BLOCK 2
HUMAN GROWTH AND ECOLOGICAL FACTORS

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UNIT 4 BIO-CULTURAL FACTORS INFLUENCING PATTERNS OF GROWTH AND VARIATION

Contents

Learning Objectives:

After going through this unit, you will:

- understand the basic concept of growth;
- know about genetic factors affecting growth and variation;
- understand the ecological factors affecting growth and variation; and
- learn about socio-cultural factors affecting growth and variation.

4.0 INTRODUCTION

First of all, let's introduce the basic ideas of growth in human beings and understand what growth is? Understanding growth is important in order to understand the totality of human beings- which is the main venture of anthropology. Growth, although generally understood and studied in the limited biological sense, can be taken as an important manifestation of the genetic, environmental and psychological well being of a person. Simply, growth may be defined as the changes in shape and size over a period of time.

Growth study is very important to make clear understanding of the evolution. It also occupies a crucial place in the study of individual variation in form and function of man. Human growth is uneven from birth to adulthood. It occurs in different patterns and also influenced by many intrinsic and extrinsic factors such as genetic, environment and social factors.

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Human growth patterns are affected by various factors such as environmental factors, social factors as well as the biological factors. Growth is the effect of the intensive change of a multifaceted system of various regulatory factors with changing interactions. Both prenatal period and postnatal life may be modulated by several factors because each individual has a genetic base with a distinct growth potential (Eveleth & Tanner, 1990). When all these factors run normal, the optimal growth can be achieved. Prenatal growth as well as post-natal growth is determined by both hereditary factors as well as environment factors. For example, the prenatal growth i.e. the length of the newborn baby and the postnatal growth after which the child is exposed to different environment are governed by both hereditary and environmental factors. There is a sudden increase in height during puberty which is also known as the pubertal growth spurt that gives an extra increase in height and after that the growth ends soon. The growth process has close connection with pubertal development, and the onset of puberty is more correlated with skeletal age than with chronological age (Marshall et al, 1976). In many countries, the environmental conditions are such that there is incomplete expression of hereditary components, and this may have consequences on prenatal and postnatal growth (Wall et al, 1993).

Many scientists have defined 'growth' in their own ways. Being seen as a quantitative dimension of the process of development, it obviously results in the increase in size. Bogin (1991) defines growth as a quantitative increase in size or mass. There are various factors influencing growth and variation, broadly classified as genetic and environmental factors. Environment is a broad term that includes a large number of interacting variables. It is a complex condition and each condition influences the organisms differently at different stages of growth. Environmental factors influencing growth may be categorised as ecological and socio-cultural factors. Ecological factors include climate, altitude and seasonal variations etc. Socio-cultural factors incorporate nutrition, socio-economic status, family size, psychological disturbances, generation changes, migration, and urbanisation.

Check Your Progress 1

1) What are the factors influencing human growth and variation?

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4.1 GENETIC FACTORS

The genetic control of growth is determined by the variations observed in the total extent and rate of growth between children and adults of varied populations living in more or less similar environments. Ethnic variation may also affect in growth patterns. The most reliable support of hereditary control over growth can be provided by twin studies. The parents' height has an influence on the stature of their children is well recognized (Wall et al, 1993; Sinha and Kapoor, 2006). On the other hand, the relationship between parent's height and the height of the

baby is not noticeable at birth but becomes more apparent toward the age of 2 years, and subsequently the association becomes greater with growing age (Smith et al, 1976).There is a large difference in the height of monozygotic twins, with identical genetic composition when reared apart than when reared together, whereas, that difference was less when compared with the difference between dizygotic twins (Shields, 1962). The possible reason for the difference in height of monozygotic twins might be environmental factors. In addition to this genetic control may also influence body proportions. In comparative terms, the Australian Aborigines and the Africans in Ibadan have the longest legs (Eveleth & Tanner, 1990). The increase of leg length in comparison to increase in total length can be proportionally different in diverse populations during the growth phase. Admixture of races lead to production of children with stature and body proportions midway between the parental populations (Eveleth & Tanner, 1990). The growth process may also be affected by hereditary diseases and chromosomal aberrations due to suppressive influence. Some of the examples are Turner's syndrome (karyotype 45,XO), other X chromosomal abnormalities, and Klinefelter's syndrome are well-known diseases related with either short or long stature. It is difficult to manipulate genetically defined growth features in spite of many new developments in endocrine therapy such as growth hormone treatment for Turner's syndrome (Ranke et al, 1991).

Hormones or secretion of the endocrine glands are of great importance in the control of growth and development. Somatotrophin is the most important growth hormone that controls growth from birth to maturity. Other important hormones that play major role in regulating growth and development are thyroid hormone and steroid hormone.

During prenatal growth, poor environmental conditions do not support optimal development of the foetus.The first parameter to be inhibited is weight gain, however after prolonged inadequacy there is negative impact on weight also (Usher & McLean, 1974). Environmental settings account for about 60% of the variability of birth weight and genetic factors for the remaining 40% (Polani, 1974). Birth weights of first-born babies have 100 g lesser than second or third babies, in case of multiple pregnancies the weight gain of each foetus after the 30th week of gestation is less than that of single-pregnancy foetuses (Underwood, 1985). Illness in the mother, malnutrition, therapeutic drug treatment, alcohol and other social drug addiction, and cigarette smoking also make an inhibiting effect on fetal growth. High risk of congenital malformations and the incidence of abnormalities is related to poor control of blood sugar levels in the first trimester to the offspring of mothers with insulin-dependent diabetes. Ensuring specific diabetic control in early gestational period is important in order to maintain a more normal environment of glucose, insulin, and ketone levels which may help in diminishing congenital anomalies (Miodovnik et al, 1988). Consumption of alcohol, addiction of drug, and smoking may have a severe effect on the height and weight of babies (Jones et al, 1973; Hoff et al, 1986; Fulroth et al, 1989). It is known that smoking increases the risk of prematurity of foetus (Fedrick et al, 1978). During prenatal growth, maternal malnutrition with a deficiency of trace elements and placental dysfunction in addition to a direct toxic effect on the foetus has been appeared to be the underlying mechanism. The incidence of congenital malformations is also increased by addiction to alcohol (Streissguth et al, 1978).

4.2 ECOLOGICAL FACTORS

4.2.1 Climate

Heat, cold and relative humidity are associated with variation in body size, proportion and composition. People living in different climatic conditions tend to show differences in their body size. Usually, people living in a hot dry climate tend to have taller and lighter body in comparison to people living in a cold climate. During the year, there are periods of more rapid growth when growth rate is three times greater than the time of slowest growth. Most rapid growth occurs in spring season and all those periods of growth rate are coordinated with the seasons. In the tropics, lower food supply during the rainy season may be responsible for the changes in growth rate (Marshall, 1971).

4.2.2 Altitude

The 'sparse air' at high altitude creates environmental stress among the people living there. The existing conditions at high altitude have an impact on the growth and maturation of children (Kapoor and Kapoor, 1986). Growth and skeletal maturation are more retarded among mountain dwellers as compared to coastal dwellers because of environmental stress. Climate is also affected by high altitude, where people exposed to lower oxygen saturation in the air have a shorter stature (Eveleth and Tanner, 1990). One of the causative factors may be seasonal food scarcities (Leonard, 1989). Size of the body appears to be more adaptive under diverse ecological conditions (Frishancho et al, 1973).

Check Your Progress 2

2) What are the ecological factors influencing growth and development? Discuss.

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4.3 SOCIO-CULTURAL FACTORS

4.3.1 Nutrition

The problem of malnutrition is still a worldwide health issue. Foetal growth is affected by maternal malnutrition whether it is a deficiency of protein, calories, or trace elements. Foetal brain development may also be reduced due to malnutrition. There are three phases of cellular growth and organ development, the first being a phase of cell proliferation, followed by a phase of proliferation with concomitant hypertrophy, and a third phase of hypertrophy alone. Disturbances of the proliferation phase of brain tissue, for example, results in a lower DNA and protein content, which is irreversible and from which the brain does not recover. Therefore, the more serious is the lack of brain growth that

occurs in the earlier phase due to malnutrition. Climate also has a regulatory effect on birth weight. The socioeconomic environment in even the well-developed countries is undergoing changes, and modern women have the opportunity of working in male-oriented industries. Over the next decade, information will be gathered about possible factors such as toxins and workload, which may interfere with providing a safe internal environment for the developing fetus (McCloy, 1989). During the postnatal period, the prenatal effects on weight and height may disappear. During infancy, catch-up growth with reference to height occurs but this may be incomplete (Fitzhardinge et al, 1989), which may severely compromise the final height.

Nutrition during post natal seems to be the most important factor influencing growth. Nutrition influences both growth and development. A required amount of food and nutrition is essential at different ages for proper growth and development. Undernutrition during childhood results in slow skeletal growth. Malnutrition results in failure to grow, involving both weight and height. Increased growth hormone secretion occurs in protein malnutrition which probably help in inducing mobilization of the enduring fat tissue (Primestone et al, 1968). On the other hand, growth hormone levels are decreased in calorie malnutrition. The affected children soon recover if malnutrition is corrected at proper time. If this reversal occurs at an early age, most children will attain a complete remission in height and weight, equal to their siblings before puberty. In fact, the retardation of growth rate is an indication of malnutrition and this condition can be improved by supplementing the diet. Higher calories are essential during the stage of adolescence. Lack of calories leads to reduced or delayed pubertal growth spurt. Anorexia nervosa is a common disease in adolescent girls. Alterations in endocrine may also occur depending on the harshness of the anorectic state which includes an increased growth hormone levels related with hidden gonadotropin and sex steroid levels (Brown et al, 1978). All of these are primarily the consequences of malnutrition, on the other hand a central mechanism with direct effects on hypothalamic function may also be involved (Eisenberg, 1981).

Skeletal development is also important for the growth process. Different hormones are involved in growth in which each of them have their own regulatory effect on skeletal maturation. Malnutrition causes retardation of skeletal deformity. Separation lines can be seen on X-ray films when there are periods of delayed growth caused by either disease or malnutrition (Blanco et al, 1974).

Check Your Progress 3

3) Explain the role of nutrition in human growth.

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4.3.2 Socio-Economic Status

The impact of socio-economic differences on the height and weight of children is well known (Kapoor et al 2013). Several studies have shown that children

belonging to a high economic group grow faster than those belonging to a low socio-economic group. Family with higher socioeconomic status includes higher income associated with better education, better nutrition, better child care, and better medical and social services. The so-called secular change occurs when all these factors induce a change in size, rate of growth, and timing of pubertal development (Eveleth and Tanner, 1990).

4.3.3 Family Size

The size of a family also influences the rate of growth of children, especially in the lower socio-economic class. Children do not get adequate care and sufficient quantity of food in a large and poor family. As such, the rate of their growth in such families is found to be comparatively more retarded growth than in big families belonging to a higher socio-economic class.

4.3.4 Generation Changes

Studies conducted during the last one hundred years in different parts of the globe revealed a marked tendency in children to become progressively larger-taller and heavier besides maturing more rapidly. Factors like better nutrition, improved hygienic conditions, control of infectious diseases, reduced family size, improved and widespread medical facilities etc. might have been responsible for the occurrence of an increase in height and weight. This trend has been termed as the 'secular trend'. The phenomenon has also been noted as regards the age at menarche. It has been found that the average menarcheal age of girls is gradually going down. The social, emotional and mental development of children may also be influenced through parental love, care and proper parent-child relationship. Adverse psychological conditions can affect the functioning of the endocrine system, which may in turn cause retardation in growth.

4.3.5 Culture

Culture too influences nutritional conditions. Nutrition not only depends on the availability of food or the socio-economic condition of the person or population concerned but also on the utilisation of food resources. The kind of food eaten, meal time, food restriction, food habits, lifestyles etc. are all culturally determined. Thus, cultural behaviour influences nutrition and thereby growth and development.

4.3.6 Migration and Urbanisation

The impact of migration and change of environment on physical characteristics are observed. Migration has been taking place for rural and urban areas. This has been due to the search for livelihood or employment, occurring more rapidly today than ever before. Migration redistributes the genetic, physiological, morphological and socio-cultural differences found in human populations (Bogin, 1991). Thus, it is likely that migration would have some effects on the growth and development of migrants and the recipient populations. A taller stature is thought to be the result of urbanization (Tanner and Eveleth, 1976), and this is almost certainly a consequence of ample food supply, sufficient health and hygiene services, education, recreation, and welfare. Various studies have shown that there are differences in growth rate in many ethnic groups but how far these are due to heredity or ecology is still not clear. Hereditary factors are clearly of

immense importance as they lay down the basic plan of growth. But environmental factors constantly condition and modify the expression of genetic potentials.

Check Your Progress 4

4) Discuss role migration and urbanization influencing growth.

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4.4 SUMMARY

Human growth patterns are influenced by various factors such as biological / genetic factors and social factors. Growth is an effect of the intensive change of a multifaceted system of various regulatory factors with changing interactions. Both prenatal period and postnatal life may be modulated by several factors influencing growth and variation in these phases of life. These factors can be broadly classified as genetic and environmental factors. Environment is a broad term that includes a large number of interacting variables. It is a complex condition and each condition influences the organisms differently at different stages of growth. Environmental factors influencing growth may be categorised as ecological factors and socio-cultural factors. Ecological factors include climate, altitude and seasonal variations etc. on the other hand socio-cultural factors incorporate nutrition, socio-economic status, family size, migration, and urbanisation etc. Human growth and variation is a complex interplay of these factors. The growth of a child to an adult is the result of both genetic and environmental forces acting together. Genetic factors set the limits of growth and environmental factors help to reach the limit.

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4.6 ANSWERS TO CHECK YOUR PROGRESS

1) Human growth patterns are affected by various factors such as environmental factors, social factors as well as the biological factors. Refer to section 4.0

2) Climate and altitude. Refer to section 4.2

3) The problem of malnutrition is still a worldwide health issue. Foetal growth is affected by maternal malnutrition whether it is a deficiency of protein, calories, or trace elements. Foetal brain development may also be reduced due to malnutrition. There are three phases of cellular growth and organ development, the first being a phase of cell proliferation, followed by a phase of proliferation with concomitant hypertrophy, and a third phase of hypertrophy alone. Refer to section 4.3.1

4) The impact of migration and change of environment on physical characteristics are observed. Migration has been taking place for rural and urban areas. This has been due to the search for livelihood or employment, occurring more rapidly today than ever before. Migration redistributes the genetic, physiological, morphological and socio-cultural differences found in human populations Refer to section 4.3.6

UNIT 5 ADAPTATION TO ENVIRONMENTAL STRESS

Contents

Learning Objectives

At the end of this unit, you will be able to;

- understand the different kinds of environmental stressors that affect the human body;
- perceive how human adapt themselves to various environmental stressors through in-built biological mechanisms (physiological and genetic) or through adoption of certain cultural practices; and
- understand that there is variation in response levels to the environmental stressors among different human population.

5.0 INTRODUCTION

Humans have inhabited varied places, almost in all the parts of the world.This is due to the fact that we have the ability to intervene the environment for our own purposes and endure various environmental stresses.

Stressors are environmental conditions (like heat, cold, high altitude, etc.) that threaten homeostasis or the normal biological function or increase strain on the human body. We endure those stressors through 'adaptability' which means that each individual is equipped with modifications in the bodily organization or

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physiology or adopt behavioural or cultural changes which enable us to survive in a particular environment within certain limits. Thus, the coping strategy of humans with these stressors may be biological and/or cultural, thereby called as bio-cultural adaptation.

> The biological adaptation consists of five levels: genetic adaptation (evolution of advantageous characteristics, eg. body, shape and size), developmental adaptation or plasticity (acquiring of appropriate responses in a particular environment (eg. Europeans living in hot tropical areas), long term acclimatization (acquired over the years but reversible during change in environment), seasonal acclimatization (changes reversible during annual cycle) and short term acclimatization (daily or irregular responses to changes)

Here we need to remember that '*Adaptation'* is a genetically fixed condition of a species or subspecies or of a specific group of organism wherein the characters are transmitted generation after generation .Whereas, '*Acclimatisation'* is a temporary biological response to environmental stress that is withdrawn once the stress is removed. These biological responses or changes are inadequate to surmount extreme ecological stress therefore humans require culture coded survival strategies as well. Culture is a learned behaviour which is passed on from one generation to the other and it eliminates the need for expected biological changes. However such adaptation of culture may result into specific biological changes.

In this unit, we will learn how human variation includes the bio-cultural response of different populations to different kinds of environmental stress, i.e, heat, cold and high attitude.

5.1 HOMEOSTASIS AND THERMOREGULATION

Let us first understand the concept of homeostasis and thermoregulation of the human body. Our body is divided into two parts - the core (where all the vital organs are present and functions) and the periphery or shell (or the extremities, like hands and feet). All the metabolic activities happens in the core, thereby it acts as the main heat reservoir and the production site of our body. The core body temperature is 98.6° F (37° C) but it varies between an acceptable range within 85°F (29.4°C) and 105°F (40.6°C). However, if the core body temperature drops or rises outside of this acceptable normal limit, then the balance or homeostasis of the body gets disturbed. The process that allows the human body to maintain its core internal temperature is known as thermoregulation.

The condition wherein the core body temperature falls below 85°F (29.4°C) is called hypothermia, whereas if the core body temperature goes above 105°F (40.6°C),then it is termed as hyperthermia. The heat produced in the core is transmitted throughout the body whereas the temperature of the periphery or shell is strongly influenced by the environment.

How is heat transferred in the human body?

Heat is lost mostly through the skin. Within the body, heat is transported by two ways-*conduction* through tissues and *convection* through blood. The flow of heat by conduction depends on the thermal conductivity of the muscle and the adipose

tissues, the change of temperature with distance in the direction and area of the flow of heat. The heat flow through convection depends on the rate of blood flow and the difference in temperature between the tissue and the blood. Here, the heat is exchanged through the thin walls of the blood capillaries between the tissues and the blood.

Check Your Progress 1

1) What is thermoregulation?

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5.2 ADAPTATION TO ENVIRONMENTAL STRESS

5.2.1 Adaptation to Heat Stress

Human beings are homoeothermic or warm-blooded animals hence they need to maintain the mean temperature of 98.6° F (37° C) consistently in all weather conditions.The human body can tolerate external temperature of 35° C but if it goes beyond this,then it may lead to fatal heat stroke.As a means of adaptation to such extreme heat stress,humans undergo a complex mechanism of generating heat as less as possible (heat gain) and releasing heat as much as possible (heat loss). This kind of adaptation to heat takes place at three levels, viz., physiological, genetic and cultural which are discussed below:

5.2.1.1 Physiological Adaptation

In case of overheating of the body, there is an immediate physiological response in the form of an increase in heat dissipation firstly through the circulatory system (radiation of heat through vasodilation) and secondly through evaporative sweating. In response to heat stress,firstly the heat load is lowered by the thermal gradient which arises due to the difference in temperature between the surrounding environment and the individual's body. In response to this thermal gradient change, the lumen of the blood vessel becomes wider. In order to allow more blood to flow through the blood vessel,the heart rate increases. This results in more release of heat from the core of the body to the environment via the shell or the periphery. This physiological response is called as *Vasodilation*.

If this process fails to maintain the heat balance and body temperature still continues to rise, then the hypothalamus is activated to stimulate the eccrine glands to release more sweat out of the body .This would depend on the difference between vapour pressure at the surface of the skin and that of the air.Various studies have shown that people who live in hot climatic regions have more number of active sweat glands than those who reside in cold region. The evaporation of 1 litre of sweat takes away 580 kcal of heat. The rate of sweating in hot climatic zones can reach up to a maximum of 4 litre an hour. But if it goes beyond this, then it results in dehydration and loss of electrolytes.Sweating is effective only

in low vapour pressure area. In higher vapour pressure area such as the tropical forest, sweating is no longer an effective cooling mechanism as thermal gradient plays a vital role in heat dissipation. Hence, heat loss occurs only through radiation.

Development of heat acclimatization takes place with less sweating and lower core temperature, if the heat load continues for some days. This acclimatization disappears if the heat load is removed. Thus, from the above discussion, we can see that there are broadly four stages of heat tolerance which are as under:

- Thermal gradient (radiation of heat by vasodilation)
- Sweating in low vapour pressure area
- Thermal gradient only in high vapour pressure area (only through radiation, no loss through sweating)
- Heat acclimatization

The response to heat stress differs in different individuals. For example, if a person from a cold climatic region visits Jaipur during summer, then the discomfort level of that person will be higher than an individual who is a native dweller of Jaipur. The former will sweat profusely, experience cardiovascular strain due to high level of vasodilation and may decide to take rest inside the house.But again, all the native dwellers of Jaipur will not respond to the heat strain in a similar way because they have different plasticity levels.

Empirical studies have shown that Europeans, Australians and Africans differ in heat acclimatization due to the differences in climatic conditions in which they dwelt. But later after acclimatization to higher level of heat stress, most of the differences disappeared.

5.2.1.2 Genetic Adaptation

In hot places with high level of humidity like the tropical forests, shores of Red sea, etc., sweating is of little or no use in cooling. Here, body size and shape play a vital role. Firstly, the small size of the body produces less metabolic heat and secondly has large surface area. Therefore, it can dissipate more heat from the body as compared to a larger body. For e.g., the presence of extremely small size Pygmies in tropical forest of Africa and South East Asia show this kind of heat loss. This relationship between body size and heat loss is called Bergmann law. This law states that the heat tolerance increases as the body size decreases .i.e., the individual with smaller body size has a relatively larger surface area than the one with larger body size. Besides body size, even the shape of the body plays a pivotal role in heat loss. Longer extremities like toes, limbs, ears and fingers having larger surface area can dissipate large amount of heat from the body. Such increase in extremities has occurred among the Nitolics of Africa. This relation between the body shape and tolerance to heat is known as Allen's rule.

Skin color is another adaptive mechanism to hot climatic conditions. Melanin pigment present beneath the epidermis provides protection from over exposure to ultra violet radiation which can cause genetic mutation in skin cell leading to skin cancer.Thus, natural selection has favored dark skinned individuals near the equatorial region where exposure to UV radiations is the most. Biotopes with high densities of UV radiation are characterised by high temperature, hence dark

skinned would be disadvantageous, as it causes a strong heating of body surface, due to low reflectance. This is explained by the differences in the numbers and function of the sweat glands among dark skinned people. The African groups have been able to maintain a lower body and skin temperatures compared to the light skinned Europeans due to lower suppression of sweat rate than the latter.

5.2.1.3 Cultural Adaptation

Culture acts as a buffer between the body and the environment where physiological responses tend to be inadequate for survival. Humans adopt certain behavioural adjustment and cultural practices to cope with heat stress. These include their food habits, clothing types, structure of houses, time of activity, etc.

In hot, wet climatic regions, the houses are open and clothing is scanty so as to increase sweating. In the deserts, houses are built in such a way to keep the inside cool even during maximum day time heat. Pueblo Indians, Middle Eastern communities construct their houses several meters beneath the surfaces because the mean temperature of the subsoil is more comfortable than the surface soil with its extreme variation. Compact geometry, minimizing surface area to internal volume, in habitation above the ground, reduces both solar heat gain and convention heat gain from desert winds.

It has been found that well-acclimatized individual wearing clothes perspire 30% less than unclothed men at rest which ultimately reduces the heat load of about 165 kcal/hr. People living in deserts wear clothes that usually cover almost their whole body so as to reduce radiation. For e.g., the Chaamba Arabs who live in the Sahara desert wear clothing that traps air in between their clothes and the skin which prevents the high air temperature from reaching the skin. In hot climates, people tend to restrict physical activities during mid-day.

Check Your Progress 2

2) What are the broadly four stages of heat tolerance?

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3) What is the significance of melanin in human?

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5.2.2 Adaptation to Cold Stress

Adaptation to cold stress is done on the basis of two mechanisms:

- Metabolic adaptation: Increased heat production through enhancement of metabolic processes; and
- Insulative adaptation: Decreases heat loss or increases insulation.

5.2.2.1 Physiological Adaptation (Cold Tolerance)

i) **Conservation of heat/ insulative adaptation:** When the body temperature drops below 28° C, the thermo receptors in the skin send signals to the hypothalamus to get activated leading to the constriction of subcutaneous blood vessels to reduce the cutaneous blood flow. This physiological response of the body to cold is called *Vasoconstriction*. It directs the flow of venous blood through the veins that are close to the arteries. So arterial blood, entering the limb at a high temperature, comes in contact with the cooled venous blood. A counter-current heat exchange establishes across the walls from the arteries to the veins, thereby decreasing the temperature of the skin and conserving the metabolic heat of the body core leading to less heat lost. It is produced by the efferent sympathetic nerves and this sympathetic stimulation can be reinforced by cooling the skin.

However, prolonged absence of blood flow to the skin may affect the supply of energy and oxygen to the tissues and may contribute to cold injury and in extreme situation may lead to frost bite. In this kind of situation, the blood vessels in the hands and feet dilate frequently which is called as Cold induced Vasodilation' (CIVD). This occurs when the body core is warm and the extremities are exposed to cold. The cyclic phenomenon of the body wherein the body alternates back and forth between vasoconstriction and vasodilation to compensate for the risks created by both the mechanisms is known as 'Lewis hunting phenomenon' or'*hunting reaction'* or *'Lewis wave'*.

Activity 1

Take a bowl of chilled water from the refrigerator and immerse your finger tips in the water for 5-10 mins. After some time, you will experience numbness on your fingers due to vasoconstriction.

An illustration of this would be the chilling sensation we experience when we immerse our finger tips in cold water for some time and later on numbness develops due to vasoconstriction. After some time, we regain sense in the fingers due to CIVD. This suggests that a periodic oscillation of skin temperature follows initial decline in the temperature of the skin during prolonged cold exposure. But, the time interval varies widely of this periodic switching over from vasoconstriction to vasodilation. For example, people who are habitual to this situation like the cold water fishermen experiences less time interval as compared to those who are not exposed to this situation regularly.

ii) **Generation of heat/metabolic adaptation:** Voluntarily through physical activity (i.e., muscular activity), adequate body heat is produced. Studies have shown that if a nude inactive individual is exposed to 5° C for 2 hours then he/she becomes unconscious. However, it has been found that physically

fit individuals could tolerate even freezing temperature without clothing for more than ten hours.

When exposed to cold surrounding for a long period, the thermoreceptors in the exposed surface of the skin send signals to the hypothalamus to undergo involuntary contractions of the skeletal muscles throughout the body for regulating heat production. This involuntary pattern of repetitive, rhythmic muscle contractions is known as shivering. It is often referred as a 'Quasi-exercising' state, since the muscles contract but do not do external work. It increases the whole body oxygen uptake (VO_2) and thus increases the cardiac output. Since shivering is a musculara ctivity, metabolic activity increases leading to more production of energy.

5.2.2.2 Genetic Adaptation

Subcutaneous fat is more in people living in colder regions as it helps in retaining more heat in the body. This is because subcutaneous fat has low thermal conductivity so heat is never lost or gained by conduction or convection. A pair of genes (cold genes) that control the burning of body fat for warmth in the cold is found among people living in colder regions, e.g. Greenland Inuit living along the coastal villages of Baffin Bay.

The size and shape of the body are of immense value to cold adaptation. The presence of subcutaneous fat in the adipose tissue which has a low thermal conductivity reduces the surface area. This helps in heat conservation, e.g., the Eskimos of Tundra region of Canada and North Pole have a bulky body due to presence of subcutaneous fat that helps in conserving heat. The size of the body of people living in colder regions is larger as compared to people living in warmer regions. This leads to greater body mass and lesser surface area. Higher the body mass and lesser the surface area, more heat will be stored by the body. Thus, individuals having cold adaptation tend to be larger in size (Bergmann's rule). Besides body size, cold adapted individuals also have relatively shorter extremities and limbs. Shorter extremities reduce the surface area of the body, therefore more heat is conserved as compared to people having shorter extremities (Allen's rule).

Coon, Garn and Birdshell have hypothesized that the Mongoloid face is adaptive to colder climates. The people of Arctic and northern Asia have broad, flat faces which helps them in reducing the effects of frostbite. Brow-ridges, frontal sinuses and nasal prominence are reduced, orbital and malar regions are more flattened and widened to add in retaining more layers of fat for additional warmth. The epicanthic fold among the Northern and Eastern Asian populations is to protect the eye from the hard driving snow. Lighter skin is prevalent among the people living in colder regions since this allows the penetration of the sun's ultraviolet rays which helps in synthesizing vitamin D in the body. Smaller, longer and narrower noses are generally found among the people in colder regions so as to moisten and warm the incoming air because the vapour pressure helps in moisture exchange between the respiratory surface and the air. Under normal conditions, soot and bacteria are cleared in the respiratory tract through mucus secretion. The rate of mucus secretion is positively correlated with humidity of the inspired air. Straight hair is mostly found among people inhabiting colder climates as it keeps the neck and head warm and also allows cold moisture to run off the scalp more easily.

Population differences in adaptation to cold has been observed in many studies. For example, in a study in which Europeans, Bushmen of South Africa and Australian aborigines were compared, the researchers observed whole body cooling in the ascending order of Bushmen- Europeans- Australian aborigines .

5.2.2.3 Cultural Adaptation

The most important of all cultural practices towards cold stress are nature of clothing, house structure, shelter and use of fire. Eskimos use the clothing of the Caribou's fur to keep themselves warm. The Inuits of the North East Siberia lives in 'Igloos', specially built houses made of snow blocks where air pockets gets trapped in the snow act as insulators. This keeps the inside temperature more than the outside temperature. The American Indian of Tierra make use of fire at night to maintain their body temperature. The Australian aborigines often burn their extremities since they sleep nude around the campfire so as to overcome frostbite and their numb limbs during the night.They also chew leaves of Duboisa and tobacco containing alkaloid for keeping their body warm.

Check Your Progress 3

4) What is the basis of two mechanism for adaptation to cold stress?

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5.2.3 Adaptation to Altitude

Increase in the altitude results in a number of changes in the environment including the decrease in the atmospheric pressure and water vapour pressure and increase in radiant energy penetration. Air in the atmosphere appears to be like layers. At the sea level, the pressure of the air will be highest and gradually decrease as we move above the sea level (i.e., towards higher altitude). Decrease in the atmospheric pressure results in decrease in the pressure of oxygen both in the air and in the lungs. This results in inadequate supply of oxygen to different organs of the body such as the brain, heart, etc., leading to headache, shortness of breath, nausea, fainting and even death.

Breathing is a mechanical process. In this process we voluntarily develop a low pressure inside the chest cavity by expanding the chest. A pressure gradient develops between the atmosphere (high pressure) and the chest cavity (low pressure) and air enters inside the lungs. If the atmospheric pressure remains low, then only a less amount of air can enter inside the lungs resulting in lesser intake of oxygen. This phenomenon is called Hypoxia. The red blood corpuscles (RBC) in our body contain haemoglobin, which binds the oxygen that enters with the air inside the lungs. The partial pressure of oxygen is directly proportional to the binding ability of oxygen to Hb. At sea level, the oxygen content of the inhaled air is high and haemoglobin becomes 97% saturated with oxygen. But, with increase in altitude, the levels of fall in the partial pressure of oxygen and Hb saturation with oxygen is lowered to a substantial level. Thus, humans suffer from low partial pressure of oxygen and oxygen stress at high altitude.

5.2.3.1 Physiological Adaptation

With their inbuilt biological mechanism and learning ability, humans have been able to survive up to the height of 5000 m. For example, permanent dwelling of humans upto this height has been found in different mountainous regions of the world such as the Andes, the Himalayas, etc. Humans adapt to high altitude primarily by managing the availability of oxygen in the body in the following ways:

- Increased breathing rate: The hypoxic condition, i.e., breathlessness due to oxygen deficiency stimulates the medulla oblongata (respiratory centre) in the brain to cause instant increase in breathing rate up to 65%. If a person remains at high altitude, this breathing rate is five times. Initially, this much percentage increase does not happen due to blowing off of large amount of carbon dioxide and change in the alkalinity of blood which supresses the neural centre. But this inhibitory effect is removed and the breathing rate is increased to five times.

- Increase in numbers of RBCs and Hb: Under hypoxic condition, the kidneys are stimulated to secrete the enzyme erythropoietin which increases the count of red blood cells. This leads to an increase in Hb level in the blood. The total blood volume also increases by 20-30%. Thus, Hb binds more to oxygen.

- Increased lung surface: An increase in lung surface means more oxygen can diffuse to bloods that one can carry on more physical activities. This is achieved through increased breathing and expanded blood capillaries of the lungs.

- Increased tissue blood supply: At high altitude, there is an increase in cardiac output and growth of additional blood capillaries in tissues ensure an increased blood supply in the tissues. This enables the individual to carry out physical activities at high altitude.

- Cellular acclimatization: The hypoxic condition at high altitude results in an increased number of mitochondria and some other cellular enzymatic system in the body. The oxygen inhaled is used by the mitochondria for cellular respiration resulting in a more efficient metabolism.

5.2.3.2 Genetic Adaptation

The inhabitants of high altitude like the Peruvian Andes (population staying at an altitude of 5000 m) and the Himalayan Tibetans are well adapted than a lowlander in the following ways:

- The size of the chest of the highlanders are greatly increased leading to a high ratio of ventilator capacity to body mass. However, the Sherpas of Nepal are an exception to this although they stay at the same altitude .Their body size is decreased to reduce the mass of the body. Lower body mass can be supported with a decreased gas exchange .
- The size of their heart is greatly increased to ensure larger supply of blood to the lungs for oxygenation.
- The nose is shortened to reduce muzzle passages. Nostrils are directed upwards.

- ❖ The capacity of haemoglobin to extract oxygen at lower partial pressure.
- ❖ The size and the weight of the babies born at high altitudes tend to be smaller than those born at sea level .

5.2.3.3 Cultural Adaptation

Some highlanders in Brazil chew some herbal leaves in order to increase their Hb content in the blood. This helps in binding more oxygen, leading to more of its availability. The highlanders have active lifestyle to build exercise tolerance and eat diet high in carbohydrates.

Check Your Progress 4

5) How do humans adapt to high altitude?

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5.3 SUMMARY

Adaptation is the process of physiological and genetic modification and behavioural or cultural changes to a particular environment and/or stress in order to survive and reproduce. Biological adaptation involves five levels: genetic adaptation, developmental adaptation or plasticity, long term acclimatization, seasonal acclimatization and short term acclimatization.

Our body maintains the heat balance between the core and periphery through various modes of heat transfer. Some environmental stressors such as heat, cold and altitude stress disturb this homeostasis. Many human populations have survived in extreme environmental stresses throughout ages, developing adaptations that have contributed significantly to the phenotypic and to some extent genotypic variation found among the present day generation.

Adaptation to heat stress involves vasodilation and evaporative sweating. During prolonged cold exposure, homeothermy is maintained by enhancement of metabolic processes that increases heat production (through shivering) and increased insulation or decrease heat loss (through vasoconstriction, vasodilation and Lewis wave). Hypoxia is the main stress related to high altitude, and different people respond differently to this condition.

With their biological plasticity and by adopting different cultural practices, human populations try to minimise these environmental stressors or increase their tolerance. Also, there is intra and inter group variations in response levels to these stressors.

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5.5 ANSWERS TO CHECK YOUR PROGRESS

1) The process that allows the human body to maintain its core internal temperature is known as thermoregulation.

2) There are broadly four stages of heat tolerance: thermal gradient; sweating in low vapour pressure area; thermal gradient only in high vapour pressure area and heat acclimatization

3) Melanin pigment present beneath the epidermis provides protection from overexposure to ultra violet radiation which can cause genetic mutation in skin cell leading to skin cancer. Thus, natural selection has favored dark skinned individuals near the equatorial region where exposure to UV radiations is the most.

4) Adaptation to cold stress is done on the basis of two mechanisms (1) metabolic adaptation: Increased heat production through enhancement of metabolic processes; and (2) insulative adaptation: Decreases heat loss or increases insulation.

5) Humans adapt to high altitude primarily by managing the availability of oxygen in the body by increased breathing rate; increase in numbers of RBCs and Hb; increased lung surface; increased tissue blood supply and cellular acclimatisation.

UNIT 6 ECOLOGICAL RULES

Contents

Learning Objectives

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

- understand what is ecology, ecosystem and ecological adaptive processes;
- describe the modified ecosystems of man; and
- know the important features and characteristics of different ecological rules.

6.0 INTRODUCTION

Human ecology is the subdiscipline of ecology that focuses on humans. More broadly, it is an interdisciplinary and transdisciplinary study of the relationship

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between humans and their natural, social, and built environments. The term 'human ecology' appeared in a 1907 work on sanitary practices in the home and surrounding environments. The term also appeared in a sociological study in 1921 and at times has been equated with geography. The scientific philosophy of human ecology has a diffuse history with advancements in geography, sociology, psychology, anthropology, zoology, family and consumer science, and natural ecology (Jaiswal, 2013; 2015).

6.1 ECOLOGY

The two components of nature, organisms and their environment are not only much complex and dynamic but also interdependent, mutually reactive and interrelated. Ecology, relatively a new science, deals with the various principles which govern such relationship between organisms and their environment.

The term ethnology was proposed by St. Hilaire (French zoologist), i.e ethnology is the investigation of the relations of the organisms inside the family and society within the family and society in the aggregate and in the community. The term hexicology was coined by St. G J Mivart (English naturalist), i.e hexicology is committed to the investigation of the relations which exist between the living beings or and their environment as regards the nature of the locality they frequent, the temperatures and the amounts of light which suit them, and their relations to other organisms as enemies, rivals, or accidental and involuntary benefactors". The term ecology was coined by combining two Greek words, *oikos* (meaning 'house' or 'dwelling place') and *logos* (meaning 'the study of') to denote such relationships between the organism and their environment. Thus, literally, ecology is the study of organisms 'at home'. There is some controversy about the author who coined the term ecology and first used it in literature. For instance, Kormondy (1969) tried to give credit for the first use of the term ecology to Henry David Throreau in 1858. There are, however, references in literature in favour of German Biologist, H. Reiter also who is said to have used this term for the first time in 1868 (Reiter,1885; Macmillan,1897).

Although, there is uncertainty about the original coining of the term, there is consensus that the German biologist, Ernst Haeckel first gave substance to this term. Haeckel, although appears to have first used the term in 1886 and he regarded the ecology of an organism as "…. the knowledge of the sum of the relations of organism to the surrounding outer world, to organic and inorganic conditions of existence….". Ecology as a distinct discipline grew out of natural history early in this century as natural historians began to collect their observations into the historical theory of ecolgy. In this process, vital was the work of Charles Darwin. Although his book On the Origin of Species was published in 1859, before the term was coined it contained many seeds that could grow to dominate modern ecology. Ecology has been defined in various ways by different authors. Warming (1895, 1905), who actually employed this science for the study of plants, defined *oekology* as "the study of organisms in relation to their environment". American Ecologist Frederick Clements (1916) considered ecology to be "the science of the community," whereas Charles Elton (1927) explain ecology as "scientific natural history" concerned about the "sociology and economics of animals i.e humanism and financial aspects of creatures"

Woodbury (1954) treated ecology as "a science which investigates organisms in relation to their environment, and a philosophy in which the world of life is

interpreted in terms of natural processes." Taylor (1936) defined ecology as "the science of all the relations of all organisms to their environments." Andrewartha (1961), Petrides (1968) and Krebs (1972) defined it as "the scientific approach to the study of environmental interactions which control the welfare of living things; regulating their distribution, abundance, reproduction and evolution."

> However, the recent development in the study of ecology has been the recognition of the fact that the biotic (living) and abiotic (non-living) components of nature are not only interrelated but both these components function in an orderly manner as a definite system. Thus structure and function should be studied together for fuller understanding of this vast nature.

In Haeckel's definition of ecology, he refers to the "surrounding outer world", which we now call the environment of an organism. His 'organic and inorganic conditions', we call biotic and abiotic environmental factors, respectively. Biotic factors are the other organisms and counter, whether of the same or different species. Abiotic factors are the physical and chemical conditions such as temperature, moisture, respiratory gases, and substrate. Odum (1963, 1969, 1971) with such an approach put forth a new definition of ecology, and in his own (1969) words "as you know ecology is often defined as the study of interrelationships between organisms and environment".

6.1.1 Scope of Ecology

Ecology is the science that need minimum time and labour for its introduction to a layman. Present day problems of varied nature in human life are directly or indirectly very much related to ecology, as their solution needs an ecological knowledge. These days ecology has been contributing very much to socio-economic, political, and other similar policies of the world. It is so common to find references of ecology in socio-economic writings, magazines, weeklies and daily newspapers. There are interdependencies not only between ecology and other areas of plant sciences, but also between ecology and physical as well as social sciences. Ecology indeed plays an important role in human welfare. This is primarily a field subject and modern ecology is concerned with the functional interdependencies between living things and their environment. Taylor (1936), in an attempt to define ecology, has very rightly pointed out the scope of ecology by stating that "ecology is the science of all the relations of all organisms to all their environments." Ecology plays an important role in agriculture (crop rotation, weed control etc.) management of grasslands (range management) , forestry, biological surveys, pest control, fisher biology, and in the conservation of soil, wildlife, forest, water supplies, etc. The international problem of environmental pollution also needs ecological assistance.

6.2 ECOSYSTEM

Ecological studies are made at ecosystem level, which is generally referred to as the most recent that commonly is referred to as the bioenergetics approach.

At ecosystem level, the units of study are comparatively very large. And there are indeed no practical units, if the nature is conceived as a single giant ecosystem-the biosphere. The overall view of this type of approach is that living organisms and their non- living environments are inseparably interrelated and interact with

each other. Keeping this view in mind, A.G. Tansley (1935) proposed the term ecosystem; ecosystem is the system coming about because of the integration of all living and non-living factors of the environment'.

Thus he regarded ecosystem that include the organism- complex and also the whole complex of physical factors that forms the environment. Though, the idea of ecosystem is by no means so recent, as allusions to the idea of unity of organism and environment can be traced back to late 1800's. we find in literature some such parallel terms as biocoenosis (Karl Mobius, 1877), microcosm (Forbes, 1877), geobiocoenosis (Dokuchaev, 1846-1903); Morozov; see Sukhachev, 1944), Holocene (Friederichs, 1930) biosystem (Thieemann,1939), bioenert body (Vernadsky, 1944) and ecosom etc. used for such ecological systems. However, the term ecosystem is most referred, where 'eco' implies the environment, and 'system' implies an interacting, inter- dependent complex.

Thus any unit that includes all the organisms i.e. the communities in a given area, interact with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycle (i.e. exchange of material between living and non- living components) within the system, known as an ecological system or ecosystem. Keeping this in view, we may think of earth, we live upon as a giant ecosystem where abiotic and biotic components are constantly acting and reacting upon each other forth structural and functional changes in it. This vast ecosystem- biosphere is, however, difficult to handle and thus for convenience we generally study nature by making it artificial subdivisions into unit of smaller ecosystems (Terrestrial- forest, desert, grassland; man – engineered as a cropland; Aquatic- freshwater, marine etc.) of different sizes. An ecosystem may thus be as small as a pond, a cropland, or as large as ocean, desert or forest. It must be remembered, however, that these units ecosystem are simply separated from each other with time and space, but functionally they are all indeed linked with each other, forming as an integrated whole. There exist practically no functional boundaries between them.

The recent development in ecological studies has been to undertake besides structure, the similarity and differences in food and energy relationship among living compounds of ecosystem that is generally referred to as the bioenergetics approach in modern ecology. Modern ecology is thus, broadly defined as the study of ecosystem.

An ecosystem is overall integration of whole mosaics of interacting organisms and their environment. It is normally an open system with a continuous, but variable, influx and loss of material energy. It is a basic functional unit with no limits of boundaries, consisting of both biotic and abiotic components interacting with each other, both necessary for maintenance of life on earth. Thus, an ecosystem represents highest level of ecological integration which is energy based and this functional unit is capable of energy transformations, accumulation and circulation. Its main function in ecological sense is to emphasize obligatory relationships, interdependence and causal relations (Jaiswal, 2015).

Check Your Progress Exercise 1

1) Write short note on Human Ecology.

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2) What is Ecosystem?

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6.3 ECOLOGICAL ADAPTIVE PROCESSES

The environment is ever changing. In order to survive in the rigors of new circumstances, the organisms should either change accordingly or follow the path of extinction. Therefore, a succession of environmental changes is paralleled by the development of adaptation features: morphological and physiological including food and feeding behavior, way of living, reproductive and defensive mechanisms and protection against bad weather etc.

6.3.1 Kinds of Adaptations

Adaptations can be classified under the following four heads:

- ❖ Structural adaptations;
- ❖ Physiological adaptations;
- ❖ Protective adaptations and
- ❖ Animal association adaptations.

Structural Adaptations

These include changes in the structure (morphology and anatomy) induced by the physical environment. Mathew has differentiated following types of structural adaptations: -

a) Cursorial Adaptations: The territorial animals living in open plains have to depend on speed for searching their food and for escaping from their enemies. They exhibit the following types of structural adaptation; body contour, change in foot posture, lengthening of distal segments of limbs, loss of digits, reduction of ulna and fibula, loss of universal movement, musculature of limbs and development of spring ligaments, tail as a balancing organs, bipedality and mental precocity.

b) Fossorial Adaptations: The animals residing either permanently or for most of the time inside the burrows or under the earth surface are known as burrowing or fossorial (L. *fossorius* or *fossus* means adapted to digging) animals and their mode of existence is described as subterranean or underground. Fossorial animals exhibit three different grades:-

- Some animals dig for getting their food, but live above the ground. These animals exhibit minimum specialization except that they posses digging apparatus.
- Other group of subterranean animals includes those forms which dig for retreat but feed above the ground. These also exhibit modifications of the limb only.
- The last group includes those animals which permanently live in underground tunnels. These are the true or total fossorial animals. These have undergone maximum specialization for digging and burrowing, most common burrowing animals are *symbranchus* (fish) , *Apodon uraeotyohlus* (Amphibian).

These exhibit modifications on: body form, head, neck, tail, limbs, limb bones and girdle, vertebral column, skin, loss of eyes, disappearance of pinnae, tactile organs, skull, winter sleep, digging organs like snout, forelimbs, teeth and tusks.

c) Arboreal (Scansorial) Adaptations: Animals climbing trees or other vertical surface or stones are known as arboreal animals or scansorial animals. The animals are distinguished as three categories:-wall and rock climbers; terrestrio-arboreal forms and true arboreal forms these forms exhibit following modifications:- size, body contour, girdles, lengthening of proximal segments of the limbs, reduction in the number of digits, syndactylity and zygodactyly, tail, development of accessory organs.

d) Volant Adaptations: The animals which are capable of soaring or gliding in the air exhibit aerial mode of existence and are themselves known as Volant forms or aerial mode creatures or flying animals. Volant forms are found in both vertebrates and invertebrates. No doubt none of the Volant creatures are purely aerial mode of existence whereas others can glide in the air for a brief period. The former represents true or active flight and the latter passive flight. Volant adaptations, though exhibited by both gliders as well as true fliers, are different and can be dealt with separately.

Active flight or true flight: - Presence of wings, stream-lined bodies, reduction of body weight, lightness of the skeleton, sternum bears a median scale, additional surfaces for the attachment of strongly developed flight muscles, strongly developed flight muscles, high rate of metabolism and specially developed sense organs.

6.3.1.1 Physiological Adaptations

Endoskeleton- The endoskeleton is light and provides larges for attachment of muscles. *Muscles and flight*- The muscles on the back are much reduced and the flight muscles on the breast are strongly developed. *Digestive Organs*- The high rate of metabolism necessitates high food requirements and quick rate of digestion. *Respiratory system*- To meet the extensive rate of metabolism greater amount of

oxygen is needed by the body tissues. Hence the respiratory system is highly developed. *Circulatory*- Rapid metabolism requires large oxygen supply to the tissues, which can be achieved by an efficient circulatory system. *Warm bloodedness*- The perfect aeration of blood is responsible for high temperature of the body, which is very essential for flight. The constant body temperature enables the bird to take flights at high altitudes and also facilitates activeness in every season. *Efficient excretion and retention* of water, *Brain and sense organs* highly developed, and *Modification in Reproductive* organs.

6.3.1.2 Cave Adaptations

Characteristics of Cave Environment- Caves are natural hollows under earth surface or in mountains formed by the underground rivers of the past. Caves are characterised by the absence of bright light and nearly uniform temperature, high humidity, feeble fluctuations of temperature and absence of air currents. But the light is plenty at the mouth of the caves and penetrates for a short distance inside. Therefore, the cave environment is separated by LULL in to three distinct regions, namely:- Twilight or dysphotic or transitional region, Region of fluctuating temperature, The inner cave region.

The inner cave region represents true cavern environment having no light, relatively high humidity and absence of air currents. The absence of light has a pronounced effect on the inhabitants of this region. The body organization of permanent cave dwellers has undergone marked changes, but these are mostly towards degeneration. Therefore, cave animals are known for their primitive organization and defenseless nature like: loss of pigmentation, slender body and reduced appendages, weak exoskeleton, absence of visual organs, tactile organs, retrogression of endocrine system.

6.3.1.3 Aquatic Adaptation

The animal species living in sea, rivers, lakes, ponds, pools and ditches are known as Aquatic Animals. These are broadly divided into two types:

- Primary aquatic animals are those which have never lived on land and even their ancestors were also aquatic. These live permanently in water and have evolved from more primitive aquatic forms e.g fishes.

  The primary aquatic adaptations are observed in fishes, which have evolved from some aquatic ancestor and live permanently in water like: body contour, presence of fins, musculature, respiratory organs, air bladder, lateral-line and skin.

- Secondarily aquatic animals are those aquatic animals which live in water but their ancestors were terrestrial. That means that these animals have secondarily taken to aquatic existence. These include turtles, crocodiles, hippopotamus, whales, porpoises, sea lions and dolphins etc.

  The secondary aquatic animals live permanently in water but most of them are amphibious in nature. Moreover, reptiles and birds come out of water to deposit their eggs on the earth. The exhibition following adaptations to live in water:- body contour, shortening of neck, integument, limbs, fins, skeleton, sense organs-eye and teeth.

6.3.1.4 Desert Adaptations

Desert have low rainfall, high evaporation and a wide range in temperature. It is unobscured by vegetation and paradoxically partially shaped by water. The chief adaptations of desert are as scarcity of water, extremes of temperature, dust storms.

Adaptations:

- **Conservation of Body water**: To avoid evaporation through body surface or to avoid loss of moisture during respiration or to avoid loss of water during excretion. A variety of adaptation examples can be seen in desert biome animals. Desert sheep, goats, camels and donkeys retain insulating fur on the tops of their bodies but have sparsely covered abdomens and legs that radiate excess heat. Jack rabbits have long legs that carry them well above the heated ground and large ears well-supplied with blood vessels. Blood flow to the ears increases to lose heat to cooler air and flow decreases when air is hotter than body temperature to avoid overheating. To save water ordinarily lost in excretion, another common desert adaptation in animals is dry feces and concentrated urine.
- **Protection against scorching sun:** In desert temperature of the air may boost up upto 45°C and that of the sand at 57-58°C. For protection against scorching sun and burning sand, desert animals have developed protective armours and several defensive mechanisms.
- **Protection against sand storms:** The nostrils, ears and eyes are protected from the dry sand of the deserts.
- **Swift running or speed:** Since desert animals have to move far and wide in search of food and water, majority of them have great speed. In addition, for protection against enemies these have to rely on speed only. The limbs are specialized and adapted to walk on sand.
- **Colour:** The colouration in desert animals is found to match with the sand dunes. The body hues are often grey, brown or red, which is often in the harmony with the ground. This blending colouration furnishes protection from the attack of predators. Warning colouration is exhibited by poisonous animals like lizard, rattle snake, spiders and red ants. In general, desert animals are less heavily pigmented and are comparatively small in size (Gloger's rule)
- **Spinescence:** The spine studded body is characteristic feature of desert animals. The most conspicuous example is flat spiny lizard, horn toad and horn lizard.
- **Venom**: Possession of venom is another attribute to desert animals for self protection. *Heloderma punctatum* is the only poisonous lizard and is found in the arid zone of Mexico. Rattle snakes, trap door spider and Tarantula spider are poisonous creatures of the desert.
- **Sense organs and intelligentia**: Organs of sight, smell and hearing are specially developed. Certain desert animals exhibit very intelligent behaviour. Puff lizard when attacked, darts into a crevice between two rocks and inflates the body to such an extent, that it cannot be pulled out. Kangaroo rat when attacked by a rattle snake, throws sand and gravel in the face of the snake with the help of its hind legs.

6.3.1.5 Deep Sea Adaptations or Adaptations to Deep Sea Life

Characteristics of Deep Sea Environment-Deep sea is remarkable for its stability or changelessness in the climatic conditions, low temperature, scarcity of food, unrelieved darkness, absence of water currents and immense pressure.

6.4 ECOLOGICAL RULES

Several ecologists have tried to explain the interaction between organism and their environment in a different perspective of analysis. In this section, let us have a look at some major concepts which laid the foundation of close observation of environment and the impact of the environment on the living organisms residing in the *milieu*.

6.4.1 Allen's Rule

"Joel Allen in 1877 posited a biological rule called Allen's rule. It expresses that the tail, snout, ears and legs of mammals are relatively shorter in colder part than in the warmer areas. Allen's rule or endotherms (Birds and Mammals) from low temperature or colder climatic condition generally have shorter appendages or limbs than the alike animals from higher temperature or warm climatic condition. The hypothesis behind Allen's rule is that endothermic creatures with a similar volume may have contrasting surface areas, which will help or hinder their temperature regulation (Weinstein and Karen, 2005).

6.4.2 Bergmann's Rule

Christian Bergmann gave a biological rule called as Bergmann's Rule. Indeed, Bergmann's Rule declares that temperature also affects the absolute size of an animal and the relative proportions of various body parts. Birds and mammals attain greater body size in cold regions than in warm areas. But poikilotherms are smaller in cold region".

"Human population living near the arctic poles like Inuit, Aleut, Sami individuals are by and large heavier than populaces from mid-scopes is predictable with Bergmann's standard. They additionally will in general have shorter appendages and trunks which approve the Allen's standard (Holliday et al., 2010). Marshall T Newman in his report in the Journal of American Anthropologist in 1953, referenced that Native American populaces are commonly reliable with Bergmann's rule and he likewise included that populaces of Eurasia additionally holds with Bergmann's rule (Marshall, 1953)".

6.4.3 Cope's Rule

"Cope's rule, postulated by the American paleontologist Edward Drinker Cope, states that the lineages of the population tend to increase in body size over evolutionary time i.e bodies get larger over time i.e population genealogies will in general increment in body size over evolutionary time.

6.4.4 Gloger' Rule

"Gloger's Rule states that some insects, birds and mammals in warm humid climates bear dark or pigment than the races of same species present in cool and

dry climates. This phenomenon is known as Gloger rule. It was named after the zoologist Lambert Gloger".

Mammalian species including human additionally demonstrated the inclination to have a darker skin shading living in central and tropical districts. This can be clarified as far as better adjustment against over the top sun based bright (UV) radiations at lower scopes. A few special cases have been seen among Tibetans who have darker skin shading living in the colder locale and in their local scope far away from the equator. This is obviously an adjustment towards the very high UV light because of ice crystal on the Tibetan Plateau (Ember et al., 2001)".

6.4.5 Gause's Hypothesis

"Gause's law or Gause's Hypothesis is often referred to as competitive exclusion principle (Hardin, 1960) or a principle where complete competitors cannot coexist. As indicated by the law two species vieing for a similar asset can't exist together at steady populace esteems, if other biological elements stay consistent or in less difficult terms when two contending species endeavor to involve a similar specialty, just a single result is conceivable; one species will drive out the other. When one animal group increase even the scarcest bit of leeway over different species one will beat the other prompting either the elimination of this contender or build up a developmental or social move toward an alternate biological specialty. Accordingly, the standard can be proposed into "Complete Competitors cannot coexist" (Gause, 1934; Hardin, 1960)".

6.4.6 Dollo's Law

"Dollo's law also called as Dollo's law of irreversibility given by Louis Dollo, This law states that evolution is irreversible it means that once the complex traits is lost than that traits will not revert back "a living being stays away for the indefinite future precisely to a previous state, regardless of whether it winds up put in states of presence indistinguishable from those in which it has lately lived ... it for the most part keeps some trace of the transitional stages through which it has passed (Louis, 1893; Gould, 1970; Goldberg, and Boris, 2008)".

6.4.7 Foster's Rule

"Foster's rule also called as the island rule, or the island effect states little species get bigger, enormous species littler, in the wake of colonizing islands (Juan and Andy, 2004; Jean and Patrick, 2007; Lomolino, 1985). J. Bristol Foster stated rule in the journal Nature, in an article titled "The evolution of mammals on islands"called as Foster's rule (Foster, 1964)".

6.4.8 Hamilton's Rule

Hamilton's rule is a well-known concept in evolutionary biology. It is usually perceived as a statement that makes predictions about natural selection in situations where interactions occur between genetic relatives. Hamilton's rule states that natural selection favours genetic success, not reproductive success *per se*. It recognizes that individuals can pass copies of their genes on to future generations through direct parentage (the rearing of offspring and grand-offspring) as well as indirectly by assisting the reproduction of close relatives (such as nieces and nephews) through altruistic behaviour (behaviour that benefits other

individuals at the expense of the one performing the action) (Queller and Strassman, 2002)".

6.4.9 Hennig's Progression Rule

"Hennig's progression rule states that in cladistics, the crudest species are found in soonest or earliest, focal or central, and part of gathering's territory or group area. This rule was developed and named by Willi Hennig (Centers of Origin, 2016)".

6.4.10 Lack's Principle

David Lack (1954) proposed a principle called "Lack's principle, this principle states that "the clutch or grash size of each species of bird or feathered creature has been altered by common determination to relate with the biggest number of youthful for which the guardians can, on average, by and large, give enough food " (Lack, 1954)".

6.4.11 Rensch's Rule

"Rensch's rule given by Bernhard Rensch in 1950 states that, sexual size dimorphism (SSD) increases with body size (hyperallometry) in taxa in which males are the larger sex and decreases with body size (hypoallometry) in those in which females are larger., (Rensch, 1950)".

6.4.12 Schmalhausen's Law

Ivan Schmalhausen proposed a law called as "Schmalhausen's law (Lewontin, 2000). According to this law, population at breaking point of resistance i.e at limit of tolerance in one angle is helpless against little contrasts in some other perspective or susceptible to little differences in some other viewpoint.

6.4.13 Von Baer's Law

Karl Ernst von Baer gave a law called as "Von's laws. Von Baer's law states that Embryos start from a typical structure i.e common form and form into progressively specific structures or start from a typical structure and form into progressively specific structures, so the enhancement of embryonic structure reflects the ordered and phylogenetic tree. In this way, all animals in a phylum share a near early nascent living being; animals in smaller taxa (classes, orders, families, genera, species) share later and later early stage stages. This was in sharp contrast to the rundown theory of Johann Friedrich Meckel (and later of Ernst Haeckel), which declared that incipient organisms experienced stages taking after grown-up living beings from progressive phases of the scala naturae from evidently most minimal to largest amounts of organisation (Opitz,et.al, 2006; Garstang, 1922)".

6.4.14 Williston's Law

Williston's Law states that parts in a living being gotten diminished in number and had worked in working (Williston, 1914)".

Check Your Progress Exercise 2

3) Write short note on Cope's rule.

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4) What is Gause's hypothesis?

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5) Write in brief about Dollo's law of irreversibility.

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6.5 SUMMARY

Human ecology is the sub discipline of ecology that focuses on humans. It is an interdisciplinary and transdisciplinary study of the relationship between humans and their natural, social, and built environments. Ecology, relatively a new science, deals with the various principles which govern such relationship between organisms and their environment. The term ecology was coined by combining two Greek words, *oikos* (meaning 'house' or 'dwelling place') and *logos* (meaning 'the study of') to denote such relationships between the organism and their environment. Woodbury (1954) treated ecology as "a science which investigates organisms in relation to their environment, and a philosophy in which the world of life is interpreted in terms of natural processes." In Haeckel's definition of ecology, he refers to the "surrounding outer world", which we now call the environment of an organism. Ecology is the science that need minimum time and labour for its introduction to a layman. Ecological studies are made at ecosystem level and it has been one of the most recent developments in ecology, which is generally referred to as the most recent developments in ecology that commonly is referred to as the bioenergetics approach. The recent development in ecological studies has been to undertake besides structure, the similarity and differences in food and energy relationship among living compounds of ecosystem that is generally referred to as the bioenergetics approach in modern ecology. An

ecosystem is overall integration of whole mosaics of interacting organisms and their environment. Adaptations can be classified under the four heads. Several ecologists have tried to explain the interaction between organism and their environment in a different perspective of analysis. In this unit, we had look at some major concepts like Allen's Rule, Bergmann's Rule, Cope's Rule, Gloger' Rule, Gause's Hypothesis, Dollo's Law, Foster's Rule, Hamilton's Rule, Hennig's Progression Rule, Lack's Principle, Rensch's Rule, Schmalhausen's Law, Von Baer's Laws and Williston's Law

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6.7 ANSWERS TO CHECK YOUR PROGRESS

1) Human ecology is the sub discipline of ecology that focuses on humans. More broadly, it is an interdisciplinary and transdisciplinary study of the relationship between humans and their natural, social, and built environments. The term 'human ecology' appeared in a 1907 work on sanitary practices in the home and surrounding environments. The term also appeared in a sociological study in 1921 and at times has been equated with geography. The scientific philosophy of human ecology has a diffuse history with advancements in geography, sociology, psychology, anthropology, zoology, family and consumer science, and natural ecology.

2) Ecosystem may be defined as the interrelationships between a biotic community and its physical environment. Again Ecological Niche or Econiche or simply Niche is a distinctive way of life of an organism acquired by the interactions occurring between the organism and its environment, both biotic and abiotic.

3) "Cope's rule, postulated by the American paleontologist Edward Drinker Cope, states that the lineages of the population tend to increase in body size over evolutionary time i.e bodies get larger over time i.e population genealogies will in general increment in body size over evolutionary time.

4) "Gause's law or Gause's Hypothesis is often referred to as competitive exclusion principle (Hardin, 1960) or a principle where complete competitors cannot coexist. As indicated by the law two species vieing for a similar asset can't exist together at steady populace esteems, if other biological elements stay consistent or in less difficult terms when two contending species endeavor to involve a similar specialty, just a single result is conceivable; one species will drive out the other. When one animal groups increase even the scarcest bit of leeway over different species one will beat the other prompting either the elimination of this contender or build up a developmental or social move toward an alternate biological specialty. Accordingly, the standard can be proposed into "Complete Competitors cannot coexist".

5) "Dollo's law also called as Dollo's law of irreversibility given by Louis Dollo, This law states that Evolution is irreversible it means that once the complex traits is lost than that traits will not revert back "a living being stays away for the indefinite future precisely to a previous state, regardless of whether it winds up put in states of presence indistinguishable from those in which it has lately lived ... it for the most part keeps some trace of the transitional stages through which it has passed.

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