BANC-101

Introduction to Biological Anthropology

School of Social Sciences
Indira Gandhi National Open University

EXPERT COMMITTEE

Professor A. Paparao
Department of Anthropology
Sri Venkateswara University Tirupati

Professor A. K. Kapoor
Department of Anthropology
University of Delhi, Delhi

Professor Satwanti Kapoor
Department of Anthropology,
University of Delhi, Delhi

Professor Rajan Gaur
Department of Anthropology Punjab
University, Chandigarh

Professor Subho Ray
Department of Anthropology
University of Calcutta
Kolkata

Professor Rashmi Sinha,
Faculty of Anthropology,
School of Social Sciences,
Indira Gandhi National Open
University, New Delhi

Dr. P. Venkatramana
Faculty of Anthropology
School of Social Sciences,
Indira Gandhi National Open
University, New Delhi

Dr. Rukshana Zaman
Faculty of Anthropology
School of Social Sciences
Indira Gandhi National Open
University, New Delhi

Dr. Mitoo Das
Faculty of Anthropology,
School of Social Sciences,
Indira Gandhi National Open
University, New Delhi

Dr. K. Anil Kumar
Faculty of Anthropology,
School of Social Sciences,
Indira Gandhi National Open
University, New Delhi

COURSE PREPARATION TEAM

Block		Unit Writers
Block 1	**Understanding Biological Anthropology**	
Unit 1	Introducing Anthropology	Dr. Prashant Khattri, Department of Anthropology, University of Allahabad, Allahabad Dr. Rameeza Hasan, Department of Anthropology, Madhab Choudhury College, Barpeta Professor Rashmi Sinha, Faculty of Anthropology, School of Social Sciences, Indira Gandhi National Open University, New Delhi
Unit 2	Relationship and Applications of Biological Anthropology	Dr. N. K. Mungreiphy, Amity Institute of Anthropology, Amity University, Noida
Unit 3	Fundamentals and subfields of Biological Anthropology	Dr. Ratika Samtani, Amity Institute of Anthropology, Amity University, Noida
Unit 4	Approaches of Traditional and Modern Biological Anthropology	Professor A. K. Kapoor, Department of Anthropology, University of Delhi, Delhi
Block 2	**Understanding Human Variation and Theories of Evolution**	
Unit 5	Human Variation and Evolution	Professor A. K. Kapoor, Department of Anthropology, University of Delhi, Delhi
Unit 6	Theories of Organic Evolution	Dr. P Venkatramana, Faculty of Anthropology, School of Social Sciences, Indira Gandhi National Open University, New Delhi Professor A. K. Kapoor, Department of Anthropology, University of Delhi, Delhi Professor Jaydip Sen, Department of Anthropology, University of North Bengal, Darjeeling, West Bengal.
Unit 7	Basic Concepts of Evolution	Professor Rashmi Sinha, Faculty of Anthropology, School of Social Sciences, Indira Gandhi National Open University, New Delhi
Block 3	**Living Primates: Human and Non-human**	
Unit 8	Classification and Characteristics of Living Primates	Professor Rajan Gaur, Department of Anthropology, Panjab University, Chandigarh
Unit 9	Behaviour of non-human primates	Dr. Ajeeet Jaiswal, Assistant Professor, Department of Anthropology, Pondicherry University, R.V. Nagar, Kalapet, Puducherry
Unit 10	Comparative Anatomy of Human and Non-human Primates	Dr. Ajeeet Jaiswal, Assistant Professor, Department of Anthropology, Pondicherry University, R.V. Nagar, Kalapet, Puducherry
Block 4	**Great Divisions of Humanity**	
Unit 11	Major Races of the World	Professor S.P. Singh, Retired, Human Genetics Department, Punjabi University, Patiala
Unit 12	Racial Classification	Professor Subir Biswas, Department of Anthropology, West Bengal State University, Berunanpukuria, PO-Malikapur, Barasat, West Bengal
Unit 13	Race and Racism	Professor Ranjana Ray, (Emeritus Professor), Department of Anthropology, University of Calcutta, Kolkata Professor Subha Ray, Department of Anthropology, University of Calcutta, Kolkata.
Practical Manual		Professor Rashmi Sinha, Faculty of Anthropology, School of Social Sciences, Indira Gandhi National Open University, New Delhi (Portions adopted from Practical Manual of the Course Physical Anthropology (MANI 002) of the Programmme Masters in Anthropology (MAAN).

Course Coordinator : Professor Rashmi Sinha, Discipline of Anthropology, SOSS, IGNOU, New Delhi

General Editor : Professor Rashmi Sinha, Discipline of Anthropology, SOSS, IGNOU, New Delhi

Editor (Content, Format & Language) : Prof. Rashmi Sinha and Dr. Monika Saini (Academic Consultant) Faculty of Anthropology, SOSS, IGNOU, New Delhi

PRINT PRODUCTION

Mr. Manjit Singh
Section Officer (Pub.),
SOSS, IGNOU, New Delhi

Secretarial Assistant
Mr. Rampal Singh and
Mr. Naresh Kumar

Cover Page Design : Dr. Monika Saini
(Academic Consultant), Faculty of Anthropology,
SOSS, IGNOU, New Delhi

November, 2019

ISBN-

Further information about the School of Social Sciences and the Indira Gandhi National Open University courses may be obtained from the University's office at Maidan Garhi, New Delhi-110 068, India or the Official Website of IGNOU : www.ignou.ac.in

Printed and published on behalf of the Indira Gandhi National Open University, New Delhi, by Director, School of Social Sciences.

Lasertypeset by Rajshree Computers, V-166A, Bhagwati Vihar, Near Sec. 2, Dwarka, Uttam Nagar, New Delhi.

Printed at :

Content

ignou
THE PEOPLE'S
UNIVERSITY

INTRODUCTION

Biological anthropology is the study of human variations, adaptations and evolution of our living and fossil relatives from a biological perspective. The subject matter of biological anthropology encompasses a wide range of topics such as human palentology, evolutionary biology, primate behaviour, human genetics and biological variations. In order to understand the contemporary human biological variations and the evolutionary history of humans, biological anthropologists study fossil hominin records as well as the nonhuman primates. The discipline also analyses individual human behaviour in terms of evolution and adaptation to understand the human uniqueness and distinctiveness.

With this backdrop, the present course on biological anthropology has been organized into four blocks keeping in mind the necessities of understanding the important aspects of human evolution and variations. The first block provides a detailed introduction of biological anthropology in four units. Unit 1 introduces Anthropology and its various branches, with a special reference to physical anthropology. The historical development, aim and scope of the discipline and as well as a discussion of the usage of the term "physical or biological anthropology" have been presented in this introductory unit. In Unit 2, the interdisciplinary approach of physical or biological anthropology in relation with other disciplines like biological sciences, earth sciences, chemical sciences, health sciences, medical sciences have been discussed. Unit 3 provides a detailed exploration of fundamentals and sub-fields of biological anthropology. Unit 4 expands on the traditional and modern approaches of biological anthropology and highlights the new methods to study human variations and evolution.

In the second block (Unit 5 through 7) a balanced coverage of the major components of human evolution and variation has been presented. Unit 5 describes the early ideas and theories on the origin of life. This unit also deals with the major sources of human variations that are responsible for racialization of humans. The last section of the unit gives an account of the racial classifications proposed by Francois Bernier, Carl Linnaeus and De Buffon. In unit 6, important theories that explained the process of organic evolution have been critically discussed. Unit 7 explains the basic principles of evolution that are crucial in understanding the mechanism of evolution. These principles include speciation, irreversibility, convergence and parallelism, adaptive radiation and extinction.

The third block comprises three units (Unit 8 through 10) on our evolutionary cousins, the non-human primates. Unit 8 focuses on the characteristics and taxonomic classification of primates. This unit also provides a detailed discussion on the origin of primates and how modern humans have developed from other living primates with which they share so many physical and behavioural similarities. Units 9 and 10 give a comparative exploration of human and non-human primates and provide additional information on how they are closely connected to us anatomically and behaviourally.

In the last block of this course (Unit 11 through 13), a detailed description on the concept of race has been presented. Unit 11 provides information on the major racial groups of the world along with a discussion on the criticism of racial classification. Unit 12 gives an account of important racial classifications proposed by various scholars. The unit also delineates the biological basis of

proposed racial classifications. Finally, Unit 13 deals with the social construct of the concept of race and racism. Various statements on race given by renowned international organizations like UNESCO and American Anthropological Association have been also included in the unit.

There is a manual concerning the practicals for this course. The practical manual on physical anthropology comprises of three sections. The first section provides the illustration and description of various instruments that are used for taking accurate and precise measurements on human body. Second section deals with Somatometry, the metric study of living human body. In the third section, a description of Somatoscopy has been given which is defined as the visual observation of physical features of various parts of human body. The practical manual also contains various diagrams and drawings depicting somatometric landmarks and standard charts of somatoscopic features for the better understanding. This practical manual will enable to understand various tools and techniques required for metric and visual observations of human body. You will be able to enumerate and describe the significant measurements of human body. Furthermore this practical manual will help to acquire knowledge of the somatoscopic features and their subsequent classification in standard forms/ categories.

Block 1

Understanding Biological Anthropology

ignou
THE PEOPLE'S
UNIVERSITY

UNIT 1 INTRODUCING ANTHROPOLOGY*

Contents

Learning Objectives

After reading this unit you will:

- understand the subject matter of Anthropology;
- know about different branches of Anthropology;
- know the history and development of Physical/Biological Anthropology; and
- comprehend the aim and scope of Physical/Biological Anthropology.

1.0 MEANING OF ANTHROPOLOGY

Most generally Anthropology is defined literally by expanding the word itself into *anthropos* and *logos*. *Anthropos* means human and *logos* mean science, thus defining anthropology as science of human. The American Anthropological Association defines Anthropology as "the study of humans, past and present. To understand the full sweep and complexity of cultures across all of human history, anthropology draws and builds upon knowledge from the social and biological sciences as well as the humanities and physical sciences. A central

* Dr Prashant Khattri, Department of Anthropology, University of Allahabad, Allahabad; Dr Rameeza Hasan, Department of Anthropology, Madhab Choudhury College, Barpeta; Professsor Rashmi Sinha, Faculty of Anthropology, School of Social Sciences, Indira Gandhi National Open University, New Delhi.

concern of anthropologists is the application of knowledge to the solution of human problems" (The American Anthropological Association Website).

> *Anthropology is the comparative study of mankind. The etymological meaning of anthropology which comes from the Greek word Anthropos for "man" and logos for "study" is not complete to give clarity about the subject. Anthropologists impose no restriction in terms of time, space or the aspect of mankind that is analyzed. It concern with the study of Homo from its beginnings right up to the present in all its manifestations and variations. Since the subject matter is large and complex, different branches of Anthropology focus in different aspects of the human experiences. The broad range of anthropological interest and focus of study has led to the creation of sub-branches and specialization which indicates difference in specific subject matter and methods of study, the inevitable consequence of necessary specialization (Dash, 2004).*

The basic idea in this definition is that anthropology is an integrative science that tries to understand human in its totality. It studies cultural and biological diversities for a better understanding of human existence. Giving a single comprehensive definition of Anthropology is rather difficult as the subject is vast and diversified hence divided into four sub-branches: Physical/ Biological Anthropology, Social-Cultural Anthropology, Archaeological Anthropology and Linguistic Anthropology.

1.1 ANTHROPOLOGY: A HOLISTIC/ INTEGRATED DISCIPLINE

Anthropology takes a holistic view of human existence. It tries to integrate all that is known about human beings and their activities. The holistic approach of anthropology can be understood in terms of its four-field approach that encompasses physical, social, archaeological and linguistic anthropology. Each of these four sub-disciplines contributes to the understanding of different aspects of humans in past and present. Rather than focusing on a single aspect of human, such as history or biology, anthropology is distinct in its holism. From a holistic perspective, Anthropology attempts to study all aspects of human culture and society in an integrated and comprehensive manner. It starts from placing the *Homo sapiens* in the evolutionary scheme to analyzing the variations within the human species. It then tries to understand the emergence and diversification of culture and emergence of civilization (McIntosh, 2008).

Being a holistic discipline, Anthropology tries to understand human existence from different angles of culture, biology, history and environment. Anthropologists are interested in understanding the origin and development of human species. They are also interested in knowing how environment affects culture and how culture has an impact over the growth and development of human. Anthropologists enquire about the existence of human variation and try to find reasons behind such variations. They are equally interested in the reconstruction of human past and its culture.

An example can illustrate this point more clearly. We all have studied about the Indus Valley Civilization in our school days and know something about the fascinating culture and society of that period. Past had been reconstructed on the basis of archaeological findings in the form of artifacts- seals, statues, objects of daily use, objects of luxury etc. People of Indus Valley Civilization knew how to write but the script has till date not been deciphered. In the absence of such evidence, reconstruction of the past is totally based upon contextual findings and scientific analysis. Some skeletal remains have been found from Harappa. They belong to both male and female. On genetic analysis of these remains, it has been established that most of the male skeletal remains were genetically not related; on the other hand most of the females are genetically related to each other. Very important insights have been gained from such findings. It can be said that since most of the females were related genetically, therefore the residence pattern after marriage could be '*matrilocal'* in nature. This is to suggest that after marriage males might have come to their wives place to reside which is opposite to what we observe generally in most societies in India that after marriage women go with their husbands. This may also have important bearing in the context of position of women in the society as it has been observed that in matrilocal societies, position of women is better than their patrilocal counterparts. Anthropological approach to the study of Indus civilization integrates almost all aspects of Harappan life that reflects anthropology takes a holistic view of human existence (McIntosh, 2008).

Check Your Progress 1

1) Anthropology is the scientific study of:

   a) Amphibians

   b) Humans

   c) Reptiles

   d) Birds

2) The subject matter of Anthropology is divided into:

   a) 03 branches

   b) 05 branches

   c) 04 branches

   d) 06 branches

3) The discipline of Anthropology is described as holistic because:

   a) It consists of many sub-disciplines

   b) It supports complete development of marginalized societies

   c) It is an integrated and comprehensive approach to study human diversities

   d) It focuses on interdisciplinary approach

1.2 SCOPE OF ANTHROPOLOGY

Anthropology as a holistic or multifaceted discipline deals with the study of man in totality. It studies man not only as a part of nature but also as a dynamic creature in terms of biological and social features. Anthropology is also referred to as a comparative study of man since it takes into consideration the similarities and differences in human body, behavior and values of all human groups. The wide scope and vastness of the anthropology necessitates its division into four branches as mentioned earlier. It must be kept in mind that anthropology retains its holistic orientation by ensuring the interconnectedness and interrelationship among its branches as well as with humanities, social sciences, biological sciences and physical sciences. The scope of anthropology and its four major branches are presented in the following section.

1.3 BRANCHES OF ANTHROPOLOGY

1.3.1 Physical/Biological Anthropology

Physical anthropology also known as biological anthropology takes into account human body, genetics and the status of man among living beings. This branch of anthropology is mainly focused on human evolution, variation and adaptations. As the name indicates, it studies the physical characteristics of man, using the general principles of biology and utilizes the findings of anatomy, physiology, embryology, zoology, paleontology and so on.

The scope of physical anthropology is embedded in its various branches i.e. primatology, palentology, human genetics, growth and development and forensic anthropology. In recent years many academic research areas of physical anthropology have evolved as specialized fields. Mention may be made of human population genetics, physiological and nutritional anthropology, and molecular anthropology. Further elaboration on the scope of physical anthropology is presented in section 1.4.4.

1.3.2 Socio-cultural Anthropology

Socio-cultural anthropology is the second major branch of anthropology, focusing on the comparative study of human culture and society. The intensive study of customary patterns in human behavior, thought and feelings and organization of social groups are all included in the purview of socio-cultural anthropology. Socio-cultural anthropology is referred by the term ‘social anthropology’ in Great Britain while similar studies are referred by the term ‘cultural anthropology’ in America. However, it is pertinent to note here that in the nineteenth century the term ‘ethnology’ was in use for similar studies.

Social Anthropology tries to find out the structure of human society that consists of customs, beliefs whole pattern of working, living, marrying, worshipping and political organization. It tries to find out the differences in the human societies and also tries to establish the similarities among these societies. The life of man has several dimensions and the attempts to study each one in detail has resulted in the origin and growth of several sub-branches from the elementary branch of social anthropology such as economic anthropology, political anthropology, psychological anthropology,

Anthropology of Religion and so on. Many new sub-branches are also coming up like – Communication and Visual anthropology, with the new demands of society (Patnaik, 2011).

1.3.3 Archaeological Anthropology

Archaeological anthropology is the science which concerns itself with the recovering and studying the relics of Man's past (Roe, 1970). It studies human cultures through the recovery and analysis of material remains and environmental data. The major time periods that are covered under archaeology include prehistoric, proto-historic and civilization. Material products scrutinized by archaeologists include tools, pottery, hearths and enclosures that remain as traces of cultural practices in the past, as well as human, plant and animal remains, some of which date back 2.5 million years (Haviland et al., 2008).

Studying societies and cultures of the remote past also falls into the scope of archaeological anthropology. Anthropologists try to reconstruct the life style of the people who either left no written records or those who left certain written material but which could not be deciphered as yet. Archaeological anthropology also helps to study the contemporary societies from the light of their socio-cultural practices set in prehistoric period times (Ember, Ember & Peregrine, 2002).

1.3.4 Linguistic Anthropology

Linguistic anthropology, another branch of anthropology deals with the study of human languages. Anthropologists who specialize in this area are particularly concerned with the relationship between language and culture behaviour. Linguistic anthropology encompasses the study of the emergence and divergence of languages over time. Initially this branch was concerned with the study of origin, evolution and development and salvaging of languages which were on the verge of disappearing. With time the various facets of language and its effect on social life were also taken into consideration. Today linguistic anthropology as an interdisciplinary science works in collaboration with anthropological linguistics, ethno-linguistics and socio-linguistics.

Language is an important aspect of human behaviour and the transmission of culture has been possible through languages. Therefore, the sub-field of linguistic anthropology also helps to understand cultural variations and human behaviour. The scope of linguistic anthropology mainly lies in the study of past and present languages. Linguistic anthropologists not only study the written languages but they also try to decipher cultures through unwritten languages.

Check Your Progress 2

4) Which field of Anthropology concentrates on human evolution adaptation and variation?

   a) Physical Anthropology

   b) Socio-Cultural Anthropology

c) Linguistic Anthropology

d) Archaeological Anthropology

5) Archaeological Anthropology is mainly concerned with:

a) Emergence and divergence of languages

b) Reconstruction of past through recovery and analysis of material remains

c) Comparative study of culture and societies

d) Study of human growth and development

6) The term 'Social Anthropology' is popular in:

a) Great Britain

b) America

c) Australia

d) Asia

1.4 BIOLOGICAL/PHYSICAL ANTHROPOLOGY: AN INTRODUCTION

Biological anthropology, also known as physical anthropology, is a scientific discipline concerned with the biological and behavioral aspects of human beings, evolution of their related non-human primates', study of their extinct hominid ancestor, their biological variability and its significance. This sub discipline of anthropology provides a biological perspective to the systematic study of human beings. Biological Anthropology echoes the shift in stressing more biologically oriented topics such as genetics, evolutionary biology, nutrition, physiological adaptation, growth and development. This shift occurred in quest of understanding origins of structure, exploring human genetics, growth and development and evolutionary history that led to advances in the field of genetics and molecular biology (Sinha, 2016).

1.4.1 Physical Versus Biological Anthropology: An Overview

During the initial stage of the inception of physical anthropology the interest was to understand the evolution and physical variations in human beings. Physical variation among human beings basically tries to answer the question of differences in colour of the skin, hair, eyes, height, weight etc. among people living in different geographical conditions. Primarily, the features that are visible to the naked eyes were studied, therefore the emphasis was on the anthropometric and somatoscopic measurements. This interest carried on till the early twentieth century and is still a major area of research. However, since the late 1950's with the breakthrough in the fields of genetics and molecular biology, the interest of the physical anthropologists have shifted to understanding biological aspects in terms of human genetics, nutrition, physiological adaptation, growth and development etc. Thus, based on the

rapidly growing interest and shift in emphasis of biologically oriented topics, many prefer to call it as biological anthropology. The usage of the term physical anthropology is however, still being retained by the American Association of Physical Anthropologists in their journals and many college courses, while some anthropologists prefer to name the subject as physical/ biological anthropology wherein both the aspects of human beings are the focus area. Thus, it can be concluded that physical anthropology was the original term, but today based on the shift in emphasis to more biologically oriented concerns the term biological anthropology is gaining popularity. Nonetheless, the subject matter tries to concentrate equally on physical and biological aspects of human beings.

1.4.2 History and Development

Physical/biological anthropology in present form is the result of successive stages of development and changes in the framework of its study. "The history of physical anthropology dates back to the time physical anthropologists deliberated on the nature and genesis of human races. 17th century witnessed the western scholars presuming that all humans were descendants of Noah and his family, consequently belonging to a single species, which meant that all contemporary human races was monogenic. German Physician Johann Friedrich Blumenbach (1752-1840) of Gottingen founder of physical anthropology, regarded as the inventor of craniology and an empirical power on the questions of human diversity divided the mankind into five races: American, Caucasian, Ethiopian, Malayan, and Mongolian.

James Cowles Prichard (1786-1848), proposed a controversial idea that as the descendants of Adam became lighter-skinned they attained higher intellects and civilization. This curiosity led him to understand that all races would become similar to western Europeans, the race that in his view had progressed farther or more rapidly. However, encountering huge number of different looking human beings, the diversity among mankind struck to them. In fact, scientific physical anthropology began in the 18th century with the study of racial classification (Marks, 1995); this scientific study of race was an answer to the presence of so many human types. Man's origin was from more than one gene picked up momentum in the scientific circles of Europe especially France and America in late eighteenth and early nineteenth centuries; stressing races were polygenic. The advocates of polygenism submitted that there was a wide variation among human population and this variation could not be attributed to the environmental difference and too great for humanity to be credited to single species. Hence, God must have created several human species right from the beginning. Philadelphia physician and advocate of polygenism, Samuel George Morton (1799-1844), in later nineteenth century reflected upon concept of human variation using anthropometric measurements.

Anthropological Society of Paris, first in the field of Anthropology, was established in 1859 by a French surgeon, Paul Broca (1824-1880) who pursued the tradition of Samuel Morton. The anthropological laboratory set up became the Centre for training program for anthropologists where activities of these early physical anthropologists were devoted to racial craniology. Anthropology became the focus and extended from Broca's laboratory to other institution and facilitated in understanding why polygenism

was favored over monogenism. The polygenists were now categorically in a position to make their point more acceptable. Broca was of the view that it was incorrect to attribute the huge diversity in races due to degeneration and also argued that it would be demeaning to consider the diversity of racial variation as degeneration from a single superior species.

Edward Tyson (1650-1708), a London based physician and member of the Royal Society, started the European primate studies and distinguished between the humans and monkeys by dissecting a chimpanzee. He concluded that the chimpanzee has more in common with man than monkeys, particularly brain. Even though the early scientific investigations were basically anatomical, lot of curiosity was generated among people in primate behavior. Thomas Henry Huxley's in Man's Place in Nature (1863) applied Darwinism to stress the origins of human. Primatology was basically concerned with the anatomy and considered evolution from paleontological record. Ernst Haeckel (1834-1919) published an encyclopedia of primate anatomy and came up with first scientific phylogenetic trees. These studies formed basis of understanding evolution of man through paleontological records. Their attempt facilitated in understanding us in present day context, though anatomy remained the focal point until after 1900.

The German tradition, led by Rudolf Virchow (1821-1902) stressed that the variation observed in the human form was a consequence of environment and disease on the human body and the lack of fit among race, nation and culture. The American tradition gave attention to the "pacified" aboriginal (Indian) inhabitants of the North American continent, finding and gathering skeletons as scientific objects, along with artifacts, languages and culture.

Subsequently, with the start of nineteenth century, anthropometry came into limelight, becoming more sophisticated under the patronage of Karl Pearson (1857-1936), co-founder and editor of the journal, Biometrika. Karl Pearson treated the measurements of bones and bodies to statistical tests that made the exercise more scientific, including computations for variation and correlation, and tests of significance for comparing samples. Physical anthropology was committed to the study of racial determinism- a philosophy that assumed the superiority of Caucasoids in the last half of the nineteenth century.

Physical anthropology was considered a mystique medical specialty in the United State after the Civil War (1861-65). Franz Boas (1858-1942) an architect of today's face of physical anthropology in 1897, led physical anthropology from just taxonomic "race" classification to practical research in human biology and unearthed and erased the doubts in the area of race and culture studies propagating the changeability of the human form. Hrdlicka (1869-1943), was a prominent physical anthropologist hired by United States National Museum in 1903 who worked hard to counter Nazi wartime belief about race and rejected the idea of racial superiority. The establishment of American Journal of Physical Anthropology in 1930 goes to him. Hooton, a Ph.D. from the University of Wisconsin, entered anthropology as an Oxford Rhodes Scholar, under R.R. Marett, and the anatomist Arthur Keith. In the following decades, Hooton trained most American physical anthropologists like Harry L. Shapiro and Carleton S. Coon whose input to the discipline is unmatched. As Harvard began to train physical anthropologists, the discipline began to diversify.

Though the emphasis continued in anatomy and medicine, human biology catered to several questions about man than just anthropometry and racial origin, Unaware of the conflict of scientific interpretation, the priceless input towards the field of anthropology continued between Germans and Amercians, by Eugen Fisher, Fritz Lenz, and Erwin Baur.

In the middle of twentieth century in 1951, a Hooton alumnus, Sherwood Washburn rediscovered the fieldwork with newer vistas in physical anthropology highlighting evolutionary process and history. Washburn's anthropology ventured to paleoanthropology and primatology. He was one of the many anthropologists who followed modern trends in biology and science and paved way for the present bio-social scenario of physical anthropology. Scientists whose prolific work and unparallel contribution laid foundation of current physical anthropology includes W K Gregory, William Krogman, Dudley Morton, Adolph Shiltz, Harry Shapiro, William Straus, T Dale Stewart and many more. Consequently, current anthropology claims diverse methodology to get a more vivid picture of animal behavior, human genetics, and medical anatomy. It has taken several roads of development in recognizing physical anthropology and giving it a very vital position in scientific fraternity'' (Sinha, 2016).

The development of physical/biological anthropological research has amazingly altered during the last three decades. The subject has made a rapid progress exploring more diversified fields covered under it. The emphasis has shifted from measurements, osteology, blood groups to nutrition, physiology and eugenics.

Check Your Progress 3

7) Which branch of Anthropology provides biological perspective to the systematic study of human beings?
   a) Biographical Anthropology
   b) Biological Anthropology
   c) Bio-cultural Anthropology
   d) Bioscience Anthropology
8) Who is considered as father of Physical Anthropology?
   a) M. D. Leakey
   b) J. F. Blumenbach
   c) K. Pearson
   d) R. Dart
9) Who is the author of *Systema Naturae*:
   a) Carl Linnaeus
   b) J. F. Blumenbach
   c) Comte de Buffon
   d) Charles Darwin

1.4.3 Aim

The old physical anthropology symbolizes the descriptive stage of the subject, distinguished by anthropometric measurements and classification of indices

and computation of statistics. This approach with stress on taxonomy remained static till genetics and its applications in the explanation of evolutionary theory surfaced; hence the objective of old physical anthropology was principally classification by which it was assumed that description of the differences would suffice for solving the problem. The new physical anthropology on the other hand concerns in understanding the processes and mechanisms involved in the problem, where classification plays a trivial role. Thus, the new physical anthropology embarks on where the old conclude, with aims and interests of both the traditions remaining same, although the accent of new physical anthropology is reorientation in methodology and comprehension and interpretation.

Physical anthropology answers the question on who were the ancestors of human species and how they evolved to the present form. They ascertain the different stages and mechanism during the evolutionary history. Human paleontologists reconstruct the skeletons of extinct that may have been our forerunners to understand the present day man. Using the fossil record and from what can be determined through comparative anatomy, the paleoanthropologists study the evolution of primates and hominids.

Physical anthropologists apply human demographic and ecological data (of birth rates, death rates, marriage practices, nutritional intake, health condition, and so on) to the study of human population genetics. Demography directly related to fertility and morality is another subject which attracts attention of physical anthropologists. The factors responsible for variation in different populations of these phenomena are answered by the physical anthropologists.

The molecular differences between species and the relative frequencies of different molecules in the same species necessitate explanation on acceptance of how these species live, or have lived in the womb, or how their ancestors lived in the distant past, is the domain of molecular anthropologist. The growth in man is reliant on two broad categories - heredity and environment. The study of growth and its related fields are important aspects of physical/ biological anthropology (Sinha, 2016).

1.4.4 Scope

Physical/biological anthropology no more remains only an academic discipline, the recent past reflect an ever increasing recognition of what anthropology has discovered and can discover about humans. The latest developments in the field have opened new avenues in physical anthropology. Globally the scope of physical anthropology is best identified within the framework of the tradition followed in the different stages of its development. These traditions may be called “old or classical” physical anthropology and “New or Analytical” physical anthropology. Ever since the coining of the term “New physical Anthropology’ by Washburn in 1951, the study of man has come long way.

Physical anthropology is generally accepted as the comparative science of man as a physical organism in context to his total surroundings, both social or cultural and physical; because development of his physical and cultural factors is reliant on the environment prevailing at that time, form an important anthropological perspective.

The extent of human variability and their factors responsible for the current distribution have been of vital concern. Genetics and anthropometry are used to determine the cause of diversification and human variations-a specialized branch of physical/biological anthropology.

Human diversity, a component of physical anthropology takes into account human taxonomy, which in anthropological perspective refers to study of races. The genetic diversities observed in different racial groups can be explored through factors of mutation, gene recombination, chromosomal alterations, isolation, genetic drift, social selection and so on. The difference in frequencies of phenotypic and genotypic characters, classification of human population form basis of race, ethnic groups, isolates or mendelian population or endogamous groups.

The stage of evolution particularly the 'prehuman' history of man to his present form is the foundation of primatology apart from anatomy, physiology and ethology. Unquestionable is the contribution of primate paleontology on extinct primates, tracing the origin of man and his evolution under palaeoanthropology.

The major concern of human evolution is to trace the ancestral form and to understand the course of evolutionary processes and mechanism involved in the making of the erect walking, bipedal brainy creature who is a tool maker. This is accomplished by the assessment of biological distinctiveness of the living as well as extinct non-human primates and by the comparison of the same with those of the living and extinct people. All living populations of the world had common ancestor irrespective of their morphometric variation. This necessitates contribution from primatology, primate paleontology, palaeoanthropology and comparative anatomy.

Human genetics a significant part of physical/biological anthropology has witnessed incredible growth. Inheritance patterns of trait in humans have generated lot of curiosity. The assessment of the gene frequency and distribution of the traits form a significant basis for evaluating the incessant process of human differentiation. The study of human genetics has facilitated for treatment and genetic counseling to prevent inherited disorders. Human population genetics use mating pattern as a method that assist in the estimate of inflow and outflow of genes that are accountable for evolution. Eugenics forms a fundamental part of physical anthropology responsible towards the progress of populations.

Growth and development in physical/biological anthropology has its own significance, be it studying secular trends (e.g., increase or decrease of weight in the next generation), stage of growth, growth pattern of a population, factors affecting nutritional status, reproductive biology, population variation all come under this branch of physical/biological anthropology.

Recent years have witnessed physical anthropology playing irrefutable service in the field of dentistry, medicine and industrial research. The scope of physical anthropology in the field of forensic science is tremendous. The various branches of physical anthropology which assists a forensic scientist in arriving at conclusion are dermatoglyphics, osteology, osteometry and serology; somatic and genetic characteristics contributing towards the determination of age and sex. Kinanthropometry uses somatological knowledge in interpreting the body types for different sports or even in relation to specific disease.

The varied dimensions of academic/research and applied significance of physical/biological anthropology have developed into a number of evidently discernable subfields of the subject as a result of advanced researches elevating physical anthropology to the level of independent discipline. The numerous specialized field of physical/biological anthropology are human population genetics, primatology, palaeoanthropology, human genetics, medical anthropology, physiological anthropology, forensic anthropology, nutritional anthropology, dental anthropology, anthropometry, ergonomics, demography, ethology, etc. (Sinha, 2016).

Check Your Progress 4

10) Who coined the term 'New Physical Anthropology'?

a) G. Mendel

b) P. Broca

c) E. Lartet

d) S. L. Washburn

11) Kinanthropometry refers to:

a) Study of measurement of human skull

b) Understanding of inheritance and hereditary traits

c) Study of human shape and size to understand growth, nutrition and performance

d) Identification of dead bodies through body measurements

12) Personal identification and reconstruction of evidences comes under the subject matter of:

(a) Human Genetics

(b) Forensic Anthropology

(c) Palaeoanthropology

(d) Anthropometry

1.5 SUMMARY

Anthropology is a subject that studies human beings in time and space. This is a holistic discipline which attempts to study all the aspects of human beings. The subject matter of the study of the four branches of anthropology reveals the multidimensional aspects of the study of man in totality. All the four branches of anthropology namely physical or biological anthropology, socio-cultural anthropology, archaeological anthropology and linguistic anthropology deals with the diverse aspects related to human biology, culture and language from the origin. The interrelationship and interconnectedness between these branches ensures the holistic orientation of the discipline of anthropology. On one hand physical/biological anthropology studies human body, genetics and the status of man among living beings whereas socio-cultural anthropology incorporates the intensive study of social behavior, customary patterns in human behaviour, thought and feelings and organisation of social groups. Archaeological anthropology deals with the reconstruction of history with the help of material remains along with skeletal remains, pollen, etc. Linguistic anthropology, another branch of anthropology deals with the study of human languages.

This unit also reflected on the history and development of the subject matter of physical/biological anthropology. It also traced the scope of physical anthropology through the lens of its various sub-fields like human evolution and variation, human genetics primatology and forensic anthropology. The varied dimensions of academic and applied significance of physical/biological anthropology have also been discussed in the unit.

1.6 REFERENCES

Dash, K. N. (2004). *Invitation to Social and Cultural Anthropology*. Atlantic Publishers & Distributors, New Delhi.

Ember, C. R., Ember, M., &, Peregrine, P. N. (2002). *Anthropology*. Pearson Education. Delhi.

Haviland, W. A., Prins, H. E., Walrath, D., & McBride, B. (2008). *Cultural Anthropology: The Human Challenge*. Cengage Learning. (Wadsworth).

Marks, J. (1995). *Human Biodiversity: Genes, Race, and History.* Aldine de Gruyter, New York.

McIntosh, J. (2008). *The Ancient Indus Valley: New Perspectives*. ABC-CLIO. California.

Patnaik, S. M. (2011). *Social Anthropology.* eGyanKosh. Accessed on: May 22, 2018. Retrieved from:

http://egyankosh.ac.in/bitstream/123456789/41233/1/Unit-1.pdf

Roe, D. A. (1970). *Prehistory: An Introduction*. Springer.

Sinha, R. (2016). *Applied Physical Anthropology: Definition and Scope.* e PG Pathshala Website: A Gateway to All Post Graduate Courses. Accessed on: May 17, 2018. Retrieved From:

http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/anthropology/01._physical___biological_anthropology_/29._applied_physical_anthropology/et/7223_et_et_29.pdf

The American Anthropological Association Website. Retrieved From:

http://www.americananthro.org/

1.7 ANSWERS/HINTS TO CHECK YOUR PROGRESS

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

UNIT 2 RELATIONSHIP AND APPLICATIONS OF BIOLOGICAL ANTHROPOLOGY*

Contents

Learning Objectives

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

- understand the relationships of biological anthropology with different fields of study; and
- comprehend the importance of interdisciplinary and collaborative learning.

2.0 INTRODUCTION

Anthropology is a holistic study of mankind with four major branches, hence the scope and subject matter is diverse. Both the theoretical and applied aspects of anthropology have close associations with other disciplines and are co-dependent at different levels.

The subject matter of physical or biological anthropology mainly consists of human biological diversity with reference to time and space. It includes the evolution of humans, their variability, and adaptations to environmental stresses. Using an evolutionary perspective that is, not only the physical form of humans such as bones, muscles and organs are examined but their functioning that allows survival and reproduction is also examined. Within the field of biological anthropology there are many different areas of focus. The center of all of them is biological variation that unites five special interests within biological anthropology:

* Dr. N. K. Mungreiphy, Amity Institute of Anthropology, Amity University, Noida

- Human evolution as revealed by the fossil record (paleoanthropology),
- Human genetics,
- Human growth and development,
- Human biological plasticity (the body's ability to change as it copes with stresses, such as heat, cold, and altitude),
- The biology, evolution, behavior, and social life of monkeys, apes, and other nonhuman primates (Martinez, 2013).

Biological anthropology studies man as a member of the animal kingdom. Generally, its approach is focused on the common theme of human evolution, variation and adaptation. Anthropologists basically seek to answer two sets of question:

(i) About the origin of humans and their evolution, this is generally studied under the topic of Human Paleontology or Paleoanthropology. The paleontologists/paleoanthropologists try to understand how humans evolved from apes to modern 'homo sapiens'. Anthropologists who specialize in study of primates are called Primatologists.

(ii) The second set includes questions about how and why contemporary human populations vary biologically; this is studied under the topic of Human variation. To understand human variation, it seeks the help of other 3 disciplines i.e. Human Genetics, Population Biology & Epidemiology. These interests link biological anthropology to other fields of science such as biology, zoology, geology, anatomy, physiology, medicine, and public health (Dhall, 2016).

The new physical/biological anthropology today mainly depends on radiographs, reflection calorimeters and spectrophotometers to study biological traits. Biophysical techniques are used to estimate mineral constituents of bone of the present and past human remains. Growth studies in relation to nutritional parameters are undertaken. To know the human variability and adaptation in a scientific way, human genetics, physiology, bio-chemistry are studied in a more extensive manner to widen the scope of physical/biological anthropology (Dash, 2004)

2.1 RELATIONSHIP WITH OTHER DISCIPLINES

Physical or biological Anthropology has an interdisciplinary approach in understanding the issue related to human evolution and variation, public health and epidemiology, nutritional studies, earth sciences, forensic science and environmental sciences to name a few. This subfield of anthropology along with different disciplines attempts to solve various human issues at different platforms.

2.1.1 Biological Anthropology and Biological Sciences

Biological or Physical Anthropology is closely associated with biological sciences in the pursuit of better understanding of human variation and evolution. Physical or Biological Anthropology studies the physical features and functioning of man, using the general principles of biology. It utilizes

the findings of physiology, anatomy, embryology, zoology and others into anthropological studies. The principle of genetics remains the same in human and other organisms (both plants and animals). Anthropological genetics is a synthetic discipline that applies the methods and theories of genetics to evolutionary questions posed by anthropologists. These anthropological questions concern the processes of human evolution, the human diaspora out of Africa, the resulting patterns of human variation and bio-cultural involvement in complex diseases. Anthropological geneticists tend to focus more on normal variation in non-Western reproductively isolated human populations. It also attempts to measure environmental influences through co-variates of quantitative phenotypes, while human geneticists less often attempt to quantify the environment in order to assess the impact of environmental-genetic interactions.

Anthropology is related to zoology, in terms of the relationship to other animals and the places of mankind in animal kingdom and the process of evolution from early pre-human forms. It is also related with anatomy and physiology as it concerns with the structure and function of the human body, the relationship of the various parts and the operation of these different parts.

Check Your Progress 1

1) Write a short note on the subject matter of physical/biological anthropology.

.....

.....

.....

2) Delineate the major difference between anthropological genetics and human genetics.

.....

.....

.....

2.1.2 Biological Anthropology and Earth Sciences

Earth science is the study of physical constitution of earth and its atmosphere. This field of study also deals with the nature and structural pattern of earth including formation of land, rock and strata. Various happenings of the past and records of the oldest life forms that flourished millions of years ago is brought into light with the help of systematic study and analysis of the earth's crust and different fossil-laden strata employing geological methods. In the study of human evolution as well as various cultural stages of man, the biological/physical anthropologists are to go a long way into the past. To study the various layers of earth and to understand the time sequences, biological anthropologists employ the knowledge and findings of the geologists. Geology plays a key role in the study of humans, particularly in the sub disciplines of paleoanthropology and archaeology. Anthropologists work closely with geologists and employ geological tools in order to reconstruct aspects of past environmental and ecological contexts from the time of our earliest human ancestors to that of modern peoples. Extrinsic selective pressures, or those that are derived from a human's surrounding environment, are revealed through the study of the earth sciences. Anthropologists place the human individual, community and population back into the environment

and attempt to understand how humans interacted with that environment. From the origins of hominins, humans' bipedal ancestors, to the appearance of modern people, anthropologists want to know about temperature, aridity and rainfall, landforms and vegetation cover, among many other factors. From these basic environmental indicators, they surmise the kinds of habitats that may have been available and exploited by humans during those times and are simultaneously compared with those of the contemporary species (Dhall, 2016).

2.1.3 Biological Anthropology and Chemical Sciences

Pollution is a worldwide problem and its potential to influence the physiology of human populations is unquestionable. Studies of human growth and development in relation to pollution have increased in number and quality since the mid-twentieth century. Many studies have found that some pollutants have detrimental effects on human growth, particularly prenatal growth. Lead, a heavy metal, is commonly found in human populations and is related to smaller size at birth and studies have reported decrements that range up to about 200 grams. Studies of humans exposed to polychlorinated biphenyls, one of the persistent organic pollutants, have reduced size at birth, advanced sexual maturation and altered hormone levels related to thyroid regulation. Thus, different pollutants exert effects through different physiological pathways. However, some studies have not observed these effects, which indicate that the situation is complex and requires further study with better study designs. Determining the effects of pollutants on human physiology and growth is rather difficult as it requires fairly large numbers of subjects who are not purposely exposed but for whom exposure can be measured. These effects of pollutants and the mechanisms of effect require further study to understand and, it is hoped to blunt or block any detrimental effects on human health and well-being.

2.1.4 Biological Anthropology and Health Sciences

Biological anthropology to a large extent is concerned with the study and understanding of human health. Anthropometry, one of the major tools of biological anthropology facilitates to understand biological variability, including morphological variation. Anthropometry, literally 'measure of humankind', was defined by Ales Hrdlicka in 1939 as 'the systematized art of measuring and taking observation on man, his skeleton, his brain or other organs, by the most reliable means and methods, for scientific purposes'. Anthropometry is the single most universally applicable, inexpensive, and non-invasive method available to assess the size, proportions and composition of the human body. Moreover, since growth in children and body dimensions at all ages reflect the overall health and welfare of individuals and populations, anthropometry may also be used to predict performance, health and survival. These applications are important for public health and clinical decisions that affect the health and social welfare of individuals and population. Anthropometric measures have been the subject of much epidemiologic and patho-physiologic research involving obesity, overweight, body fat distribution and health outcomes. In short, the assessment of health risks by using anthropometry is a well-established and time honored concept in the scientific literature.

In recent years, anthropometric indicators such as body mass index (BMI) and waist circumference (WC) are repeatedly shown to be simple yet powerful predictors of common adult chronic conditions such as type 2 diabetes mellitus (T2DM), cardiovascular disease (CVD) etc. The importance of anthropometric indices for promotion of health and primary care can be summarized at three levels: individual, community and population level. At the individual level, the measurements can be promoted both for health care providers' use in clinical applications and for patients' use in self-monitoring over time. At the community level, simple anthropometric measurements can help in identifying sub-populations in which the risk of chronic disease is concentrated, allowing these individuals to benefit from targeted interventions to reduce health risks. At the population level, secular trends in body measurements can be tracked to help evaluate societal and environmental changes that affect individual energy balances and to monitor the effects of large-scale prevention strategies (Seidell et.al., 2001).

Check Your Progress 2

3) What is Anthropometry? Explain the importance of anthropometric indices in health care sector.

.....

.....

.....

2.1.5 Biological Anthropology and Medical Science

Now-a-days, Biological anthropology tries to explore the nature and extent of various hereditary or genetic diseases. The impact of genetics on biological anthropology has opened a new dimension in which various diseases and genetic abnormality oriented happenings have now, become the important issues of discussion of biological anthropology. Various nutritional patterns, growth, deformations and their impact, anthropologists study in the light of medical sciences. In this way physical anthropology has been combined with medical science to bring forth a new discipline-Medical Anthropology (Jaiswal, 2011).

In addition to the above, family history and pedigree analysis are other important sources often used by biological anthropologists which are yet powerful clinical tools. Although traditionally associated with the evaluation of rare Mendelian single-gene disorders in individuals and their relatives, family history play an important role in risk assessment and prevention of common chronic diseases. On the other hand, pedigree analysis helps to foresee the possible genetic defects by studying the nature of inheritance of a particular trait. Numerous studies on diseases of major public health importance (e.g., cancer, heart disease, diabetes, and stroke) consistently show that the odds of developing one of these conditions are significantly increased by having one or more close relatives with the disease. The development of family history as a public health tool has experienced major advances in recent years. Family history is a significant and independent risk factor for major common, chronic diseases. As such, it is often included in risk assessment tools and professional guidelines on assessing health risk and intervening early among those at risk. A clear consensus is also emerging about shaping the future of family history as a key element of personal medical records.

Furthermore, anthropological genetics tries to find out the evolutionary questions, patterns of human variation and bio-cultural involvement in complex diseases through methods and theories of genetics. Since 1984, there has been a shift in emphasis in anthropological genetics, primarily from population structure (based on blood group and protein markers) and genetic epidemiology, to the study of human origin and the human diaspora (Crawford, 2007).

2.1.6 Biological Anthropology and Biostatistics

The modern physical or biological anthropology has increased its dependence on statistical techniques to measure the extent of homogeneity and heterogeneity among different population groups or communities. Additionally, the use of bio-statistical methods becomes very crucial when the set of all possible items in a population is very large and the study requires lots of money and time in order to do a comprehensive analysis of all of the items. For example, during a field survey, there is just not enough time or resources to talk to every participant, informant, every process step or look at every quality of life (e.g. socio-economic variables). If the study unit is large, it may be too costly to survey all the villagers to determine their socio-economic level. Evaluating or estimating attributes or characteristics of the entire system, process, product or project through a representative sample can be more efficient while still providing the required information. To legitimately be able to use a sample to extrapolate the results to the whole population requires the use of one or more of the following statistical sampling methods- random, systematic, stratified, cluster, haphazard and judgmental sampling.

2.1.7 Biological Anthropology and Biomedical Research

Anthropology particularly biological anthropology is concerned to a large extent with the study of human biological variability by racial and ethnic groups. Now a days it is even more common to compare the prevalence of risk factors for various diseases and health outcomes between members of different racial and ethnic groups in epidemiologic and public health studies. When these comparisons are made, health disparities between racial and ethnic groups have been well documented. In fact, one of the two primary goals of the US Department of Health and Human Services' (USHHS) "Healthy People 2010" was to eliminate health disparities among segments of the population, including differences that occur by gender, race or ethnicity, education or income, disability, geographic location or sexual orientation.

The use of race or ethnicity in epidemiologic and public health research affects the quantification and explanation of health outcomes, including health disparities. Although researchers have questioned the value of using race and ethnicity as scientific variables. Methodological guidelines have been purposed that aimed at increasing the integrity of these variables. It is quite clear from studies pertaining to racial and ethnic groups that researchers have not yet come to a consensus concerning their scientific use. Continued professional commitment is needed to ensure the scientific integrity of race and ethnicity as variables. At a minimum, researchers should clearly state the context in which these valuable epidemiologic and public health research variables are being used, describe the method used to assess these variables and discuss

all significant findings. Doing so will ensure continued constructive scientific dialogue about the interpretation of findings regarding race or ethnicity and will promote the successful development of intervention strategies aimed at eliminating health disparities linked to race and ethnicity.

2.1.8 Biological Anthropology and Nutrition

Nutritional anthropology has emerged as a new branch of applied anthropology over the past twenty years and its methods are having an important influence on the methods of nutritional survey and nutritional epidemiology. The field of nutritional anthropology has continued to develop rapidly. It requires the use of physical or biological anthropological techniques for studying key aspects of the nutrition of individuals, families, and communities. The methodological options in nutritional anthropology and strategies for field research also provides a background for more specialized information on social behaviour and household functioning, the determinants of food intake, the analysis of energy expenditure, and appropriate statistical methodologies. Nutritional anthropology studies food and nutrition from evolutionary, behavioral, social and cultural perspectives.

Check your Progress 3

4) How does biological anthropology play an important role in family risk assessment?

.....

.....

.....

2.2 APPLICATIONS OF BIOLOGICAL ANTHROPOLOGY

As an important branch of anthropology, biological anthropology itself is further divided into several sub-fields. Owing to its interdisciplinary nature, biological anthropology offers many applications in the fields of health and epidemiology, nutrition, medicine, forensics, human ecology and sports. Here we will be learning some of the significant applications of physical/biological anthropology:

- Ergonomics (Gr. ergon, meaning “work,” and nomos, meaning “law.”) or human engineering, deals with designing of machines, work methods and environments to take into account the safety, comfort, and productiveness of human users and operators. As learnt earlier in this unit, anthropometry is the science of measurement of the human body, which is divisible into static measurements and dynamic measurements. Static measurements are useful to determine the space to fit persons and necessary clearance around the body. While working different parts of the body move and accordingly the objects to be used are designed for which dynamic measurements are important. The body size and limb proportions vary from population to population. Age and sex are two other factors that should be taken into account. Physical/Biological Anthropology provides necessary information on these different aspects, which are useful in designing machines, weapons, furniture, garments and footwear, etc.

- Health is the most precious wealth. Physical Anthropologists have roles to play for healthy existence of mankind. Examination of clinical symptoms and anthropometry are important methods for assessment of health and nutritional status. Indices like BMI (Body Mass Index), weight for age, height for age, etc. are some of the common methods used by anthropologists in the assessment of growth and nutritional status, especially among the children of different populations. Anthropometric characters of individuals are also indicative of certain diseases like diabetes, cardiovascular problem, tuberculosis and malarial infection, etc.
- Knowledge of prevalence of certain defective genes in the populations, such as G-6-PD deficiency will be of great help to the physicians while treating malarial patients. Such persons cannot be given malarial drugs because it is fatal to them. Anthropological knowledge about the merits and demerits of inbreeding, blood group compatibility of the couples and genetic diseases will be of immense value for the common people in making decision about choosing life partners. Recent trend of molecular anthropology probes into human origin and dispersion at DNA level which entails identification of genetic codes that determine susceptibility and resistivity to diseases and subsequently determinants of adaptation, which are likely to discover in different human populations of different echo niches. This kind of knowledge will be of invaluable help in the advancement of genetic medicine.
- Kinanthropology (Gr. kineein meaning to move) is the anthropology of sports. It is, in fact, the application of anthropological knowledge in the selection of suitable sports persons for different events to achieve maximum performance. Individuals are of different body structures and temperament. Some are stocky and sluggish while some are lean and agile; some have proportionately longer limbs and shorter trunk while some have just the reverse. They can be categorized into different somatotypes, such as ectomorphic, mesomorphic and endomorphic. People from different continents and countries are of different body structures, such as height, weight, muscular structure and limb proportions, etc. Kinanthropologists deal with sorting of jargon of such data on human variation, so that exploitation of sports talents by mistaken selection and unnecessary training can be avoided. Kinanthropologists take anthropometric measurements of the sports talents and the latter are also subjected to physiological and biochemical tests along with various motor performance tests. By doing so, young and grooming sports talents can be sorted in accordance with their suitable events so as to achieve maximum human performance in different fields of sports.
- Physical anthropological knowledge about mechanism of inheritance of various genetically determined traits and about their frequencies in different populations is useful in the settlements of medico-legal cases, such as disputed paternity or maternity, identification of biological relatives, etc. Forensic anthropology, an important branch of physical anthropology deals with the identification of individuals with the help of biological remains for forensic purposes. With the help of expert knowledge of the human skeleton, dentition, hair, fingerprints (dermatoglyphics), saliva and blood genetics, DNA sequencing, and

archaeological methods, physical anthropologists provide invaluable assistance in the identification of victims and perpetrators of crimes and casualties of accidents and wars. Because of the wide spectrum of problems, methods, and practical applications, physical anthropologists specialize in one or a few subareas (Tuttle, 2018).

Besides these general applications of physical anthropology there are many specific applications which deserve mention in this connection. A number of studies have been conducted by the scholars who reflected the usefulness of physical anthropology in diverse fields of human life (Jaiswal, 2011).

- The anthropometric study of men and women conducted by the Bureau of Homo Economics in America in order to improve the clothing size, may be regarded as remarkable contribution in this field. Another study concerning the human body in relation to the physical surroundings include Hooton's study for seating accommodation in trains. During recent time much emphasis is being laid to design the seats and thereby making the sitting arrangements more comfortable. It has been understood that a close correlation exists between health and good posture. If a seat creates trouble in keeping the body in a good posture, it results in various disabilities in skeletal, muscular and other parts of the body.
- On the other hand the correctness in sitting posture enhances alertness and endurance as well as improvement in circulation and respiration of the persons concerned. Body measurements in working position can thus improve the design of seats in offices, educational institutions, in public vehicles, etc. Therefore the designers of these sitting arrangements are required to have a knowledge regarding various anthropometrical perspectives. Modern furniture designers in many countries utilize the results of anthropometrical studies to plan their activities in a scientific way.
- In the army, the data of anthropological investigations are extensively used in the Western countries. The anthropometric surveys on the military personnels are considered essential to get their body measurements done which are used to meet various demands. In Mexico, the National Military Academy has been doing effective work in this line since 1951. Here the results of biometric investigations are extensively used in the selection of cadets. The anthropometric data are greatly used in military research and development.
- The Air Forces very often utilize the anthropometric data in solving spatial problems in aircraft and also in improving flight clothing. Anthropometry is used to design the cockpit according to body size, gun-turrets, and seats for the passenger aircraft, designing of tank and gun-sight, pressure suits and helmets, anti-gravitational suits and so on. The quartermaster Corps takes the help of anthropometry for making better fitted and efficient clothing. They emphasize on finding out the relationship between clothing sizes and body measurements so that the clothes may fit a good number of the military personnel with minimum or no alteration. It can then be easily said that measurements of the body are extensively used to meet the various requirements to solve practical problems (Jaiswal, 2011).

2.3 SUMMARY

Biological anthropology extends the study of what it is to be human through time and space to focus on humans from a biological perspective. Biological anthropology deals with the evolution of humans, their variability, and adaptations to environmental stresses. Within the field of biological anthropology there are many different areas of focus. And the different subfields are interrelated with different disciplines of study for better collaboration, understanding and efficiency in dealing with human situations and issues. It plays major role in understanding the process of human origin, evolution, variation and adaptations. The subject matter of biological anthropology is of immense applied value in the fields of health, nutrition, medicine, forensics and sports.

2.4 REFERENCES

Crawford, M. H. (Ed.). (2007). *Anthropological Genetics: Theory, Methods and Applixxxcations*. Cambridge University Press.

Dash, K. N. (2004). *Invitation to Social and Cultural Anthropology*. Atlantic Publishers & Distributors, New Delhi.

Dhall, M. (2016). Relationship of Biological Anthropology with other Branches. epgPathshala: A Gateway to all Post-graduate Courses. Accessed on : 2018, March 30. Retrieved from: https://epgp.inflibnet.ac.in/ahl.php?csrno=1

Jaiswal, A. (2011, March 27). Relation of Physical Anthropology to other Sciences. Accessed on 2018, May 02. Retrieved from: http://anthropologicalstudy. blogspot.com/2011/03/relation-of-physical-anthropology-to.html

Jaiswal, A. (2013). Human Genetics and Applied Biophysical Anthropology: A Comprehensive Treatment of Biophysical Anthropology. Heritage Publisher, New Delhi.

Jaiswal, A. (2011). Applied Physical Anthropology. Accessed on 2018, May 12. Retrieved from: http://anthropologicalstudy.blogspot.com/2011/03/applied-physical-anthropology.html

Seidell, JC., Kahn, H.S., Williamson, D.F., Lissner, L., & Valde Z, R. (2001). Report from a Centres for Disease Control and Prevention Workshop on use of Adult. Anthrometry to Public Health & Primary Health Care. The American Journal of Clinical Nutrition 73(1), 123-126.

Tuttle, R. H. (2018). Physical Anthropology. In Encyclopedia Britannica. Accessed on: 2018, May 20. Retrieved from: https://www.britannica.com/science/physical-anthropology

2.5 ANSWERS/HINTS TO CHECK YOUR PROGRESS

1) Physical or Biological Anthropology studies the physical features and functioning of man, using the general principles of biology. It utilizes

the findings of physiology, anatomy, embryology, zoology and others into anthropological studies. For further details kindly refer section 2.0

2) Anthropological geneticists tend to focus more on normal variation in non-Western reproductively isolated human populations. Anthropological geneticists also attempt to measure environmental influences through co-variates of quantitative phenotypes, while human geneticists less often attempt to quantify the environment in order to assess the impact of environmental-genetic interactions.

3) Anthropometry is a major tool to study and understand human biological variability, including morphological variation. It consists of measurement of humankind. The importance of anthropometric indices in health care sector can be summarized at three levels: individual, community and population level. For further details kindly refer section 2.1.4

4) Family history, a source often used by biological anthropologists, is a simple yet powerful clinical tool of risk assessment. Family members resemble each other in risk of disease because of shared biological, cultural, and behavioral factors. Although traditionally associated with the evaluation of rare Mendelian single-gene disorders in individuals and their relatives, family history can play an important role in risk assessment and prevention of common chronic diseases. For further details kindly refer section 2.1.5.

UNIT 3 FUNDAMENTALS AND SUB-FIELDS OF BIOLOGICAL ANTHROPOLOGY*

Contents

Learning Objectives

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

- describe the subfields of anthropology and the role of biological anthropology in them;
- summarize the origins of modern biological anthropology; and
- critically discuss the contemporary subfields of biological anthropology: human evolution, human variation and adaptation, human genetics, human growth and development.

3.0 INTRODUCTION

Biological Anthropology is the study of human biological evolution and human bio-cultural evolution. Every human is a product of evolutionary history, or all the biological changes that have brought humanity to its present form. Depending on their areas of interest, physical anthropologists might examine molecular structure, bones and teeth, blood types, breathing capacity and lung volume, genetics and genetic history, infectious and other types of disease, origin of language and speech, nutrition, reproduction, growth and development, ageing, primate origins, primate social behavior, brain biology and many other topics dealing with variation in both the living and the dead-sometimes the very long dead. In dealing with such topics, physical anthropologists apply methods and theories developed in other disciplines as well as in their own as they answer questions that help us understand who we are. For example, physical anthropologists might draw on the work of geologists who study the landforms and layering of deposits of soil and rock that tell us when earlier humans lived. Or they might obtain information from paleontologists, who study the evolution of life-forms in the distant past and thus provide the essential context for understanding the world in which earlier humans lived. Some physical anthropologists are trained in chemistry,

* Dr. Ratika Samtani, Amity Institute of Anthropology, Amity University, Noida.

so they can analyze the chemical properties of bone and teeth to determine what kind of food were eaten by those earlier humans. Or to learn how living humans adapt to reduced-oxygen settings, such as in the high altitudes of the Peruvian Andes Mountains, physical anthropologists might work with physiologists who study the ability of lungs to absorb oxygen.

> *"Physical Anthropology is the science that considers humans as biological organisms in terms of both their evolutionary history and biological variation. At the beginning of the 20th century, the field was first known as physical anthropology because the focus was on the physical variation of modern and fossil humans and nonhuman primates. Much of the early research was based on descriptions of physical variation with little or no theoretical background. In the 1950's, with the development of genetics and evolutionary science, research in physical anthropology became more focused on biological and genetic processes. As a result, the term "biological anthropology" became popular to emphasize the new focus on biological processes within a genetic and evolutionary framework" (Ryan, 2002).*

We will focus the outlines of Human Evolution, Human variation and adaptation, Human Genetics and Human Growth and Development in this unit.

3.1 HUMAN EVOLUTION

Evolution is a change in living organisms over time. Both cultural and biological evolution is of immense interest to the anthropologists. Although all living creatures ultimately share a common ancestry, they differ from one another through the process of evolution. Biological evolution refers to genetic change over successive generations. The process of change is characterized by descent with modification, as descendant populations diverge from ancestral ones. Thus, the process of evolution provides a mechanism to account for the diversity of life on earth.

Mechanism of Organic Evolution: Organic evolution pertains to the gradual changes that have taken place in living organisms for their better adaptability to the environment. Macroevolution focuses on the formation of new species (speciation) and on the evolutionary relationships among groups of species**.** It may involve the following processes:

- Speciation
- Parallelism
- Convergence
- Mosaic Evolution
- Extinction
- Speciation refers to the formation of species or separate groups of interbreeding organisms that are reproductively isolated from other organisms. An example of speciation is the Galápagos finch. These finches live on different islands in the Pacific Ocean and are adapted to different eating habits. These birds don't breed with one another and have therefore developed into different species with unique characteristics.

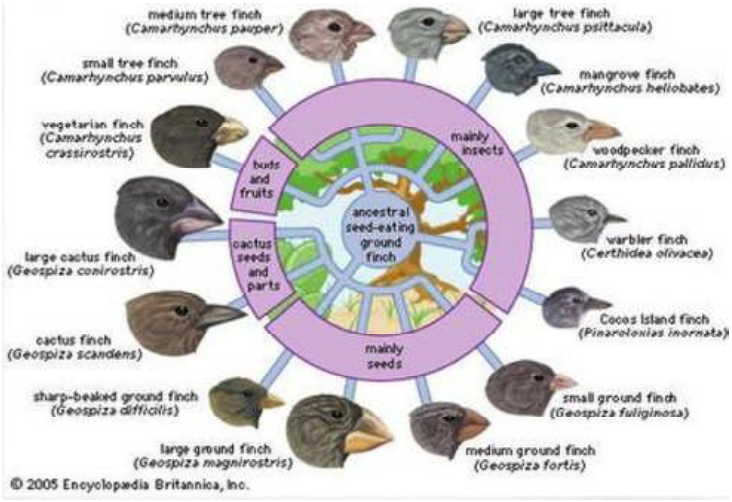


Fig. 1: Speciation in Galapagos Finches

Source: https://www.britannica.com/science/speciation

- Parallelism refers to the evolutionary development of similar traits and adaptations from the same ancestral trait in two related groups of animals. For example; the arm swinging locomotion of gibbons is parallel to the arm swinging locomotion of spider monkeys.

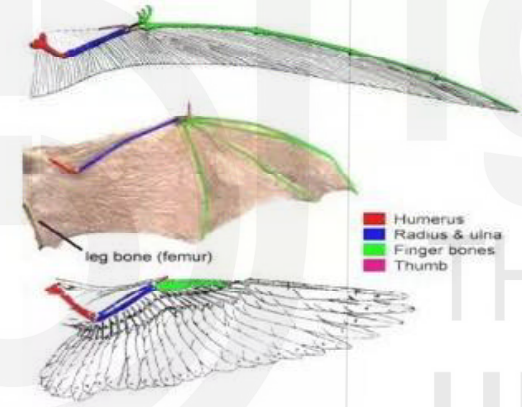


Fig. 2: Parallel evolution of vertebrate wings (pterodactyl, bat and bird)

Source: https://www.quora.com/What-are-some-impressive-examples-of-independent-parallel-evolution

- Convergence refers to the evolutionary development of similar traits and adaptations in two groups of organisms that are not closely related. For example; the wings of bats and wings of butterflies are convergent structures.

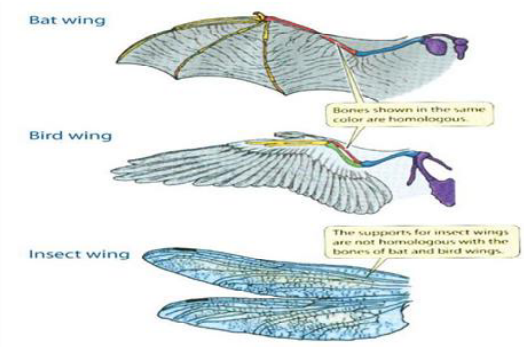


Fig. 3: Convergent evolution of bat, bird and insect wings

Source: http://peabody.yale.edu/exhibits/tree-of-life/convergent-evolution-recurrence-form

- Mosaic Evolution refers to the differential evolution of component parts of an organism. That is, all the parts of the organism do not change at the same rate in the course of evolution and all parts of the organism do not change in the same time period. For example, the foot and pelvis of the fossil ancestors of man was clearly transformed from quadrupedal to bipedal types in a relatively short time. The skull particularly the brain case of hominids changed relatively little until the erect bipedal structure had been perfected; then it changed rapidly relative to further changes in the pelvis and foot.

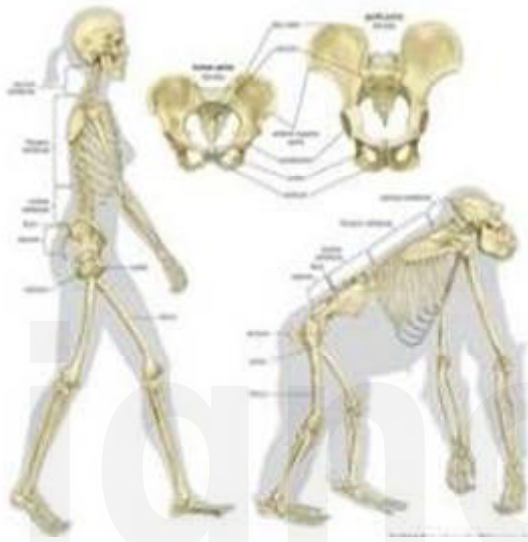


Fig. 4: Transformation from quadrupedalism to bipedalism

Source: https://www.britannica.com/science/bipedalism

- Extinction refers to the disappearance of a group or organisms from the evolutionary record. There are many ways in which a species can become extinct. A species may develop a way of life that would prevent its survival, should the environment change. For example, the wooly mammoths, well adapted to a glacial climate, became extinct as the climate grew warmer and as a major predator (man) appeared.

  Geologists have suggested that 'life' or living organic matter must have originated about 3-4 billion years ago on this earth. The term 'life' or 'living matter' is attributed to the organic molecules of nucleic acid. The first life must have originated in water, particularly, the sea, possibly in form of aquatic bacteria. 'Life' invaded only after evolving gradually in the course of several millions of years. The evolutionary scale of geologists comprises of three major eras: Palaeozoic, Mesozoic and Cenozoic. Of these, Cenozoic era is further divided into seven epochs: Palaeocene, Eocene, Oligocene, Miocene, Pliocene, Pleistocene and Holocene (Balter, 2005). It is during the epoch of Pleistocene that the ancestors of man evolved. Holocene or the present epoch is the time period of man or *Homo sapiens*.

  A brief look at the major theories of organic evolution that will help you to understand the process of evolution.

  Theories of Organic Evolution: The three major theories of Organic evolution are: Lamarckism, Darwinism and the Synthetic theory.

a) Lamarckism: The first theory of evolution, Lamarckism, was propounded by Jean Baptiste Lamarck, a French Zoologist in 1809. This theory

is popularly known as "Inheritance of Acquired Characters". Lamarck emphasized in his theory on the effects producing factors that influence evolution:

i) ***Effect of changing environment:*** Changes in environment leads to changes in needs and wants of organisms. This brings about changes in activities, thereafter leading to changes in organs of organisms for better adaptability. Lamarck believed that such changes could be inherited.

ii) ***Effect of use and disuse of organs:*** According to Lamarck, changed environmental conditions leads to the conscious effort on the part of the organism to either excessively use a particular organ or totally disuse an organ. He believed that excessive use of a particular organ led to its further development and specialization, while the disuse led to its atrophy. Such changed characters could be transmitted to their offsprings.

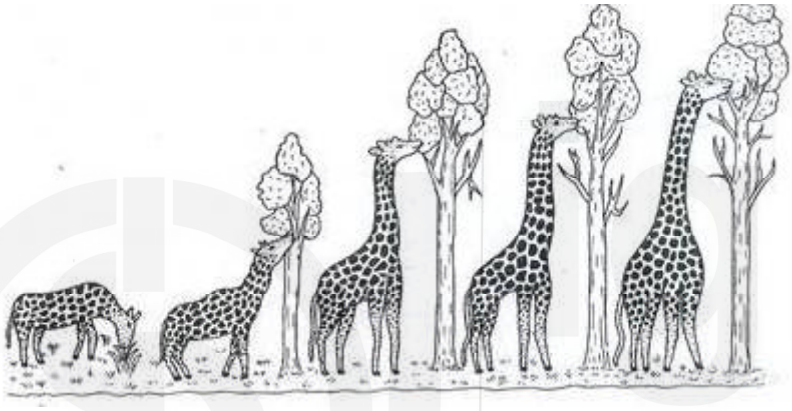


Fig. 5: Elongation of Giraffe's neck

***Source*:** http://www.yourarticlelibrary.com/theories/lamarckism

As an example of the specialization and modification acquired by an organ, Lamarck suggested the case of giraffes. Lamarck was of the opinion that the giraffes had small necks and were used to feeding on short herbs. When the herbs became scanty, the ancestral forms were obliged to browse on the leaves of trees. In attempting to do this, they had to stretch their necks. After continuous stretching, the change became substantial, resulting in an extraordinary long neck.

Lamarck's theory faced several crucial drawbacks. Weismann (1883), a German zoologist proved that use or disuse of organs does not bring any modification even after being operated for several generations. He conducted his experiments on rats by cutting off their tails for successive generations, but did not see tail-less rats in any of the upcoming generations. He therefore propounded the theory of "continuity of germplasm" wherein it was maintained that germplasm was heritable but not somatoplasm and since environment affects principally the somatoplasm, these changes cannot be inherited.

b) Darwinism: Charles Darwin, a British naturalist, in the year 1859 published his book on the 'Origin of Species' and proposed the "Theory of Natural Selection" and the concept of Organic Evolution. He attributed several factors to the cause of evolutionary changes.

i) ***Overproduction:*** Potentially, all living organisms have the ability to reproduce at a very high rate. Thus, any given population is usually

able to reproduce many more young individuals that can adequately be raised in the region they occupy.

ii) ***Variation:*** Darwin pointed out that all living organisms vary. No two organisms are exactly alike. There are always some variations. Since environment varies from region to region, the variations that living organism shows also differ from region to region. Such variations are preserved and transmitted to their offsprings. In nature, favorable variations are more prone to be inherited than the unfavorable ones.

iii) ***Struggle for existence:*** Since the amount of space, food, residential areas and other requirements of life are limited; there is a severe competition between the individuals for these essentials of life. In other words, there is a struggle for existence.

iv) ***Natural selection and the survival of the fittest:*** In the face of the struggle for existence, only those organisms that are most well adapted to the environment or fit in life can survive. Thus, nature eliminates the least fitted organisms by means of several natural calamities and preserves the well-adapted ones. Thus, natural selection maintains more or less constant number of every species.

Darwin also faced criticism because:

- His theory does not account for the presence or origin of variations among living organisms.
- Natural selection cannot carry a species beyond its natural range of variability.

c) **The Synthetic Theory/Neo-Darwinism:** In the late 1920s and early 1930s, biologists realized that mutation and natural selection weren't opposing processes, but instead they both actually contributed to biological evolution. The two major foundations of the biological sciences had finally been brought together in what is called the Modern Synthesis. From such a "modern" (that is, the middle of the twentieth century onward) perspective, we define evolution as a two-stage process. These two stages are:

- The production and redistribution of variation (inherited differences among organisms)
- *Natural selection* acting on this variation, whereby inherited differences, or variation, among individuals differentially affect their ability to successfully reproduce.

The synthetic theory considers evolution to be the result of changes in the gene frequency of population. These changes produce variations. These variations lead to effective adaptation to the environment. Changes in gene frequency occur through the impact of the forces of evolution such as selection, mutation, isolation, genetic drift and gene flow or migration or hybridization which will be dealt subsequently in the Unit.

The study of human variation considers how and why human populations differ genetically from each other. Biological anthropologists who study human variation have a wide range of interests, including human adaptation, genetics,

growth and development, demography, health, epidemiology, nutrition, life history and disease.

"Human beings differ from one another in a variety of ways. Intrinsic to the study of human variation is the recognition of human differences, that is, the study of what is often considered "race". Until the 1950's much of physical anthropology was devoted to racial description and classification. Because the concept of race was and still is, so ingrained in society, physical anthropologists have examined this issue in terms of evolutionary processes rather than racial classifications defined by society" (Ryan, 2002).

Check Your Progress 1

1) What is meant by Mosaic Evolution?

.....

.....

.....

2) Give one example of Lamarck's theory.

.....

.....

.....

3) Write a note on Synthetic theory.

.....

.....

.....

3.2 HUMAN VARIATION AND ADAPTATION

You have learnt in the previous section that biological anthropologists view human variation as the result of the evolutionary factors – mutation, genetic drift, gene flow and natural selection. To survive, all organisms must maintain the normal functions of internal organs, tissues and cells within the context of an ever changing environment. Even during the course of a single, seemingly uneventful day, there are numerous fluctuations in temperature, wind, solar radiation, humidity and so on. Physical activity also places stress on physiological mechanisms. The body must accommodate all these changes by compensating in some manner to maintain internal constancy, or homoeostasis.

An adaptation is a characteristic that enhances the survival or reproduction of organisms that bear it, relative to alternative characteristics (especially the ancestral condition in the population in which the adaptation evolved). Natural selection is the only mechanism known to cause the evolution of adaptations; so many biologists would simply define an adaptation as a characteristic that has evolved by natural selection. Three types of human adaptations exist:

- **Acclimatization**: short-term biological change, as with immune resistance to disease;
- **Genetic change**: long term biological change e. g. mutation; and
- **Cultural change**: non-biological change, as with technology.

Acclimatization is another kind of physiological response to environmental conditions and it can be short-term, long-term, or even permanent. These responses to environmental factors are partially influenced by genes, but some can also be affected by the duration and severity of the exposure, technological buffers (such as shelter or clothing), individual behavior, weight and overall body size. The simplest type of acclimatization is a temporary and rapid adjustment to an environmental change. Tanning is a kind of acclimatization. Tan fades once exposure to sunlight is reduced. In this example, the physiological change is temporary.

Contrary to acclimatization, genetic adaptations last for many generations. These changes occur due to long term exposure of a genetic stressor or mutations. Adaptations caused by genetical changes are mainly environmental specific. These genetic adaptations or changes can be advantageous in one environment while it can also have detrimental effect in another environment. One of the typical examples of genetic adaptions includes variation in size and shape of human body in different altitude and temperature conditions.

Cultural changes are non-biological changes consisting of changes in socio-cultural traits. Similar to genetic changes, cultural changes can be more or less adaptive depending on the environment. Technology plays an important role in mediating socio-cultural changes that occurs via multiple processes and at multiple scales. These cultural changes can also alter the cultural equilibrium, if there is one. For example, a game-changing cultural innovation, such as the transition from foraging to agriculture, could allow a population to feed many more people; thus, a cultural innovation can alter the size of the population (Creanza et al., 2017).

3.3 HUMAN GENETICS

The term "Genetics" is derived from the Greek word '*gen*' which means '*to become*' or '*to grow into*'. It is the science of inheritance which tries to explain how characters are transmitted through generations. Genetics is the scientific study of the laws of inheritance. Human genetics is defined as the study of how genetic inheritance takes place in the human species, or how inheritance of various characteristics from parents to children takes place.

Scientists began to understand the mechanics of heredity and how evolution works in populations long before molecular biologists identified the genetic basis of evolutionary change. With the discovery of DNA (deoxyribonucleic acid) molecule in 1953 by Watson and Crick, scientists came to understand how genetic information is stored in the chromosomes of a cell. Genes, specific portions of DNA molecules, direct the synthesis of the protein molecules upon which all living organisms depend. Through the process of biological reproduction, each of us inherits a combination of genes from our biological parents that creates a unique new individual.

Concept of gene

A gene is the basic physical and functional unit of heredity. In humans, genes vary in size from a few hundred DNA bases to more than 2 million bases. Genes are present in two copies, one inherited from each parent in every person. Most genes are the same in all people, but a small number of genes (less than 1 percent of the total) are slightly different between individuals. Alleles are forms of the same gene with small differences in their sequence of DNA bases. These small differences contribute to each human's unique physical features.

Each chromosome contains many genes which in turn are made up of DNA. James Watson and Francis Crick were the first scientists to formulate an accurate description of the molecule DNA's complex, double-helical structure. The inception of a three-dimensional, double-helical model for the structure of DNA by Watson and Crick in 1953 paved way to open up genetic components in detail. Let us learn the characteristic features of the DNA model:

- DNA is a double-stranded helix, with the two strands connected by hydrogen bonds. Adenine bases are always paired with Thymines and Cytosiness are always paired with Guanines.
- Most DNA double helices are right-handed; that is, if you were to hold your right hand out, with your thumb pointed up and your fingers curled around your thumb, your thumb would represent the axis of the helix and your fingers would represent the sugar-phosphate backbone. Only one type of DNA, called Z-DNA, is left-handed.
- The DNA double helix is anti-parallel, which means that the 5' end of one strand is paired with the 3' end of its complementary strand (and vice versa). As shown in Figure, nucleotides are linked to each other by their phosphate groups, which bind the 3' end of one sugar to the 5' end of the next sugar.
- Not only are the DNA base pairs connected via hydrogen bonding, but the outer edges of the nitrogen-containing bases are exposed and available for potential hydrogen bonding as well. These hydrogen bonds provide easy access to the DNA for other molecules, including the proteins that play vital roles in the replication and expression of DNA. Crick went on to do fundamental work in molecular biology and neurobiology. Watson became the Director of the Cold Spring Harbor Laboratory and headed up the Human Genome Project in the 1990s.

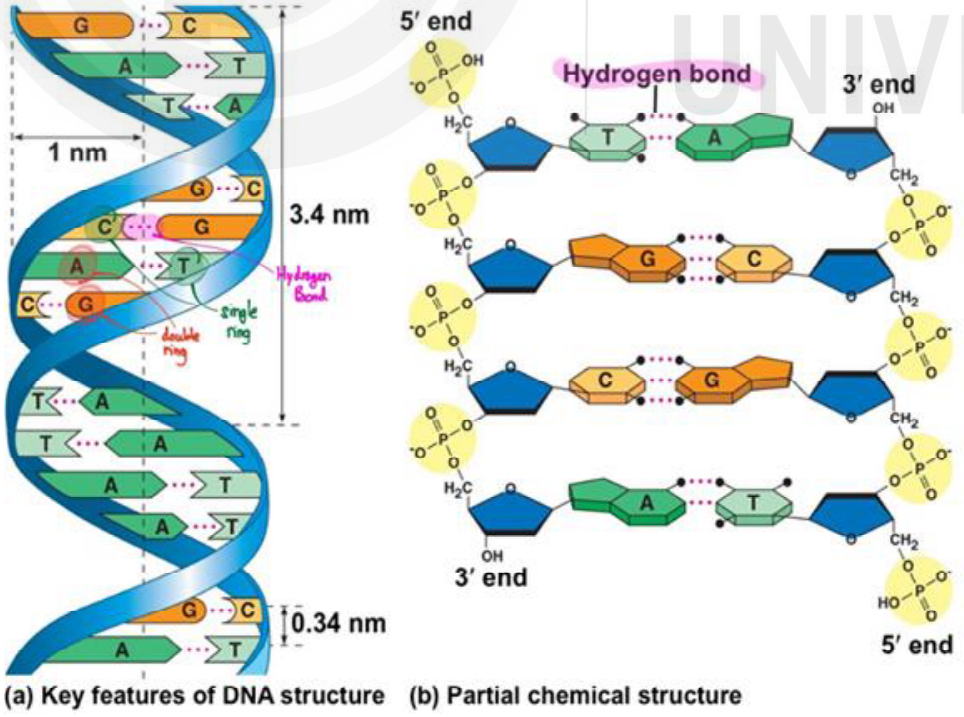


Fig. 1: Structure of DNA

Source: http://logyofbio.blogspot.com

Check Your Progress 2

4) Write a short note on the process of acclimatization.

.....

.....

.....

5) What is human genetics?

.....

.....

.....

.....

3.4 HUMAN GROWTH AND DEVELOPMENT

Growth is the progressive increase in the size of a child or parts of a child. Development is progressive acquisition of various skills (abilities) such as head support, speaking, learning, expressing the feelings and relating with other people. "Though growth and development may occur simultaneously, they are distinct biological processes. Growth may be defined as a quantitative increase in size or mass. Measurements of height in centimeters or weight in kilograms indicate how much growth has taken place in a child. Additionally, the growth of a body organ, such as the liver or the brain, may also be described by measuring the number, weight, or size of cells present. Development is defined as a progression of changes, either quantitative or qualitative, that lead from undifferentiated or immature state to a highly organized, specialized and mature state" (Bogin, 1999). In short, in biological systems, *growth* is a quantifiable change in size, while *development* indicates a transformation of structure. A very simple example of this concept is a small caterpillar that eats lots of leaves and grows large.

The assessment of growth and development is very helpful in finding out the state of health and nutrition. Continuous normal growth and development indicates a good state of health and nutrition. Abnormal growth or growth failure is a symptom of disease. Hence, measurement of growth is an essential component of the physical examination. There are various measurements that are used to measure growth. These are: weight, height, head circumference, mid upper arm circumference (MUAC) Plan, the eruption of teeth, etc. The purposes behind monitoring of growth are manyfold viz. early detection of abnormal growth and development, facilitating early treatment or correction of any conditions that may be causing abnormal growth and development, providing an opportunity for giving health education and advice for the prevention of malnutrition.

The factors that promote development include good nutrition, emotional support, play and language training. In monitoring development, we notice at what age the child achieves various milestones, such as smiling at the mother, sitting without support, grasping objects with his/her hands, standing, walking and talking. It would be interesting record at what age the child has achieved the various milestones.

There is a set of principles that characterizes the pattern and process of growth and development. These principles or characteristics describe typical

development as a predictable and orderly process; that is, we can predict how most children will develop and that they will develop at the same rate and at about the same time as other children. Although there are individual differences in children's personalities, activity levels and timing of developmental milestones, such as ages and stages, but the principles and characteristics of development are universal patterns. The major principles that characterize the pattern and process of growth and development are as follows:

- Development proceeds from the head downward**:** This is called the cephalocaudle principle. This principle describes the direction of growth and development. According to this principle, the child gains control of the head first, then the arms and then the legs.
- Development proceeds from the center of the body outward: This is the principle of proximo-distal development that also describes the direction of development. This means that the spinal cord develops before outer parts of the body.
- Development depends on maturation and learning: Maturation refers to the sequential characteristic of biological growth and development. The biological changes occur in sequential order and give children new abilities.
- Development proceeds from the simple (concrete) to the more complex: Children use their cognitive and language skills to reason and solve problems. For example, learning relationships between things (how things are similar), or classification, is an important ability in cognitive development.
- Growth and development is a continuous process: As a child develops, he or she adds to the skills already acquired and the new skills become the basis for further achievement and mastery of skills.
- Growth and development proceed from the general to specific: The infant's first motor movements are very generalized, undirected and reflexive, waving arms or kicking before being able to reach or creep toward an object. Growth occurs from large muscle movements to more refined (smaller) muscle movements.
- There are individual rates of growth and development: Each child is different and the rates at which individual children grow are different. Although the patterns and sequences for growth and development are usually the same for all children, the rates at which individual children reach developmental stages will be different.

Human stages of growth and development are differentiated by age and key stages of scientifically supported psychomotor development. Psychomotor development is progress in mental and motor skill activity. The process of growing and developing begins on the cellular level even before conception in the womb and continues throughout life until death. Human growth can be divided into stages according to age. Most human stages of growth and development occur in infancy, childhood and adolescence (Beall, 2000). Important stages of human growth and development are given below (Human growth and development, n. d.).

a) **Infancy**

A baby is considered an infant from birth through the first year of life. During this first year, babies develop skills that will be lifelong resources. Learning how to control the head, move by crawling and sit are called gross motor skills. Using the thumb and finger to pick up pieces of food and hold a pacifier are called fine motor skills.

b) **Childhood**

After age of 1 year, a child's growth slows down considerably. The toddler years are more mobile and exploratory. Middle childhood occurs at about the age of 6 years and children have a better sense of right and wrong then.

c) **Juvenile**

As children approach the ages of 9 and 10 years, they become more independent and might start noticing the physical changes of puberty. A major growth spurt can occur at this time as the body begins sexual development.

d) **Adolescence**

From ages 12 to 18 years, children experience distinct mental and physical changes. It is the transitional period in a person's life between childhood and adulthood. Adolescence is commonly defined as the stage of life that begins at the onset of puberty, when sexual maturity or the ability to reproduce is attained.

e) **Adulthood**

Adulthood is often noted when a person is considered chronologically, legally and behaviorally ready to hold responsibilities such as operating a motor vehicle, voting, taking the vows of marriage, entering into a contract and serving in the armed forces.

f) **Senescence**

Senescence is considered the stage of negative growth. During this stage, structure and functions of organ of body decline or deteriorate. The biological ageing produces progressive and irreversible changes affecting most of the body organs and leading a gradual decline in all the activities of an individual.

Check Your Progress 3

6) What are the major stages of human growth? Explain any two stages.

.....

.....

.....

3.5 SUMMARY

Biological Anthropology is one of the major branches of Anthropology with several subfields. This branch majorly consists of Human Evolution, Human Variation and Adaptation, Human Genetics and Human Growth and

Development. The unit has tried to incorporate the types and mechanism of human evolution and the theories put forward by Lamarck, Darwin along with the criticism faced by them. The concept of adaptation to geographic variations and the physiological effects visible in form of skin color, high altitude adaptations, etc. temporary or long-term has been discussed. The discovery and structure of DNA and its use thereafter in studying human evolution are important aspects of biological anthropology. This units also gives a background in human growth and development from before birth, through childhood, into adulthood and through death and grief.

3.6 REFERENCES

Alemseged, Z., Spoor, F., Kimbel, W. H., Bobe, R., Geraads, D., Reed, D., & Wynn, J. G. (2006). A Juvenile Early Hominin Skeleton from Dikika, Ethiopia. *Nature*, *443*(7109), 296.

Balter, M. (2005). Are Humans Still Evolving? *Science*, *309*(5732), 234-237.

Beall, C. M. & Steegmann Jr. A. T. (2000). Human Adaptation to Climate: Temperature, Ultraviolet Radiation and Altitude. In Human Biology: An Evolutionary and Biocultural Perspective, eds. S. Stinson, B. Bogin, R. Huss-Ashmore and D. O'Rourke, pp. 163–224. New York: John Wiley.

Bogin, B. (1999). *Patterns of Human Growth* (Vol. 23). Cambridge University Press.

Creanza, N., Kolodny, O., & Feldman, M. W. (2017). Cultural Evolutionary Theory: How Culture Evolves and why it Matters. *Proceedings of the National Academy of Sciences*, *114*(30), 7782-7789.

Growth and Development Essay. (n. d.). Brightkite. Accessed on: April 18, 2018. Retrieved From: https://brightkite.com/essay-on/growth-and-development-4

Human Growth and Development. (n. d.). Accessed on: April 19, 2018. Retrieved from: http://courses.aiu.edu/Human%20Growth%20and%20Development/1/01.Human%20Growth%20Development.pdf

Relethford, J. H. (2010). *The Human Species: An Introduction to Biological Anthropology, (*Ed. 8). State University of New York. Mc Grew Hills.

Ryan, A. S. (Ed.). (2002). *A Guide to Careers in Physical Anthropology*. Greenwood Publishing Group.

3.7 ANSWERS HINTS TO CHECK YOUR PROGRESS

1) Mosaic Evolution refers to the differential evolution of component parts of an organism. That is, all the parts of the organism do not change at the same rate in the course of evolution and all parts of the organism do not change in the same time period. For further details kindly refer section 3.1

2) As an example of the specialization and modification acquired by an organ, Lamarck suggested the case of giraffes. Lamarck was of the opinion that the giraffes had small necks and were used to feeding on short herbs. When the herbs became scanty, the ancestral forms were obliged to browse on the leaves of trees. In attempting to do this, they had to stretch their necks. After continuous stretching, the change became substantial, resulting in an extraordinary long neck which was generation after generation.

3) The synthetic theory considers evolution to be the result of changes in the gene frequency of population. These changes produce variations. These variations lead to effective adaptation to the environment. Changes in gene frequency occur through the impact of the forces of evolution such as selection, mutation, isolation and genetic drift, gene flow or migration or hybridization. For further details kindly refer page no. 36.

4) Acclimatization is another kind of physiological response to environmental conditions and it can be short-term, long-term, or even permanent. These responses to environmental factors are partially influenced by genes, but some can also be affected by the duration and severity of the exposure, technological buffers (such as shelter or clothing) and individual behavior, weight and overall body size. The simplest type of acclimatization is a temporary and rapid adjustment to an environmental change. Tanning is a kind of acclimatization.

5) Human genetics is defined as the study of how genetic inheritance takes place in the human species, or how inheritance of various characteristics from parents to kids takes place.

6) Human growth can be divided into six stages according to age. These stages are: (a) Infancy (b) Childhood (c) Juvenile (d) Adolescence (e) Adulthood and (f) Senescence. For the details of stages kindly refer section 3.4.

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

* Professor A. K. Kapoor, Department of Anthropology, University of Delhi, Delhi.

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

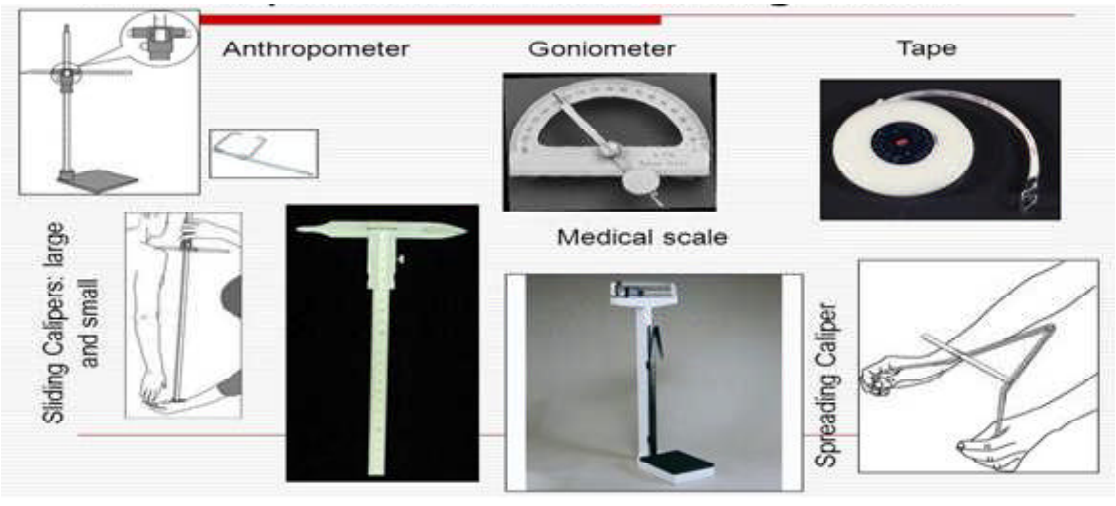


Fig. 1: Anthropometric Tools

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).

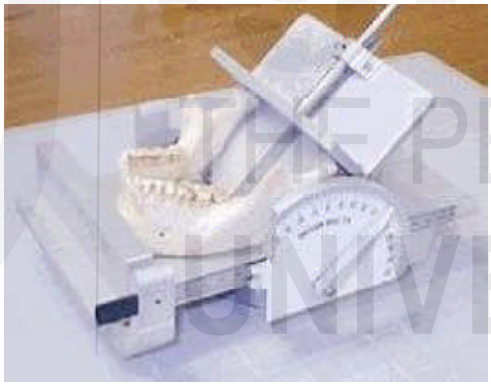
(a) Osteometric board

(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.

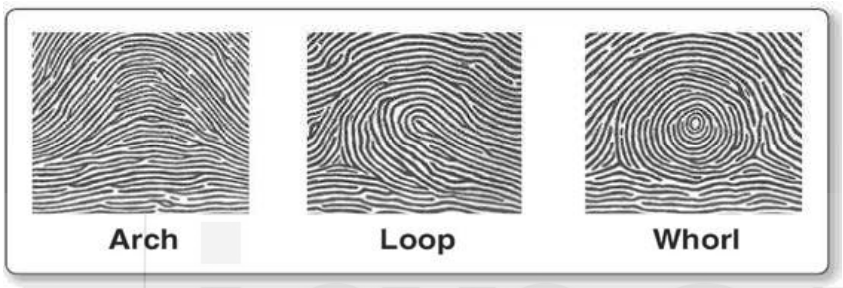


Fig. 3: Major types of Dermatoglyphic patterns found on the fingertips: Arch, Loop and Whorl

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.

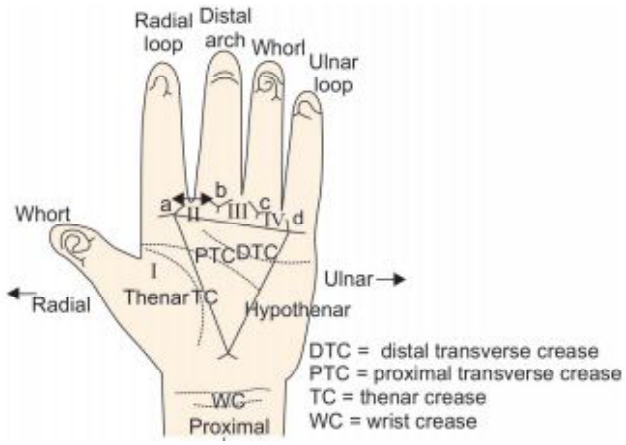


Fig. 4: Palmar region

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.**).**

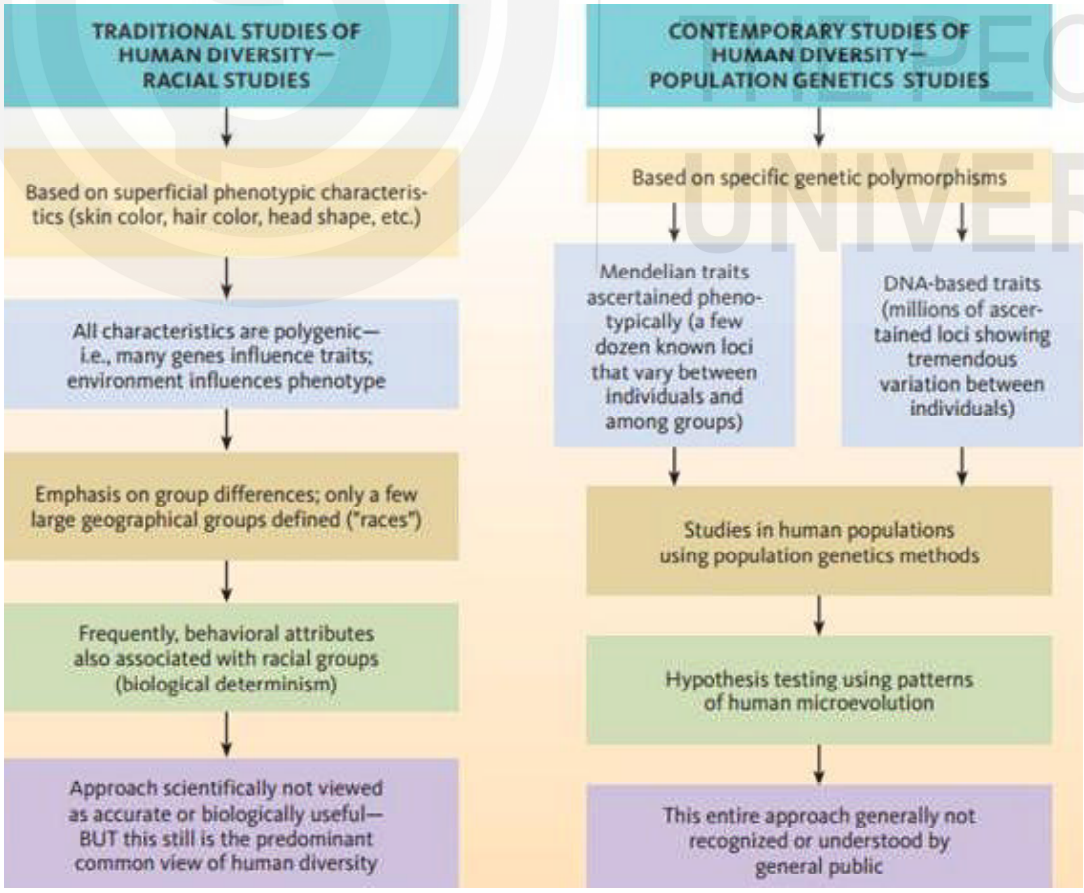


Fig. 5: Former and Contemporary Approaches to the Study of Human Variation

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.

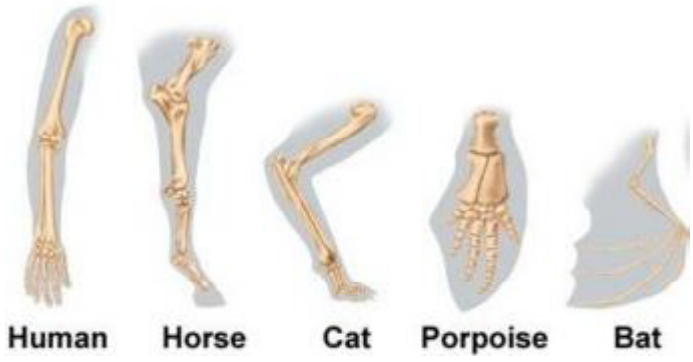


Fig.6: Homologous structure

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

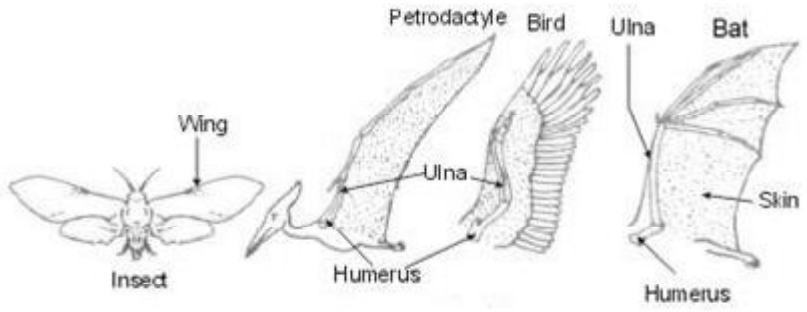


Fig. 7: Analogous structure

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.

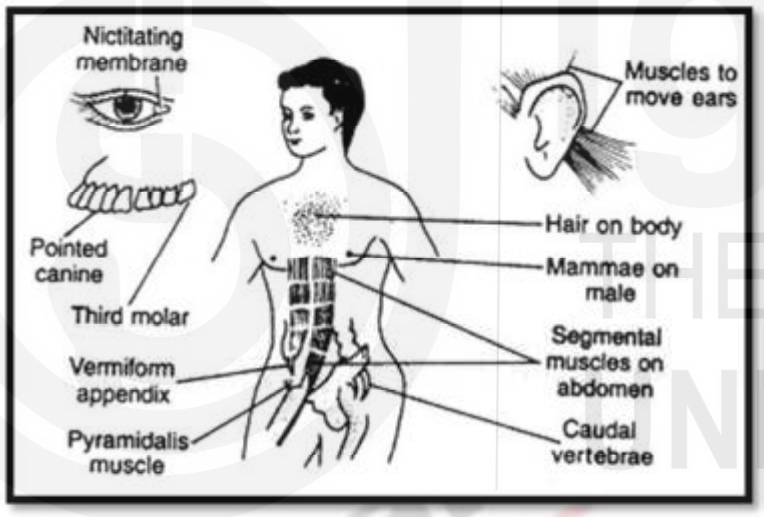


Fig. 8: Vestigial organs in man

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.

4.5 REFERENCES

Abernethy, B. (2013). *Biophysical Foundations of Human Movement*. Human Kinetics.

Brown, D. E. (2010). *Human Biological Diversity.* Tylor & Francis.

Cameron, N. (1984). *The Measurement of Human Growth*. Taylor & Francis.

Campbell, B. G. (1967). *Human Evolution: An Introduction to Mans Adaptations*. Transaction Publishers.

Cann, R. L., Stoneking, M., & Wilson, A. C. (1987). Mitochondrial DNA and human evolution. *Nature*, *325*(6099), 31-36.

Cavalli-Sforza, L. L., & Feldman, M. W. (2003). The Application of Molecular Genetic Approaches to the Study of Human Evolution. *Nature Genetics*, *33*, 266-275.

Larsen, C. S. (Ed.). (2010). *A Companion to Biological Anthropology* (Vol. 20). John Wiley & Sons.

Lohman, T. G., Roche, A. F., & Martorell, R. (1988). *Anthropometric Standardization Reference Manual*. Human Kinetics Books.

Mascie-Taylor, C. N., Yasukouchi, A., & Ulijaszek, S. (Eds.). (2010). *Human Variation: From the Laboratory to the Field*. CRC Press.

Modern Human Variation and Adaptation. Retrieved From: http://anthropology.msu.edu/iss220-fs12/files/2012/08/understanding_humans_ch04.pdf

Molnar, S. (2015). *Human Variation: Races, Types and Ethnic Groups*. Routledge.

Pandey, G. (2010). *Biocultural Evolution*. Concept Publishing House, New Delhi.

Scott, G. R., & Turner, C. G. (2000). *The Anthropology of Modern Human Teeth: Dental Morphology and its Variation in Recent Human Populations* (Vol. 20). Cambridge University Press.

Sharma, R. N. & Sharma, R. K. (1997). *Anthropology.* Atlantic Publishers and Distributors, New Delhi.

Somatoscopic Observation. Retrieved From: http://eacharya.inflibnet.ac.in/data-server/eacharya-documents/5717528c8ae36ce69422587d_INFIEP_304/138/ET/304-138-ET-V1-S1__file1.pdf

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)

SUGGESTED READINGS

Unit 1 Introducing Anthropology

Boaz, N. T., & Almquist, A. J. (1999). *Essentials of Biological Anthropology*. Prentice Hall, New Jersey.

Buettner-Janush, J. (1973). *Physical Anthropology: A Perspective*. John Wiley and Sons, New York.

Ember, C. R., Ember, M. & Peregrine P.N. (2002). *Anthropology*. Pearson Education. Delhi.

Harrison, G. A., Weiner, J. S., Tanner, J. M., & Barnicot, N. A. (1964). Human Biology. An Introduction to Human Evolution, Variation and Growth. Oxford University Press.

Jurmain, R., Kilgore, L., & Trevathan, W. (2011). Essentials of Physical Anthropology. Wadsworth Cengage Learning, USA,

Lasker, G. W. (1976). *Physical Anthropology*. Holt, Rinehart and Winston, New York.

Stein, P. L., & Rowe, B. M. (1974). *Physical Anthropology*. McGraw-Hill, New York.

Unit 2 Relationship and Applications of Biological Anthropology

Boaz, N. T. (1997). *Biological anthropology: a synthetic approach to human evolution*. Prentice Hall.

Burr, D. B., & Haines, D. E. (1984). Graduate education and the role of the physical anthropologist in biomedical teaching and research. *American journal of physical anthropology*, *64*(2), 155-159.

Dash, K. N. (2004). *Invitation to social and cultural anthropology*. Atlantic Publishers & Distributors, New Delhi.

Ghosh, A., Liu, T., Khoury, M. J., & Valdez, R. (2010). Family history of diabetes and prevalence of the metabolic syndrome in US adults without diabetes: 6-year results from the national health and nutrition examination survey (1999–2004). *Public health genomics*, *13*(6), 353-359.

Gopalan, C., Rama Sastri, B. V., & Balasubramanian, S. C. (2007). Nutrition value of Indian foods. NIN, ICMR, Hyderabad.

Martinez, V. (2013). *What is Anthropology?* Florida Atlantic University. Retrieved from: https://www.coursehero.com/file/8837996/ANTHROPOLOGY-BOOK-CHAPTER-17/?openRetag=true

Sing, C. F., Haviland, M. B., & Reilly, S. L. (1996). Genetic architecture of common multifactorial diseases. *Variation in the human genome*, *197*.

Wildman, R. E., & Medeiros, D. M. (2000). Advanced human nutrition. CRC Press.

WHO Expert Committee. (1995). Physical status: the use and interpretation of anthropometry. Report of a WHO expert committee, technical report series no. 854. Geneva.

http://helid. digicollection. Org/en/d/Jh0211e/.

Unit 3 Fundamentals and subfields of Biological Anthropology

Gardner EL, Simmons MJ, Snustad DP. 2006. *Principle of Genetics* (8th Edition). John Wiley & Sons

Papalia, D. and Olds, S. 2003. *Human Development* (9th Edition) McGraw-Hill

Unit 4 Approaches of Traditional and Modern Biological Anthropology

Campbell, B. G. (1967). *Human Evolution: An Introduction to Mans Adaptations*. Transaction Publishers.

Larsen, C. S. (Ed.). (2010). *A companion to biological anthropology* (Vol. 20). John Wiley & Sons.

Sharma, R. N. & Sharma, R. K. (1997). *Anthropology.* Atlantic Publishers and Distributors, New Delhi.

Singh, I. P., & Bhasin, M. K. (2004). *A manual of biological anthropology*. Delhi: Kamla-Raj Enterprises.

Unit 5 Human Variation and Evolution

Bancel, N., David, T., & Thomas, D. (Eds.). (2014). *The Invention of Race: Scientific and Popular Representations* (Vol. 28). Routledge.

Fenchel, T. (2002). *The origin and early evolution of life*. Oxford University Press, USA.

Jackson, J. P., & Weidman, N. M. (2004). *Race, racism, and science: Social impact and interaction*. Abc-Clio.

Shukla, B. R. K. and Rastogi S. (1990). *Physical Anthropology and Human Genetics An Introduction*. Palaka Prakashan, Delhi.

Unit 6 Theories of Organic Evolution

Darwin, C. (1859). *On the Origin of the species.* London: John Murray.

Diettrich, O. (1992). Darwin, Lamarck and the evolution of Science and culture. *Evolution and cognition, 2* (3).

Dobzhansky, T. (1953). *Gnetics and the Origin of Species.* New Yorl : Columbia University press.

Lewis, R. (1980). Evolution: A System of Theories. *Perspectives in Biology and Medicine, 23*, 551-572.

Mayr, E. (1942). *Systematics and origin of Species.* New York: Columbia University Press.

Rastogi, V. B. (1989). *Organic Evolution.* Meerut: Kedar Nath Ram Nath.

Unit 7 Basic Concepts of Evolution

Dobzhansky, T., & Dobzhansky, T. G. (1982). *Genetics and the Origin of Species* (Vol. 11). Columbia university press.

Endler, J. A. (1977). *Geographic variation, speciation, and clines* (No. 10). Princeton University Press.

Fan, S., Elmer, K. R., & Meyer, A. (2012). Genomics of adaptation and speciation in cichlid fishes: recent advances and analyses in African and Neotropical lineages. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *367*(1587), 385-394.

Nelson, H., & Jurmain, R. (1988). *Introduction to physical anthropology*. St. Paul, MN: West Publishing Company.

Machado, H. E., Pollen, A. A., Hofmann, H. A., & Renn, S. C. (2009). Interspecific profiling of gene expression informed by comparative genomic hybridization: a review and a novel approach in African cichlid fishes. *Integrative and comparative biology*, *49*(6), 644-659.

Sahney, S., Benton, M. J., & Ferry, P. A. (2010). Links between global taxonomic diversity, ecological diversity and the expansion of vertebrates on land. *Biology letters*, rsbl20091024.

Tarkhnishvili, D., Murtskhvaladze, M., & Gavashelishvili, A. (2013). Speciation in Caucasian lizards: climatic dissimilarity of the habitats is more important than isolation time. *Biological Journal of the Linnean Society, 109*(4), 876-892.

Unit 8 Classification and Characteristics of Living Primates

Petter, J. J., & Desbordes, F. (2013). *Primates of the World: An Illustrated Guide*. Princeton University Press.

Fleagle, J. G. (2013). *Primate adaptation and evolution*. 3rd edition. Elsevier, New York.

Heads, M. (2010). Evolution and biogeography of primates: a new model based on molecular phylogenetics, vicariance and plate tectonics. *Zoologica Scripta, 39*(2), 107-127.

Rafferty, J. P. (2011). *Primates: The Britannica guide to predators and prey*. Britannica educational publishing.

Rasmussen, D. T. (2002). The origin of Primates. In The Primate Fossil Record. W. C. Hartwig (Ed.). pp. 5–11.Cambridge University Press.

Simpson, G. G. (1961). Principles of animal taxonomy. Columbia University Press, New York.

Unit 9 Behaviour of non-human primates

Andrews, P. J., & Stringer, C. B. (1989). *Human evolution: an illustrated guide*. Cambridge University Press.

Brauer, G., & Smith, F. H. (Eds.). (1992). *Continuity Or Replacement: Controversies in Homo Sapiens Evolution: Selected Papers from the Symposium on Controversies in Homo Sapiens Evolution/Zagreb/July 1988*. AA Balkema.

Bruce, E. J., & Ayala, F. J. (1978). Humans and apes are genetically very similar. *Nature*, *276*, 264-65.

Unit 10 Comparative Anatomy of Human and Non-human Primates

Wood, B. (1994). The oldest hominid yet. *Nature*, *371*(6495), 280.

Bilsborough, A. & Wood, B. (1986). The Nature, Origin and Fate of Homo erectus. In B. Wood, L. Martin & P. Andrew (Eds.), *Major Topics in Primate and Human Evolution.* (p. 295 – 316). Cambridge University Press, Cambridge.

Birdsell, J. B. (1972). *Human evolution: An introduction to the new physical anthropology*. Rand McNally.

Brauer, G., & Smith, F. H. (Eds.). (1992). *Continuity or Replacement: Controversies in Homo Sapiens Evolution: Selected Papers from the Symposium on Controversies in Homo Sapiens Evolution/Zagreb/July 1988*. AA Balkema.

Bruce, E. J., & Ayala, F. J. (1978). Humans and apes are genetically very similar. *Nature*, *276*(5685), 264.

Buettner-Janusch, J. (1966). *Origins of man: physical anthropology*. John Wiley & Sons.

Campbell, B. (1963). Quantitative taxonomy and human evolution. In *Classification and human evolution* (Vol. 37, pp. 50-74). Aldine Chicago.

Campbell, B. G. (1972). Conceptual progress in physical anthropology: fossil man. *Annual Review of Anthropology*, *1*(1), 27-54.

Clochon, R. L. & Corruccini, R. S. (Eds.). (1983). *New Interpretations of Ape and Human Ancestry*. New York, Plenum.

Dobzhansky, T. (1937). *Genetics and the Origin of the Species*. New York.

Suggested Readings

Day M. H. (1988). *Guide to Fossil Man*. University of Chicago Press, Chicago.

Fleagle, J. G. (1988). Primate adaptation & evolution. San Diego; Academic Press.

Gebo, D. L. (2014). *Primate comparative anatomy*. Johns Hopkins University Press.

Harrison, G. A., Tanner, J. M., Pilbeam, D. R. & Baker, P. T. (1988). *An Introduction to Human Evolution, Variation, Growth and Adaptability*. (3rd ed.). Oxford: Oxford University Press.

Jaiswal, A. (2013). *Glossary of Biophysical Anthropology Terms: A Comparative Treatment of Biophysical Anthropology*, Heritage Publishers, New Delhi, India.

Klein, R. G. (1992). The archeology of modern human origins. *Evolutionary Anthropology: Issues, News, and Reviews, 1*(1), 5-14.

Melotti, U. (1985). Competition and cooperation in human evolution. *Mankind Quarterly*, *25*(4), 323.

Parker, S. T. E., & Gibson, K. R. E. (1990). "Language" and intelligence in monkeys and apes: Comparative developmental perspectives. Cambridge University Press, New York.

Pilbeam, D. (1982). Hominoid evolution and hominid origins. In *Recent Advances in the Evolution of the Primates* (pp. 43-61). Vatican Rome.

Simpson G. G. (1953). *The Major Features of Evolution*. Columbia University Press, New York.

Simson, E. L. (1972). *Primate Evolution*. New York: Macmillan.

Unit 11 Major Races of the World

Anemone, R. L. (2011). *Race and Human Diversity: A Biocultural Approach, CourseSmart eTextbook*. Routledge.

Coon, C S., Garn, S. M. & Birdsell, J. B. (1950). Races. A study of the problems of race formation in man. Charles C Thomas, Springfield, Illinois.

Das, B.M. (2004). *Outline of Physical Anthropology*. Kitab Mahal, New Delhi.

Deniker, J. (1900). *The Races of Man*. Scribner's, New York.

Dobzhansky, T. (1958). *Evolution, Genetics and Man*. John Wiley and Sons, New York.

Franco, F. C. M., Araujo, T. M. D., Vogel, C. J., & Quintão, C. C. A. (2013). Brachycephalic, dolichocephalic and mesocephalic: Is it

appropriate to describe the face using skull patterns?. *Dental press journal of orthodontics*, *18*(3), 159-163.

Hooton, E.A. (1946). *Up from the Ape*. Mcmillan, New York.

Kephart, C. (1961). *Races of Mankind: Their Origin and Migration.* Peter Owen Limited, London

Montagu, M. F. A. (1960). *An Introduction to Physical Anthropology*. Charles C. Thomas, Springfield.

Singh, I. P. & Bhasin, M. K. (2004). *A Manual of Biological Anthropology*. Kamla-Raj Enterprises, Delhi.

Unit 12 Racial Classification

Brace, C. L. (2005). *"Race" is a four-letter word: the genesis of the concept*. New York: Oxford University Press.

Molnar, S. (2015). *Human variation: races, types, and ethnic groups*. Routledge.

Shukla, B. R. K., & Rastogi, S. (1999). *Physical Anthropology and Human Genetics: An Introduction*. Palaka Prakashan, New Delhi.

Wolpoff, M. H., & Caspari, R. (1997). *Race and human evolution*. Simon and Schuster, New York.

Unit 13 Race and Racism

American Anthropological Association Statement on Race (May 17, 1998). Accessed on: 2018, May 22. Retrieved from: http://www.americananthro.org/ConnectWithAAA/Content.aspx?ItemNumber=2583

Baker, P. T. (1967). The biological race concept as a research tool. *American journal of physical anthropology*, *27*(1), 21-25.

Boyd, W. C. (1950). *Genetics and the races of man: an introduction to modern physical anthropology*. Little, Brown and Company, Boston.

Critiquing Race (n. d.). Retrieved from: http://www.understandingrace.org/history/science/critiquing_race.html

Dobzhansky, T. (1944). On species and races of living and fossil man. *American Journal of Physical Anthropology*, *2*(3), 251-265.

Fluehr-Lobban, C. (2018). *Race and racism: An introduction*. Rowman & Littlefield. Heyer, E., Balaresque, P., Jobling, M. A., Quintana-Murci, L., Chaix, R., Segurel, L., & Hegay, T. (2009). Genetic diversity and the emergence of ethnic groups in Central Asia. *Bmc Genetics*, *10*(1), 49.

Suggested Readings

Hooton, E. A. (1946). *Up from the Ape*. The Macmillan Company.

Joshi, P. C. (2015). Symposium on People of India. *The Eastern Anthropologist*, *68*(2), 419-474.

MacMaster, N. (2001). *Racism in Europe: 1870-2000*. Palgrave Macmillan.

Mayr, E. (1963). Populations, species, and evolution. *An abridgment of animal species and evolution*. Cambridge Belknap Press. UK.

Molnar, S. (2015). *Human variation: races, types, and ethnic groups*. Routledge.

Montagu, M. F. A. (1942). Man's most dangerous myth: the fallacy of race. Columbia University Press. New York, US.

Outram, S. M., & Ellison, G. T. (2006). Anthropological insights into the use of race/ethnicity to explore genetic contributions to disparities in health. *Journal of biosocial science*, *38*(1), 83-102.

RACE-The Power of an Illusion (n. d.). Accessed on: 2018, May 17. Retrieved from: http://www.pbs.org/race/000_About/002_04-experts-03-02.htm

Reilly, K., Kaufman, S., & Bodino, A. (Eds.). (2003). *Racism: A global reader*. ME Sharpe.

United Nations Educational Scientific and Cultural Organization Statement on Race (1951). Retrieved from: http://unesdoc.unesco.org/images/0017/001789/178908eb.pdf

Practical

Mukherji, D., Mukherji, D., & Bharati, P. (2009). *Laboratory Manual for Biological Anthropology*. Asian Books.

Singh, I. P., & Bhasin, M. K. (1968). *Anthropometry: A Laboratory Manual on Biological Anthropology*. Delhi: Nazia Offset Press.

Wilder, H. H. (1920). *A laboratory manual of anthropometry*. P. Blakiston's Son & Company.