BANC-101

Introduction to Biological Anthropology

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Indira Gandhi National Open University

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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 3
Living Primates: Human and Non-Human

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UNIT 8 CLASSIFICATION AND CHARACTERSTICS OF LIVING PRIMATES*

Contents

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8.1 Taxonomy/Classification

8.2 Who are Primates?

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8.4 Taxonomy of Living Primates

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8.8 Answer/Hints to Check Your Progress

Learning Objectives

After going through this unit you will understand:

- origin of primates;
- taxonomy of primates; and
- characteristics of living primates.

8.0 INTRODUCTION

The order Primates is one of the twenty orders of the class mammalia. A primate is any mammal from the group that includes the lemurs, lorises, tarsiers, monkeys, apes and humans. The members of the primate order are characterized by a set of characteristics, which define this group. A majority of the primates have nails instead of claws, a clavicle, a bony ring encircling the orbits, males with a hanging penis and scrotal testes, females with a pair of mammary glands on their chest, a well-developed caecum, a calcarine fissure in brain and an opposable thumb or big toe. Before we try to learn the details of classification of primates it would be worthwhile to understand some basic concepts of classification.

The order Primate, with its 300 or more species, is the third most diverse order of mammals, after rodents (Rodentia) and bats (Chiroptera). Although there are some notable variations between some primate groups, they share several anatomic and functional characteristics reflective of their common ancestry. Primates are a homogeneous group morphologically and it is only in the realm of behaviour that differences between primate taxa are clearly discriminant. It can be said that the most successful primates (judged in terms of the usual criteria of population numbers and territorial spread) are those that have departed least from the ancestral pattern of behaviour (Rafferty, 2011).

Prof. Rajan Gaur, Department of Anthropology, Panjab University, Chandigarh

8.1 TAXONOMY/CLASSIFICATION

Taxonomy is a branch of biology that is basically concerned with the classification and naming of organisms. The term taxonomy is a combination of two Greek roots, *Taxis* (arrangement) and *Nomia* (method). A taxonomy or classification uses names or other such labels to arrange various groups of plants and animals in "Pigeonholes" that demonstrate how all of them are related. In a way, taxonomy is the classification of plant and animals into groupings based on common biological features. It primarily deals with the orderly arrangement of the organic world and their exact naming. Very simply, taxonomy is the study of classification of organisms and the rationale behind the classification. It is in some respects similar to systematics, which, besides classification, encompasses more of evolution and biodiversity. In addition to classification, taxonomy also helps scientists to understand how various groups of organisms are related to one another.

The basis of taxonomy is the species, which are the basic units of living world. Concept of species is of concern to geneticists, biologists, palaeontologists, anthropologists, ecologists, bio-geographers, etc. But it is a concept that is understood differently by different disciplines:

- 'Evolutionary Species Concept', explains a species as "a lineage …evolving separately from others and with its own evolutionary role and tendencies" (Simpson, 1961).
- 'Biological Species Concept', defines species as "groups of actually or potentially interbreeding populations which are reproductively isolated from other such groups" (Mayr, 1963).
- 'Phylogenetic Species Concept' describes species as "an irreducible cluster of sexual organisms within which there is a parental platform of ancestry and descent and that is diagnostically distinct from other such clusters by a unique combination of fixed characters" (Christoffersen, 1995).
- 'Genetic Species Concept' delineates a 'genetic species' as "a group of genetically compatible interbreeding natural population that is genetically isolated from other such groups" (Baker and Bradley, 2006).

With this basic background of taxonomy we are better equipped to understand primate taxonomy. However, it is also important to understand who are primates and the various features that characterise primates.

8.2 WHO ARE PRIMATES?

Primates are a diverse and very successful group of eutherian mammals (Eutheria or Placentalia is the most taxonomically diverse of three branches of extant mammals, the other two being Metatheria or Marsupialia and Prototheria or Monotremata). The word 'primate' in Latin means 'first'. It is a name of an order of class mammalia that contains prosimians, monkeys, apes and humans. Primates are an ancient group that probably separated from the primitive mammalian stock about 65 million years. It is probable that primates originated from some type of an insectivorous mammal that lived in the late Cretaceous (Fleagle, 1998; Szalay and Delson, 2013). From tiny shrew-like creatures, the primates in time have grown into an amazing variety of forms. Some of the primates are the most generalized of the mammals

while others display unmatched morphological and behavioural specializations. The living primates greatly vary in size. The smallest living primate, the pygmy mouse, weighs around 30 grams while the largest, the male eastern low-land gorilla, may weigh over 200 kilograms. The study of how the primates evolved and how they live today is termed as primatology.

With the exception of humans, almost all of the living primates are found in the tropical and subtropical parts of the world on north and south of the equator, in South and Central America, Africa, Asia and the islands of Indonesia. But the primates have always not been restricted to these parts. Fossils of many primates have been discovered from regions which are not tropical at all, such as parts of British Isles, Northern United States, tip of South America - places where no primate of today could survive (Devore & Eimerl, 1966).

Check Your Progress 1

1) What do you understand by taxonomy?

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2) Who are the primates?

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8.3 PRIMATE ORIGIN

Primates are one of the better-known mammalian groups. There are about 400 living species and they have maximum diversity in lowland tropical rainforests, including mangrove and freshwater swamp forests (Heads, 2010). Though primate phylogeny is now better understood but there is hardly any consensus about their evolution with respect to where and when they originated. The earliest primates probably evolved sometimes in the late Cretaceous or in the Palaeocene (Fleagle, 2013). The earliest recognised species of Plesiadapiformes, *Purgatoriusceratops*, is commonly considered the earliest and most primitive primate (Radhakrishnan, 2006). However, it has also been suggested that the basal primate in a phylogenetic sense may be the fossil *Altanius*, from the Eocene of Mongolia and the oldest primate fossil may be *Altiatlasius*, from the Late Paleocene of Morocco (Fleagle and Gilbert 2006). Still, the interpretation of these fragmentary fossils, in particular their phylogenetic status, is controversial. Where did the primates first originate? This question has always concerned palaeoanthropologists. Anthropologists and other biologists have been debating for over a hundred years whether the true centre of origin of primates was in Africa, Asia or America. But no indisputable answer is as yet available. The issue has become more vexed with the recent developments in molecular biology. The problem of primate origins in space is related to the question of their origin in time. While dates based on fossils suggest an origin for primates in the Palaeocene, at approximately 56 million years, while the molecular clocks indicate a date of approximately 90 million years in the Cretaceous period (Janecka et al., 2007).

Several views are available for the centre of origin of primates. Fleagle and Gilbert (2006) supported Asia as centre of origin. But Rasmussen (2002) favoured Africa or India. On the other hand Bloch et al. (2007) supported North America while Arnason et al. (2008) proposed South America as the centre of origin of primates. Of the various theories, the African origin hypothesis appears to be the front runner although some also favour the Indo-Madagascar hypothesis (Heads, 2010). The debate thus remains unsettled.

In simple terms, the primate phylogeny can be considered to begin in the Palaeocene epoch spanning approximately from 65 to 55 millions of years ago with the appearance of the Plesiadapiformes in Europe and North America. The Plesiadapiformes are believed to have been a group of small mammals with primate-like characteristics. True primates or euprimates or primates of modern aspect, appeared in the Eocene epoch (spanning ~55 to 37.5 million years ago). The primate evolutionary history is not so straight forward due the general fragmentary and incomplete nature of the primate fossil record and the differences in their interpretation.

8.4 TAXONOMY OF LIVING PRIMATES

The order primate is traditionally divided into Prosimii and Anthropoidea, based on a classification system proposed by Simons (1972) and subsequently by Fleagle (1998). According to the traditional system, the prosimians included lemurs, lorises and tarsiers. They are clubbed together because they were considered morphologically more primitive than other primates. The anthropoids included the monkeys, apes and humans. However, recent biochemical, DNA hybridization, RNA sequencing and anatomical studies indicate that tarsiers are closer to anthropoids. Furthermore, the nostrils of tarsiers and anthropoids are encircled by dry skin while lorises and lemurs

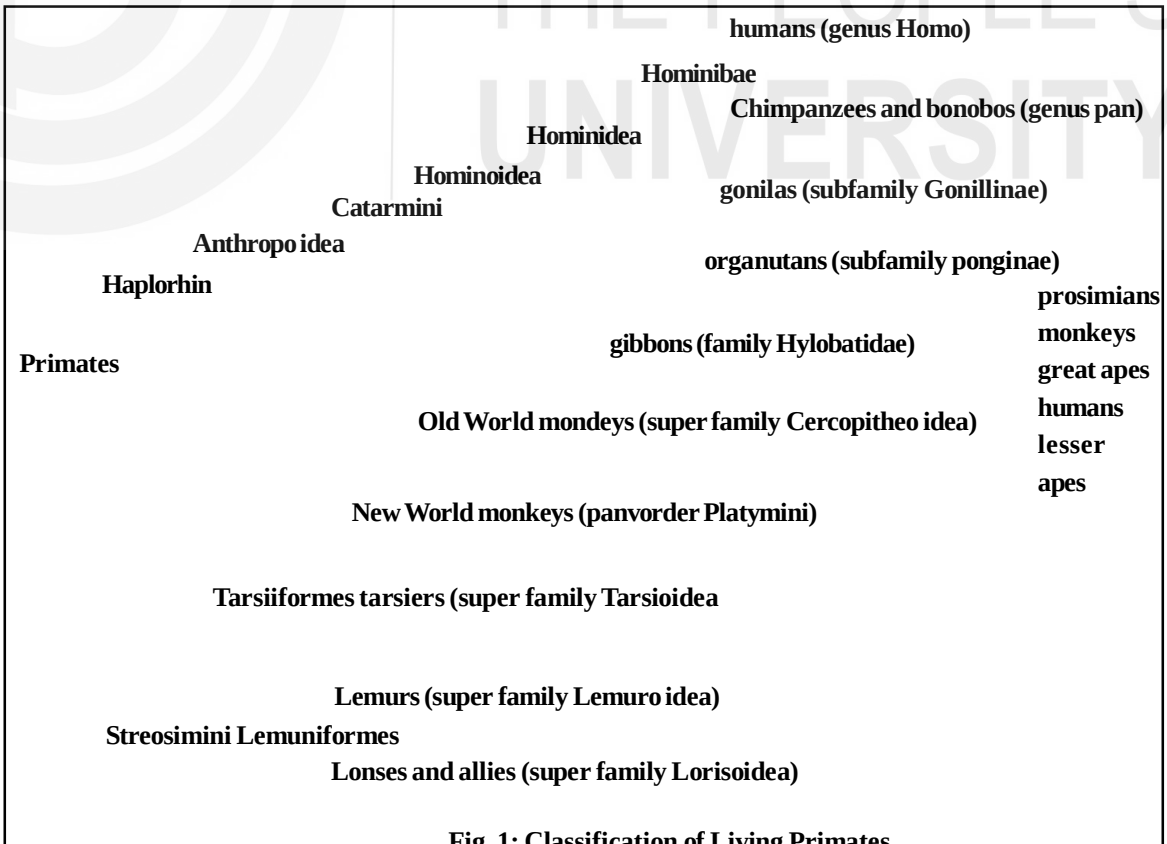


Fig. 1: Classification of Living Primates

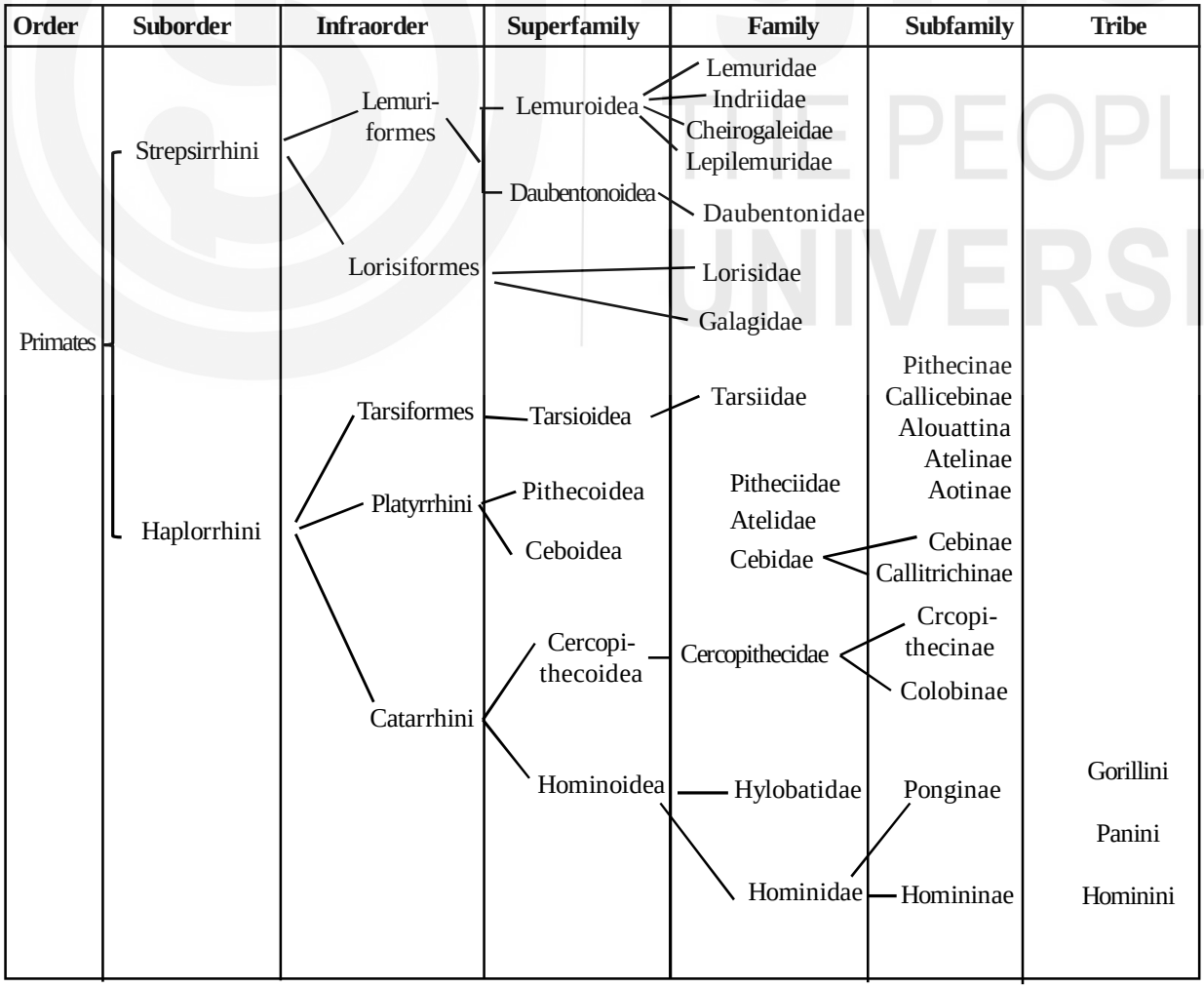
Source: Cartmill and Smith, 2011; Groves, 2001

have wet nostrils. Apart from these, there are other physical differences, for example the absence of a tapetum (a layer in the retina that helps in night vision) in tarsiers and anthropoids, due to which several taxonomists have created two new primate suborders- the Strepsirrhines (which includes lemurs and lorises) and the Haplorrhines (that incorporates tarsiers, monkeys, apes and humans). Thus, in the new system the tarsiers have been removed from prosimii and included under anthropoidea.

Another major difference between the traditional and the new classification system of primates is the position of apes vis-à-vis humans. In the traditional system (Fleagle, 1998), humans and apes were grouped under superfamily hominoidea. The great apes, which included orangutans, gorillas, chimpanzees and bonobos, were then separated into the family pongidae, while humans were grouped into the family hominidae. In recent years, this practice has lost favour. Molecular evidence has convinced most taxonomists that African apes (Gorilla and chimpanzee) are closer to humans than Asian Orangutan.

The taxonomic classification of order primates (modified after Fleagle, 2013) is summarized in Table-1. The Table below shows classification of the living primates along with their groups and commonly used names (shown on the right).

Table 1: Taxonomic Classification of Extant Primates (Modified after Fleagle, 2013)



The major characteristics of various taxonomic groups of primates are given as follows:

Suborder: Strepsirrhini (earlier Prosimii)

Fleagle (2013) calls it a Semiorder while many others term it as a Suborder. It includes lemurs and lorises. The nostrils (rhinarium) of strepsirrhines is moist and bare, like that of a dog. Strepsirrhines have a reflective layer, the *tapetumlucidum*, behind the retina, which increases the amount of light for night vision. Most are nocturnal with prominent whiskers, large and mobile ears and large eyes adapted for a nocturnal lifestyle. Highly developed sense of smell. Upper lip is divided and attached to gums by a membrane. They have a protruding snout (rostrum), a tooth comb formed of lower incisors and canines, an orbital bar and a grooming claw on second digit of foot and flat nails everywhere else. Suborder strepsirrhini has two infraorders: Lemuriformes and Lorisiformes.

Infraorder: Lemuriformes

It includes all lemurs. They are restricted to the island of Madagascar and the neighbouring island of Comores. They range in body size from the 30 gram pygmy lemur to the 10kg for Indri. Lemuriformes show a broad range of dietary and locomotor adaptations. Some species, like the sifaka, primarily leap using long hindlimbs and cling to vertical branches. Others are arboreal quadrupeds, or spend substantial time on the ground. Lemuriformes has two superfamilies: Daubentonoidea and Lemuroidea.

Daubentonoidea

This superfamily has a single subfamily, Daubentonidae with a single genus *Daubentonia* (the aye-aye). This moderately sized, black animal with large ears has extreme specializations but still retains some basic features to be classified under lemuriformes.

Lemuroidea

It includes four families: Chirogaleidae, Indriidae, Lepilemuridae and lemuridae. The chirogaleids are the most primitive and the smallest of the Lemmuroids. The family Indriidae includes genera *Indrii*, *Propithecus* and *Avahi*. Lepilemuridae family consists of the genus *Lepilemur* and Lemuridae family includes *Lemur, Hapalemur, Prolemur, Eulemur*and *Varecia*.

Infraorder: Lorisiformes

The lorisiformes are all nocturnal primates who exist in forest regions of Africa and Asia. Their diets primarily consist of fruits, gums/exudates and insects. Like lemurs they have a tooth comb and a grooming claw on the second digit. The tympanic ring in the ear region of lorisiformes is fused to the later wall rather than being suspended in the bulla as in lemurs. The infraorder consists of two families: Lorisidae and Galagidae.

Suborder: Haplorrhini (termed Semiorder by some)

It is a new suborder created to incorporate tarsiers which were earlier included under prosimii in the traditional primate classification system. The haplorhines are considered the “higher” primates. This suborder includes tarsiers, monkeys, apes and humans. Scientists believe that haplorhines first appeared in the Eocene around 50 million years ago. These are the ancestors of today’s monkeys and apes. The extant haplorhines are divided into three

infraorders namely Tarsiiformes, Platyrrhini and Catarrhini. The platyrrhines and catarrhines are together termed as anthropoids.

Infraorder: Tarsiiformes

Tarsiiformes are amongst the smallest and very unusual of all extant primates. They are found in Southeast Asia. They show a mixture of prosimian and anthropoid traits. Several of the traits which they share with lower primates are primitive features such as high cusped molars, unfused mandibular symphysis, multiple nipples, grooming claws on second digit of feet. Tarsiers have very long legs and ankles. Tarsiers possess some striking and unique features also, which include the unusually large size of its eyes that is even larger than the size of its brain.

This infraorder has only one family – Tarsiidae. Currently there are three living genera of Tarsiformes: *Carlito* (from Philipines), *Cephalopachus* (mainly from Borneo and Sumatra) and *Tarsius* (manly from Sulawesi islands).

Infraorder: Platyrrhini

The platyrrhines are also known as the New World monkeys. All anthropoid primates living in Central and South America are included in this infraorder. The term platyrrhini refers to the shape of nose in these primates. Living platyrrhines are small to medium size anthropoids. Platyrrhines have broad, flat dry noses with outwardly directed nasal openings. This feature probably distinguishes them from the Old World monkeys, which generally have narrow nostrils. They lack a bony tube between eardrum and outer ear, tympanic ring fused to the side of the auditory bulla, presence of three premolars in contrast to two of Old World monkeys, absence of a hypoconulid on the first two lower molars in most members, lack ischial callosities (bare patches of skin on rump) found in some Old World monkeys, most have a well-developed tail which is prehensile and used like fifth limb in some genera, imperfect opposability of thumb and poorly developed finger grip, large and strongly opposable hallux, special scent glands in some, arboreal and mostly diurnal.

In traditional classification, platyrrhines are subdivided into two families – Cebidae and Callithricidae. But based on recent molecular systematics, it is divided into three families: Pitheciidae, Atelidae and Cebidae consisting of 19 living genera (Fleagle, 2013).

Family: Pitheciidae

This family consists of two subfamilies: Callicebinae and Pitheciinae.

Family: Atelidae

It includes two subfamilies: Alouattinae and Atelinae.

Family: Cebidae

This family consists of three subfamilies: Aotinae, Callitrichinae and Cebinae.

Infraorder: Caterrhini

The catarrhines comprise the old world monkeys, apes and humans. The word Catarrhini, like Platyrrhini, refers, to the shape of the nose. Caterrhine nostrils are narrow, close together and face downward, unlike the platyrrhine monkeys in whom the nostrils are round and laterally facing. The catarrhine

monkeys are in general larger than playrrhine monkeys. Catarrhines have only two premolars in each quadrant as compared three among the platyrrhines. They have a bony tube between eardrum and outer ear. They are mostly diurnal. Most have a well-developed grip and opposable thumb and big toe, except humans. This infraorder is usually divided into two superfamilies, the Cercopithecoidea (Old World monkeys) and the Hominoidea (apes and humans).

Superfamily: Ceropithecoidea

Cercopithecoids are also commonly known as Old World Monkeys. Of all the living caterrhines, they are the most numerous and diverse. Ceropithecoids are found all over Africa and Asia and some parts of Europe. It has one family, cercopithecidae and two subfamilies: Cercopithecinae and Colobinae.

Superfamily: Hominoidea

Superfamily hominoidea comprises the humans and the apes. Living hominoids are characterized by the absence of tails and by rather primitive rounded molars. In the new systematic classification of primates that also considers molecular evidence, Hominoidea comprises two families: Hylobatidae and Hominidae.

Family: Hylobatidae

Hylobatids are the smallest and most numerous of the apes and comprise the siamangs and the gibbons (*Hylobates, Symphalangus, Hoolock*). Because of their size they are occasionally referred to as lesser apes. The hylobatids are distributed in northeast India and tropical forests of Southeast Asia.

Family: Hominidae

This family includes the great apes and the humans: chimpanzees, orangutans, gorillas, bonobos and humans. Some of the main features of Hominidae include a larger brain compared to body size, sexual dimorphism, relatively larger body size, semi-upright to upright posture and the associated differences in skeletal parts.

There is an on-going debate as to how close humans are to the African great apes. In the traditional classification apes are considered in a separate family, the Pongidae and the humans are included in their own family, the Hominidae. In the new taxonomic system that considers molecular evidence, humans are combined with the great apes in family Hominidae but are separated from them at a lower classification category—the tribe. In a growing concensus among primatoloists, humans are assigned to the tribe Hominini while chimpanzees and bonobos are relegated to the tribe Panini.

Check Your Progress 2

3) Describe in brief taxonomy of living primates.

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8.5 PRIMATE CHARACTERISTICS

According to Mivart (1873), "Primates are unguiculate, claviculate placental mammals, with orbits encircled by bone; three kinds of teeth at least one

time of life; brain always with a posterior lobe and calcarine fissure; the innermost digits of at least one pair of extremities opposable; hallux with a flat nail or none; a well-developed caecum; penis pendulous; testes scrotal; always two pectoral mammae". They have incisors, canines, premolars and molars (premolars may be absent in milk dentition). They have at least one pair of grasping extremities (grasping hands or feet). Either the thumb or the big toe is opposable. One pair of mammary glands present on the chest and in males, a hanging penis and testes in a pouch of skin. Main characteristics of primates are:

- ***Pentadactyle hands and feet:*** Except spider monkey, which has four finger on each hand and five toes on each feet, all primates have retained the ancient mammalian trait of pentadactylism.
- ***Increasing refinement of hands and feet for grasping objects:*** This characteristic has been one of the main hallmarks of primate evolution. There is a trend of increasing manual dexterity. This feature has been further enhanced by the development of highly sensitive tactile pads at the tips of fingers and toes, in contrast to most other mammals.
- ***Presence of flat nails:*** Primates possess flat nails to protect fingertips with dermatoglyphs (fingerprints) on fingers and toes.
- ***Presence of opposable thumbs***: Primates have opposable thumb for power grip (for holding on) and precision grip (for manipulating small objects, as in humans and some apes).
- ***Presence of clavicle and the generalized limb structure of early mammals***: Primates have retained the primitive mammalian limb structure, one upper limb bone (e.g. humerus in fore limbs and femur in hind limbs) and two lower limb bones (e.g. radius and ulna in fore limbs and tibia and fibula in hind limbs). Strong clavicles and highly flexible shoulder joints have permitted most primates to use their arms very efficiently in climbing trees. Many mammalian orders have lost various bones, particularly fusing of the two lower limb bones, as in the case of horses.
- ***Erect posture:*** All primates have a marked tendency towards erectness in their upper bodies. This can be seen in their sitting and standing postures as well as in occasional bipedalism.
- ***Reduction in the sense of smell:*** The importance of sense of smell has been reduced in primates. Consequently, the olfactory center of the brain, the rhinocephalon, has proportionally decreased in size. The skeletal structures associated with smell, the snout length and facial protrusion, have steadily and progressively decreased (the lemurs and the baboons are exceptions).
- ***Increased dependence on visual sensation:*** The orbits of primates (eye sockets) exhibit a high degree of frontation (placement toward the front of the face), which increased the overlap of visual fields thus enhancing the binocular vision and depth perception and producing what is termed as stereoscopic vision. All living members of the order primates have stereoscopic vision. Most living diurnal primates probably have some sort of colour vision, which is very helpful for a diurnal life.
- ***Relatively large brain, as compared to body size:*** There is a trend of continuous development of brain with increasing elaboration and differentiation of the cerebral cortex. The enlargement of cerebral cortex is related to improved manual dexterity and enhanced hand-eye

coordination, which is a significant aspect of primate evolution.

- ***Reduction in number of teeth:*** Primates have reduced number of teeth, as compared to primitive mammalian dentition, with a maximum of two incisors, one canine, three premolars and three molars in each quadrant of jaw. They have retained a simple generalized cusp pattern on molars. This allows them to exploit different food sources.
- ***Presence of mammary glands:*** Most primates have one pair of mammae on the chest.
- ***A trend towards smaller litter size, longer gestation periods and prolonged period of juvenile growth:*** The gestation period increases from at least 4 months in case of more primitive small prosimians such as *Microcebus* and *Galago* to nine months in case of humans. The consequence of long gestation period is that offsprings are born more mature and therefore, have a greater chance of survival. Reduced litter size (usually just one in most primates) permits more individual attention to young and allows more mobility with young clinging to the mother. There is a trend of increase in the postnatal growth period from lower to higher primates, which may vary from less than 1 year among nocturnal prosimians to roughly 15 years in case of man (Buettner-Janusch, 1969).
- ***Increase in the natural life span:*** There is a trend of marked increase in the natural life span of all primates. Tiny mouse lemurs (*Microcebus*) are known to survive for 8 years while equivalent-sized rodent mice rarely survive beyond 2 years. Large monkeys, such as baboons, the males of which may weigh up to 90 lbs, have may live up to 30 years, while domestic dogs of comparable size may have a life span of only 10-12 years. The average life span of humans ranges between 70 to 80 years.
- ***Complex social behavior:*** The vocalizations, visual displays and specific social behaviours, such as infant care and grooming, are very complex and diverse among primates. It would not be wrong to state that the primates are the most social of all the mammals.

It may be noted that all the above characteristics may not be found in each and every member of the order. But several of these traits occur in most living primate groups.

Check Your Progress 3

4) What are the characteristics of primates?

.....

.....

.....

8.6 SUMMARY

The order Primates is one of the twenty orders of the class Mammalia. There are roughly 400 species of living primates which are distributed, with the exception of humans, in the tropical and subtropical parts of the world on north and south of the equator, in South and Central America, Africa, Asia and the islands of Indonesia. The primates are characterised by a set

of traits such as possession of nails instead of claws, a clavicle, a bony ring encircling the orbits, males with a hanging penis and scrotal testes, females with a pair of mammary glands on their chest, a well-developed caecum, a calcarine fissure in brain and an opposable thumb or big toe. All these traits may not be found in each and every member of the order primates. Dates based on fossils suggest an origin for primates in the Palaeocene, at approximately 56 million years ago. The separation of the ape-line from the Old World monkey lineage is thought to have happened in the Miocene epoch (~22.5 million years ago). Order Primate, these days, is considered to have two suborders: Strepsirrhini (which includes lemurs and lorises) and the Haplorrhini (that incorporates tarsiers, monkeys, apes and humans). The humans and great apes are now placed together in the family hominidae separate from gibbons and siamangs which are grouped under family hylobatidae. The gorilla and chimpanzee are grouped into subfamily homininae along with humans distinct from orangutan that is placed in the subfamily ponginae. Apart from anatomical features, the recent primate classification has also taken into consideration the molecular evidence.

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8.8 ANSWER/HINTS TO CHECK YOUR PROGRESS

1) Taxonomy is a branch of biology that is basically concerned with the classification and naming of organisms. The term taxonomy is a combination of two Greek roots, *Taxis* (arrangement) and *Nomia* (method). For more details kindly refer section 8.1

2) Primates are a diverse and very successful group of eutherian mammals. The word ‘primate’ in Latin means ‘first’. It is a name of an order of class mammalia that contains prosimians, monkeys, apes and humans. For more details kindly refer section 8.2

3) The order primate is traditionally divided into Prosimii and Anthropoidea. According to the traditional system, the prosimians included lemurs, lorises and tarsiers. The anthropoids included the monkeys, apes and humans. However, recent biochemical, DNA hybridization, RNA sequencing and anatomical studies indicate that tarsiers are closer to anthropoids. Several taxonomists have created two new primate suborders- the Strepsirrhines (which includes lemurs and lorises) and the Haplorrhines (that incorporates tarsiers, monkeys, apes and humans). For further details kindly refer section 8.4

4) Primates are unguiculate, claviculate placental mammals, with orbits encircled by bone; three kinds of teeth, at least one time of life; brain always with a posterior lobe and calcarine fissure; the innermost digits of at least one pair of extremities opposable; hallux with a flat nail or none; a well-developed caecum; penis pendulous; testes scrotal; always two pectoral mammae. (Mivart, 1873). For more details kindly refer section 8.5.

UNIT 9 BEHAVIOUR OF NON-HUMAN PRIMATES*

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Learning Objectives

Once you are through with this unit, you will appreciate:

- concept of Primate Behaviour; and
- some of the significant issues like Sociobiology, Social Behaviour and Kinship Recognition.

9.0 PRIMATE: INTRODUCTION

The definition of the order primates is difficult, since the primates are not characterized by any one distinctive trait. This was noted by the British anatomist Sir Wilfred Legros Clark (1895-1971), who pointed out that, unlike other, mammalian orders, which are defined in terms of some major adaptation, the primates are characterized by their adaptability. They are noted for their generalized anatomy and their variability and flexibility in locomotion and behaviour.

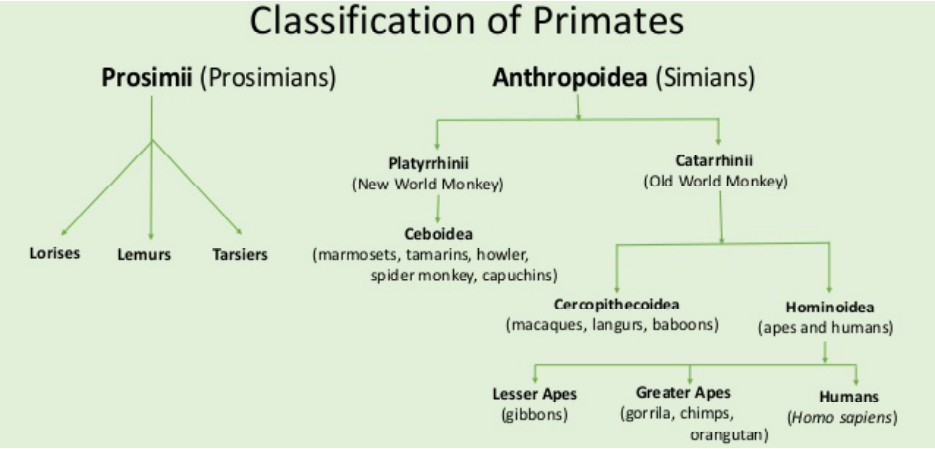

Fig. 1: Classification of Primates
Source: https://www.slideshare.net

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Table 1: Classification of non-human primates (A sample of scientific and common names)

Non-Human Primates

New World Monkeys	Family: *Callitrichidae*	
	Genera and species	*Callithrix sp*. (marmosets, titis)
		Cebuella sp. (pygmy marmosets)
		Leontopithecus sp. (lion tamarins)
		Saguinus sp. (marmosets or tamarins)
	Family: Cebidae	*Alouatta sp*. (howler)
	Genera and species	*Aotus trivirgatus* (owl, night)
		Ateles fusiceps, A. paniscus (spider)
		Callicebus sp. (titi)
		Cebus albifrons, C. nigrivittatus, C. apella (capuchin)
		Lagothrix logothricha (wooley)
		Saimiri sciureus (squirrel)
Old World Monkeys	Family: Cercopithecidae	*Cercopithecus sp*. (African greens, grivets, vervets, guenons)
	Genera and species	*Colobus sp*. (colobus)
		Erythrocebus (patas)
		Macaca arctoides (stumptailed macaque), *M. fascicularis* (cynamolgus or crab eating), *M. fuscata* (Japanese), *M. mulatta* (rhesus), *M. nemestrina* (pigtailed), *M. radiata* (bonnet), *M. sylvanus* (Barbary)
		Mandrillus sp. (drills, mandrills)
		Papio sp. (baboons)
Great Apes	Family: Pongidae	*Gorilla gorilla* (gorilla)
	Genera and species	*Pan troglodytes* (chimpanzee), P. paniscus (pygmy chimpanzee, bonobo)
		Pongo pygmaeus (orangutan)
Lesser Apes	Family: *Hylobatidae*	
	Genera and species	*Hylobates sp*. (gibbons)
Lower Primates	Family: *Cheirogaleidae* (dwarf and mouse lemurs)	
	Family: *Daubentoniidae* (aye-aye)	
	Family: *Indriidae* (indris and sifkas)	
	Family: *Lemuridae* (lemurs)	
	Family: *Lorisidae* (bush babies, pottos, lorises, galagos)	
	Family: *Tarsiidae* (tarsiers)	

Source: http://www.vdh.virginia.gov/content/uploads/sites

You have already learnt the classification and characteristics of human and non-human primates in the previous unit. In this unit, we will be discussing the primate behaviour and its significance in anthropology.

> *Behaviour, including social behaviour, is characterized by variability and this variability is the material on which selection works during evolution. There are two sources of variability in primate: social behaviour and social organization. (By social behaviour we mean that the ways in which animals interact with one another; by social organization we refer to the network of relationships making up the structure of the group as a whole). The first is the product of what can be called ultimate causes and is the outcome of interaction between individuals and their socio-ecological circumstances. Both sources of variability are inextricably intertwined in actual life, but are analytically distinct. The result of the variability is that some individuals achieve greater individual fitness than others and if we include the effects of their behaviour on their kin, then some individuals achieve greater inclusive fitness than others (Quiatt and Reynolds, 1995).*

To understand the adaptability characteristic of this order, we must first realize that this characteristic is actually a response to the arboreal environment. Almost all primates live on trees. Even the more terrestrial forms, such as the baboons, readily take to the trees. Humans may be the only exception, but even with them the potential to climb is well developed. In fact children from many cultures enjoy playing on trees.

The arboreal environment differs significantly from the terrestrial one. Trees provide a three dimensional environment with holes and in moving through the tree the animal is moving not only forward and backward, left and right, but also up and down. The arboreal environment is also unpredictable, since when an animal leaps to a branch it may break. Adolph Schultz (1981-1976) noted that in a study of one of the apes, the gibbon, 31 percent of a set of 260 adult skeletons showed at least one healed feature.

The major difficulty in discussing primate characteristics is the variability of the group. In other words, not all primates exhibit the same complex of features. Clark (1934) speaks of primate trends which are developed to greater or lesser degree in the various primate species.

Because some primates show fewer characteristics of the “ideal” primate complex than others, it is possible to rank-order the living species according to how closely they conform to the ideal. Such a sequence might list in ascending order the tree shrew, lemur, tarsier, new world monkey, old world monkey, chimpanzee and *Homo sapiens*. This implies an evolutionary sequence and an idea that humans have evolved directly from this sequence of modern forms of course that somewhere seems incorrect because a species cannot be descended from its contemporary. Some modern forms may possess specific characteristics which were present in population ancestral to the hominids. These forms may share a common ancestry with humans. But it must be remembered that the modern nonhuman primates are end products of long evolutionary sequences, just as people are; thus, they cannot be human ancestors. These trends do indicate the relieve time distance from a common ancestor. So, for instance, Chimpanzees and humans

have a more recent common ancestor than monkeys and humans, but monkeys and human have a more recent common ancestor than tarsier and humans and so on.

Moving about through the trees, primates have retained a rather generalized anatomy for locomotion, but here it should be noted that most mammalian groups are characterized by a number of specializations with respect to movement.

The forelimb structure of the primates corresponds well to the generalized limb structure of early placement ancestors. Note the presence of the clavicle (collarbone), the two separate bones in the lower arm and the five fingers (Pentadactylism). This arrangement permits a great degree of flexibility in the shoulder, forearm and hand, an asset when moving through the trees.

Among terrestrial mammals, the olfactory sense, or sense of smell, plays a crucial role. Hunters realize that when they approach an animal like a gazelle, the animal is not able to see them, especially if they freeze when it is looking up. Smell is relatively unimportant in the trees. Most odors tend through the ground and the wind blowing through the trees would eliminate their usefulness. Also, the sense of smell does not give arboreal animals the type of information it needs, such as the exact direction and distance of one branch from another. Thus, in the primates the sense of smell has diminished. The olfactory regions of the brain have been reduced and the muzzle or snout has become smaller.

Most mammals see only a two-dimensional black and white field and depend more on the olfactory sense. Through sight, these animals are aware of movement, but they cannot pick out and judge details, especially of stationary objects. Most primates see in three dimensions and in colour. Colour vision helps distinguish detail, for close colours may blend together in black and white and stationary objects stand out in a three dimensional field. Such vision developed as a response to the selective pressures of the arboreal environment, where precise information of direction and distance is crucial. This vision provided the primates with more detailed information about the nature of their environment than any other mammalian form. A great deal of what we consider primate intelligence may be due to the primate's great awareness of the environment.

Most primate eyes are encased in boney eye sockets, a feature not found in other mammalian skulls. The eye socket is not found in most of the lower primates, although these forms do have a bony ring which completely encircles the eye. The eyes have rotated to the front of the face, permitting three-dimensional, stereoscopic vision. This type of vision is made possible by a realignment of the optic nerves.

Primates are highly social animals and vision plays a key role in primate communication. Unlike dogs who smell one another on meeting, primates communicate largely through visual stimuli, although vocalizations also play important roles. For example, body postures and facial expressions are frequently used. Facial expression is made possible in many primates to the differentiation of the muscles of the face, which in other mammals exist as a relatively undifferentiated muscle sheet. Also, unlike other mammals, many primates have an upper lip which is not attached to the upper gum. This permits a wide range of gestures, including the kiss.

Not all anthropologists agree with the hypothesis that all characteristic features of primates developed primarily as an adaptation to locomotion in the trees. Matt Cartmill (1943-present) notes the excellent arboreal abilities of the arboreal rodents and marsupials many of which lack the primate like features for example arborealism. He further notes that some primate like specializations, especially the grasping feet and hands, are found in other groups such as some arboreal marsupials. These animals are insectivorous as are many of the prosimians or "lower primates".

Primates are also known for their great intelligence related in part to their great awareness of the environment plus the ability to manipulate this environment. Nonhuman primates normally do exceptionally well on various psychological tests. The primate brain is large in relation to the size of the body and those areas which control complex behavioural patterns. That permits a great degree of behavioural flexibility.

Much primate adaptability is the result of behavioural adaptations which are learned. Most primates live in large social units and have a long childhood period. This adaptability is due in large part to the nature of the arboreal environment. Primate characteristics have to be thought of more in terms of evolutionary trends than in terms of specializations. Among the important features of primates in general are the presence of a generalized limb structure and five fingers per limb, locomotors flexibility, nails and tactile pads on digits, reduction of the sense of smell and elaboration of the sense of vision with stereoscopic colour vision, the hemochorial placenta, great intelligence and a large brain.

Check Your Progress 1

1) Primates include:

   a) Lemurs, lorises, tarsiers

   b) Monkeys

   c) Apes

   d) All of the above

2) Human evolution isn't simply about how we have changed physically over the last:

   a) 70 million years

   b) 80 million years

   c) 60 million years

   d) 65 million years

9.1 PRIMATE BEHAVIOUR

Humans are categorized under primate biological group which includes lemurs, lorises, tarsiers, monkeys and apes. All of these species are considered social, smart and adaptive of using their hands. This group of species is found to be very vocal and communicative with the members of their social group. And they move around in a wide variety of ways, even sometimes on two legs.

Human evolution isn't simply about how we have changed physically over the last 70 million years, but also about how our behaviour has changed. Prime bevaviour to a great depends on its environment or studying an animal in relation to its environment (called behavioural ecology). Obviously, defining an environment is a complex thing to do, inclusive of both biotic and abiotic factors (Jaiswal, 2013).

Factors that might need to be taken into account include:

- quantity and quality of different kinds of food
- distribution of food resources
- distribution of water
- distribution and types of predators
- distribution of sleeping sites
- activity patterns (nocturnal/diurnal)
- relationship with other (non-predator) species and
- impacts of human activity.

"We study nonhuman primate behaviour to help us better understand our own species behaviour. Since we are primates - primate behaviour includes humans. Yet, clearly there are differences in behaviour among different species of primates - especially humans. Similar behaviours may also have different causes. What may be instinctual in one species may be learnt in another. And yet the similarities may give us some knowledge of the roots of some human behaviours. All mammals can learn and rely at least partially on learnt behaviour for survival". Basically there are five different areas of primate behaviour that we would be learning (Primate Behaviour, n. d.):

i) Sexuality

ii) Infant care and other care-giving

iii) Grooming and touch

iv) Aggression and violence

v) Communication

Check Your Progress 2

3) Areas of primate behaviour include:

   a) Sexuality

   b) Infant care and other care-giving

   c) Grooming & touch

   d) All of the above

4) Areas of primate behaviour include:

   a) Aggression & violence

   b) Communication

   c) Grooming & touch

   d) All of the above

9.2 SOCIAL BEHAVIOUR OF NON-HUMAN PRIMATE

Most primates, including humans, spend their lives in large social groups or communities. In case of semi-terrestrial species, such as baboons, being in a large community helps provide protection against predatory cats, dogs and hyenas. It also helps protect scarce food resources. This is especially true for non-human primates when the food is fruit. Leaf-eaters, such as colobus monkeys and langurs, tend to form smaller social groupings since there is little competition for their food. Very few nocturnal species of primates are mostly small, relatively solitary hunters. There are exceptions to these general patterns. For instance, the vegetarian orangutans lead mostly solitary lives except for mothers with their children before they go off on their own.

Most non-human primate communities are more or less closed to contact with members of other communities. Most often, they are tied to a particular locale and rarely migrate outside of their home range. This aloofness from other troops prevents high concentrations of individuals which could result in rapid depletion of local resources. Communities usually avoid each other and are aggressive towards outsiders. As a result, social interactions between members of different troops are usually very rare, especially for females. Chimpanzees are a notable exception. When chimpanzees from different troops come together, there is often an exciting, friendly encounter lasting several hours, following which, some of the adult females switch groups. Apparently, they are seeking new mates. Occasionally, however, contact between communities of the comparatively unpredictable chimpanzees will develop into genocidal violence. Interactions within non-human primate communities are usually unlimited. Subgroups are rarely closed from group interaction. All members of a community have daily face to face, casual communication. The most common type of subgroup consists of a mother and her young offspring.

In some forest living primates, contact between groups of the same species is in the form of a specialized territorial defense behaviour. Instead of avoiding each other, groups actively converge near their common territorial border and make hostile displays. Howler monkeys, indris, siamangs and gibbons all produce exceptionally loud vocalizations for this purpose. This is a ritualized, essentially harmless form of aggression that is intended to intimidate members of the neighboring community. All four of these species live in home ranges that are usually so small that the food resources of neighboring territories can be seen and become attractive.

9.2.1 Non-human Primate Social Group Composition

While there is considerable variation in social group composition among the primates, there is very little variability within each species. In fact, most non-human primate species are limited to only one of the following six basic patterns:

1) Single female and her offspring
2) Monogamous family group
3) Polyandrous family group

4) One-male-several-female group
5) Multi male-multi female group
6) Fission-fusion society (Social Behaviour, n. d.)

9.2.2 Kinship

Kinship refers to relationships that are recognized between individuals based on family ties. Among humans, those ties are created by marriage and shared descent from ancestors. Among non-human primates, they are due to descent. Most non-human primates apparently recognize only matrilineal descent. That is, they know who their mother is but not their father. Socially recognized paternity is unimportant or non-existent for them. The strongest social unit is a mother and her young children. Chimpanzees maintain their bonds with their mother well into adulthood. When they are threatened by others, even large male chimpanzees may go to their aged mother to be soothed by grooming. The social ranking of juvenile rhesus macaques precisely corresponds to the ranking of their mothers. Shared descent from the same female is also the basis of close relationships between macaque sisters, aunts and nieces. Another indication of the recognition of matrilineal descent is the fact that incest in the form of mother-son mating is rare for primates.

Although most of the data are from Old World monkeys, particularly macaques and baboons, wherever substantial data on kinship and behaviour are available positive correlations, with maternal kinship at least, have been reported. The data for play and mounting behaviour show weaker correlations with kinship but age and sex also strongly correlate with play and mounting behaviour and for example, the availability of male peers among kin as play partners may only be likely in large matrilines (Dittus, 1979).

9.2.3 Gender Differences

Behavioural differentiation of male and female primates involves more than just mating behaviour. Males are usually larger and physically dominant over females. Extreme sexual dimorphism is particularly characteristic of the semi-terrestrial monkeys and the great apes. The manner in which male and female children socialize often differs. Following infancy, age-based play groups are usually the primary socializing group for males. These juvenile male cohorts often spend much of their time on the fringes of the troop territory in active physical play. For example, nearly half of the waking hours of young male gorillas are spent in rough play. This is comparable to the amount of time human children play if given the opportunity. For most non-human primates, play is critical for developing social bonds and social skills. Young female monkeys and apes are more often socialized in the safer areas of the community territory by their mothers and other older female relatives. Their play is usually less rough and focuses more on developing parenting skills and social ties among the females with whom they usually spend their lives. As adults, male primates are more likely to leave the community to join roaming bachelor groups and eventually join other communities. Chimpanzees are somewhat of an exception. While male chimpanzees often roam, it is the females who switch communities. However, they usually stay physically close to their own mothers until they become sexually mature around 11 years of age or somewhat later" (Primate Behaviour, n. d.).

9.3 SOCIOBIOLOGY

Sociobiology, the study of the biological bases for social behaviour, has its primary tenet the expectation that phenotypes should behave in ways that promote the continuation of their genotypes. Sometimes it is a much maligned and misunderstood topic, partly because people often do not like the idea that their activities are influenced by their genes and partly because the vocabulary of sociobiological theory is sometimes used by bigots to promulgate personal prejudices. Sociobiology presumes that genetic components in social behaviours are subject to the same selection processes as any other gene influenced characteristic. The fundamental problem of sociobiology is that the heritability of behaviour is poorly known. Consequently this topic is strong on conceptual models and weak on documentable examples whose mechanisms of inheritance are understood (Smuts & Cheney, 1987).

Thus, we think that if an organism is going to reproduce and continue its existence, it must behave in ways that benefit its genotype. At the very least, if it is to remain successful (extant), it should not consistently act in ways that endanger the existence of the genotype it represents. The idea that behaviour should make evolutionary sense is the basis for sociobiology theory.

The primary concept in sociobiology is kin selection, the idea that we share our genotype with our kin and if we behave in ways that promote their success then we benefit our own genotype. Parental investment in offspring is a common and conspicuous form of kin selection. In a more general sense, kin selection is cooperation between closely related individuals that results in leaving more of their gene alleles in the population's gene pool (Hamilton, 1964). Social behaviour is a familiar form of this type of kin selection, since members of the same breeding population are likely to share most of their genotype. Altruism, behaving in a manner that produces a net loss while neighbors gain, seems to be an unprofitable long term strategy. However, reciprocal altruism, an act that incurs relatively minor risk but produces a large gain from reciprocation by a neighbor, is an important and frequent feature in biological communities. For example, sentinel or alarm behaviours exchanged between different species that habitually forage near each other produces substantial mutual gain at low risk (Wood, 1992).

Fitness refers to the reproductive success of a genotype. If a genotype does not reproduce, its fitness is zero. The genotype in the population with the greatest average number of surviving offspring is described as the most fit genotype in the population. W.D. Hamilton (1964) proposed the idea that an individual attempts to maximize its inclusive fitness, a dimension that includes both its own reproductive fitness plus that of close relatives. In this model, an individual's behaviour should be influenced by the degree of relatedness (Mayr, 1982; Jaiswal, 2013).

Check Your Progress 3

5) Sociobiology, the study of the ……..bases for social behaviour.
   a) Biological
   b) Social
   c) Cultural
   d) None of the above

6) The primary concept in sociobiology is …….
   a) Natural selection
   b) Chemical selection
   c) Ecological selection
   d) Kin selection

7) Fitness refers to the reproductive success of a:
   a) Genotype
   b) Phenotype
   c) Both a and b
   d) None of the above

8) A model of inclusive fitness however, does not explain all social behaviour or all:
   a) Physical systems
   b) Social systems
   c) Biological systems
   d) All of the above

9.4 PRIMATE SOCIO-ECOLOGY

Primates groups are tied to particular locations. They do not wander at random, but stay in a familiar area and utilize familiar resources. An area used by a group is called its home range. Within the home range there is often a subarea that is intensively used, a core area, which contains most frequently used resources such as a water source or preferred sleeping sites. Territoriality is the defense of the home range by aggression and display from intrusion by other groups of the same species. Territoriality is more likely (but not mandatory) in situations in which the core area approximates the home range.

Species often specialize in particular niches which means they inhibit in a particular habitat and exploit certain resources in that habitat. Thus several species of primates may live in the same area but use different resources. Species with overlapping ranges are said to be sympatric. Those with non-overlapping ranges are called allopatric species (Jaiswal, 2013).

9.5 SOCIETY

Primates generally live in groups that have clear boundaries for membership and complex organization. Relationships between individuals are controlled by dominance rank, political alliances, friendships, kinship, role, age, gender and situation. Composition of the social group can be influenced by historical circumstance, but there is usually a typical or usual composition and social structure for each species. The nature of the social group is shaped by inherited characteristics of bonding, personality and motivation. Elaborate rules usually control social interactions such as proximity, attention, mating, coordination of movements during foraging and performance of roles (Andrews, 1986; Jaiswal, 2013).

Perhaps the simplest society is the monogamous pair, in which the typical adult social group consists of a single breeding adult pair and their immature offspring. This should not be confused with a monogamous family or a monogamous pattern of consort behaviours. In a monogamous society, the two adults have no allies or nonaggressive relationships with other adults outside of their pair bond. Such species are usually highly territorial and intolerant of outsiders.

Another simple society is the noyau social group characterized by individual adult females who establish separate ranges. The individual female and her immature offspring are the primary social group. A male tries to establish a range that includes the ranges of several females and consorts with them during the mating season (Andrews, 1984).

A one-female society consists of a single adult female, several adult males and their progeny. A one-male group includes a single adult male, several adult females and their progeny. Multi-male multi-female groups are composed of several adults of both genders and are often further divided into subgroups based upon kinship, bonding, age, or rank (Andrews, 1984).

Check Your Progress 4

9) Within the home range there is often a subarea that is intensively used is referred as:

   a) Home range

   b) Territoriality

   c) Core area

   d) Niche

10) Primates generally live in …… that have clear boundaries for membership and complex organization.

   a) Single

   b) Groups

   c) Society

   d) All of the above

9.6 SUMMARY

Humans are part of the biological group known as primates. Primates include lemurs, lorises, tarsiers, monkeys and apes. Human evolution isn't simply about how we have changed physically over the last 70 million years, but also about how our behaviour has changed. Prime bevaviour to a great depends on its environment. We study nonhuman primate behaviour to help us better understand our own species behaviour. Similar behaviours may also have different causes. Sociobiology is the study of the biological bases for social behaviour - the primary concept being kin selection. Fitness refers to the reproductive success of a genotype. A model of inclusive fitness however, does not explain all social behaviour or all social systems. The numbers in the inclusive fitness models are somewhat misleading in primate populations. There exists a series of replicators that grade from a nucleotide to all of life. Probably the most powerful force that promotes social life

is kin selection. Acts and emotions which are very beneficial when directed at kin sometimes produce illogical and unfortunate consequences when stimulated and performed outside of their adaptive context. Selection in a large and heterogeneous social group may promote distinctions between degrees of kinship. It is very important to remember that a set of genes that produces social behaviours can be subject to stabilizing selection. There may be conflicts of interest between different members of a group. In order to be tolerated by the group, a newcomer (or an immature individual) may have to conform to certain standards of expected behaviour and perform certain acts. Animals who share space or resources are bound to come into conflict with each other from time to time. Primates groups are tied to particular locations. Primates generally live in groups that have clear boundaries for membership and complex organization. Simple society is the noyau social group characterized by individual adult females who establish separate ranges.

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9.8 ANSWER/HINTS TO CHECK YOUR PROGRESS

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

UNIT 10 COMPARATIVE ANATOMY OF HUMAN AND NON-HUMAN PRIMATES*

Contents

10.0 Introduction

10.1 Primate Evolutionary Trends

- 10.1.1 Limbs and Locomotion
- 10.1.2 Teeth and Diet
- 10.1.3 Senses, Brain and Behaviour

10.2 Morphological and Anatomical Features of Apes

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- 10.2.2 Gibbons
- 10.2.3 Orangutan
- 10.2.4 Chimpanzee
- 10.2.5 Gorillas

10.3 Comparison of Morphological and Anatomical Features of Man and Apes

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- 10.3.3 Backbone
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10.7 Summary

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10.9 Answers/Hints to Check Your Progress

Learning Objectives

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

- understand factors affecting primate anatomy;
- describe the trends of primate evolution;
- know the characteristic of apes and man; and
- explain the comparison of morphological and anatomical features of man and apes.

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10.0 INTRODUCTION

A primate's survival is reflected in its behavioural ecology, how it uses its environment, its anatomy and its evolutionary history. A simple triangular model (figure 1) illustrates this relationship. Behaviour, anatomy and the environment are at the corners of the triangle. Behaviour affects anatomy and the environment, while the environment affects anatomy and behaviour. Evolutionary history affects all three. For example, behaviour such as locomotion determines where a primate moves and how it is capable of moving its body. Most of these abilities are the result of a long history of adaptation to enhance survival in a given, usually arboreal environment. Heads, teeth and bodies are thus mosaic structures that reflect a species' evolutionary past as well as their current survival abilities. Consider, for example, the body of humans as a series of upper body adaptations that reflect our arm-swinging ancestral past, while our hips and legs reflect a more recent evolutionary modification for bipedalism. The same is true for our teeth and our heads. In short, primate and human bodies are true time capsules of our ancestral past (Gebo, 2014).

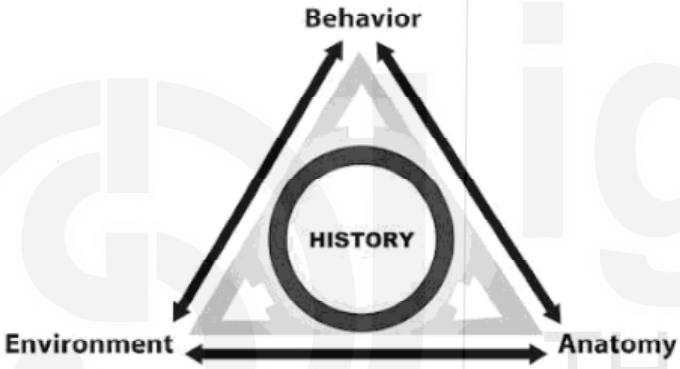

Fig. 1: Simple Triangular Model of PrimaeAdaptation

Source: Gebo, 2014

Understnding primate adaptations is important since this information allows us to comprehend survival abilities and it helps us to sequence the morphological changes that explain primate phylogeny. Adaptation and phylogeny go hand in hand in the science of primatology. By definition, an adapttion is a characteristic that allows an organism to survive and reproduce in its environment. A niche is an organism's way to make a living; in other words, a niche is how an organism finds the resources needed to survive and compete against other organisms. When it comes to species, we often seek to examine how a single group is creatively modified into an array of different forms. We call this species explosion an adaptive radiation and it means that closely related organisms have evolved to exploit different ecological niches. Adaptive radiations are the heart and soul of biology (Gebo, 2014).

Check Your Progress 1

1) How primate behaviour is influenced by environment and anatomy? Explain with suitable example.

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10.1 PRIMATE EVOLUTIONARY TRENDS

Although this unit focuses on the comparative anatomy of human and non-human primates, it is helpful to include a brief overview of primate evolutionary trends. Structurally, primates are not easily distinguished as a group chiefly because of the fact that, as an order, we and our close relatives have remained quite generalized. Unlike the specialized dentition of rodents or the specialized limbs with great reduction of digits found in artiodactyls (cows, deer, camels, pigs) primates are characterized by their extreme structural specializations.

For this reason, we cannot point to a single anatomical feature that can be applied exclusively and universally to the primates. On the other hand, there is a group of evolutionary trends (Clark, 1971) which, to a greater or lesser degree, characterize the entire order. Keeping in mind, these are set of general tendencies and are not synonyms with progress. In evolutionary terms, we are using "trend" only to reflect a series of shared common characteristics (i.e., general homologies).

A common evolutionary history with similar adaptations to common environment challenges is reflected in the limbs and locomotion, teeth and diet and in the sense, brain and art behaviour of the animals that make up order. Following is a list of those evolutionary trends that tend to set the primates apart from other mammals.

10.1.1 Limbs and Locomotion

- Retention of five digits in the hands and feet-pentadactyle.
- Nails instead of claws.
- Flexible hands and feet with a good deal of prehensility (grasping ability).
- A tendency toward erectness (particularly in the upper body).
- Retention of the clavicle (collar bone).

10.1.2 Teeth and Diet

- A generalized dental pattern, particularly in the back teeth (molars).
- A lack of specialization in diet. This attribute is usually correlated with change in pattern of teeth.

10.1.3 Senses, Brain and Behaviour

- A reduction of the snout and the proportionate reduction of the smell (olfactory) areas of the brain.
- An increased emphasis on vision with elaboration of visual areas of the brain. A trend related to the decreased dependence on smell. Except for some specialized nocturnal forms, colour vision is most likely present in all primates.
- Expansion and increasing complexity in the brain.
- A more efficient means of foetal nourishment, as well as longer period of gestation (with single births the norm), infancy and extension of the whole life span.
- A greater dependency on highly flexible learned behaviour is correlated with longer periods of infant and child dependency. As a result of both these trends, parental investment in each offspring is increased so that although fewer young are born, they receive more efficient rearing.
- Adult males often associate permanently with the group.

10.2 MORPHOLOGICAL AND ANATOMICAL FEATURES OF APES

Apes are a group of anthropoid primates native to Africa and Southeast Asia. In traditional use, apes are excluded from humans and are differentiated from other primates in terms of locomotion. Apes are divided into two extant branches or super families: Hominoidea (gibbons or lesser apes) and Hominids (great apes).

10.2.1 The Apes: Characteristics of the Apes: General

- They have no tail.
- Only apes (and humans) have five cusps on their teeth, known as Y-5 pattern. Monkeys have four cusps to their teeth.
- Locomotion is by several means, in the trees and knuckle-walking on the ground (Quadrupedal).
- The arms are long in comparison with their hind limbs.
- Their rib cages are flattened from front to back.
- Their brains are larger than those of monkeys, which allow them to learn quite complex behaviour patterns.
- The upper lip is free of the gums. This allows the apes to have mobile and expressive faces, so they use facial expression for communication.

10.2.2 Gibbons

- These are the smallest of the apes, the largest being no more than 10.5 kg.
- They live in the dense tropical forests of Southeast Asia.
- They are acrobatic brachiators 75 per cent of the time, the rest is spent quadrupedally or bipedally.
- They show no sexual dimorphism. (Apes vs Humans & Skeletal Differences, n. d.)
- Face and Ischial callosities are devoid of hair covering.
- Digital formula: 3>2>4>5>1.
- Digits except thumb are provided with nails.

10.2.3 Orangutan

- They live in thick tropical rain forests in Sumatra and Borneo.
- They are fruit eater.
- They have reddish hair coating on the body.
- They brachiate and often hang by their arms, which are very long. They have long curved hands.
- They tend to be too heavy to swing from one tree to another, so they have to come down on to the ground where they knuckle - walk to the next tree.
- Live in small group of 2-4 members.

- Each night they make a new nest to sleep in.
- Digital formula: 3>4>2>5>1.
- Their thumb is short and other fingers are long bear flat nails.

10.2.4 Chimpanzee

- Found in forest fringe and open woodland habitats in Africa.
- They are knuckle walkers on the ground and in the trees and they brachiate and can walk on two legs.
- Their main diet is fruit, supplemented by insects such as termites. They do not eat meat very often but it is greatly relished when they do.
- Their visual sense is highly developed; each animal looks different and is recognized by facial features.
- They live in troops of about 20 animals; children remain with their mothers for 4 or 5 years. During this time they learn from their mothers many complicated behaviors, including how to raise young babies.
- These are highly intelligent animals, able to fashion tools out of a piece of stick, throw stones when frightened, or pickup sticks to defend themselves.

10.2.5 Gorillas

- They are found in Africa
- These are the forest dwellers and spend most of their lives on the forest floor.
- They forage for food, mostly eating a type of celery and many leaves and shoots rather than fruit.
- They are nomadic, travelling daily to new feeding areas in groups of about 12-20 animals.
- They show sexual dimorphism; the males are bigger and have large canine teeth.
- They make nests each night.
- Fore limbs are considerably longer than hind limb (Apes vs Humans & Skeletal Differences, n.d.).

10.3 COMPARISON OF MORPHOLOGICAL AND ANATOMICAL FEATURES OF MAN AND APES

10.3.1 The Skull

The skull consists of a rounded brain case which surrounds and protects the brain and also provides attachment for muscles, especially those used for chewing. In an ape, the foramen magnum (the hole through which the spinal cord passes) lies towards the rear of the skull, so large neck muscles are needed to prevent the head from sagging forward. These are particularly strongly developed in male gorillas and run from the nuchal crest on the rear of the skull to the large spines (parts that stick out the back of each vertebra) of the thoracic vertebra.

In a human skull the foramen magnum is more or less in the center of the skull. As a result the skull is balanced on the first neck vertebra. So little muscle muscular energy is used to support it and the neural spines are correspondingly small (Apes vs Humans & Skeletal Differences, n. d.).

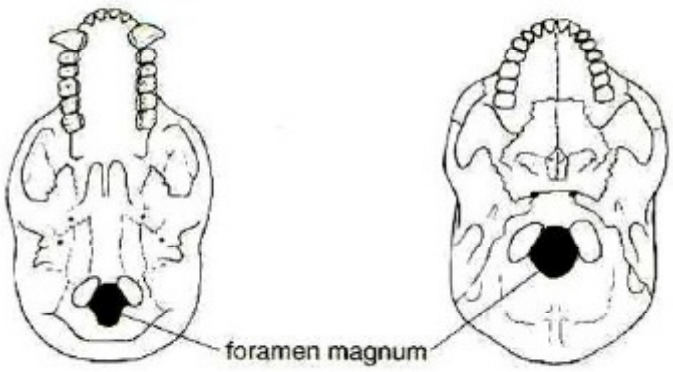

Fig.2: Position of Foramen Magnum in ape (left) and Human Skull (Right)

Source: Jaiswal, 2013

Characteristics of Modern Human Skulls

- Small mandible with prominent chin.
- Small zygomatic arch gap through which jaw muscles pass.
- No sagittal crest so reduced jaw muscles.
- Vertical face with no snout/muzzle.
- No brow ridges and forehead is vertical.
- Large brain size (cranium capacity). Enlarged particularly in the frontal and occipital regions, associated with increased reliance on vision and advanced thinking including speech.

Characteristic of Gorilla Skulls

- Large mandible with no real chin.
- Prominent snout/muzzle.
- Massive zygomatic arch - gap through which jaw muscles pass.
- Large saggital crest- attachment of strong jaw muscles.
- Nuchal crest- attachment of strong neck muscles.
- Receding forehead.
- Large brow ridges.
- Smaller cranium capacity (Apes vs Humans & Skeletal Differences, n. d.).

10.3.2 Teeth and Jaws

The teeth are much smaller with reduced enamel thickness in humans. This is probably due to the development of tools as weapons and food cutters, the size of teeth would be less important.

- There is a noticeable reduction in the size of the incisors.
- There is no sexual dimorphism in humans.
- The tooth row (dental arcade) is parabolic (bow shaped) in humans but is U-shaped in apes.

- In apes the lower canine fits into a gap or diastema between the upper canine and first premolar.

The apes has a large lower jaw with large teeth thick enamel particularly molars. This causes the lower jaw to protrude and gives a sloping face. In modern humans the lower jaw is reduced because the teeth are smaller with less enamel. The shorter lower jaw causes the face to be flatter in shape. In apes, the upper jaw teeth arrangement is U shaped whereas in humans the teeth arrangement is bow shaped.

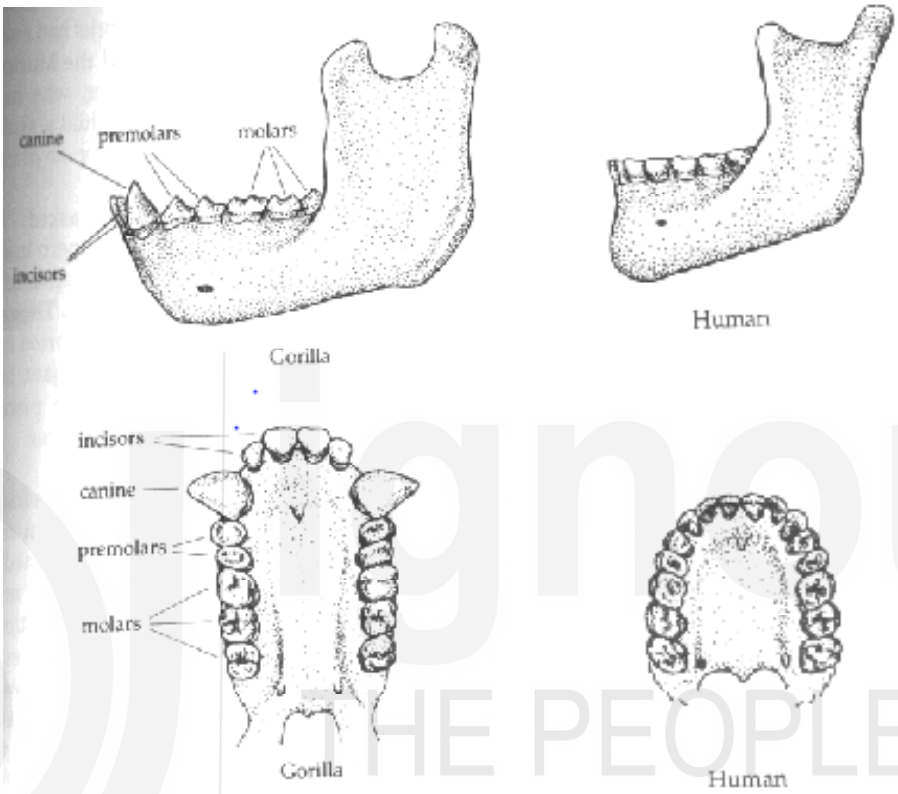

Fig.3: Comparison of Teeth and Jaw Structures of Ape and Human

Source: http://www.talkorigins.org

10.3.3 Backbone

An ape's backbone has a single gentle curve, a human backbone is 'S' shaped. This enables the weight to be carried nearly directly above the hip joints (Apes vs Humans & Skeletal Differences, n.d.).

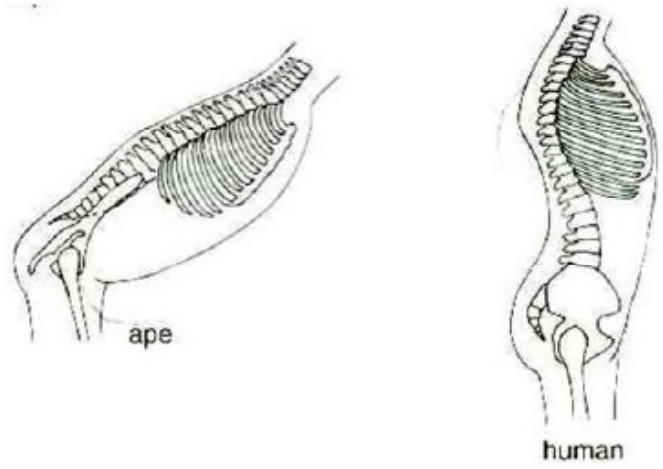

Fig.4: Apes (Left) and Human Backbone (Right)

Source: Jaiswal, 2013

10.3.4 Hip Girdle

In quadrupedal mammals the hip bone is long, but in humans it forms a bowl shaped support for the abdominal organs. It reduced height and brings the sacroiliac joint close to the hip joint (Apes vs Humans & Skeletal Differences, n.d.).

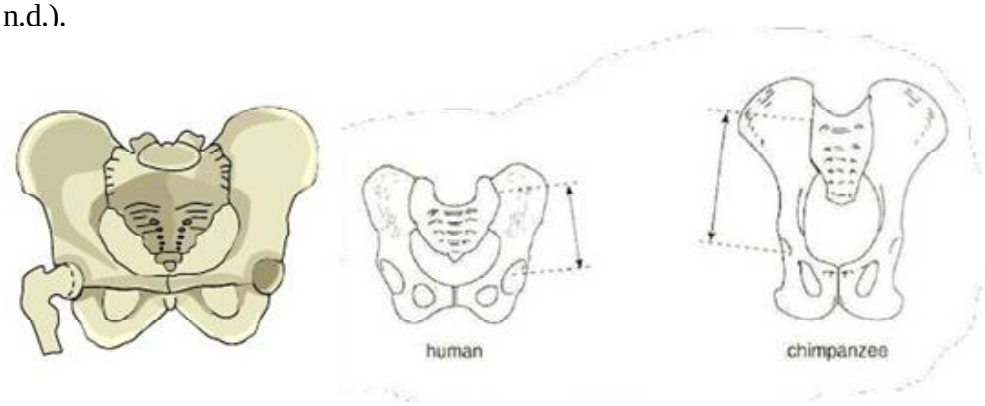

Fig. 5: Hip girdle of Human (Left) and Apes-Chimpanzee (Right)

Source: Jaiswal, 2013

10.3.5 Knee

Unlike apes humans are 'knock-kneed', each knee being almost directly underneath the center of the hip girdle. As a result, when one foot is lifted off the ground, the other is only slightly to one side of the center of gravity and there is little tendency to lose balance. The only way an ape can avoid falling over is to lean to other side. When an ape attempts to walk on two legs it therefore sways from side to side. Humans have a larger 'carrying angle' or better known as the valgus angle. This angle allows the leg to be close to the body's center of gravity (Apes vs Humans & Skeletal Differences, n. d.).

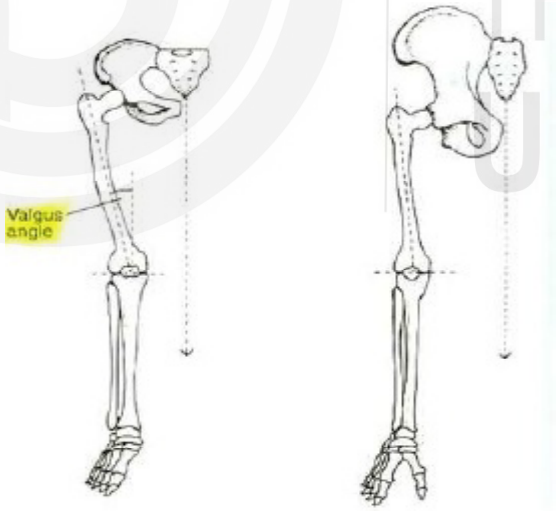

Fig. 6: Knee of Human (Left) and Apes (Right)

Source: Jaiswal, 2013

10.3.6 Foot

The foot in man supports and transmits body weight and acts as a locomotor organ. But in apes the foot is also a grasping organ besides being an organ for locomotion. These differences in function have led to certain structural variations in the feet of man and apes. With regard to the general shape and arrangement of bones, the foot of man resembles that of the apes. The differences are:

In man the great toe is non-opposable. It is the biggest digit and is in line with the other digits. In the apes the great toe is opposable. It is not well developed and it is not in line with the other digits.

In man the lateral toes are reduced in size, the fifth one is very small. In the apes the lateral toes are well developed.

In man either the first or the second digit is the longest, while in the apes the third one is the longest digit.

In man the dorsal and ventral surface of all digits are in the same way, the ventral surfaces being directed downward. In the apes the ventral surface of the great toe does not face downwards laterally.

In man the head of the first metatarsal also included in the common transverse metatarsal ligament while in the apes it is not found in that manner.

In man the metatarsal of all the digits are incorporated in the tissue of the foot. A common covering includes the digits up to the midpoint of the basal phalanx while in the apes the great toe is free from the common covering.

In man the first metatarsal presents a flattened area at its posterior and to articulate with the flat articular facet of the cuneiform bone. In the apes the articular region of the cuneiform is convex and that of the metatarsal is concave (8 unique comparisons between man and ape, n. d.).

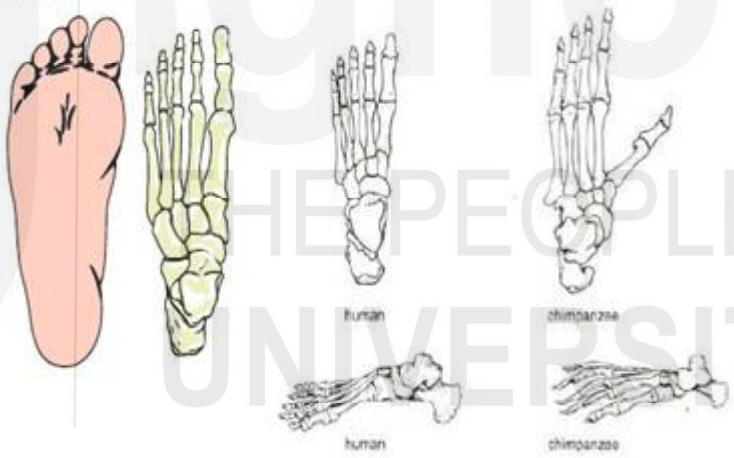

Fig.7: Evolution of Primate Foot

Source: Jaiswal, 2013

10.3.6.1 Comparison of Femur of Man and Gibbon

In general form and arrangement, a femur of man resembles that of a gibbon in the following characters.

The femur of gibbon is long and slender, its shaft is straight and cylindrical showing more or less circular cross section, in man the femur is not so long and is comparatively stout. Its shafts are not perfectly straight but slightly curved and it presents three surfaces and three borders thus the cross-section is not circular.

Upper Extremity

- In gibbon the neck of femur is short, stout and forms a less obtuse angle on the shaft.
- In gibbon the lesser trochanter is placed postero-medially whereas in man it is placed posteriorly.

Shaft

- The linea aspera is faintly developed in the gibbon but in man it is well developed forming a ridge.
- In gibbon the popliteal area is not well marked. The area is convex from side but straight from above to downwards. In man the popliteal area is well marked. It is convex from side to side as well as above downwards.

Lower Extremity

- In gibbon two condyles are almost equal in size while in man the medial condyle is larger than the lateral.
- The medial condyle does not extend below the lateral condyle in the gibbon, but it does so in man.

10.3.7 Hand

The human hand is essential in manipulating objects. The key features are the thumb, which in human differs from that of apes in two important ways:

- It is relatively longer.
- The first metacarpal is connected to the wrist by a saddle joint.
- This enables the thumb to be brought across the hand and touch the tip of any finger.

Another distinctive differences seen in the hand is the phalanges. In humans the phalanges (fingers) are straight, in apes they are curved, allowing the hands to act as hooks during brachiating.

All primates can hold things using a power grip but humans can also use a precision grip for fine manipulative movements (Apes vs Humans & Skeletal Differences, n. d.).

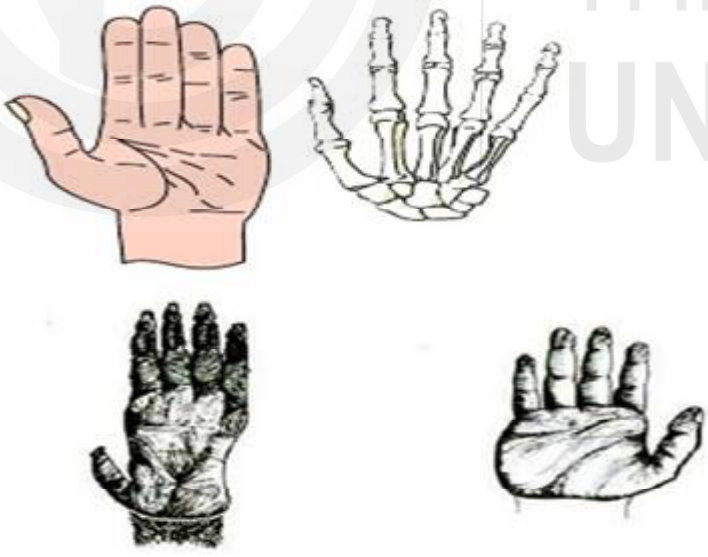

Fig. 8: Evoluation of Primate Hands

Source: Jaiswal, 2013

10.3.8 Chest

The human's chest is flatter from front to back than in apes. This causes the body weight to be concentrated as close to the spine as possible (Apes vs Humans & Skeletal Differences, n. d.).

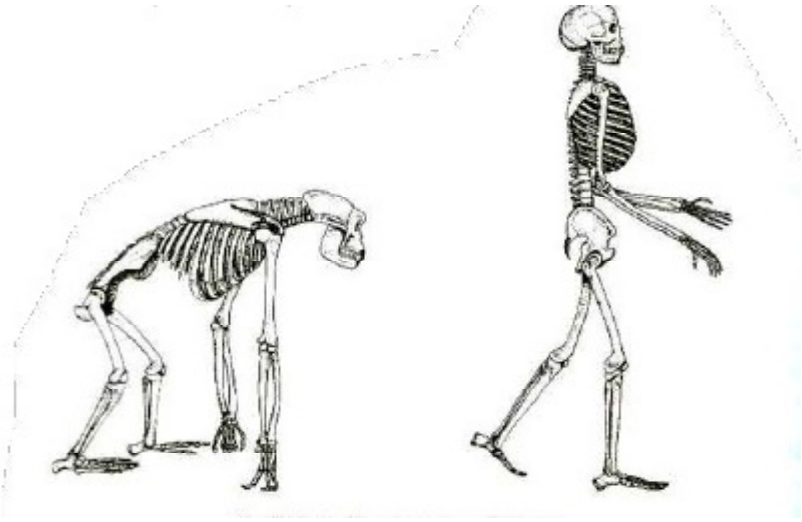

Fig. 9: Gorilla and Human Skeleton

Source: Jaiswal, 2013

10.3.9 Shoulder

Humans have a longer clavicle (collar bone) than apes**.** The scapula (shoulder blade) in humans is positioned on the back, rather than on the sides of the chest as in quadrupeds (Apes vs Humans & Skeletal Differences, n. d.).

10.3.10 Skin

Humans have just as many hair per square cm of skins as a chimpanzee. The difference is humans have very fine and short hair that give the impression of nakedness. Humans' skin does differ to that of apes as we have a greater density of sweat glands (Apes vs Humans & Skeletal Differences, n. d.).

Check Your Progress 2

2) Give a comparative account of teeth and jaw structure of man and ape.

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10.4 SUMMARY OF SIMILARITIES AND DIFFERENCES BETWEEN CHIMPANZEES, AUSTRALOPITHS AND MODERN HUMANS AS A RESULT OF MILLIONS OF YEARS OF EVOLUTION

S.No.	Modern chimpanzees	Australopiths	Modern humans
1	Canines larger and project out from teeth row	Canines slightly larger, but non-projecting	Canines of similar size to other teeth and non-projecting
2	Extended canine size determined by sexual dimorphism	Moderate canine size determined by sexual dimorphism	Minimal canine size determined by sexual dimorphism
3	Thin tooth enamel	Moderate tooth enamel	Thick tooth enamel

4	Dental wear pattern shows grinding action	Dental wear pattern shows crushing action	Dental wear pattern shows crushing action
5	Cranial capacity 400 cc	Cranial capacity 350 - 540 cc	Cranial Capacity > average 1000 cc
6	Foramen magnum opens toward rear of skull	Foramen magnum opens between rear and base of skull	Foramen magnum opens at base of skull
7	Tibiae thin and angled	Tibiae thicker and straighter	Tibiae thick and straight
8	Rib cage broad and extends past vertebral column	Rib cage broad and extends past vertebral column	Rib cage broad and extends past vertebral column
9	Scapulae on the back, shoulder joints oriented to the sides	Scapulae on the back, shoulder joints oriented to the sides	Scapulae on the back, shoulder joints oriented to the sides

10.5 RELATION OF ANATOMY AND POSTURE

The way a species sits, stands or hangs during feeding also influences its anatomy. For example, a siamang's ability to hang by its arms and legs may be more important in enabling it to feed from small branches than as a means of moving from one place to another. Likewise, the structure of a marmosets hand is influenced by the need to hold and process food as well as to grasp a support when moving.

We can relate details of primate anatomy to differences in locomotion and posture and can use the information to reconstruct the behaviour of species known only from fossil. However, we scarcely understand why some species leap, others are arboreal quadrupeds, some swing by their arms and one is a biped.

10.6 HOW ANATOMY IS RELATED TO MOVEMENT

From field studies we can learn the movements of each species and the ecological context in which they are used. Understanding how anatomy is related to movements is complicated by the fact that most primates can move in many ways, most leap at some times and run quadrupedally at others and many occasionally suspend themselves from branches. Anatomy hence reflects a series of compromises and an ability to do many things. Nevertheless differences in the frequencies with which primate species use different types of locomotion are reflected in muscles and bones. For example, two closely related species of larger Presbytis from Malaysia show differences in muscular and skeletal anatomy that are associated with the fact that one leaps about 20 per cent more frequently than the other.

Check Your Progress 3

3) Describe the important feature of skull of Modern Human and Gorilla.

.....

.....

.....

4) Give the descriptive account of the relation of anatomy and posture of primates.

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.....

10.7 SUMMARY

Evolution can be best described as the process of gradual modification in the living organisms (plants or animals) so as to establish diversity in the world of living beings. Structurally, primates are not easily distinguished as a group chiefly because of the fact that, as an order, we and our close relatives have remained quite generalized and there is a list of those evolutionary trends that tend to set the primates apart from other mammals. A common evolutionary history with similar adaptations to common environment challenges is reflected in the limbs and locomotion, teeth and diet and in the sense, brain and art behaviour of the animals that make up order. There is an evolutionary belief that all humans are derived from apes. Whether this is universally accepted or not, there are some who believe the differences between the two are too significant to prove otherwise.

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10.9 ANSWER/HINTS TO CHECK YOUR PROGRESS

1) Primate behaviour is affected by anatomy and the environment, while the environment affects anatomy and behaviour. Evolutionary history affects all three. For example, behaviour such as locomotion determines where a primate moves and how it is capable of moving its body. Most of these abilities are the result of a long history of adaptation to enhance survival in a given, usually arboreal, environment.

2) The significant differences between teeth and jaw pattern of man and ape include:

   - In humans, teeth are much smaller with reduced enamel thickness. This

is probably due to the development of tools as weapons and food cutters, the size of teeth would be less important. The apes has a large lower jaw with large teeth thick enamel particularly molars. This causes the lower jaw to protrude and gives a sloping face.

- In modern humans the lower jaw is reduced because the teeth are smaller with less enamel. The shorter lower jaw causes the face to be flatter upper jaw shape.
- In apes the upper jaw teeth arrangement is U shaped whereas in humans the teeth arrangement is bow shaped.

3) The important feature of skull of Modern Human and Gorilla are as follows:

   a) Modern human skull: Small mandible with prominent chin, small zygomatic arch, gap through which jaw muscles pass, no saggital crest so reduced jaw muscles, vertical face with no snout/muzzle, no brow ridges and forehead is vertical, large brain size (cranium capacity), enlarged particularly in the frontal and occipital regions, associated with increased reliance on vision and advanced thinking including speech.

   b) Gorilla skull: Large mandible with no real chin, prominent snout/muzzle, massive zygomatic arch - gap through which jaw muscles pass, large sagittal crest- attachment of strong jaw muscles, nuchal crest- attachment of strong neck muscles, receding forehead, large brow ridges, smaller cranium capacity.

4) The way a species sits, stands or hangs during feeding also influences its anatomy. For example, a siamang's ability to hang by its arms and legs may be more important in enabling it to feed from small branches than as a means of moving from one place to another. Likewise, the structure of a marmosets hand is influenced by the need to hold and process food as well as to grasp a support when moving. We can relate details of primate anatomy to differences in locomotion and posture and can use the information to reconstruct the behaviour of species known only from fossil. However, we scarcely understand why some species leap, others are arboreal quadrupeds, some swing by their arms and one is a biped.

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