UNIT 4 APPROACHES OF TRADITIONAL AND MODERN BIOLOGICAL ANTHROPOLOGY*

Contents

Learning Objectives

After going through this unit, you will be able to:

- understand the subject matter of Biological Anthropology;
- comprehend the traditional and modern approaches of Biological Anthropology;
- know about different methods and techniques to study human variations; and
- study various methods and evidences to understand human evolution.

4.0 INTRODUCTION

Biological anthropology is the study of human variability, adaptation and evolution from a biological perspective. Even with numerous methodological and theoretical developments over the last 150 years, one of the major objectives of biological anthropology consists of understanding of evolution, the discovery or recognition of primate and hominid fossil and assessment of human variations. The

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fundamental subject matter of biological or physical anthropology is an interest in and an exploration of, human origin and variation. Biological anthropology makes use of many disciplines including anatomy, physiology, genetics and evolutionary biology to throw light on the existing significant differences among individuals and to trace the lines of human evolution.

4.1 TRADITIONAL AND MODERN APPROACHES IN BIOLOGICAL ANTHROPOLOGY

During the second half of the nineteenth century, biological anthropology was dominated by studies of anatomy, craniology, skeletal biology, human origin and race. Most of the physical anthropologists were trained as physicians or anatomists and their primary data were gathered by anthropometric and osteometric measurements and not to forget morphological observations. There was little interest in evolution; races or human varieties were seen as fixed and unchanging; typological approaches were applied to concept of race; studies seldom applied scientific methods of hypothesis testing; and knowledge of the impact of the environment on humans was limited. Around seventy years ago, S. L. Washburn (1951) formulated 'new physical anthropology' where main focus was made on the primate and human evolution and human variation with genetics as an important unifying perspective.

During the late 20th and early 21st century, many important tools that physical anthropologists have had maintained the viability of the discipline. These tools and approaches are:

a) *bio cultural/bio behavioural approach capable of solving scientific problems that are intractable for unidisciplinary social or biological scientists;*

b) *theoretical perspective and process applied to human, evolution, whose explanatory power is truly remarkable;*

c) *an ability to view humans and their behaviour in deep time and in evolutionary perspective and to use this information to foresee problems in contemporary societies and reverse;*

d) *the exploration of human biology and behaviour within a population perspective; and*

e) *the application of comparative approaches to human societies, to non-human primate relatives and to our evolutionary antecedents. Using these valuable tools, along with the application of the scientific method, physical or biological anthropologist made substantial growth in a number of sub-fields throughout the millennium (Larsen, 2010).*

Check Your Progress 1

1) Which of the following topic is covered by Biological Anthropology?
   a) Human variation
   b) Kinship Studies
   c) Ethno semantics
   d) Prehistory

2) Who coined the term "New Physical Anthropology"?

a) S. L. Washburn

b) C. Darwin

c) J. B. Lamarck

d) T. Dobzhansky

Furthermore, quality researches into the field of molecular genetics and human genome project revolutionized the field of biological anthropology. At the same time researches in primatology, especially studies of naturalistic behaviour and of the ecology of non-human primates in the wild, has expanded substantially. This is partly because of our interest in our closest relatives among mammals and also because of habitat loss and the need to preserve the threatened and endangered species of primates. Finally, in palaeoanthropology, new discoveries are providing a finer resolution to non-human primate and human origin and to web of our evolutionary pathways- one of the earliest objectives of biological anthropology (Larsen, 2010). Considering human variation and evolution, the two mainstays of biological anthropology, the present unit focuses on different methods and approaches to study these topics.

4.2 METHODS TO STUDY HUMAN VARIATIONS

During the first half of the nineteenth century, the natural historians who laid the foundations for biological anthropology were mainly concerned with human variation. In the nineteenth century, numerous attempts were made to study and measure human variations through visual and statistical methods. For example, statistical methods were applied to the interpretation of variation in size and the concept "average man" was introduced as a scientific way of establishing types. Such "ideal types" or averages worked well for sorting out widely differing species, but matters became more difficult when investigators were dealing with closely related organisms and "type". This difficulty increased when search for forms that matched notions of ideal specimen was encountered and caused many problems in studies of human variation and evolution. This subjective imagery impeded the understanding of the scope of human variation and served only to contribute to increase the number of types. Major types were used to divide humans into a few "basic" races actually obscuring individual diversities (Molnar, 2015). Any group, large or small, were said to vary around some ideal or average. With an increase in the knowledge of human biology and biological anthropology, new methods and techniques were established to precisely measure and understand human variations and evolution. Let us now look at some of the major methods and techniques to study human variations:

4.2.1 Anthropometry

Anthropometry has been an important science for measuring and analysing morphological or anatomical variation of humans for more than 150 years. It is defined as the scientific study of the measurements of the human body according to standardized units, landmarks and instruments. Prior to innovations that could identify variation at microscopic levels, including physiological, biochemical, endocrinological and genetic ones, morphology was the prime means

of classification of nature. The strength of anthropometry as a measure of human variation is its relative cheapness and simplicity of application. Two standards are considered absolutely crucial for the science of anthropometry: The measurement of human growth (Cameron, 19884) and Anthropometric Standardization Reference Manual (Lohman, Roche & Martorell, 1988). Anthropometric methods used to study human variations can also be employed for the comparison of groups (children or adults) living at the present time and for comparison between modern and ancestral humans within the evolutionary history (Mascie-Taylor, Yasukouchi & Ulijaszek, 2010).

4.2.1.1 Sub-divisions of Anthropometry

Anthropometry can be sub-divided into four major sections: somatometry, cephalometry, osteometry and craniometry. The first two sections i.e. somatometry (measurement of living individuals and of cadavers) and cephalometry (measurement of the head and face) are associated with anthropometry in the traditional sense of being the study of living humans whereas osteometry (measurement of human skeleton) and craniometry (measurements of skull) deals with measurements of skeleton and remains. Craniometry also includes measurements of dental features and post-cranial skeleton measurements. Study of human "hard parts" is useful in understanding human variation in the past, as these are the structures that may persist for long periods of time in fossil or archaeological contexts (Brown, 2010). These techniques are also used to study age and sex variations in humans in addition to the understanding of differences between larger and smaller groups.

4.2.1.2 Tools of Anthropometry

In anthropometry, stadiometers are used to measure height (stature), anthropometers to measure length of body segments, weighing machine to record body weight, steel tapes to measure body segment circumferences, spreading calipers to measure head, face etc. (where curved areas are to be measured), sliding calipers to measure body (with blunt ends) and bone diameters (with sharp ends), skinfold calipers to measure thicknesses of skin and subcutaneous fat, scales to measure masses and so on. Simple or complex mathematical manipulations are used to derive indices to describe the shape of a body segment (Abernethy, 2013).

AnthropometrIc Measuring Tools

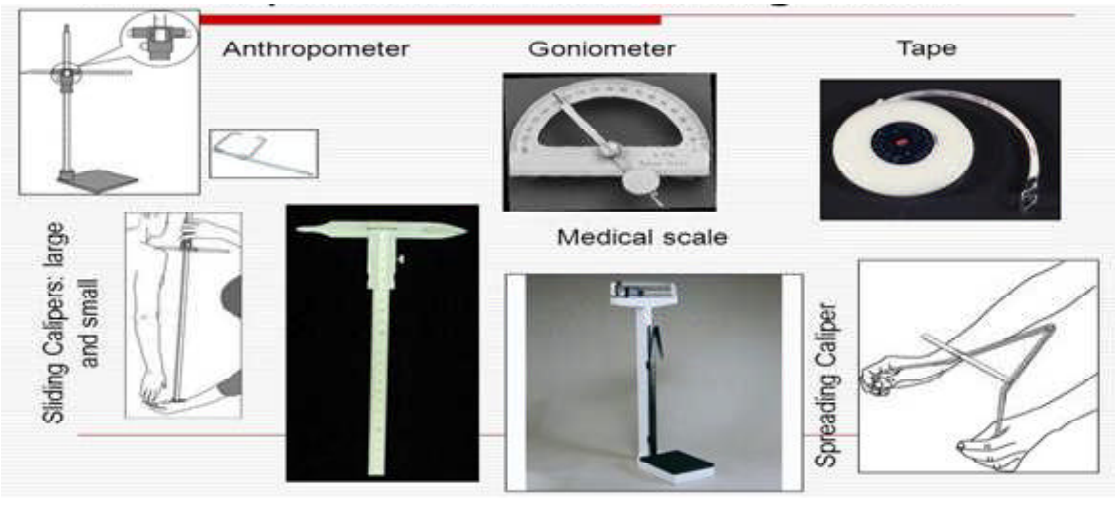


Fig. 1: Anthropometric Tools

Source: https://slideplayer.com

On the other hand, major osteometric and craniometric tools consist of osteometric board (to take linear and angular measurements on the long bones), Parallelograph (to measure torsion angle i.e. the angle between two axes of long bones), Pelvimeter (to take measurements on the pelvis), Craniophore (to keep the skull in proper position while taking measurements), Palatometer (used for taking measurements on the palate), Mandibulometer (used for taking measurements on the mandible), Goniometer (used for taking angular measurements on the skull and faces).

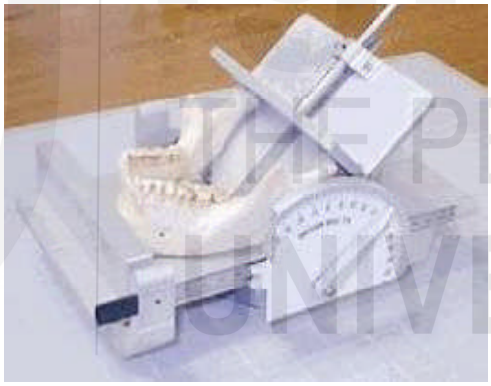
(a) Osteometric board

(b) Pelvimeter

Source: (a) https://paleo-tech.com/paleo-tech-lightweight-field-osteometric-board/

(b) https://www.alibaba.com/product-detail/pelvimeter

(c) Craniophore



(d) Mandibulometer

Fig. 2: Osteometric and Craniometric tools

Source: c) https://www.amazon.in/Microtroniks-SAI513-SAI-Cubic-Craniophore/dp/B01N8UEU31

d) http://www.shop2000.com.tw

Check Your Progress 2

3) The scientific study of the measurements of the human body is defined as:

   a) Anthropometry

   b) Odontology

   c) Craniometry

   d) Isometry

4) Which instrument is used to measure torsion angle?

   a) Pelvimeter

   b) Parallelograph

   c) Goniometer

   d) Mandibulometer

5) Craniophore is used for:

   a) Taking measurements on pelvis

   b) Keeping skull in proper position while taking measurements

   c) Taking angular measurements on the skull and faces

   d) Checking the accuracy of measurements

4.2.2 Somatoscopy

A corresponding method, traditionally known as somatoscopy is the description of morphological physical characteristics of humankind based on visual observation of morphological traits. The visual assessment of bodily traits is made in relation to a set of standardized observations that also leads to some degree of subjectivity. These visual observations include skin color, hair color, eye color, face form, nose form, lip form etc. The study of somatoscopic observations is important for understanding human variations and for establishing a common morphological features for a group of individuals, a community or an ethnic group which itself is an objective of biological anthropology (Somatoscopic Observation, n. d.).

From the early 1800 to 1950, research in human variation dealt primarily with body dimension (anthropometry) and visible traits (somatoscopy). Less emphasis was placed on other traits and systems such as serology and dermatoglyphics. In 1950, the immunologist W. C. Boyd opined that traditional studies of human variation emphasizing measurements and qualitative traits of unknown inheritance are out-dated. He advocated the use of serological characters (e.g. ABO, Rh, MN blood group antigens) and other traits to study human variations. These traits such as the ABO blood types are *phenotypes*. Phenotype refers to the observable physical characteristic or trait of a person. These phenotypes are the direct products of the genotype. Genotype is defined as genetic makeup of an individual with reference to a single trait. During the 20th century, several loci were recognized and the frequencies of many specific alleles were obtained from many human populations (Scott & Turner, 2000).

4.2.3 Serology

Serology is defined as the scientific study of blood and its properties. Attributes of blood have increasingly been used in anthropological genetics because their mode of inheritance is relatively simple. One such set of attributes comprises the blood groups, which are complex chemical substances found in the wall of the red blood cell. These substances are antigenic and can be detected through their reactions with antibodies. A number of quite different blood group systems are now known.

The first to be discovered and still the most important in blood transfusion is, the ABO system. Whereas the antibodies to the other systems are only obtainable through immunisations, those to the ABO systems are naturally occurring in human blood serum. The ABO system basically involves three genes, A, B and O (though there are subtypes of A). Every individual inherits two of these genes from parents and so the genotype (genetic constitution) must be one of the following: AA, AO, BB, BO, AB, or OO. O is recessive to both A and B and thus there are four possible phenotypes (genetic constitutions detectable by blood grouping): A, B, AB (universal recipient) and O (universal donor). The ABO genes constitute a polymorphic system that is several genes occur with frequencies such that the latest frequent of them occurs with a frequency exceeding that due to mutation alone. Certain selective advantages and disadvantages of the ABO genes in human populations are known. Thus, stomach cancers are more frequent among individuals of group A than they are in the population at large. Again, duodenal ulcers are almost 40% more common among persons of blood group O than in the individuals of the other ABO blood groups. Globally, the ABO variation is also striking. The percentage of the blood group B exceeds 30% among the mongoloids of Central and East Asia, but the B gene is virtually absent in the Australian aborigines, the American Indians and in Basques. Many Amerindian tribes are 100% O; some others have very high A frequencies **(**Sharma & Sharma, 1997**)**.

The Rhesus blood group system is more complicated. It involves a number of closely linked genes. One pair of genes in this series determines whether an individual is Rhesus positive, Rh+ (DD or Dd), or Rhesus negative, Rh- (dd). Many populations are polymorphic for these rhesus characteristics. In many parts of the North-West Europe and Africa the Rh- frequency is around 15% and among the Basques it rises towards 40%. It is absent, however, from Amerindian, Australian Aborigines and most Eastern Asians **(**Sharma & Sharma, 1997**)**.

An examination of the occurrence of the M and N genes for the MN blood group system shows that most populations have an M frequency of 0.5-0.6. However a higher frequency is found among North-East Asia; while N is higher in Australian Aborigines, New Guineans and Melanesians. Anthropologically, the Diego, Kell Duffy, Kidd, Lutheran and P are also of special interest due to their affinity with many human groups **(**Sharma & Sharma, 1997**)**.

Check Your Progress 3

6) The universal blood donors for the ABO system are type:
   a) A
   b) B
   c) O
   d) AB

7) The occurrence of N gene for MNS blood group is found to be higher among:
   a) Indian
   b) Europeans
   c) New Guineans
   d) Africans

4.2.4 Dermatoglyphics

Dermatoglyphics is an important approach of physical or biological anthropology that studies variable human physical characteristic. It is the study of variations in the pattern of ridges found on the fingers, palms and soles that has a complex genetic basis. These skin ridges develop in humans between 11th and 17th week of gestation and are mainly used for better gripping. Ridge patterns appear to be at least partially determined by genetic factors, but there are also important effects caused by developmental processes. The details of the genetic basis for dermatoglyphic variability in human populations are poorly understood and are likely to be highly complex. Fingertip patterns have been generally categorized into three basic patterns: arches, loops and whorls.

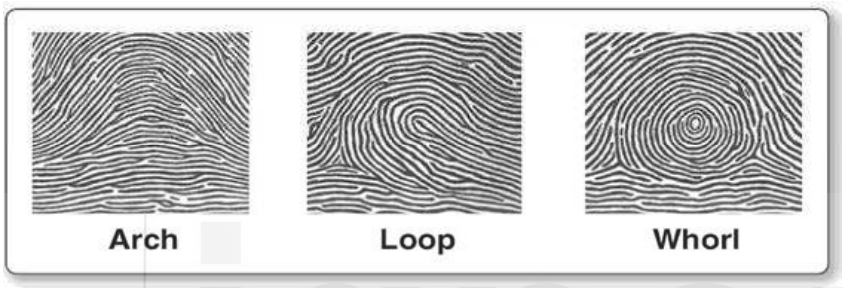


Fig. 3: Major types of Dermatoglyphic patterns found on the fingertips: Arch, Loop and Whorl

Source: Brown, 2010

Identical twins have different fingerprints, due to differences in the environment for each individual while in the womb. Individuals with certain genetic abnormalities (for example, Down Syndrome) display some specific ridge patterns. Varying frequencies of the ridge patterns are useful in distinguishing closely related populations, however it can help in understanding microevolutionary process in human population biology. In addition to fingertip patterns, palmar surface is also used to study variability among human populations. The palmar surface is divided into four anatomical directions i.e. proximal, distal, radial and ulnar. Palmar region is also divided into six configurational areas:

- Hypothenar,
- Thenar and
- interdigital area I-IV.

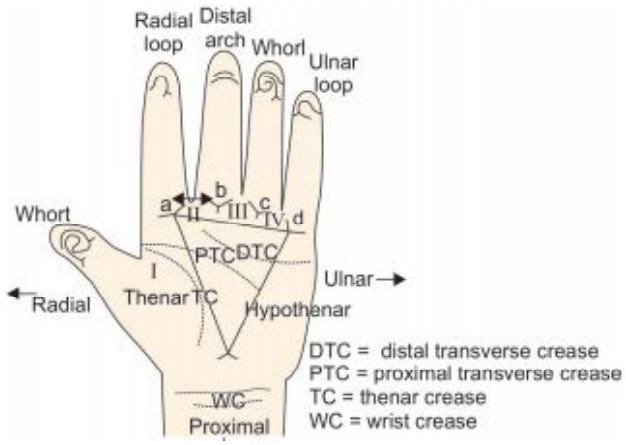


Fig. 4: Palmar region

Source: http://www.jaypeejournals.com

Main line formula and analysis of ridge characteristics are important techniques to study variability in human palmar area. Thus, dermatoglyphics, with a complex genetic basis is of interest in studies of human variations but these traits are of little or no value in attempts to categorize human populations into larger groupings of races **(**Brown, 2010**).**

In the beginning of 1990, with the advent of genomic studies, new techniques were devised to study human variations. In the contemporary period, with the knowledge of DNA sequencing, entire genes and even larger segments of DNA can be identified which made human comparison possible. During the last decade, the knowledge and understanding of human biological variation have increased dramatically due to the accessibility of human genome to physical anthropologist.

4.2.5 Polymorphism at DNA Level

Due to the advancing knowledge in Human Genome Project, considerable insights regarding human variation at the DNA level have been gained by biological anthropologists. Recently, many variations in DNA in the human genome have discovered. For example, there are hundreds of sites where DNA segments are repeated, in some cases just a few times and in other cases hundreds of times. These areas of nucleotide repetitions are called microsatellites and they vary tremendously from person to person. In fact, every person has their own unique arrangement that defines their distinctive "DNA fingerprint." Anthropologists and biologists have collected DNA samples from contemporary human populations from around the world and examined over 600,000 loci (mostly SNPs). Their results show that African populations are significantly more variable than all those outside Africa **(**Modern Human Variation and Adaptation, n. d.**).**

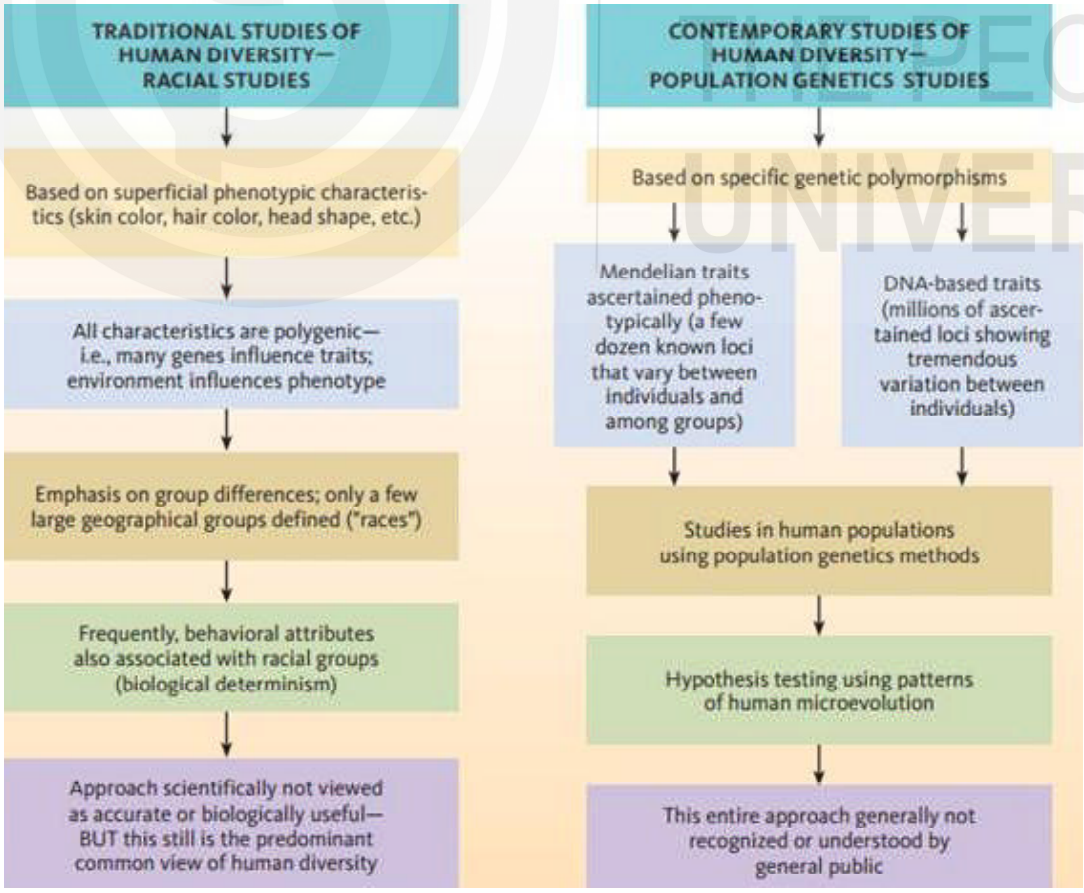


Fig. 5: Former and Contemporary Approaches to the Study of Human Variation

Source: http://anthropology.msu.edu

Check Your Progress 4

8) The three basic types of finger print patterns are :
   a) Whorls, Accidentals and Loops
   b) Loops, Arches and Whorls
   c) Whorls, Arches and Accidentals
   d) Arches, Loops and Rings

9) Polymorphic DNA loci containing repeated sequences of nucleotides are known as:
   a) Oligonucleotides
   b) Microsatellites
   c) DNA Markers
   d) DNA Ladders

4.3 METHODS TO STUDY HUMAN EVOLUTION

The understanding of human evolution is based on the interpretation of comparative anatomy and embryology, palaeontology, dating methods, geographical distribution of species and invisible molecular structure that have changed and modified along with the time. There are numerous evidences which support the occurrence and understanding of human evolution which in turn are also used as crucial methods to study human evolutionary process; some of the important methods and approaches of studying are given:

4.4.1 Comparative Anatomy

The method comparative anatomy deals with the comparative study of the body structures of different animal species including humans to understand the course of evolution. Several anatomical and morphological structures present in related animal species provide an important means to trace the evolutionary lines. These anatomical structures include:

Homology and Analogy: Similarities in the anatomical structure of different animals having different functions is referred to as homology and structures are termed as homologous structures. Contrary to it, anatomically dissimilar animals showing similarity in their functions because of adaption along similar lines are defined as analogy and structures are called analogous structures. For example: the structure of feet of bat, forearms of horse and forearm of man are homologous structure whereas flying organs of butterfly, aves and bat present examples of analogous structure.

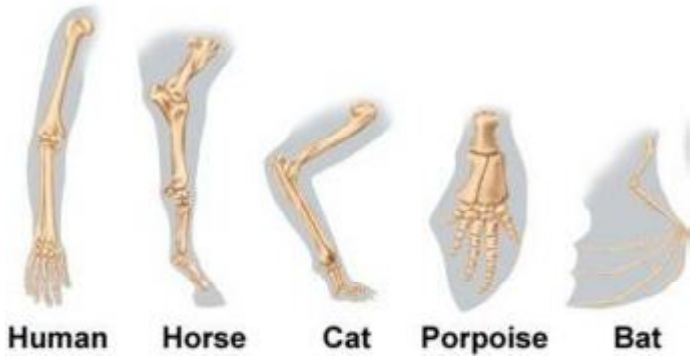


Fig.6: Homologous structure

***Source*:** https://www.differencebtw.com/difference-between-homologous-and-analogous-structures/

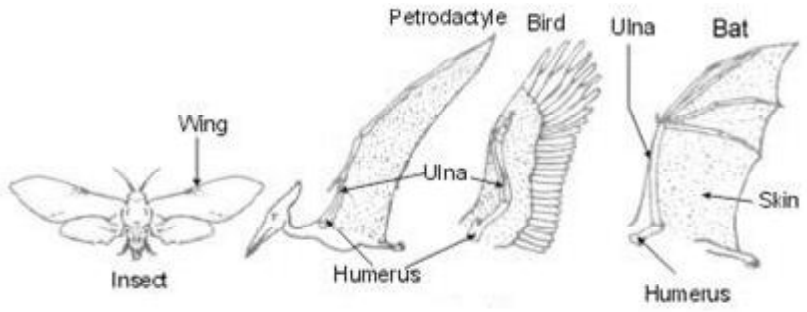


Fig. 7: Analogous structure

Source: https://www.studyrankers.com/2016/11/to-study-homology-and-analogy-of-animals.html

Vestigial Organs: These organs bear testimony regarding the evolution of animals. Vestigial organs are remains of developed organs that have become useless or unessential after evolution. Humans and other animals show a number of instances of vestigial organs. For example: The vermiform appendix in man is a vestigial organ. Appendix is found in developed form in other primates which helps in the digestion of coarse food materials.

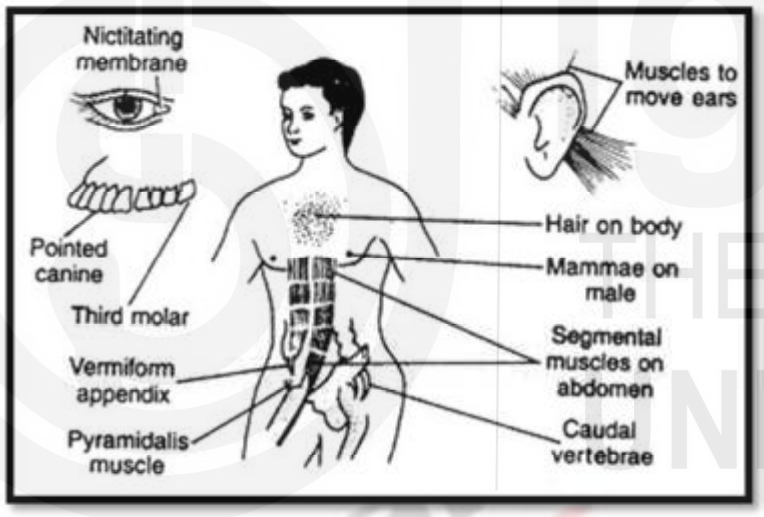


Fig. 8: Vestigial organs in man

Source: https://shoker24.files.wordpress.com/2015/03/382_vestigial-rgans.png

Adaptive modification: Adaptive modifications in the organs of animals belonging to same class support evidences for evolution. For example, the forearms of animals belonging to class mammalia have assumed different forms according to functions in different times (Pandey, 2010).

4.4.2 Comparative Embryology

Embryological studies (individual development in earlier phases) also suggest the path of evolution. Ernest Haeckel (1866) postulated biogenetic law or recapitulation theory as he observed the generalised developmental pattern between the embryos of different animal groups. On the basis of this law attempts were made to understand that embryological changes in all multicellular animals exhibit similarity. In early stage, embryo of fish, salamander, birds and man exhibit similarity to a great extent which indicates that these animals would have evolved from a common ancestor.

4.4.3 Paleontology

Paleontological methods (study of fossils) offer important evidences to study evolution. When fossils are arranged chronologically, they present strong proof of stages through which the evolution of animals had taken place. Entire geological time scale has been formulated on the basis of fossils discovered from different stratum of rocks. Fossils have been helpful not only in establishing geological time scale, but they have also helped in solving the problem of missing link **(**Pandey, 2010).

4.4.4 Dating Methods

The determination of age of fossils is essential to elucidate their relationship in order to understand the path of evolution. The advanced methods used in stratigraphy and radiochemistry made it possible to establish both relative and absolute dates for many groups of fossils. Relative dating method is based on the thorough knowledge of stratigraphy which is the study of the layers or strata which makes up parts of the earth's crust. The determination of relative age of fossils in a section of excavation is comparatively easier than fossils obtained from different sites some distance apart. In latter case, the stratigrapher needs to correlate the sequence in different sites to determine the age of one fossil in relation to other, which may introduce considerable uncertainties.

Absolute dating depends on being able to determine the age in years of certain geological deposits which may contain fossils or more often underly or cover bearing strata. The techniques have been developed as a result of the discovery that certain naturally occurring radioactive elements decay at constant, known and measurable rates into other known elements. Radioactive potassium (K^{40}) and radioactive carbon (C^{14}) are two such elements that decay into argon and nitrogen respectively. These techniques can be used both directly and indirectly to date fossils in a number of ways and forms an essential basis for the construction of a reliable phylogenetic lineage (Campbell, 1967)

4.4.5 Geographical Distribution of Species

Another strong evidence for evolution is provided by geographical distribution of species. Geographical distribution is one of the causes that lead differences in the biological structure of animals. Due to geographical isolation many related species isolate and get adapted to the changed environment. But in spite of local changes and modifications, they exhibit 'similarities' which provides evidences for evolution.

4.4.6 Molecular Biology

Researches in the field of molecular biology present many evidences in support of evolution. Important molecular biological methods to understand evolution include:

Amino-acid sequences in Proteins: Evolution of amino acid sequences in different proteins is helpful in understanding the process of evolution. For example, in mammals, difference of one amino-acid in a protein named haemoglobin shows time distance of 70 lakhs from other animals. Some other proteins like insulin, cytochrome etc. show more distance of time. From the distance of time period the rate of evolution can be predicted.

Nucleotide sequence in Protein: Nucleic acids like DNA and RNA possess nucleotides. By studying the nucleotide sequences of these nucleic acids, evolutionary processes can be understood. In this method, hybridisation of DNA in vitro of two animals is done and difference is calculated on the basis of thermal stability (Pandey, 2010).

Furthermore, the comparison of mitochondrial genome of animals is an important method to examine the tempo and mode of molecular evolution. Mitochondria are transmitted along only female lineages and mtDNA is genetic haploid, the effective size of a population of mtDNA is a quarter of that of the corresponding autosomes. The mutation rate of the mitochondrial genome is about ten times higher than that of nuclear DNA which provides an abundance of polymorphic sites to study the rate of evolution (Cavalli-Sforza and Feldman, 2003). Cann, Stoneking & Wilson (1987) derived two important conclusions from the analysis of mtDNA. These conclusions are:

- the first major separation in the evolutionary tree of modern human was between Africans and non-Africans and
- the time back to the most common recent ancestor of modern human mtDNA was 190,000 years (Cavalli-Sforza & Feldman, 2003).

Check Your Progress 4

10) Structures or organs which are similar in their morphology but dissimilar in functions are called:
    a) Homologous Structures
    b) Analogous Structures
    c) Vestigial Organs
    d) Atavistic Organs
11) Who proposed recapitulation theory?
    a) Charles Darwin
    b) Ernest Haeckel
    c) Johann Friedrich Blumenbach
    d) Carl Linnaeus
12) The study of life of the geologic past based on fossil records is known as:
    a) Meteorology
    b) Paleoanthropology
    c) Paleontology
    d) Archaeology
13) mtDNA is transferred along:
    a) Maternal Lineage
    b) Paternal Lineage
    c) Both Maternal and Paternal Lineage
    d) Not a specific lineage

4.4 SUMMARY

The subject matter of biological anthropology is mainly concerned with the understanding of human origin and evolution and assessment of human variations. Biological anthropologists consider human variations as the product of the evolutionary process. The process of evolution brings out changes in certain biological traits that eventually results into the diversities between ancestral and descendant human groups. The discipline of biological anthropology offers many well defined methods and techniques to study the evolutionary theory and human variability. In the beginning of nineteenth century human variations were explored and analyzed in terms of racial categories. Recently, biological anthropologists developed new genetic techniques that permit the study of human genetic variation at a level never before conceived. Such researches and developments will have a profound influence on the clear understanding of human diversity and will also protect particular human groups from the risk of certain diseases. Moreover, through the use of these new techniques and approaches, the broader history of our species is coming under closer genetic scrutiny with a clear understanding of the path of human evolution.

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4.6 ANSWERS/HINTS TO CHECK YOUR PROGRESS

1. (a)
2. (a)
3. (a)
4. (b)
5. (b)
6. (c)
7. (c)
8. (b)
9. (b)
10. (a)
11. (b)
12. (c)
13. (a)