BLOCK 2

HUMAN ECOLOGY: BIOLOGICAL DIMENSIONS

UNIT 5 ADAPTATION TO VARIOUS ECOLOGICAL ZONES*

Contents

Learning Objectives

After studying this unit, student will be able to:

- understand the concept of adaptation and its various form;
- comprehend the process of adaptation in various climatic zones; and
- know the impact of urbanization and industrialization on human adaptation.

5.0 INTRODUCTION

From the origin of the genus *homo* to the appearance of the *sapiens* species, many significant changes have occurred in the human body that allowed their survival in the changing environment. The evolutionary selection process has produced a set of adaptive characteristics in humans that enabled our evolving species to flourish in diverse climatic conditions. These changes, modifications or adjustments are the outcome of the process of adaptation. The term *adaptation* is used in the broad generic sense of functional adaptation, and it is applied to all levels of biological organization from individuals to populations. Adaptation is basically a process by which organisms attain a beneficial adjustment to the environment. This adjustment can be either temporary or permanent and can be acquired either through short-term or lifetime processes. The process of adaptation is aimed at improving the organism's functional performance during environmental stresses by involving physiological, structural, behavioral, or cultural changes. In case environmental stresses are beneficial to differential mortality and fertility, then the changes may be adapted and established in the population through the changes in the genetic composition, and thus a population attains a level of genetic adaption. In this context functional adaptation, along with cultural and genetic adaptation, is considered as part of a continuum in an adaptive process that enables individuals and populations to maintain both internal and external environmental homeostasis. Therefore, the concept of adaptation is

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applicable to all levels of biological organization, from unicellular organisms to the largest mammals, and from individuals to populations (Frisancho, 1993).

The process of human adaptation involves many structural and functional changes in human body either at independent or integrated level. These changes occur through various forms of adaptations i.e. acclimatization, acclimation and habituation. As these forms have already been discussed in the previous unit (Unit-1), therefore, the present unit defines them in a brief way. Acclimatization refers to changes occurring within the lifetime of an organism that reduce the strain caused by stressful changes in the natural climate or by complex environmental stresses whereas Acclimation are those adaptive biological changes that appear in response to a single experimentally induced stress. Lastly, Habituation is defined as a gradual diminution of normal neural responses to a repeated stimulus.

The present unit describes different forms of adaptations and their applications to the humans to survive in various climatic conditions. The unit also explains the concept of habitat, ecosystem and ecology

5.1 HABITAT, ECOSYSTEM AND ECOLOGY

A habitat is the physical and biological environment used by an individual, a population, a species, or perhaps a group of species such as whale habitat having whale species and wildlife habitat supporting a group of wild organisms. Habitat is organism specific; it relates the presence of a species, population, or individual (animal or plant) to an area's physical and biological characteristics. Habitat implies more than vegetation or vegetation structure; it is the sum of the specific resources that are needed by organisms. Wherever an organism is provided with resources that allow it to survive, that is habitat.(Hall et al., 1997).

An ecosystem is a group of interacting organisms (usually called a community) and their physical environment they inhabit at a given point of time such as a lake or a forest, and it may or may not correspond to the habitat of a species. A forest ecosystem may constitute the sole habitat of a squirrel, but a frog's habitat might include both the forest and a lake, and a bark beetle's habitat might only be certain species of trees spread widely across the forest. It is much harder to delineate ecosystem in the real world- to decide where one ecosystem ends and another begins because the web of interactions do not have clean breaks (Hunter and Gibbs, 2007).

Ecology can be defined as the science of relationships between living things and their environment. The science of ecology is aimed at understanding the process by which living organisms interact with each other and with the physical and chemical components of their surrounding environment. It also attempts to study the way those processes lead to patterns in the geographical distribution and abundance of different kinds of organisms (Schmitz, 2007).

5.2 ENVIRONMENTAL STRESSES AND HOMEOSTASIS

Environmental stresses serve as triggering factors for bringing changes or modifications in the organisms. Environmental stress is typically defined as any factor or condition that disturbs or interferes with the normal functioning of an individual. For e.g. severe cold and low oxygen availability are considered as environmental stresses for people living at high altitude. The respective effect of an environmental stress varies with different stages of an organism such as age and type of an organism and the particular process of an organism that is affected. These stresses eventually disturb an individual's ability to maintain a stable internal equilibrium or environment which is referred as Homeostasis.

On a functional level, all adaptive responses of the organism or the individual are made to restore internal homeostasis. These controls operate in a hierarchy at all levels of biological organization, from a single biochemical pathway, to the mitochondria of a cell, to cells organized into tissues, tissues into organs and system of organs, to entire organisms. For example, the lungs provide oxygen to the extracellular fluid to continually replenish the oxygen that is being used by the cells, the kidneys maintain constant ion concentrations, and the gastrointestinal system provides nutrients. Homeostasis is a function of a dynamic interaction of feedback mechanisms whereby a given stimulus elicits a response aimed at restoring the original equilibrium. For example, when faced with heat stress, the organism may simply reduce its metabolic activity so all heat-producing processes are slowed down, or may increase the activity of the heat-loss mechanism. In either case, the organism may maintain homeostasis, but the physiological processes will occur at a different set point. The attainment of full homeostasis or full functional adaptation, depending on the nature of the stress, may require short-term responses, such as those acquired during acclimation or acclimatization (Frisancho, 1993).

Check Your Progress

1) What is meant by adaptation and its different forms?

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2) Explain Homeostasis by giving one example.

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Many a times, technological and cultural adaptations allow humans to decrease the severity of the environmental stresses by creating a new environment. This new environment protects the organism from the external environmental stresses and thereby the organisms do not require making any changes in their internal equilibrium. However, in few cases, despite the technological adaptation to the environmental stresses, humans have developed biological responses that enable them to be adapted to their extreme environmental conditions. For example, the Inuit people who live in the Arctic area have adapted themselves culturally and physiologically to live in the extreme cold. On the cultural level, they live in special houses (*Igloo*) and wear animal skins and fur to keep their body warm (Figure 5.1 a& b). Their physiological adaptations include high metabolic rate and consumption of food containing high protein and fat.

5.3 HUMAN ADAPTATION TO CLIMATE

In search of the mechanisms of how humans adapted to the changing climates biological anthropologists, physiologists, epidemiologists, nutritionists, and human geneticists studied humans living under diverse and extreme environments. This type of research centers upon studying indigenous population and comparing them to other populations (Frisancho, 1993). This unit deals with three major climatic stresses i.e. Heat, Cold and High Altitude.

5.3.1 ADAPTATION TO HEAT

Heat dissipation is the fundamental problem of all humans and other homotherms as they are frequently exposed to the heat stress. Humans experience heat stress in varied geographical areas such as tropical equatorial areas or temperate zones having vast land areas. Generally hot climates are classified into two categories: hot dry or hot-wet climates. Hot-wet or hot-humid climates are usually found in the tropical rain forests located around the equator while the hot-dry climate is typical of the desert regions such as the Kalahari, the Sahara of Africa and the southwestern United States.

In order to tolerate heat stress, humans develop synchronized physiological responses that enable them to lose heat in an efficient manner and adapt to the heat stress. Adaptation to heat occurs through the process of acclimation. When a non-acclimated person becomes exposed to heat stress, he/she exhibits an increased heat and circulatory strain because of a poor peripheral heat conductance and a low sweating capacity. During the first four days of exposure to heat stress, an increase in blood flow from the internal core to the shell may increase the peripheral heat conductance from 5-6 times its normal value. Simultaneously, there is an excessive increase in sweat rate and sodium loss, which lowers the skin and rectal temperatures. During this period, the circulatory strain is also decreased by the return of the heart rate to pre-exposure levels (Frisancho, 1993).

With the repeated exposure to heat stress, humans attain full acclimation by maintaining high peripheral heat conductance and even distribution of sweat over the skin. This leads to the lowering of the sweat output which used to be comparatively higher during the initial period of heat exposure. The decreased rate of sweating further reduces the skin temperature, which means that a lower skin temperature is achieved at an equivalent rate of sweating. Simultaneously, as a result of the decrease in skin temperature, the rectal temperature is also decreased and finally the circulatory stability is maintained.

Individual Factors affecting Heat Tolerance

- **Age:** Individuals above the age of 45 years have the lower capacity to tolerate heat stress than the younger individuals. Preadolescents (younger than 11 years of age) and older individuals (46-67 years of age) sweat less than the adolescents (15-16 years) and adults (20-29 years) because of the incomplete physiological development and deterioration of thermoregulatory mechanism.

- **Body Size and Shape:** The rate of heat loss is directly proportional to the body surface area and to the difference between the temperature of the body core and that of the surrounding. Therefore, individuals having bigger surface area or larger body size can emit the heat at a greater rate than the individuals with smaller surface area. Conversely, the thickness of body is inversely proportional to the rate of heat loss. In other words, among the fat individuals, the rate of heat flow is less than their lean counterparts.

- **Physical Fitness:** An individual's heat tolerance capacity is also influenced by his or her state of physical fitness. In general, heat acclimation is directly proportional to the physical fitness which means the more fit one is, the faster heat acclimation occurs. However, heat acclimation develops when the individual exercises during the heat exposure and it will not develop without any exercise even the individual is exposed to heat stress.

- **Cardiovascular Function:** As measured by maximum oxygen intake (aerobic capacity), tolerance to work in heat stress is related to cardiovascular fitness. Experimental studies have shown that subjects with a high maximum oxygen intake have a greater tolerance to heat stress than those with low oxygen intake. In addition, tolerance to heat stress is affected by the capacity to expand the vascular volume (Frisancho, 1993).

Humans have also developed cultural and behavioral adaptations to deal with the heat stresses. According to Hanna (1983), humans' material culture provide special habitations and clothing which establish a favorable microclimate and counter the high potential of radiation, convection, and conductive heat gain whereas behavioral techniques center largely upon avoidance.

5.3.2 Adaptation to Cold

An environment with an air temperature of 5 degree Celsius may be described as 'cold'(Parsons, 2014). Under the cold climatic conditions, humans loose body heat and experience severe discomfort. Globally, there are four major types of cold environment: polar, High Mountain, glacial and periglacial. The periglacial environment consists of the Arctic and Antarctic regions where solar radiations are less intense.

Adaptations to chronic cold exposure can be categorized into three basic patterns: habituation, metabolic adaptations and insulative adaptations. The exact determinant of which pattern will be induced by chronic cold exposure is unclear, but the magnitude and extent of body cooling, frequency and duration of exposure, and individual factors all influence the adaptive process. Habituation is characterized by blunted shivering (various grades of muscle contraction for delaying the decrease in body temperature) and cutaneous vasoconstriction (narrowing of the blood vessels which reduces blood flow); body temperature may decline more in the acclimatized than un-acclimatized state. It is the most common cold adaptation and results from periodic short-term cold exposures. Metabolic adaptations are characterized by enhanced thermogenesis that develops when cold exposures are more pronounced, but not severe enough to induce significant declines in core temperature. Insulative adaptations are characterized by enhanced vasoconstriction and redistribution of body heat toward the shell that develops from repeated cold exposures severe enough to induce marked declines in core temperature (Swaka et al., 2002).

Factors affecting Cold Adaptation

- **Surface Area:** The shape and size of an individual's body largely determines his ability to adapt to the cold environment. In case of individuals having bigger surface area or large body size, the heat required tomaintain a constant temperature will be lesser than the individuals with smaller surface area or small body size.
- **Insulation of Fat:** One of the most important factors affecting heat loss is the degree of artificial or natural insulation. In humans, subcutaneous fat represents the most important form of natural insulation. The greater the fat layer, the lower the skin temperature, and consequently, the smaller the gradient between the body's surface temperature and that of the environment (Frisancho, 1993).
- **Physical Fitness:** The thermoregulatory abilities of an individual increases with his physical fitness. Therefore, physically fit individuals have more effective thermoregulatory abilities to cope with cold stress than the physically unfit or less fit individuals.
- **Age:** Due to increased vascularization and higher metabolic rate, younger individuals have better thermoregulatory responses to cold environment than older individuals.
- **Nutrition:** Lack of proper nutrition causes reduced response to cold stress. The intensity of shivering also increases in the absence of essential body fats.

Much of the way people adapt to cold is cultural rather than biological. For example, Inuit people of northern Canada live in a region that is very cold for much of the year. To cope with this, they long ago developed efficient clothing having animal skin and fur (Figure 5.1 a) that keep their bodies warm. The Inuit and other Eskimos are provided with an artificial tropical environment inside their clothing. They also live in special houses (igloo), (Figure 5.1 b) a type of shelter built of snow. Such cultural adaptations allow Inuit to inhabit in the extreme cold environments (Haviland et al., 2011).

Check Your Progress

3) How physical fitness affect heat tolerance?

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4) How Inuit people adapt to cold climate?

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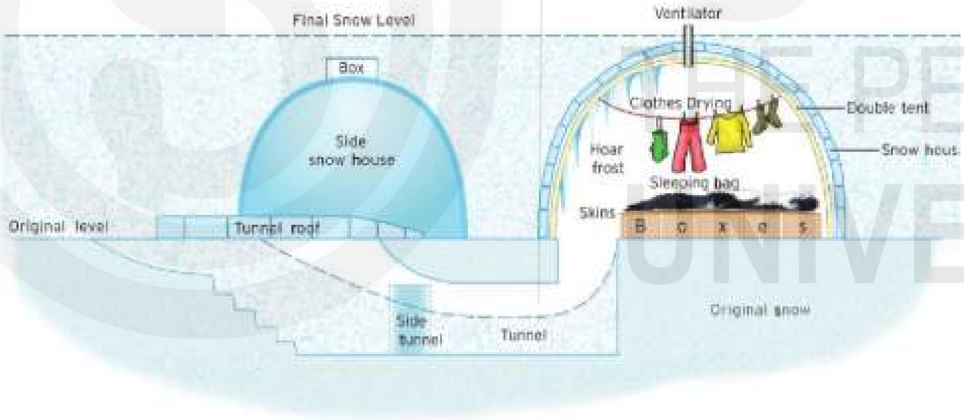

b)

Image 5.1 (a) Typical Inuit Suit- at the arms and legs suit can be opened and used as a "thermal window" (b) Cross cut view of an igloo-the two snow house parts are connected by a tunnel (Steinach and Gunga, 2015).

5.3.3 Adaptation to High Altitude

An elevation of 2400-2500 meters above mean sea level is referred to as high altitude. At high altitudes, humans encounter many significant environmental stresses like lower amount of oxygen level in the air, decrease in barometric pressure, cold and dry winds, limited availability of nutrients and rough topography. Hypoxia, the reduced availability of oxygen at high altitude is one of the most important physiological challenges of high altitude.

Hypoxia is a severe environmental stress for human populations living at high altitude, one which is not readily modified by technological or behavioral responses. Hypoxic condition gets worse as the barometric pressure falls at high altitude. Partially to compensate for this, humans need to breathe more often and more deeply at altitude. But despite this, as the altitude increases, the concentration, or partial pressure, of oxygen in the blood falls to values that are not compatible with sustained human life at altitudes much above about 7,000 meters. Much confusion in the study of physiological responses to high altitude hypoxia arises from the failure to recognize the difference between acute, chronic and lifelong exposure. Acute response to high altitude elicits specific responses to hypoxia as well as general stress reactions that are not observed in high-altitude natives (Ballew et al., 1989 &Bartlett et al., 2010).

With the increasing hypoxic conditions, arterial partial pressure of oxygen decreases followed by a decline in the arterial oxygen saturation. In order to overcome this decline and attain homeostasis, the human body responds in short and long term. Short term response includes increase in ventilation (hypoxic ventilator response) and in long term production of red blood cell is increased.

Long-term high-altitude populations display unique circulatory, respiratory, and hematological adaptations to life at high altitude. Hematocrit (the percent of whole blood composed of red blood cells) and hemoglobin (the oxygen-carrying metalloprotein in erythrocytes) concentration increases with rising altitude among high-altitude sojourners. When acutely exposed to high altitude, lowlanders exhibit an immediate rise in ventilation known as the hypoxic ventilatory response (HVR). This important response to short-term high-altitude exposure is not maintained over the long-term, and resting ventilation returns to low-altitude levels after several days. Another noteworthy pulmonary response to acute high-altitude exposure is pulmonary vasculature vasoconstriction, a subsequent consequence of which is pulmonary hypertension. Pulmonary hypertension is characteristic of several altitude-associated disorders, including acute mountain sickness (soroche) and CMS (chronic mountain sickness also called Monge's disease), and is a leading pathophysiological mechanism in the development of high-altitude pulmonary edema (HAPE) (Bigham and Lee, 2014).

Factors affecting High Altitude Adaptations

- **Age:** Physiological response of an individual to high altitude is affected by his or her age. During the first few days at high altitude, younger individuals have higher hemoglobin concentration than older ones.
- **Physical Fitness:** Generally, physically fit individuals have increased vascularization, maximum aerobic capacity and increased size of the striated and cardiac muscles which help them to better able to tolerate the stress of hypoxia than the unfit individuals.

Sherpas, who live at the high altitude areas of Nepal Himalayas, represent one of the most iconic examples of human adaptation to high altitude. Comparative physiological studies have suggested that their remarkable performance in the hypoxic environment is because of numerous distinctive adaptive phenotypes which include advantageous levels of hemoglobin, oxygen saturation and birth weight, and the elevated reproductive success of Sherpa women (Bhandari and Cavalleri, 2019). On the cultural level, Sherpas construct their houses in a cluster and wear special woolen clothing to adapt to the high altitude environment.

5.4 IMPACT OF URBANIZATION AND INDUSTRIALIZATION ON HUMAN ADAPTATION

Globally, urbanization and industrialization has led significant alterations in the environment, causing novel environmental stresses to act upon the human population. Under the combined influence of urbanization and industrialization, earth's climate is constantly undergoing massive transformations resulting into many natural calamities such as drought, floods, tsunamis etc. Industrial units, vehicular population and excessive consumption of domestic fuel are majorly responsible for the production of greenhouse gases, which ultimately result into global warming. In addition to this, a range of environmental toxins has been released into the atmosphere due to urbanization and industrialization over the last 200 years. Industrialized urban development has occurred at varying times across the globe. Since the onset of the Great Acceleration (post-1950) extensive pollutant emissions have dramatically altered the composition of the atmosphere and degraded air quality at global, regional and local scales with severe levels of air pollution regularly experienced in a number of different cities (Power et al., 2018).

In the face of these environmental changes, human population is altering their behavior and struggling to adapt to the altered environmental conditions. In India, the increasing trend of urbanization is the outcome of the rapid elevation of industrial activities, affecting the local environment of many urban cities. The comparatively higher temperature of urban areas is influencing the adaptive thermal responses of the organisms inhabiting these areas. Other examples of human adaptations to climate change include:

- One of the classical examples of adaptation to the severe level of air pollution comes from the metropolitan cities of India. Urban and affluent people of these cities have introduced many structural and technological adaptations in their lives to deal with the whopping levels of air pollution such as installation of air-purifiers, building of in-door facilities for outdoor activities, use of facial masks etc. On the behavioral level, many anti-pollution strategies and laws have also enforced to reduce the emission from automobiles and factory outlets.

- Due to global warming, people inhabiting coastal areas constantly face many unpredictable climatic stresses like rise in sea level, change in coastal wave frequency and intensity. Therefore, the coastal populations have identified few structural and non-structural adaptive options. Structural adaptations include building dykes around islands and mangrove plantations, or beach restoration while non-structural adaptations involve information dissemination, land use control programs and risk insurance.

Check Your Progress

5) What do you understand by Hypoxia?

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6) Give one example of the impact of urbanization on human adaptation.

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5.5 SUMMARY

The term adaptation includes all the physiological, cultural, behavioral and technological changes that enable an organism or population to adjust and live in different environmental conditions. These changes or adjustments occur through various forms of adaptations i.e. acclimatization, acclimation and habituation. The process or mechanism of each form of adaptation depends largely on the nature of the environmental stresses. All adaptive responses of the organism are made to restore internal homeostasis, the state of stable internal equilibrium. Humans face different environmental stresses in hot, cold and high altitude climates and demonstrate various physiological and cultural responses. Urbanization and industrialization has also posed novel environmental stresses which led many adaptive changes in the human culture and behavior. Knowledge of human adaptation to various environmental stresses helps to understand the human physiology in different ecological settings and gives the insights into human evolution and variations.

5.6 REFERENCES

Ballew, C. A. R. O. L., Garruto, R. M., & Haas, J. D. (1989). *High altitude hematology: paradigm or enigma* (pp. 239-262). New York: Oxford University Press.

Bartlett, R., Gratton, C., & Rolf, C. (Eds.).(2010). *Encyclopedia of international sports studies*.Taylor & Francis.

Bhandari, S., &Cavalleri, G. L. (2019).Population history and altitude-related adaptation in the Sherpa. *Frontiers in physiology*, *10*, 1116.

Bigham, A. W., & Lee, F. S. (2014). Human high-altitude adaptation: forward genetics meets the HIF pathway. *Genes & development*, *28*(20), 2189-2204.

Hall, L. S., Krausman, P. R., & Morrison, M. L. (1997).The habitat concept and a plea for standard terminology. *Wildlife society bulletin*, 173-182.

Hanna, J. M., & Brown, D. E. (1983). Human heat tolerance: an anthropological perspective. *Annual Review of Anthropology*, *12*(1), 259-284.

Haviland, W. A., Prins, H. E., & McBride, B. (2011). *Anthropology: The human challenge*. Cengage Learning.

Hunter Jr, M. L., & Gibbs, J. P. (2007). *Fundamentals of Conservation Biology*.Third Edition. Australia: Blackwell Publishing.

Frisancho, A. R. (1993). The Study of Human Adaptation Human Adaptation and Accomodation: Enlarged and Revised Edition of Human Adaptation. USA: The University of Michigan Press.

Gunga, H. C. (2015). *Human Physiology in Extreme Environments*.Elsevier.

Parsons, K. (2014). *Human thermal environments: the effects of hot, moderate, and cold environments on human health, comfort, and performance*. CRC press.

Power, A. L., Tennant, R. K., Jones, R. T., Tang, Y., Du, J., Worsley, A. T., & Love, J. (2018). Monitoring impacts of urbanisation and industrialisation on air quality in the Anthropocene using urban pond sediments. *Frontiers in Earth Science*, *6*, 131.

Schmitz, O. J. (2007). *Ecology and ecosystem conservation*. USA: Island Press.

Sawka, M. N., Castellani, J. W., Pandolf, K. B., & Young, A. J. (2002). *Human adaptations to heat and cold stress*.Army Research Institute of Environmental Medicine. Natick, USA.

5.7 ANSWERS/HINTS TO CHECK YOUR PROGRESS

1) Adaptation is basically a process by which organisms attain a beneficial adjustment to the environment. Various forms of adaptation include Acclimation, Acclimatization and Habituation. For more details refer section 5.0.

2) Homeostasis is an individual's internal ability to maintain a stable equilibrium. For example, when faced with heat stress, the organism may simply reduce its metabolic activity so all heat-producing processes are slowed down, or may increase the activity of the heat-loss mechanism.

3) An individual's heat tolerance capacity is also influenced by his or her state of physical fitness. In general, heat acclimation is directly proportional to the physical fitness which means the more fit one is, the faster heat acclimation occurs. For more details refer section 5.3.1.

4) To cope with the cold stress, Inuits long ago developed efficient clothing having animal skin and fur that keep their bodies warm. They also live in special houses (igloo) to deal with cold climate. For more details refer section 5.3.2.

5) Hypoxia is the reduced availability of oxygen at high altitude. This is a severe environmental stress for human populations living at high altitude, one which is not readily modified by technological or behavioral responses. For more details refer section 5.3.3.

6) One of the classical examples of adaptation to the severe level of air pollution (led by industrialization)is the installation of air-purifiers in homes of the affluent people who live in urban cities. For more details refer section 5.4.

UNIT 6 INFLUENCE OF ENVIRONMENTAL FACTORS*

Contents

Learning Objectives

After reading this unit the learner will understand:

- About the environment;
- The different factors affecting growth and development; and
- The influence of environmental factors on growth and development.

6.1 INTRODUCTION

Growth and development of individual(s) is influenced by many factors. Some of the factors which influence growth and development are: Heredity, Environment, Nutrition, Physical activity, etc. Growth and development was believed to be purely influenced by heredity or genetic factors but environment also plays a vital role in the growth and development of human beings.

Diet, nutrition and socioeconomic resources are often considered to be the prime influence on human physical growth and developments. Climate, temperature and altitude are the most studied features of the natural environment. In addition we also have the anthropogenic factors such as air pollution, metals (mercury, lead) pesticides and herbicides. Most of the anthropogenic factors pose adaptive changes.

The study of human growth in relation to the natural environment is one of the fundamental research areas in the study of human variation and adaptation. The theory that growth is a way for individuals to adapt to their immediate physical environment has been around since the 1960s. Therefore growth responses are

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part of the adaptive potentialities of human beings i.e. the view that reduced or slow growth can be adaptation to the physical environment and therefore beneficial to the individual. This is different from the view that slow growth is a direct result of adverse circumstances, this is a view usually applied to reductions in the growth relations to diet or socioeconomic status. Tanner (1962), the world's expert on growth and development used child growth as an index of community wellbeing and the equality of growth among different social groups as a measure of the egalitarian distribution of health resources. According to this view, slow growth indicates poor health and the lack of adaptation in the midst of nutritional or social disadvantage and adversity. This unit will focus on the effects of environment on growth, including factors that are part of the physical environment and anthropogenic factors.

What is environment?

Environment is derived from the French word *'environ'* or *'environer'* which means 'around' or 'to surround'. So, environment is the space surrounding the individual which can be the built in world of human creation. It includes the surrounding of all human interactions in society. It also includes the biotic as well as abiotic components. The climate, temperature, geography of the region like high altitude, etc. are the abiotic components and bring about a whole lot influences on the growth and development of humans.

Balanced Precision

This refers to the idea that the independent variable i.e. the cause and the dependent variable i.e. 'the effect' should be measured with equal precision. In the earlier growth studies it was examined that size as the dependent variable in relation to the age as the independent variable.

However, at present studies of growth and the environment require accurate and reliable measurements of both individual growth and the environmental factors. Sometimes measuring the environment may be easy or difficult. It is easy to measure when the environmental factor is not modified by behavior or culture and that the population living in the community has the same level of exposure, for example: population living in high altitude.

Check Your Progress

1) What is the etiology of the word environment?

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6.2 FACTORS AFFECTING GROWTH AND DEVELOPMENT

6.2.1 Effect of Temperature and Climate

Climate influences growth and development thereby determining body size and proportions. According to Allen's (1877) and Bergmann's rules (1847), body size and proportion of warm blooded, polytypic animals are related to temperature. Allen's rules states that longer extremities and appendages relative to body size are found in warmer climates, while in colder climates the extremities and appendages are shorter relative to the body size. Bergmann's rule states that in colder climates the body sizes are larger or broader and in warmer climates body size is leaner. Newman (1953) tested Allen's and Bergmann's rules through examination of aboriginal males in North and South America spanning 1000 years and observed a clinical distribution of body size. According to Newman, the smaller statures observed near the equator supports Bergmann's rule and the shorter legs among the Inuit's supports Allen's rule. Schneider et al. (1988) demonstrated that amount of body surface tends to increase from cold to hot climates for the purpose of heat retention. These indicates that in cold regions humans weigh more and have a shorter extremities relative to trunks thereby supporting Bergmann's and Allen's rules. However, there are some exceptions to this rule, such as the pygmy population in equatorial Africa which may be due to the use of general measure of climate (mean annual temperature) that is not having the greatest impact of size and shape.

The relationship observed between body proportion and environmental temperature can be best explained in terms of body's thermoregulatory process. In hot environments, heat dissipation is crucial to avoid hyperthermia stress or overheating. A body that has greater surface area relative to total body size or volume more efficiently dissipates heat produced by the body's metabolism and activity. A greater surface over which wind can pass is beneficial to humans in hotter climates through the process of convection which is the transfer of heat from the body to the environment through the movement of air over the body. However in cold environments, it is reversed because here heat retention is important to avoid hypothermia, thus less surface area through which heat would be lost is more adaptive. For example the small stature and low body mass among the pygmies of the tropical rainforest in Africa is an adaptive body shape because the high humidity in these environments limits the effectiveness of sweating, which dissipates heat through evaporation. The smaller body mass of these populations minimizes heat retention (Bogin 1988).

Malina and Bouchard (1991) suggested that the typical body shape associated with extremes in temperature have implications for development. These observations suggest that either growth in hot environment is prolonged as there is an association between delayed maturation and linear body type or that growth in cold environments is shortened because of the relationship between a stocky body type and maturation. Therefore in humans, there appears to be a general relationship between climate and body size that adheres to the Allen's and Bergmann's rules. Human population in cold climate such as the Inuit are generally shorter and stockier than population in hot climates such as the Bushmen in Africa who are more leaner.

6.2.2 Effect of Season

As we already know that there are different seasons in a year and each season has a varied impact on the growth of humans. Among healthy children it has been observed that there is seasonal variation in growth rates. In a classic study done by Palmer (1933), it was found that growth rates for height are greater during the spring and summer months while rates of weight gain are greater during the fall and winter months at temperate latitude. Tanner (1962) in his study found that greatest increase in weight are often in September through November and can be up to five times the weight gain in the minimal months from March to May. Approximately two thirds of the annual weight gain occurs between September and February. However, this seasonal rhythm in weight gain is not established in children until about 2 years of age.

Seasonal variation growth is not limited to temperate zones, it has also been found that variation in growth rates occurs between dry and rainy seasons in tropical climates. In the tropical wet climate of India, it was found that there is association between excessive monsoon rainfall during infancy and stunting (18% increase) whereas in the mountainous regions in North India excessive rainfall during infancy is associated with reduced risk of stunting. Bogin (1978) in his study of the patterns of growth in height for children in Gautemala city found that preadolescent boys and girls and post adolescent boys follow seasonal pattern but adolescent children do not follow this pattern. It was further found that approximately 75% of the preadolescent children and 65% of the post adolescent boys reached a maximum rate of growth during the dry season and a minimum growth rate during the rainy season. Meanwhile, approximately 25% of the preadolescent children and 33% of the post adolescent boys demonstrated an opposite pattern of growth. The absence of an effect on the rate of growth during adolescence may be due to the pubertal growth spurt which is quite large and its occurrence is highly variable among individuals. According to Bogin (1978) the possible explanation for all seasonal variation in growth in height maybe seasonal variation in sunlight which influences the endocrine system and hormones involved in growth regulation.

In a study among children in Zaire, Africa found that the growth in height was more rapid during the dry season than the rainy season. Even though the length of day was longer in the rainy season, actual exposure to bright sunlight or insulation was greater during the dry season thereby supporting the role of sunlight in growth regulation (Bogin, 1988). Bogin (1978) in his study among children in Gautemala also found that children who were 5-7 years old grew faster during the dry season as compared to the rainy season as exposure to sunlight was greater during the dry season. Exposure to sunlight has long been recognized/ known as an important factor for skeletal development. Ultraviolet light stimulates the production of cholecalciferol, vitamin D_3 in human skin and vitamin D_3 increases intestinal absorption of calcium and regulates the rate of skeletal remodeling and mineralization of new bone tissue (Griffin and Ojeda, 1996).

Check Your Progress

2) Explain the effects of season on growth and development?

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6.2.3 Effect of High Altitude

A height greater than 2500 meters (8000feet) is defined as high altitude. High altitude imposes many environmental challenges and the challenges increase with an increase in altitude (Moore at al., 1998). High altitude is a multi stressor environment and the stresses are hypoxia, nutritional stress, cold and radiation. At high altitude the atmosphere contains fewer elemental molecules like oxygen, nitrogen, etc. per cubic unit of air although their proportions are the same as at sea level. In this type of environment the partial pressure of oxygen i.e. the air pressure due to the oxygen molecules in the atmosphere is reduced, which is known as hypoxia and it can lead to hypoxemia or insufficient oxygen reaching the tissues. Hypoxia is a unique stressor for humans living in high altitude. The partial pressure of oxygen in the environment affects the amount of hemoglobin in the blood that is saturated with oxygen, which in turn affects metabolism as oxygen is required for normal metabolic activity. Human populations can be found in several high altitude regions all over the world including the Andes in South America, the Himalayas in India, the high plain of Ethiopia and the Rocky Mountains in the United States.

Moore at al. (1998) found that in high altitude there is a reduction in birth weight which is approximately 100 gm per 1000m but the exact amount varies depending on other characteristics of the populations. Haas (1980) reported a mean birth weight of 3165g for Indians at high altitude (3600m) in Bolivia and a mean body weight at low altitude (400m) of 3427g for Indian mother's also born at low altitude. At high altitude the entire distribution of birth weight is shifted lower so that there is also a greater percentage of low birth weight babies weighing 2.5 kg or less born at high altitude. However, length of residency of a population may be an important factor mediating the effects of high altitude on birth weight. This is thought to reflect greater genetic adaptation to high altitude among populations of longer residence.

Several researchers on the subject have concluded that the longer a population has resided at high altitude, the smaller is the decline in birth weight (Frisancho, 1993; Moore at al., 1998). Population in the Rocky Mountains have lived at high altitude for the shortest period of time and they experience the greatest reduction in birth weight relative to sea level inhabitants (Moore et al., 1998). Tibetans are generally regarded as having resided at high altitude for the longest. Although exact dates of migration to high altitude are under investigation, they may be as long as 50,000 years and Tibetans are found to experience the least reduction in birth weight.

At high altitude the average weight of the placenta can be 10-13% greater than at sea level and is more often irregularly shaped (Chabes and Pereda, 1967; Kruger and Arias Stella, 1970). The higher birth weights observed among Andean and Tibetan at high altitude is consistent with the theory that increased oxygen reaches the fetus reducing fetal hypoxic stress (Beall and Stergman, 2000). The Tibetan adaptive strategy for pregnancy at high altitude appears to be to maximize the increase in uterine blood flow rather than arterial oxygen content, while in Andean population, increased arterial oxygen content maintains sufficient fetal – placental oxygen delivery (Moore et al., 1998). Another characteristic of growth at high altitude is an enlarged chest size and accelerated chest development despite delayed growth and smaller body size. Along with chest size, there is an increase in lung volume in high altitude populations. This increase may be an adaptation to reduced oxygen availability since at high altitude, greater lung volumes are associated with increased surface areas that allow for greater gas exchange (Frisancho, 1993; Moore et al., 1998).

Altitude also plays an important role in the age of onset of menarche and menopause. A study among the Bhotias settled at different altitude found that there is variation in the age at menarche depending on altitude (Kapoor and Kapoor, 1986). Rang Bhotias who migrate up to 12,000ft showed a late onset of menarche (16 years) followed by Rang Bhotias (15.6 years) who are settled at an altitude of 7,000 to 9,000ft. And the Bhotias settled at comparatively lower altitude (3,000 to 5,000ft) showed an earlier onset of menarche (15.1 years) as compared to the former two. However, the total fertility period among the Bhotias were similar such that early onset of menarche was associated with early onset of menopause and late onset of menarche with late onset of menopause.

Check Your Progress

3) What are the effects of high altitude on growth and development?

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6.3 POLLUTANTS

Besides temperature, climate and season, there is a pertinent role played by pollution on growth and development of humans. Pollution is usually defined as unwanted materials (eg. lead, mercury, particulate matter/ air pollution) or energy (eg. noise and radiation) produced by human activity or natural processes such as volcanic action. Anthropogenic pollutants are produced from power plants that generate energy, manufacturing industries, transportation, the construction of homes and factories and even agriculture. Once created, pollutants are dispersed globally to virtually all populations by the dispersion of air and water through the food chain.

The five criteria used for judging the casual basis of statistical associations are:

1) A strong association
2) Biologic credibility to the hypothesis
3) Consistency with other studies
4) Compatible time sequence
5) Evidence of the dose – response relationship

Besides, the best way to assess exposure is to measure the pollutant of interest in the person or an immediate result of pollutant in the person. For example, in a study of lead, it is best to measure lead in the blood or bone.

6.3.1 Effect of Air Pollution

Air pollution means the release of anthropogenic or non anthropogenic pollutants in the air which are detrimental to human health and growth. It is found that air pollution causes retardation of growth in children. Studies have found that the proportion of children classified as having slow growth rates (<10 cm over 2 years) was 2 to 3 times higher in the highly polluted area than the low polluted area. In a study of over 10,000 children between the ages 7-12 years, skeletal maturation was delayed significantly in the more air polluted districts (Schmidt & Dolgner, 1977). It is possible that air pollution exerts an affect like high altitude hypoxia, limiting the oxygen available for growth. Mikusek (1976) found that girls from an air polluted town were delayed in all growth dimensions except chest development, a selective effect similar to the sparing of growth of chest circumference seen in some studies of high altitude Andrean children.

The effect of air pollution may begin prenatally. For example, an early study of birth weight in different sections of Los Angeles found that weights decreased in relation to the severity of the air pollution and the effect was evident after controlling for some of the other large influences on birth weight. A study using births in the Czech national birth register in 1991 found that low birth weight was increased in relation to the level of sulphur dioxide air pollution and to a lesser extent the level of suspended particulate matter (Bobak, 2000).

There are different types of pollutants. Organic pollutants include many insecticides and herbicides used in agriculture and pest control, polychlorinatedbiphenyls (PCBs) are a group of 209 compounds that share a basic common structure to dioxin which is thought to be one of the most toxic substances known. PCBs may affect endocrine function, physical growth, maturation and cognitive or behavioural development of children and youth. Evidence of the effects of PCBs on humans comes from two types of studies, studies of acute poisoning or an occupational accident and studies of chronic low level exposure, usually from ingestion of foods with slight but measurable contamination.

Check Your Progress

4) What are pollutants?

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6.3.2 Effect of Lead

Lead has been a common pollutant since it was first added to paint and gasoline. In the late 1970s, one in six African-American children from the central sections of large cities had lead levels that exceeded 25 μg/dl which was the definition of lead poisoning at that time. A study has found that there is reduction in birth weight of nearly 200g in relation to the log of maternal blood lead level (Borchein et al., 1988).

The affect of pollutants on birth weight has been studied largely because birth weight is routinely collected as part of public health surveillance. Data from the second National Health and Nutrition Examination Survey(1976-1980) wherein about 7000 children less that 7 years old were involved showed that lead level was negatively related to the stature, weight and chest circumferences after controlling for other important influences on growth (Schwartz, 1986). This study found that when compared to children with blood level of O_2, heights of children with the mean lead level were 1.5% shorter at the mean age of 59 months. The other study used a data set of 7-12 year old children whose blood lead levels were above the median for their age and sex were 1.2cm shorter than those with lead below the median (Frisancho, 1991). The other study used anthropometric data from the Third National Health and Nutrition Examination Survey (1988-1994) for non-Hispanic children 1-7 years old, and found statistically significant reductions of 1.57cm in stature and 0.52 cm in head circumference for each 10 μg of lead in the blood (Ballew et al., 1999). These studies are cross-sectional, that is lead and stature were measured simultaneously and consequently there are chances that short children simply exposed to more lead rather than lead reduces child growth.

There are few longitudinal studies which have been done on lead and growth. In the Cincinnati study, infants born to mothers with prenatal lead level changes over the interval of 3-15 months of age grew less over that period (Shukla et al., 1987; 1989).

Similarly, when the children reached 33 months of age, two groups of children has decreased stature, those with low lead levels prenatally but high lead levels from 3-15 months and the children with high levels in the prenatal and postnatal period. Low lead levels and decreasing lead levels were not related to growth measures.

Check Your Progress

5) What are the effects of lead pollution?

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6.3.3 Effect of Radiation

Radiation is an energy that exists in several forms, some of which can be extremely damaging to cells. There are some studies which found that women who had been exposed prenatally to medical X-rays were about 1.5 times more likely to experience menarche before the age of 10 years (Meyer, 1981) and others have detected post natal growth retardation (Brent, 1979).

6.3.4 Effect of Noise

Studies on noise are hampered by difficulty in measuring a child's past exposure to noise. It is usually estimated by distance from a powerful noise source, such as an airport. The quality of the study varies in terms of the accuracy of noise exposure measurement and the degree to which other influence on growth are controlled.

Schell in his study compared births to women residing near an aircraft who were exposed to noise levels of 100 decibels or more to births to women exposed to less airplane noise and observed a difference of 316g of birth weight among female infants which is an extremely large amount (Schell, 1982). Similarly Knipschild et al. (1981) found a significant reduction in birth weight among females but not males. Noise is a classic physiological stressor, as it activates the hypothalamic-pituitary- adrenal axis in the same way as the other stressors. Noise stress stimulates the autonomic nervous system, which stimulates the adrenal medulla to produce epinephrine and norepinephrine. It also stimulates the pituitary gland, which in turn affects the adrenal cortex, the thyroid and the gonads. Corticosteroids produced by the adrenal cortex affect growth directly. The thyroid gland regulates metabolism and its hormones are essential for normal growth and development. Influences on gonadal functioning can influence growth and maturation.

6.3.5 Effect of Cigarette Smoking

Cigarette smoke contains a large variety of compounds, including carbon monoxide and cyanide that can have a variety of detrimental effects on human functioning and growth. These compounds can cross the placenta and affect the fetus, and second hand cigarette smoke may affect children in households with smokers (Misra and Nguyen, 2000). Smoking cigarette before growth is complete (i.e. as a child or adolescent) may also affect growth but this problem has not been studied sufficiently.

Prenatal Growth is very strongly affected by maternal cigarette smoking. Maternal cigarette smoking is the single greatest influence, after gestational age on birth weight in well off countries (Kramer, 1987), where nutrition is adequate and cigarette smoking is common. In population suffering from nutritional stress, few women smoke during pregnancy, so the effect is minimal or absent. Women who smoke during pregnancy have babies on average 200g less than babies of non smokers. The reduction in birth weight is related to the number of cigarettes smoked. Maternal smoking causes reductions of only 2 days or less in gestational length, which cannot account for the birth weight decrement. When birth weights of infants whose mothers are smokers and non smokers are compared at each week of gestation from weeks 36 through 43, infants of smokers consistently have lower mean birth weights.

The reduction in mean birth weight is related to a downward shift of the entire distribution of birth weight. In other words, the 90th weight percentile of smokers' babies is lower than the 90th percentile of the non smokers' babies. Similarly the frequency of low birth weight (LBW less than 2500g) is more common among smokers, again irrespective of gestational age, and it is approximately double among smokers.

Maternal smoking also is significantly associated with shorter body lengths (about 1cm), reduced arm circumference and in some studies, slightly reduced head circumference (Haste et al., 1991; Olsen, 1992). The sizes of the decrements depend on the amount and timing of cigarette consumption by the mothers in the population. The pattern of reductions may indicate when cigarette smoking begins to depress prenatal growth. Peak weight velocity, including fat deposition, occurs later in the pregnancy than rapid growth of the body length and head circumference. Thus, the greatest impact of smoking may be registered in the last trimester of pregnancy.

In some respects, the stress to the fetus from maternal cigarette smoking resembles the stress of high altitude hypoxia. The primary constituent of tobacco smoke is carbon monoxide. Carbon monoxide with an affinity for adult hemoglobin 200 times that of oxygen has an even greater affinity for fetal hemoglobin. It is estimated that if a mother smokes 40 cigarettes per day there is a 10% concentration of carboxyhaemoglobin equivalent to a 60% reduction in blood flow to the fetus. Thus cigarette smoking exacerbates fetal hypoxia.

Check Your Progress

6) What are the effects of maternal cigarette smoking on child's health?

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6.4 SUMMARY

Growth and development of individual(s) is influenced by many factors. Some of the factors which influence growth and development are: heredity, environment, nutrition, physical activity, etc. Growth and development was believed to be purely influenced by heredity or genetic factors but it was later found that environment plays a vital role in the growth and development of human beings. The climate, temperature, geography of the region like high altitude, etc. are also part of the environment. So, environmental factors bring about a whole lot influences on the growth and development of humans. Diet nutrition and socioeconomic resources are also often considered to be the prime influence on human physical growth and developments are sensitive to a wide variety of features of the environment. Climate, temperature and altitude are the most studied features of the natural environment. In addition we also have the anthropogenic factors such as air pollution, metals (mercury, lead) pesticides and herbicides. Most of the anthropogenic factors pose several adaptive changes.

Factors affecting growth and development also include temperature and climate, season and seasonal variation. Growth is not limited to temperate zones alone; it has also been found that variation in growth rates occurs between dry and rainy seasons in tropical climates. Though high altitude imposes many environmental challenges and the challenges increase with an increase in altitude. However, due to the plasticity of the human body, it is adjusted to live in the particular type of environment. Pollution is usually defined as unwanted materials or energy produced by human activity or natural processes such as volcanic action. Anthropogenic pollutants are produced from power plants that generate energy, manufacturing industries, transportation, the construction of homes and factories and even agriculture. It is found that air pollution causes retardation of growth in children. The effect of air pollution may begin prenatally. Lead has been a common pollutant since it was first added to paint and gasoline. In the late 1970s, one in six African-American children from the central sections of large cities had lead levels that exceeded 25 µg/dl which was the definition of lead poisoning at that time. The affect of pollutants on birth weight has been studied largely because birth weight is routinely collected as part of public health surveillance. Radiation is an energy that exists in several forms, some of which can be extremely damaging to cells. The vast use of mobile phones and its towers are also presumed to damage body cells in the long run. Noise is a classic physiological stressor, as it activates the hypothalamic-pituitary- adrenal axis in the same way as the other stressors. Cigarette smoking can also have a variety of detrimental effects on human functioning and growth as it contains a large variety of compounds, including carbon monoxide and cyanide.

6.5 REFERENCES

Allen Joel Asaph. The influence of Physical conditions in the genesis of species. Radical Review 1:108-140; 1877.

Ballew C, Khan LK, Kaufmann R,Mookdad A, Miller DT, Gunter EW. Blood lead concentrations and children’s anthropometric dimensions in the third national health and nutrition examination survey 1988-1994. J. Pediatr. 134: 623-630. 1999

Beall CM, SteegmanJr . At Human adaptation to climate: Temperature , ultraviolet radiation , and altitude . In. Stinson S. , Bogin B, Huss- Ahmore R, O’Rouke D (eds). Huyman Biology: An Evolutionary and Biocultural Perspective. New York: Wiley 2000.

Bergmann C. Ueber die Verhältnisse der Wärmeökonomie der Thiere zu ihrer Grösse. Gottinger Studien 3: 595– 708; 1847.

Bobak M. Outdoor air pollution, low birth weight and prematurity. Environ Health Perspect. 2000.

Bogin B. Seasonal Pattern in the rate of growth in height of children living in Guatemala. Am J Phys Anthropol. 49; 1978.

Bogin B. Patterns of Human Growth. Cambridge : Cambridge University Press,1988.

Bornschein RL, Grote J, Mitchell T, Succop PA, Dietrich KN, Kraft K. Effects of prenatal lead exposure on infant size and birth. Lead exposure and child development, 1988.

Brent RL. Effects of ionizing radiation on growth and development. In Klinberg MA , Weatherall JAC . Epidemiologic Methods for Detection for teratogens . New York, S. Karger Publishing, 147-183; 1979.

Chabes A, Pereda J, Hyams L , Barrientos N, Perez J, Campos L , Comparative morphometry of the human placenta at high altitude and at sea level . Obstetric Gynecol, 1967.

Frisancho AR. Human Adaptation and Accommodation. Ann Arbor: University of Michigan Press, 1993.

Frisancho AR, Ryan AS. Deceased stature associated with moderate blood lead concentrations in Mexican American children, 1991.

Griffin JE, Ojeda SR. Textbook of endocrine Physiology. Oxford: Oxford University Press, 1996.

Haas JD. Maternal adaptation and fetal growth at high altitude in Bolivia. In: Greene LS, Johnston FE (eds). Social and Biological predictors of Nuttritional Status, Physical growth and Neurological Development. New York: Academic Press, 1980.

Haste FM, Anderson HR, Brooke O, Bland JM, Peacock J. The effects of smoking and drinking on the anthrometric measurements of neonates, 1991.

Kapoor AK, Kapoor S. The effects of high altitude on age at menopause and menopause. Int. J. Biometeorol., 30, 21-26, 1986.

Knipschild P, Meijir H , Salle H. Aircraft noise and birth weight Inter Arch Occupation environ health, 48: 131-136; 1981.

Kramer MS. Intrauterine growth and gestational duration determinants. Pediatr., 1987.

Kruger H, Arias Stella J. The placenta and the newborn infant at high altitudes. Am. J. Obstetric Gynecol 1970.

Malina RM, Bouchard C. Growth, Maturation and Physical activity, Champaign, IL: Human Kinetics Books, 1991.

Meyer MB, Tonascia J. Long term effects of the prenatal X ray of human females. 1981.

Mikusek J. Developmental age and growth of girls from regions with high atmospheric in Silesia 1976.

Mishra DP, Nguyen RHN. Environmental tobacco smoke and low birth weight: a hazard in the workplace. Environ Health Perspect., 2000.

Moore LG, Niermeyer S, Zamudio S. Human Adaptation to high altitude: Regional and lifecycle perspective . YearbPhys Anthropol., 1998.

Newman MT. The application of ecological rules to the racial anthropology of the aboriginal New World. Amer Anthropol., 55; 1953.

Olsen J, Cigarette smoking in pregnancy and the fetal growth . Does the type of tobacco play a role? Int J Epidemiol., 1992.

Palmer CE. Seasonal Variation of average growth in weight of elementary school children. Pub Health Rep., 48; 1933.

Schell LM. The effects of chronic noise exposure on human prenatal growth, 1982.

Schmidt P, Dolgner R. Interpretation of some results of studies in schoolchildren living in areas with different levels of air pollution, 1977.

Schneider PL, Beede DK, Wilcox CJ. Nycteroberemal patterns of acid dase status, mineral concentration and digestive function of lactating cows in natural or chamber heat stress environment. J. Anim Sci. 66: 112-125; 1988.

Schwartz J, Angle CR, Pitcher H. Relationship between childhood blood lead levels and stature, 1986.

Shukla R, Bonschein R, Dietrich KN, Mitchel T, Grote J Berger OG. Effects of fetal and early postnatal lead exposure on the child's growth in stature – the Cincinnati Lead study, 1987.

Shukla R, Bornschein R. Dietrich KN, Buncher C , Berger OG , Hammond P. Fetal and infant lead exposure: effects of growth in stature, 1989.

Tanner JM. Growth at Adolescence. Oxford: Blackwell Science, 1962.

6.6 ANSWERS TO CHECK YOUR PROGRESS

1) Environment is derived from the French word *'environ'* or *'environer'* which means 'around' or 'to surround'.

2) In a classic study done by Palmer (1933), it was found that growth rates for height are greater during the spring and summer months while rates of weight gain are greater during the fall and winter months at temperate latitude.

3) High altitude imposes many environmental challenges and the challenges increase with an increase in altitude (Moore at al., 1998). High altitude is a multi stressor environment and the stresses are hypoxia, nutritional stress, cold and radiation. Altitude also plays an important role in the age of onset of menarche and menopause.

4) Pollutants are usually defined as unwanted materials (eg. lead, mercury, particulate matter/ air pollution) or energy (eg. noise and radiation) produced by human activity or natural processes such as volcanic action.

5) Lead has been a common pollutant since it was first added to paint and gasoline. It was found that there is reduction in birth weight of nearly 200g in relation to the log of maternal blood lead level.

6) Cigarette smoke contains a large variety of compounds, including carbon monoxide and cyanide that can have a variety of detrimental effects on human functioning and growth. These compounds can cross the placenta and affect the fetus, and second hand cigarette smoke may affect children in households with smokers (Misra and Nguyen, 2000). Smoking cigarette before growth is complete (i.e. as a child or adolescent) may also affect growth but this problem has not been studied sufficiently. Prenatal Growth is very strongly

affected by maternal cigarette smoking. Maternal cigarette smoking is the single greatest influence, after gestational age on birth weight in well off countries (Kramer, 1987), where nutrition is adequate and cigarette smoking is common. In population suffering from nutritional stress, few women smoke during pregnancy, so the effect is minimal or absent. Maternal smoking also is significantly associated with shorter body lengths (about 1cm), reduced arm circumference and in some studies, slightly reduced head circumference (Haste et al., 1991; Olsen, 1992).

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UNIT 7 ECOLOGICAL ADAPTATION TO VARIOUS DISEASES*

Contents

Learning Objectives

In this unit you will learn:

- Relations between ecology and diseases;
- How does Adaptation to infectious diseases takes place;
- How does Adaptation to non-infectious diseases occur in different geographical regions of the world; and
- Understanding of Ecology of malnutrition and nutritional stress.

7.1 INTRODUCTION

The human body reacts to environmental changes with varied biological and cultural ways. We can acclimatize to a wide range of temperature and humidity. We are constantly responding in physiological ways to internal and external stresses such as bacterial and viral infections, altitude changes, pollution of different types and dietary imbalance etc. This ability to adapt to different environmental conditions has made it possible for us to persist in different ecological zones. We live successfully in humid tropical forests, harsh deserts, arctic wastelands, and even densely populated cities with considerable amounts of pollution. It is observed that interaction between man and his/her environment is competitive. We have been able to control our environment or at least to mitigate its worst effect by adaptive mechanism of one sort or another. This struggle may be against passive component e.g. physical and climatic factors such as environmental temperature or atmospheric pressure which is not alterable or it may be against the biological environment which may be achieved by adaptive responses.

7.2 RELATIONS BETWEEN ECOLOGY AND DISEASES

Humans normally respond to environmental stresses in four ways: 1. Genetic changes; 2. Developmental adjustment; 3. Acclimatization; and 4. Cultural

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practices and Technology. When an environmental stress is constant and persist for several generations, successful adaptation may develop through biological evolution. Those individuals who inherit a trait that offers an advantage in responding to particular stresses are more likely to survive longer and pass on more of their genes to the next generation by natural selection. For instance, people whose ancestors have lived in areas that have had endemic malaria for thousands of years often inherit immunity to this diseasethrough genetic mutation or alteration. The high incidence of sickle-cell trait among the people of Central Africa is largely the result of indirect selection for this trait by malaria. Heterozygous carriers of the sickling gene usually do not have sickle-cell anemia and are sufficiently resistant to the malarial microorganism that they are at a selective advantage. Another example of a genetic solution to an environmental stress is our ability to produce sweat as an aid in cooling our bodies in hot environments. Adjustments to environmental stresses achieved by change in growth patterns and development are classified as development adjustments. This takes place during childhood and it results in irreversible anatomical and/ or physiological changes known as developmental adjustment or developmental acclimatization.

Check Your Progress

1) Write 4 ways by which human body respond to the environmental stresses.

   a) ....

   b) ....

   c) ....

   d) ....

7.3 ADAPTATION TO INFECTIOUS DISEASES

In the context of infectious diseases, it seems important that appropriate steps must be taken so that people are able to adapt and at the same time all possible approaches should be adopted to ensure the disadaptation of the disease producing agents to the environment. Most of the public health measure which try to prevent the spread of diseases fall in this category. It is through such measures that we have won the battle with scarlet fever. In this case there appears to be a dramatic decrease in severityand less virulence of the organism causing scarlet fever. However, poliomyelitis still continues and has not been controlled. The pattern of distribution of infectious diseases is often determined by climatic and geographical factors. It is noted that the organism causing particular disease are most likely to flourish in a certain range of temperature or humidity. It is also noted that a particular intermediate host or vector may be necessary for the transmission of disease from one individual to another. Malaria parasite sporozoa are transmitted by the anopheles mosquito. This mosquito requires stagnant water and a relatively high temperature for its breeding. Accordingly the disease has been completely eradicated by adopting appropriate anti mosquito measures in Europe and many other parts of the world. However, still there are malaria endemic areas in many pockets all over the world. Thus it is necessary that the environment favouring the vector must be changed and at the same time direct attack must be made on the causative organisms. This can be done with the help of appropriate chemical or drugs.

The cultural and technological adaptations acquired by us against the environmental stresses may facilitate the spread of infectious diseases. We are aware of the relationships between overcrowding on account of poverty or any other reason and the incidence of tuberculosis. Better and quicker modes of transportations are helpful in spreading the disease from one part of the world to another. However, now the authorities in different countries have adopted stringent health examination measures and stress on previous immunization. As a consequence of deforestation and swamp drainage for the sake of space and food requires readjustment of ecological balance and an enlightened policy of conservation in many areas. It appears that the disease which emerges from our contact with other living organism represent phases of ecological conflict which have not yet been resolved in our favor. We still struggle with smaller creatures like rodents, insects, fungi and microorganisms. Some of these are parasites on our food and shelter; others are directly parasitic or injurious to our body. The geographical background is possibly the biggest factor governing the type and abundance of parasites and pathogens. Many microorganisms may be water born, air born or carried by insects or other animals. Thus the relation between host and organism may often take a complex course depending on the number of stages and the factor involved e.g. vector, intermediate, host, and one or more reservoir. It is apparent that ecological relationships are strongly influenced by physical features such as wind, rain, water, drainage, temperature and humidity. It is likely that the pathogens itself may have a limited environmental tolerance. The character of our settlement and the type of housing may also introduce factors favourable to the spread of particular diseases e.g. in cold climate and hot dry countries where nomadism prevails there is crowding of people in small living quarters. This overcrowding may be conducive to the spread of diseases like tuberculosis. Human settlements may require clearance and deforestation and in turn may provide conditions favourable for the propagation of infectious diseases.

There are two fold responses to infectious diseases: immediate ones which depend on the adaptive flexibility of the individual and the responses taking longer to come into play but more specific in their actions. Immediate responses are the physiological processes which attempts to counteract the effect of invading organisms e.g. symptoms and signs of the diseases such as inflammation, pain, fever etc. More prolonged exposure to many infections may result into a greater or lesser degree of immunity. Infact the proteins or polysaccharides of the invading organisms may act as antigens and stimulate the production of antibodies. Once such antibodies are formed, they may persist in the body or may rapidly be reformed in case a second infection occurs. If a disease is wide spread or severe in nature then such an infectious disease may act as most efficient selective agent. Those persons who are able to combat the disease will be able to survive and others eliminated. Such a resistance may be due to increased physiological adaptability or an increased capacity for an immune response or both. In case successive generations are exposed to a particular disease there may be some amelioration in its severity. However, transmission of such a disease to populations without previous experience of the condition may be marked by high morbidity and mortality rate. Many of the infectious diseases like tuberculosis, cholera, HIV, Hepatitis B, Hepatitis C and leprosy are noted to occur during the pre-reproductive and reproductive phases of life certainly increase their selective significance. The relationship between human blood group and resistance to infectious diseases has been explored. Blood group B provides some type of resistance to small pox in South Central Asia and the Indian sub-continent. It has been suggested that the A antibody which is present in the serum of group B individuals has some beneficial effect on the immune response to this disease, though there are no definite proof establishing this.

Check your progress

2) Name two fold responses to the infectious diseases.

a) ....

b) ....

Thus it is clear that the resistance to infectious disease may involve one or both of the factors. These may be genetic factors making for natural resistance or there may be an active immunity acquired only as a result of contact with the disease agent. Itmay be noted that the capacity to develop immune reactions may be considered as a physiological attribute possessed by the human species as whole and a product of evolutionary selection.

Whenever the body is invaded by a pathogenic organism the defence process sets in by the production of modified protein in highest concentration in the blood called antibodies. Such antibodies have a special property of penetrating or adhering to the surface and acting on the pathogens thus preventing its activity and multiplication. Such antibodies formed are specific and persistent and remain in the blood stream and are capable of counteracting the re-entry of pathogens. It may be possible that a disease which has reached a certain state of balance and may be mildly endemic in one population may spread in serious epidemic waves through population which may not have acquired immunity. Haldane (1949) has postulated that infectious diseases might have been the most effective agent of natural selection in man by favoring the survival and reproduction of these individuals possessing genes making the resistance. Many chronic and degenerative diseases may not act as selective agents. While the genetic factors will no doubt be shown to be of importance in many more diseases, it seems in general to play a subsidiary role in determining the distribution and occurrence of infectious disease. The Australian aboriginals despite their geographical separation, suffers from the same type of diseases (infectious and others)as the Europeans and in the same way (Cleland 1966).

7.4 ADAPTATION TO NON-INFECTIOUS DISEASES

In non-infectious diseases, too the whole complex of environmental factors and biological responses (inborn and acquired) must always be considered when trying to account for regional variation. The fact that African are more susceptible to frost bite than the Eskimos or North American Indians may be attributable to both lack of acclimatization and genetic susceptibility. The malformation of the central nervous system , spina-bifida and anencephaly, whose exact etiology is not known, have been shown from family and ethnic studies by Carter (1969) to involve genetic factors, social class, birth order, and maternal age effects as well as secular seasonal variation indicate that environmental factors are also important in their causation.

The geographical aspect of cancer has received much attention in the hope that a study of local conditions associated with high or low may give a clue to etiology.

But on the whole this approach has raised as many problems as it has solved. Cancer of one kind or another has been reported in all human populations, but there are remarkable variations in the incidence of particular neoplasm. Higginson and Oettle (1960) made a survey of cancer in Bantu people of the Transvaal and compared the observed incidence of various types of tumors with the incidence to be expected in American Whites, African American, and Danish population of corresponding age distribution. They found cancer of colon, stomach and rectum to be much less common in Bantumales and the rate for cancer of the breast and body of the uterus to be much lower in Bantu females than in the control groups. On the other hand, cancer of the liver (hepatoma) and to a lesser extent of the oesophagus was much more frequent in the Bantu males. In some respects the rate for Bantu and African American were very different, but both had a low incidence of cancer of the mouth, lip and skin, attributable in part to their pigmentation and a high rate of cancer of cervix uteri as compared with either of the white groups.

Striking racial differences in the incidence of coronary disease are found to be associated with diet high in fat. The difference in fat consumption of Europeans and Bantu in South Africa, reflecting economic status are paralleled by the liability to coronary diseases, highest among Europeans and lowest among the Bantu (Higginson and Pepler 1954; Soliman 2019). Interestingly enough, the low fat, low calorie diet of much African population, while disadvantageous in certain respects, would seem to have favoured an extremely low incidence of diabetes mellitus.In Africa due to secular changes in diet and lifestyle, particularly in North Africa and urban centres in sub-Saharan Africa, there are an increase in cardiovascular disease, cancer, and obesity and its co-morbidities like hypertension and type 2 diabetes (Boutayeb 2006; Mufunda et al 2006; Davis 2008). Low vitamin D status has been implicated in diabetes and cancer. Serum 25OHD has been found to be low in obese adults and may be due to sequestration of vitamin D in subcutaneous fat and its consequent reduced bioavailability (Rajakumar et al 2008).

At high altitude, the pattern of growth and development in body size and the organ system concerned with oxygen transport differs from the low altitude pattern. The high altitude follows two directions of responses in which accelerated and slow pattern occur simultaneously. High altitude hypoxia accelerates the growth of oxygen transport organ system such as placenta, lungs, heart and thorax. On the other hand, joint effect of hypoxia and cold increases energy requirement. This in turn affects the energy balance and results in prenatal and post natal growth retardation of musculo-skeletal system, which affects both birth weight and stature. Because ofthis two directional response,human growth, in high altitude population must be viewed as the result of interaction and adaptation of the organism to competing stress of hypoxia, cold, and energy requirement that characterizes the high altitude environment. Besides enhanced caloric needs in cold climates, an increase in fat intake is also advantageous in helping preserve body temperatures. A clinical consequence of inadequate fat intake in the Arctic is the sort of "rabbit hunger" (Stefansson, 1956).Three clinical entities specific to a high altitude environment have been identified. These include acute mountain sickness, pulmonary edema and Monge's disease (Fig 3.1). Acute mountain sickness has been clearly associated with hypoxic stress, and is characterized by headache, malaise, dizziness, shortness of breath, sleep difficulties and stomach upset. Usually symptoms of acute mountain sickness disappear without treatment.

In contrast, pulmonary edema is a severely debilitating disease. And can be fatal if patient is not treated rapidly. Monge's disease or chronic mountain sickness is a severally debilitating disease that occurs mostly among highland natives with prolonged residence at high altitude and is associated with a loss of functional adaptation.

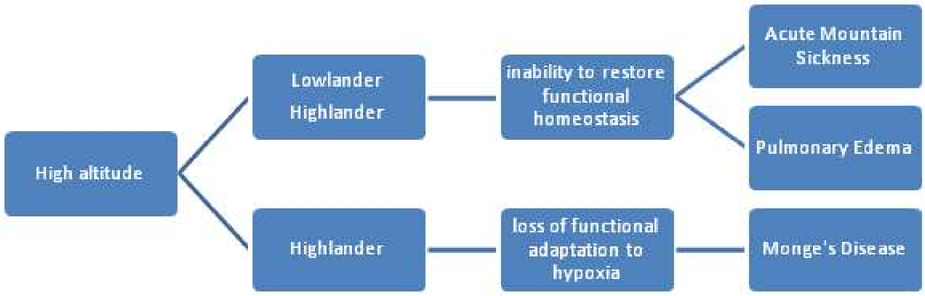

Figure 3.1: Schematization of group incidence and general characteristics of diseases associated with high altitude environment

There is evidence suggesting that altitude acclimation may be related to the low incidence of hypertensive and other cardiac diseases in high altitude population. Athletic performance at sea level does not appear enhanced by acclimatization to high altitude. On the other hand, the advantage of acclimatization to moderate altitude are evident in the middle and long distance runs of the 1968 Olympics held in Mexico in which highland athletes excelled.

Check Your Progress

3) Name three clinical challenges at high altitude.

a) ....

b) ....

c) ....

7.5 ECOLOGY OF MALNUTRITION AND NUTRITIONAL STRESS

Laboratory and experimental studies suggests that there is synergistic relation between malnutrition and infection whereby malnutrition predispose the organism either through low production of immuno-globulins on the mesopharangeal secretion or inhibition of the cell mediated immuno-response. The infection in turn exacerbates the effect of malnutrition and therefore new infections may emergeor existing one become more severe. Thus a vicious cycle between, malnutrition, infections and immune-deficiency is established. This synergistic interaction calls attention to the fact that nutritional programme oriented to improving and understanding the etiology of malnutrition must also include programme for control of infection. There is conclusive evidence indicating that maternal chronic undernutrition retard prenatal growth. Hence variation in maternal calorie and protein reserves are the most important factors affecting new born body size and composition as revealed in Dutch feminine (Stein and Susser 1975). The relationship between maternal nutritional status and prenatal growth is so well defined that any change in maternal calorieintake or change in calorie and protein reserves are reflected in dramatic change in birth weight. It can be safely concluded that about one half of incidence of prematurity observed among developing nations is either directly or indirectly related to malnutrition. Because of the cumulative effect of prenatal undernutrition, prenatal growth retardation, and chronic under-nutrition after birth, growth during the post natal period is slow and eventually leads to reduced adult body size.

Undernutrition and malnutrition provide gross and general stress of a nutritional nature. There are multiple qualitative deficiencies due to metabolic interactions of the various nutrients. Deficiency diseases primarily attributable to a single nutrient have strong ecological associations e.g. rickets and osteomalacia with cold climates. Scurvy and pellagra were reported more innorthern and southern parts of the world's temperate zones respectively. Similarly Beri-beri and kwashiorkor were found to be associated with warmer temperate and hot climates zones. Pellagra has been reported to be linked with maize cultivation, whereas Beri-beri has an association to more dietary usage of milled rice. Pellagra, due principally to niacin deficiency, is much more prevalent in the world's temperate zones than elsewhere and is more severe during the warmer months' (Gillman and Gillman 1951). Pellagra reached epidemic proportions during the 19th century in European countries such as France, Italy, and Rumania. The thiamine deficiency associated with diets based largely upon milled rice is the undeniable cause of beri-beri. Accordingly, this deficiency disease is largely restricted to Southeast, but it is also present to some extent in Venezuela, the Minas Gerais area of Brazil, the former Cameroons, and Madagascar (Amer. Geogr. Soc. 1953).A strong seasonal association with the deficiency diseases has been reported. For instance, rickets, osteomalacia, and scurvy displayed an association with the winter months, pellagra with the summer months, and kwashiorkor and Marasmus with the "hungry months".In Central America, partial starvationduring the first year of life from insufficient maternal milk is more likely toresult in marasmus (progressive wasting of the body) than kwashiorkor (Scrimshaw et al. (1957).

In terms of mortality and morbidity rates, the greatest nutritional stresses are present in the underdeveloped countries of the world, especially where agricultural output and/or productivity are low. These are principally the countries of the tropics and warmer temperate zone, where the vectors of disease seem to be most strongly fixed. Disease often goes along with poor nutrition, and the two are largely synergistic in relationship. The underdeveloped countries are currently plagued by many of the nutritional deficiency and other diseases common less than several centuries ago in the more advanced countries. As Gordon's (1952:49) data suggest, the technologically more advanced countries have proceeded quickly to develop new mortality patterns, with the degenerative diseases such as atherosclerosis and cancer responsible for higher mortality. Atherosclerosis, for example, has a quite clear association with high intake of saturated fat and with reduced physical activity, and hence has very obvious ecological and cultural implications. We have very strong ecological and cultural correlateswith the nutritional stress. Diseases due to nutritional deficiency are iodine deficiency, vitamins deficiency like folate, vitamin A, Vitamin C, Thiamine (B1), Riboflavin (B2), Niacin and Vitamin B12 etc.Vitamin-wise there is incomplete evidence that cold climates slightly decrease the need for niacin and increase it for ascorbic acid (Dugal and Fortier 1952). Increased requirements for dietary Vitamin D also characterize cold climate living, since clothing and cloudy skies reduce the amount of ultraviolet radiation received by the body.

Check Your Progress

4) Namesome deficiency diseases showing association with ecological variations.

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7.6 SUMMARY

Let us summarise what we have learnt in this unit. We have understood that we have ability to adapt to different environmental conditions which has made it possible for us to survive in different ecological zones. We live successfully in humid tropical forests, harsh deserts, arctic wastelands, and even densely populated cities. It is observed that interaction between man and his/her environment is competitive. We have been able to control our environment or at least to mitigate its worst effect by adaptive mechanism/s. We normally respond to environmental stresses in four ways i.e. by genetic changes, developmental adjustment; acclimatization and cultural practices & Technology. There are two fold responses to infectious diseases: immediate ones which depend on the adaptive flexibility of the individual and the responses taking longer to come into play but more specific in their actions. Resistance to infectious disease may involve genetic factors making for natural resistance or there may be an active immunity acquired only as a result of contact with the disease agent. There are synergistic relation between different types of nutritional stress and infections. Deficiency diseases primarily attributable to a single nutrient have strong ecological associations e.g. rickets and osteomalacia with cold climates etc.

7.7 REFERENCES

Boutayeb A. (2006). The double burden of communicable and non-communicable diseases in developing countries. Trans Roy Soc Trop Med Hyg. 100:191–9.

Carter, C. 0. (1969). Spina bifida and anencephaly: A problem in genetic-environmental interaction. Journal of Biosocial Science 1: 71-8 3.

Cleland, J.B. (1966). 'Ecology Environment and Disease' in Cotton, B.C. (ed) Aboriginal Man in South and Central Australia, part 1, Adelaide

Davis CD. (2008). Vitamin D and cancer: current dilemmas and future research needs. Am J ClinNutr. 88:565S–9S.

Dugal, LP and G. Fortier. (1951). Ascorbic acid and acclimatization to cold in monkeys. Journal of Applied Physiology5: (3) : 143-46

Frisancho RA. (1979). Human Adaptation. A functional interpretation. The CV Mosby Company, St. Louis.

Gillmanj., and T. Gillman. (1951). Perspectives in human malnutrition. New **York,** Grune and Stratton.

Haldane J. (1949). The rate of mutations of human genes. Hereditas35 (Suppl): 267–273.

Higginson John, A. G. Oettlé. (1960). Cancer Incidence in the Bantu and "Cape Colored" Races of South Africa: Report of a Cancer Survey in the Transvaal (1953–55), JNCI: Journal of the National Cancer Institute, 24(3): 589–671.

Higginson, J.; Pepler,W.J. (1954). Fat intake, serum cholesterol concentration, and atherosclerosis in the South African Bantu. II. Atherosclerosis and coronary artery disease. J. Clin. Investig. 33, 1366–1371

Jurmain R, L. Kilgore, W. Trevanthan, H. Nelson. Essentials of Physical Anthropology. Fifth edition. Wadsworth.

Mufunda J, Chatora R, Ndambakuwa Y, Nyarango P, Kosia A, Chifamba J, et al. (2006) Emerging non-communicable disease epidemic in Africa: preventive measures from the WHO Regional Office for Africa. Ethn Dis. 16:521–6.

Rajakumar K, Fernstrom JD, Holick MF, Janosky JE, Greenspan SL. (2008). Vitamin D status and response to Vitamin D (3) in obese vs. non-obese African American children. Obesity (Silver Spring). 16:90–5.

Soliman G. A. (2019). Dietary Fiber, Atherosclerosis, and Cardiovascular Disease. *Nutrients*, *11*(5), 1155. https://doi.org/10.3390/nu11051155

Stein Z, M. Susser. (1975). The Dutch feminine 1944-45 and the reproductive process Part 1. Interrelations of caloric relations and six indices of birth. Pediatr Res. 9:70-75

Stefansson V. (1956). The fat of the land. New York, The Macmillan Co.

7.8 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress

1) Humans normally respond to environmental stresses in four ways: 1. Genetic changes; 2.Developmental adjustment; 3. Acclimatization; and 4. Cultural practices and Technology.

2) There are twofold responses to infectious diseases: immediate ones which depend on theadaptive flexibility of the individual and the responses taking longer to come into playbut more specific in their actions.

3) Three clinical entities specific to a high altitude environment have been identified. Theseinclude acute mountain sickness, pulmonary edema and Monge's disease

4) Some deficiency diseases, attributable to a single nutrient have strong ecological associations e.g. rickets and osteomalacia with cold climates. Scurvy and pellagra were reported more in northern and southern parts of the world's temperate zones respectively.

UNIT 8 APPLICATION OF ECOLOGICAL RULES*

Contents

Learning Objectives

From this unit, you will be able:

- To know about various ecological rules; and
- To understand applicability of ecological rules in human population.

8.1 INTRODUCTION

A German scientist Ernst Haeckel coined the term "ecology" in 1866 (Haeckel, 1866). Hippocrates and Aristotle (Ancient Greek philosophers) first laid the foundation of ecology in their studies on Natural History. It was in the late 19^{th} century, the concept of modern ecology had developed (Laferriere and Stoett, 2003). The chief foundation of modern ecological theory were evolutionary adaptation and natural selection of diverse species according to the environment.

Ecology denotes the dynamic interrelation of the community with its total environment. The adjustments necessary for successful existence in a particular habitat are termed 'adaptations'. Adaptability is the component for making up group or society. Ecological interactions are to be understood (a) as biological processes affecting the functioning, growth and form of the group's members, and (b) as non-biological processes taking the form of cultural, technical and social responses.

Human groups vary greatly in size and organization. There are two main channels of organism-environmental interaction. One concerns the biological changes induced in human body by the stresses or demands of the environment or in the course of acting on the environment.

Secondly, there are biological responses specific to particular individual and determined by particular genotypes. Traits of this kind may be entirely peculiar to a few individuals; or they may confer special advantages on particular advantages like proportion of extremities with respect to trunk in different climatic conditions. This concept we will discuss further in detail.

* Contributed by Dr. Meenal Dhall, Assistant Professor, Department of Anthropology, University of Delhi, Delhi

The intrusion of human communities into natural ecosystems may lead to a situation of stable or of dynamic equilibrium. In the first case the human group maintains its essential biological characteristics more or less unchanged over long period of time- its population size, density and composition, its energy and nutrient balances, its general standard of living. The social structure and technology will reflect this conservatism. Approximations to ecological stability are attainable in different habitats, with different economies, and at high or low population densities. Dynamic ecological equilibrium which characterize many expanding and developing communities require that the constantly increasing needs for food, water, raw material, waste disposal are met by increasing activity and energy output and intensified exploitation of both the biotic and abiotic environment.

8.2 TERMS AND CONCEPT

Like any other living beings, human also modified and altered themselves whenever they come into contact with the environment. The immense power of adaptation of man is reflected in terms of it's such a wide distribution. This wide distribution may be owing to a possibility that man has the extra-dimension of culture by which he can meet or at least reduce the effects of environmental stresses. Primarily, the adjustment to any stress depends upon the kind, amount and degree of the stress as how much is it? How much malnourishment? Or how much hard work? Duration of the stress indicates the time period of the stress such as 12 days of hard work, 5 days of heat exposure, or 10 years of malnourishment. However, the adjustments in the organism are harder not solely dependent on the above condition of stress, to a great extent that are related to the ecosensitivity of the individual or population.

Ecological success: Ecological success may be thought of in terms of 'standard of living'. Such standards may be biological, medical or demographic. The population size and its maintenance, the mortality, longevity or nutritional status are examples of overall indices of 'fitness'or adjustment. Depopulation is perhaps the most telling index of maladjustment. For example, the failure of an immigrant group to establish itself. The analysis of the 'efficiency' and 'capacity' of an ecosystem require detailed surveys of specific societies.

Ecosensitivity: Ecosensitivity may be defined as the individual's response to a particular stress. The essentiality differs from person to person and is controlled by the genotype of the individuals. It is not necessary that all the individuals will response equally to the same stress. On the contrary, the effect of the same stress may have similar response. Further, it was observed that the children of heteromorphy (eg. Tall × small stature people) are more ecosensitive than the children from the union of homomorph type (tall × tall). Similarly, males were found to be more ecosensitive than the females. This concept may still be applied in future in the studies dealing with human ecology.

Whenever a stress is encountered, all living organisms have defensive mechanism to prevent its effect. To elucidate, if any foreign elements enter human body, antibodies are produced to encounter and or remove the same from the body. In human beings, we have even an extra somatic dimension of defence mechanism that is culture. Viewing in this perspective culture acts as shield between the ecological stress and body stress. Most of the physiological characters among normal individuals have similar potentialities (within narrow range) to meet minor variation of climatic and other environmental stress. Such a process of minor adjustments alterations in function of human body or short term physiological changes are known as adaptation. For example, in a high altitude area, the Oxygen atmospheric pressure is low and under such circumstances to fulfil the demand of oxygen for energy acquisition is difficult to be made by ordinary (normal) ways of oxygen transport and hence the system carrying the oxygen have to be further activated. This is done simply by increasing the respiratory rate, heart rate, haemoglobin content and number of red blood corpuscles. These changes are common and possible in all human being and are classed under adaptation when a person continues to live in a particular environment; it sets in further physiological changes.

At high altitude there will be increased in force vital capacity and the time respiratory volumes and also the changes in other cardio-respiratory function to meet the stress. Such responses which occur within the lifetime of individual are classed as acquired acclimatization.

Check Your Progress

1) What is Ecological success?

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8.3 APPROACHES IN THE STUDY OF HUMAN ECOLOGY

There are three different ways in the problem of ecology that have been studied. They are:

i) Comparative method

ii) Cause and effect

iii) Multiple stress and strain relationship

Comparative method

Most of the morphological character such as stature is controlled by heredity and environment. Even the genetic traits such as colour blindness, haemophilia and ABO blood group are though clearly controlled by genetics yet their population frequency are subjected to environmental modification, considering this, it is possible to make comparison of genetically similar population living in different environment and genetically dissimilar population living in similar environments to study the respective role of environment and heredity. This way of study was found to be practical and seemingly without incorporating much errors. When we compare genetically similar population or population living in similar environment, there is always a difference between two such groups and as such comparison may not be futile. For example, two Caucasian are more similar to each other than a Caucasian and an Asian who share the same environment (Risch et al, 2002).

Similarly, the differences in the two populations also include a part of environmental differences as the two populations living in similar environments may show wide variation in their micro climate and specially culture when we are dealing with human population. Like two Mongoloids of different caste or clan living in same environment but due to different cultural and food practices they were different from each other. Hence, it may be concluded that this method has limitation in the studies of human ecology.

Cause and effect method

This approach is based on the fact that each effect has a cause and through serutination of the effect, it is possible to find the cause e.g. Linear physique is common among humans inhabiting in hot climates. This may be caused by the temperature of the biomic and explanatory hypothesis may be forwarded that the individuals with linear physique have lower ratio of body surface/ body weight than the fat individuals. For example: the Australian Aborigins living in hot climatic conditions.

This is important not only in increasing heat dissipation by radiation but also heat production is reduced. Therefore such a physique may be adaptive to hot climate. Despite its simplicity and wide applicability, it has one major drawback that it does not study system as a whole and the interrelationship between its components.

Multiple stress-strain relationship

Stress is a term generally given to the external factors which is one way or the other makes an impact or hinders the normal way of life. These stresses are to some extent met by the responses developed by the body which are known as strains e.g. the stress of hot climate may set in such stress as the increase in sweat rate, heartbeat, respiratory rate, etc. experienced has taught that stresses either occur in isolation nor in a group of one or two rather they are almost always multiply. These stressors remark numerous stresses in the human body and as such a relationship may be denoted as multiple stress-strain relationship not only occur in simple societies but is also equally applicable to the modern societies. For example, people living in high altitude have faced some important stresses such as low atmospheric pressure; low oxygen etc, under such circumstances to fulfil the demand of oxygen for energy acquisition is difficult to be made by ordinary ways. So, there will be increased force vital capacity and the changes in other cardio respiratory function to meet the stress.

Check Your Progress

2) Explain environmental difference?

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8.4 ECOLOGICAL RULES

Various ecologists tried to elucidate the interaction between organism and the environment in which they are living. They analysed this relationship from different perspective.

Allen's rule

This rule was first put forward by an American Biologist, Joel Asaph Allen in 1877. Allen's rule states that in hot regions, extremeties (in humans such as the arms and legs) are long to provide maximum surface area for dissipating heat. In cold regions, limbs are short to reduce surface area. In closely related homeotherm types, the relative dimensions of the protruding and the exposed parts of the body decreases with the average temperature at the habitat.

Allen's rule concerned with change in the shape of body to achieve an optimal volume to surface area ratio eg. Two cylinders of same volume but the attenuated cylinder is twice the surface area of the other. Larger appendages or smaller appendages as cylinders that can vary in the ratio of volume/ surface area.

Animals dwelling in cold climatic conditions are facing a major problem of heat loss. Loss of heat from the body mostly occurs near the outer surface or skin. So, larger the surface area of the body with respect to its total body size, more heat will be lost from the body surface and vice versa. For example, the black-tailed Jack rabbit found in hot dry areas always have a long head, long ears and long legs whereas hare of Arctic region have shorter ears relative to its size of head and the shape of head is spherical instead of being long (Griffing, 1974). Another good example is the short ears and stocky limbs of polar bear (Hogan, 2008).

There is less evidence for Allen's rule than other rules in human populations. There is evidence for shorter lower extremities in cold climate people but not especially short upper extremities. In some studies ratio of arm span to height is greater in hotter climate adapted population, eg. Ratio of sitting height to stature is higher in Eskimo population, several Siberian groups, Koreans and Northern Chinese than in most other population of the world. But there is no evidence of arm length reduction relative to sitting height in these cold climate populations. eg. Eskimos (cold), Australian Aborigins (Hot), Nilotes or East Africa. Applicability of Allen's rule in human population is rare but some evidence was found. Tall and slender bodies with long limbs are generally observed among members of the Masai tribe of East Africa. This body feature assist in heat loss of the body. This type of body shape is mostly prevalent in the hot tropical regions of the world but this may be a disadvantage among subarctic regions.

Bergmann's rule

Bergmann rule was put forward after a German Biologist Carl Bergmann. In 1847, he described the differences in the physiology of organism according to the climatic conditions in which they lived. This rule states that among the varieties of homeothermal species, higher the average temperature of its habitat smaller is its body size. Cold adapted animals tend to be large since of two animals of the same shape, the larger has less surface area for dissipation of heat relative to its mass.

Ratio of surface area by volume is generally lesser among endothermic birds and mammals living in cold climatic conditions when compared to the animals of warmer areas. Example of this feature are larger size of polar bears than the spectacled bears inhabiting near the equator, length of penguins of Galapagos Island have shorter length than penguins of Arctic region.

Applicability of Bergmann's rule in man is fairly well established. Robert's D.F (1952) examined male and female sample from New and Old world for significant negative correlation between body weight and mean annual temperature. These body build differences are in part differential growth responses to environmental differences. Reduction in growth among migrants from temperate to tropical climates. Ratio of mass/surface area of body is lower in tropical groups. On average, human population inhabiting near the cold arctic poles such as Aleut, Sami people, Inuit have heavier body form than those living in mid-latitude regions.

Gloger's Rule

The third ecological rule that is Gloger's rule was put forward by a zoologist named Constant in Wilhelm Lambert Gloger in 1833. This rule is developed on the basis of co-variation of climate and avian plumage colour. It states that birds and mammals living in warmer humid climates have more melanin and therefore have darker skin or feathers than those of the same species living in the cooler and drier areas. This rule has confirmed in more than 90% of 52 North American bird species.

The population of darker skin humans also live in warm climatic areas of equatorial region. Dark pigmentation of skin seems to have some advantages in tropical regions because the thick layer of melanin protects sensitive inner layers of the skin damaging from the sun's ultra violet rays, therefore dark skinned people in the hot regions are safer than the light skinned people. Likewise, light skin people also presumably must have some advantage in the cold regions but they are more susceptible to skin diseases. However, exception has found among Tibetans that these groups of people are living in the colder climatic condition in which their habitat is farther from the equator but they have darker skin colour. This is due to the apparent adaptation towards the extremely high ultra violet irradiation from the ice crystals on the Tibetan plateau (Diamond, 2005).

Check Your Progress

3) Describe Allen's rule.

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8.5 SUMMARY

Ecology deals with the study of dynamic relationship between the community and its total environment. Evolutionary adaptation and natural selection are the basic foundation of modern ecological theory. Both biological processes and non-biological processes should be understood to know the ecological interactions between them. Human beings are surviving in extreme climatic conditions because of the fact that they can modify and alter themselves for adaptation in the particular environment. The interference of human communities into natural ecosystems may lead to circumstances of constant or of dynamic equilibrium. Wide distribution of human beings in different geographical regions is due to their image power of adaptation in different environmental conditions. This can better be defined with the term ecosensitivity which determines an individual's response to a particular stress. Responses of the individuals to the same stress may be varied from person to person. All living organisms can prevent environmental stress with their own defensive mechanism. Various approaches have been developed to study human ecology, viz. Comparative method, cause and effect and lastly the multiple stress and strain relationship. The relationship between organism and the environment in which they inhabit are analysed by various ecologists from diverse point of view. So, various ecological rules were established by them for better understanding. Allen's rule, Bergmann's rule, Glogers rule etc are some of the commonly known ecological rules applied to all living organisms including human beings. Allen's rule discussed transformation of body shape to accomplish an optimal volume to surface area. This rule is applicable to Eskimo population, Siberian, Koreans, Northern Chinese, Australian aborigins, Nilotes and Masai tribe of East Africa etc. Bergmann's rule mainly focussed on variations in the physiology such as body temperature with respect to its body in different climatic conditions. Though, this rule is applicable to all living organisms, it is also well established in man than Allen's rule as for example, heavier body form prevalent among Aleut, Sami people, Inuit living near the cold Arctic poles. The third rule also known as the Gloger's rule discuss the colour change according to the variation of climate. This rule states that population living in warm and humid climatic condition have more melanin which results in darker skin colour as compared to those existing in cooler and drier region. The advantage of having darker skin colour than fair complexion is its protection from skin diseases.

8.6 REFERENCES

Allen, Joel Asaph. (1877). The influence of Physical conditions in the genesis of species. Radical Review 1: 108–140.

Bergmann, C. (1847). Uber die Verhaltnisse der warmeokonomie der Thiere zu uber Grosso. *Gottinger Studien*, *3*, 595-708.

Diamond, J. (2005). Geography and skin colour. *Nature*, *435*(7040), pp.283-284.

Haeckel, E. (1866). *Generelle Morphologie der Organismen. Allgemeine Grundzüge der organischen Formen-Wissenschaft, mechanisch begründet durch die von C. Darwin reformirte Descendenz-Theorie, etc* (Vol. 2).

Laferrière, E., & Stoett, P. J. (2003). *International relations theory and ecological thought: towards a synthesis*. Routledge.

Gloger, C.W.L. (1833). *Das Abändern der Vögel durch Einfluss der Klima's: nach zoologischen, zunächst von den europaischen Landvogeln...* A. Schulz.

Griffing, J. P. (1974). Body measurements of black-tailed jackrabbits of southeastern New Mexico with implications of Allen's rule. *Journal of Mammalogy*, *55*(3), 674-678.

Hogan, C. M. (2008). Polar Bear: Ursus maritimus, Globaltwitcher. com, ed. *N. Stromberg*.

Risch, N., Burchard, E., Ziv, E. and Tang, H. (2002). Categorization of humans in biomedical research: genes, race and disease. *Genome biology*, *3*(7), pp.comment2007-1.

Roberts, D. F. (19520. Basal metabolism, race and climate. *The Journal of the Royal Anthropological Institute of Great Britain and Ireland*, *82*(2), 169-183.

8.7 ANSWERS TO CHECK YOUR PROGRESS

1) Ecological success may be thought of in terms of 'standard of living'. Such standards may be biological, medical or demographic.

2) The differences in the two populations also include a part of environmental differences as the two populations living in similar environments may show wide variation in their micro climate and specially culture when we are dealing with human population.

3) This rule was first put forward by an American Biologist, Joel Asaph Allen in 1877. Allen's rule states that in hot regions, extremeties (in humans such as the arms and legs) are long to provide maximum surface area for dissipating heat. In cold regions, limbs are short to reduce surface area. In closely related homeotherm types, the relative dimensions of the protruding and the exposed parts of the body decreases with the average temperature at the habitat. Allen's rule concerned with change in the shape of body to achieve an optimal volume to surface area ratio