroyed. Since most of the dead organisms get deposited in water, therefore, the most favorable conditions for fossilization are present in sea. Fossilization takes place when the tissues of an organism are replaced by minerals. Sometimes replicas of soft tissue are preserved by bacteria that leave a mineral coat of phosphate or pyrite over the surface of the tissue. Alternatively, fine-grained sediments may sometimes preserve a hardened external cast of an organism. In addition to hard parts (pollen, shell, bone, teeth) that are more apt to fossilize, other materials, such as wood, may also sometimes be fossilized. Fossil wood may be so abundant in some areas that partial reconstruction of an ancient forest may be possible. Sometimes the fossil wood is not mineralized. The cellulose has decayed, but the lignin may still be present. A partial fossil forest of the swamp cypress (Taxodium) has been preserved as lignin stumps in 8 mya deposits in Hungary. The trees had been quickly buried in sands that partly preserved the plant material up to the point of burial. Similar swamp forests from the Late Miocene of Hungary once housed *Rudapithecushungaricus*, one of the last survivors of the once diverse European fossils ape radiation (Cachel, 2015).

There are, however, many other ways in which life-forms have left traces of their existence. Sometimes insects were trapped in tree sap, which later became hardened and chemically altered. Because inside the hardened amber there was little or no oxygen, the insects have remained remarkably well preserved for million of years, even with soft tissues and DNA still present. This fascinating circumstance led author Michael Crichton to conjure the *Jurassic Park* novel and motion pictures. Leaf imprints in hardened mud, or similar impressions of small organisms, or even the traces of dinosaur feathers are fossils (Jurmain et al., 2011).

1.5.1 Physico-chemical Conditions For Fossilization

Environmental conditions: Preservation of fossils is a fairly exceptional phenomenon that necessitates particular conditions. The body must be rapidly isolated from oxygenated environment, immediate burial by fine grained sedimentary deposits, the subsequent deposition of large quantities of sedimentary deposition (load) leading to prevent oxidation, the expulsion of water and to compaction. However, the best sediments for good preservation are (a) the water borne sediments from the degradation and decomposition of older rocks in the form of argillaceous and (b) the wind borne material in the form of loess or volcanic ashes has yielded fossils of terrestrial organisms.

Geographic, topographic and climatic conditions also influence preservation, winds and currents in particular encourage accumulation of organic remains. Similarly, certain modes of life are shown to lend themselves to a greater or lesser extent to fossilization. Colonising, gregarious, fixed, boring or burrowing organisms are more easily preserved than those which live in isolation or lead a wandering existence(Jain and Anantharaman, 1996).

Chemical conditions: Soon after death the soft parts of organism undergo decomposition by the activity of bacteria. Similarly, organic matter associated with the mineralized parts like proteinaceous material of shells, bones, tests etc. often disappear, regarding these initially hard parts porous and brittle. Chemical exchanges also occur between the decomposing organism and the sediment which contains it. The organic matter engaged in this process infact results from photosynthesis by phytoplankton; about a million tons of organic substances having this origin are deposited annually in the oceans in present day conditions. However, it has been known for some years that organic substance themselves have been able to "fossilize" in many sediments and preservation of the substance of the soft parts can occasionally occur. The constant refinement of methods of investigation in chemical analysis makes it possible to reveal the preservation of an ever increasing number of constituents of living matter. Palaeobiochemistry has thus grown up, the results of which are of interest to various branches of modern palentology. The absence of fossils in the Pre-Cambrian formations may have resulted from the absence of proteins in the hard parts of the organisms (Jain and Anantharaman, 1996).

Check Your Progress

3) How do geologists and paleontologists contribute to the field of Palaeoanthropology?

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4) Explain one important technique of fossil preservation?

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1.6 SIGNIFICANCE OF FOSSILS

The value of any fossil depends upon its position in the geologic column and geographic location. There is definite relation between the fossil contents of rocks and the position of those rocks in geologic column. Older rocks have simpler organisms and recent rocks have more complex and varied assemblage of the contained fossil organisms (Jain and Anantharaman, 1996).

- ***Study of Chronostratigraphy:*** The purpose of chronostratigraphy is to organize the sequence of rocks on a global scale into chronostratigraphical units so that all local as well as worldwide events can be related to a single standard scale. It is concerned with the age of strata and their time relations. The organisms now represented as fossils lived at definite times during the geologic past and hence have chronological sequence. The character of the included fossil indicates conclusively the time when the sediments were laid down.

- ***Study of Biostratigraphy:*** Marine sediments have several fossil species occurring in a particular sequence; each species confined to one part of the succession only and representing the time when that species was living. Here in lies the application of palaeontology: Biostratigraphy. Using the sequence of fossil fauna/flora, the geologic column has been divided into geochronological units (era, period, epoch and age). In biostratigraphy fossil contents of the beds are used in interpreting the historical sequence.

- ***Study of Paleogeography:*** The adaptations of organisms are characteristic of particular environments, hence those shown by fossil forms may indicate the extent and boundaries of former lands, water deltas, mountains, deserts, lakes, rivers, shore lines and the positions of deep and shallow seas(Jain and Anantharaman, 1996).

- ***Study of Palaeoclimate:*** The variation of temperature and the degree of moisture is perhaps most clearly indicated by fossil plants and animals. The palm fossil indicates warm climate, corals exhibit warm tropical climate and forams exhibit temperate climate. It is also provided by the rapid diminution in the number and kind of growing animals and the increase of grazing forms after the beginning of Miocene.

- ***Study of Palaeoecology:*** Palaeoecology is the study of ancient organisms in relation to their total physical, chemical and biological environment. It also explains how these organisms have adapted to a particular ecological niche in which they feed and breed. It also helps to find out the nature of these adaptations and the relationships of the animals with each other and their environments.

- ***Study of Organic Evolution:*** No line of evidence more forcefully and clearly supports the fundamental postulate of evolution-"descent with accumulative modifications"- than that furnished by fossils. The panorama of organic evolution is visualized by paleontologists from the study of the fossil record left in the rocks by former organism(Jain and Anantharaman, 1996).

Check Your Progress

5) What do you understand by fossilization?

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6) Write a short note on significance of fossils.

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1.7 SUMMARY

The field of Palaeoanthropology emerged in Europe during the Pleistocene period for the discovery of humans from the growing archaeological evidences. Paleoanthropology is an interdisciplinary branch of anthropology that is concerned with the origins and development of early humans. Paleoanthropologists reconstruct the way of life of prehistoric peoples through the artifacts and fossils found. The field draws from and combines geology, vertebrate paleontology, archeology, physical anthropology, and paleoecology. Paleoanthropology finds applications in education, economy and in reconstruction of human past. Palaeoanthropologist with their knowledge of the past life can reconstruct the palaecology, palaeoenvironment and community structure which can provide important clues about early humans and their interaction and competition with past fauna and flora as well as about the evolution of man.Much of what we know about the history of life comes from studying fossils. This unit explores how fossils are formed and preserved. Examples are drawn from human body, fossil halls of natural museum and Dinosaur fossil remains.

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1.9 ANSWERS TO CHECK YOUR PROGRESS

1) The field of paleoanthropology studies origin and development of early humans as an interdisciplinary branch of anthropology. For further details refer section 1.1.

2) The field of Paleoanthropology reconstruct past of humans by gaining information from fossil record of primates, genetics analysis of humans and other surviving primate species, and the history of changing climate and environments in which the human species evolved.

3) Geologists do the initial survey to locate potential early hominin sites. Many sophisticated techniques can contribute to this search, including aerial and satellite photography. Paleontologists can also (through comparison with known faunal sequences) give quick and dirty approximate ages of fossil

sites in the field without having to wait for the expensive and time-consuming chronometric analyses.

4) Recrystallization is a type of preservation where the crystalline minerals forming an organism's hard parts fuse to form larger, more stable crystals. For further details refer section 1.4.

5) Fossilization is the process by which the body of an organism is converted into a fossil by petrification or by gradual addition or replacement of organic material by inorganic substance. For further details refer section 1.5.

6) Fossil records are widely used in the study of the following: (a) Chronostratigraphy (b) Biostratigraphy (c) Paleogeography (d) Palaeoclimate (e) Palaeoecology and (f) Organic Evolution. For further details refer section 1.5.