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.

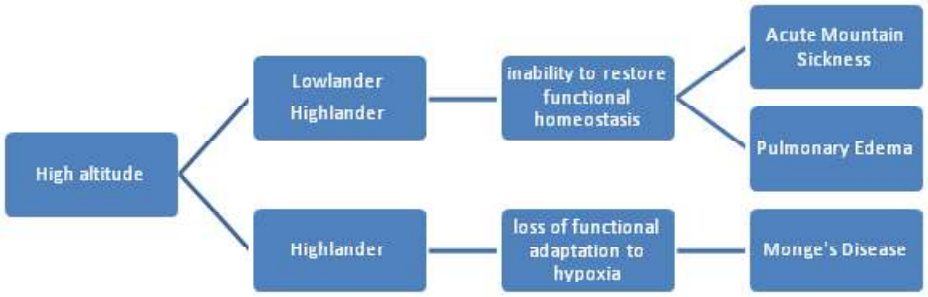

Figure 3.1: Schematization of group incidence and general characteristics of diseases associated with high altitude environment

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.

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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.