ECOLOGICAL ANTHROPOLOGY

Since its inception, the discipline of Anthropology has broadly dealt with "environmental" questions, including human perceptions of the natural world and the relationship between "Nature" and "Culture," as well as the ways human populations use culture as an adaptive strategy to cope up with their habitats and ecosystems. Late in the 19th century and early in the 20th studies of humans and their environment moved from the "environmental determinism" of the anthropogeographers, to the "environmental possibilism" of the ethnographers, and to the "cultural ecology" of Julian Steward. More recently, "Environmental Anthropology" has grown as a specialisation within Anthropology, focusing broadly on the study of environmental issues, problems, and solutions from an anthropological perspective.

Ecology is the study of the interaction between living things and their environment. **Human ecology** is the study of the relationships and interactions among humans, their biology, their cultures, and their physical environments.

DEVELOPMENT OF ECOLOGICAL PERSPECTIVE IN ANTHROPOLOGY

Interest in the study between people and the environment around them has a long history in anthropology. Since the beginnings of the discipline in the 19th century, scholars have been concerned with the ways in which societies interact with their environment and utilise natural resources, as with the ways in which natural processes are conceptualised and classified (Rival, 1998). Much of this interest centred on the study of subsistence patterns by which populations adapted to particular biophysical conditions. Precisely for this**, according to E. F. Moran (1996) environmental research in Anthropology has been a part of the discipline from its very beginning**. It is often referred to as the ecological approach in Anthropology. Ecological or environmental approach in Anthropology includes topics as diverse as Primate Ecology, Human Ecology, Ethno-ecology, Historical Ecology, Political Ecology, Ecofeminism, Environmentalism, Environmental Justice, Evolutionary ecology, Traditional Ecological Knowledge (TEK), Conservation, Environmental Risk, Liberation Ecology, and a number of other areas, many of them interdisciplinary in scope and methodology.

Defining Ecological Anthropology

Ecological Anthropology is broadly concerned with people's perceptions of and interactions with their physical and biological surroundings, and the various linkages between biological, cultural, and linguistic diversity. **Ecological anthropology tries to explore the multilevel ways in which humans adjust to their surrounding by both biological and socio-cultural processes.**

Salzman and Attwood (1996) defined Ecological Anthropology is a subfield of anthropology that **deals with complex relationships between humans and their environment**, **or between nature and culture, over time and space**. It investigates the **ways that a population shapes**

its environment and may be shaped by it, and the subsequent manners in which these relations form the population's social, economic, and political life.

Seymour-Smith (1986) Ecological Anthropology attempts to provide a materialist explanation of human society and culture as products of adaptation to given environmental conditions.

According to Ellen (1982) Ecological Anthropology applies a systems approach to the study of the interrelationship between culture and environment.

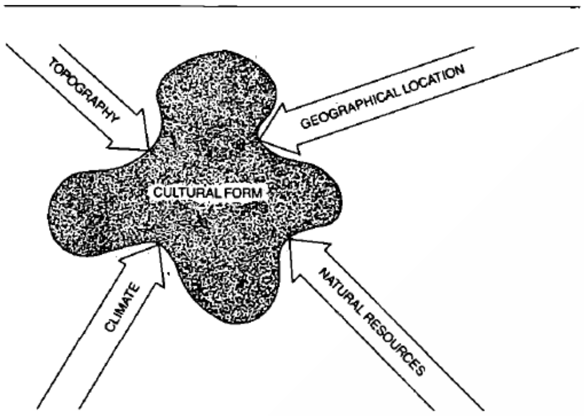
Orlove defines ecological anthropology as the study of the relationship among the population dynamics, social organization and culture of human population and environment in which they live.

UNDERSTANDING CULTURE-ENVIRONMENT RELATIONSHIP: THEORETICAL PERSPECTIVES IN ENVIRONMENTAL OR ECOLOGICAL ANTHROPOLOGY

Environmental or Ecological Anthropology embraces within its realm, the study of the complex relations between people and their environments (Salzman and Attwood, 1996). Human populations, socially organised and oriented by means of particular cultures, have ongoing contact with and impact upon the land, climate, plant and animal species, and other humans in their environments and these in turn have reciprocal impacts. Environmental or Ecological Anthropology directs our attention to the ways in which a particular population purposely or unintentionally shapes its environment, and the ways in which its relations with the environment shape its culture and its social, economic and political life. Environmental or ecological anthropology only became fully established in the 1960s. Nevertheless, anthropological interest in the environment and ecology goes back a long way. The following constitute the main theories regarding the relationship between culture and environment and how these have evolved over time and with the development of Anthropology as a discipline.

Environmental Determinism

The theory of environmental determinism claims that environmental features have a direct impact on the features of human behaviour, and thus, on human society. It is based on the belief that the environment (most notably its physical factors such as landforms and/or climate) determines the patterns of human culture and societal development. This theory rose to prominence in the late nineteenth century as a central concern of Human Geography, or Anthropogeography, as it is sometimes called. The German scholar **Friedrich Ratzel** was impressed by the influence of the natural setting on the ways of life of peoples and held the view that the habitat of a people cannot be neglected in assessing those influences that play on the formation and functioning of culture. However, his followers changed this to a more rigid formulation, which held that **the habitat is the determining factor in shaping a way of life, which is called environmental determinism**.



Environmental Possibilism
The early work of American anthropologists like that of Goldenweisser (1937) was characterised by a stress on historical and cultural descriptions, which focused on the uniqueness of human groups. According to this view, which has come to be known as historical particularism, environment was seen as an inert force that narrows human options but which played no dynamic role in the surfacing of observable human traits or institutions. It is belief that people not environment are the architect of their own cultures. Any environment offers a variety of ways that a culture can develop. The culture is shaped by the choices the people make in interacting with their environment. **In The Mind of Primitive Man (1911), Boas noted that the environment furnishes the material out of which people shaped and developed the artefacts of daily life but it was historical forces and diffusion, which primarily explained the particular forms that given artefact took.**

Cultural Ecology

According to Steward, Cultural Ecology is the study of the relationship between culture and natural environment in which two orders of phenomena are involved: (i) all the biotic and abiotic features of the natural environment and (ii) the cultural elements by which human beings adapt with the environment including technology and economic organisation. But Steward did not believe in a circular causality of all the parts of the ecosystem in which every part has an equal role to play for the maintenance of the whole. This is the reason that **he subdivided culture into 'core' and 'secondary features**. Another important aspect of the contribution of Julian Steward lies in the field of Cultural Evolution. For him, human ecosystems are dynamic and social evolution is not unilinear, it is multilinear, since each culture *adapts* to its local environment and also *changes* in its unique way.

His theory of **Cultural Ecology stands intermediate between the deterministic and possibilist position** and refers to 'a reciprocal or interactional phrasing of man-environment relations which assumes that neither man nor environment is necessarily dominant' (Anderson, 1973, p.185). Steward developed Cultural Ecology as a framework for causal explanation of cultural differences and similarities.

Steward framed his approach in terms of adaptation and the adaptive processes through which a historically derived culture is modified in a particular environment, arguing on analytical and empirical grounds that over the millennia, cultures in different environments have changed tremendously, and these changes are basically traceable to new adaptations required by changing technology and productive arrangements.

Steward was concerned with cross-cultural comparisons and with the causal connection between social structure and modes of subsistence. The **crucial focus in his approach was neither on environment nor culture. Rather, the process of resource utilisation**, in its fullest sense, was research priority. The cultural ecological approach proposed by him involved both a problem and a method. The problem was to test whether the adjustment of human societies to their environments required specific type of behaviour or whether there is considerable latitude to human responses. The method, according to him, involved three procedures:

- Describing the natural resources and technology used to extract and process them.
- Outlining the social organization of work for these subsistence and economic activities.
- Tracing the influence of these two phenomena on other aspects of culture.

The theory of Cultural Ecology, as developed by Steward, **paid primary attention to those features which empirical analysis showed to be most closely involved in the utilisation of environment in culturally prescribed ways, which he referred to as culture core**. He defined a culture core as the constellation of features which are most closely related to subsistence activities and economic arrangements. Yet, **cultural ecology could neither provide a model for explaining the origin and persistence of cultural features, nor for determining the extent of environmental influence in the evolution of specific cultures.**

Geertz (1963) has pointed out that the **concept of culture core, as advanced by Steward, proved to underestimate the scope, complexity, variability, and subtlety of environmental and social systems**. **Vayda and Rappaport** (1968), among others, found the concept of the culture core to give undue weight to culture as the primary unit of analysis, and found the presumption that organisation for subsistence had causal priority to other aspects of human society and culture to be both untested and premature.

The Concept of Ecosystem

In the **1960s and 1970s**, the field became influenced by new concepts developed by anthropologists who largely structured their data based on **ecological models**. Roy A.

Rappaport, and Andrew P. Vayda (1968), developed an **ecosystem approach** that treated **human populations as one of a number of interacting species and physical components** and transformed **Cultural Ecology into Ecological Anthropology.**

While Steward tied culture with the environment, a new approach, called the **"new ecology,"** tied culture with the emerging science of systems ecology (e.g.,Vayda and Rappaport, 1968). The **ecosystem approach**, brought into play by anthropologists like Rappaport (1968) and Vayda (1969), conceptualised **human populations as participants in ecosystems**. They suggested that **instead of studying how cultures are adapted to the environment, attention should be focused on the relationship of specific human population to specific ecosystem.** In their view, human beings constitute simply another population among the many populations of plants and animals species that interact with each other with the non-living components (climate, soil, water etc) of their local ecosystem. Thus, the **ecosystem rather than culture, constitutes the fundamental unit of analysis** in their conceptual framework for human ecology. The **analytic unit shifted from "culture" to the ecological population,** which was seen as using culture as one of the means (the primary means) of adaptation to environments.

Geertz in his Agricultural Involution (1963) was the first to argue for the usefulness of the ecosystem as a unit of analysis in Social/Cultural Anthropology. Its merits were stated: system theory provided a broad framework, essentially qualitative and descriptive, that emphasised the internal dynamics of such systems and how they develop and change.

Vayda and Rappaport were perhaps the first anthropologists to advance the notion of 'the possibility and desirability of a single science of ecology with laws and principles that apply to man as they do to other species. They first focused on an analysis of energy input and output in technology and social organisation of work to collect and produce food. All of this was set within the biological framework of limiting factors and carrying capacity. **Components of culture such as religion and warfare were viewed as regulating mechanisms that helped to maintain a balance between the population and its resources**. This theoretical framework was implemented **by Rappaport (1967) in his fieldwork among the Tsembaga** of New Guinea. He viewed their **ritual and warfare as regulating the delicate balance between the human and pig populations** to reduce competition between the two species, with humans being surprisingly close to pigs in physiology, body and group size and omnivorous diet. He argued that a **human population was a species within the ecosystem**; that the system operated according to laws of nature that could be understood in the light of system theory. In this framework major cultural processes like **ritual could be understood to play cybernetic (automatic control system) functions**.

This 'biologisation' of the ecological approach in Cultural Anthropology led to the label of Ecological Anthropology replacing Steward's label of Cultural Ecology, although the **two are**

sometimes used as synonyms. Through the work of Rappaport in particular, the cybernetic/ecosystemic view became a dominant trend in environmental or Ecological Anthropology.

HUMAN BIO-CULTURAL ADAPTATIONS

Humans have occupied a wide range of habitats because of their ability to intervene environment- the living and inanimate, for their purposes. This approach **is largely based on a notion of adaptability**, which regards individuals as being equipped with a set of biological traits that provide means of survival within certain limits. It involves physiological, structural, behavioural or cultural changes aimed at improving the organism's functional performance in the face of environmental stress. These **adjustments can either be temporary or permanent, acquired either through short term or lifetime processes.** Thereby expressed in terms of phenotype variation of continuous trait, physiological acclimatisation and learned behaviour. There seems to be few situations in which human population **develop genetic adaption to specific environment** expressed in terms of phenotypic variation which eventually leads to differences in allele frequency between populations. On the other hand, decades of research affirm that biological plasticity or physiological acclimatisation is species wide adaptive mechanisms which enable individuals to maintain internal constancy or homeostasis.

ADAPTATION: MEETING THE CHALLENGES OF LIVING

Humans adjust remarkably well to new conditions and to challenges. As in other organisms, such adjustments—functional responses within particular environmental contexts—**occur at four different levels. *Genetic* adjustments or adaptation** occurs at the population level via natural selection. Here, the biological change is inherited and is not reversible in a person (e.g., someone with sickle-cell anaemia). ***Developmental* (or *ontogenetic*) adjustments** occurs at the level of the individual during a critical period of growth and development, childhood especially. The capacity to make the change is inherited, but the change is not inherited and is not reversible. For example, children living at high altitudes develop greater chest size prior to reaching adulthood than do children living at low altitudes. The expanded chest reflects the need for increased lung capacity in settings where less oxygen is available. ***Acclimatization* (or *physiological* adjustment)** occurs at the individual level, but unlike developmental adaptation it can occur anytime during a person's life. In this kind of adaptation, the change is not inherited and can be reversed. For example, exposure to sunlight for extended periods of time results in tanning (also discussed further below). Lastly, ***cultural* (or *behavioural*) adjustment** involves the use of material culture to make living possible in certain settings. For example, wearing insulated clothing keeps people from freezing in extreme cold.

Mutation-changes in the structure of a gene-are the ultimate source of all genetic variation. Because different genes make for greater or lesser chances of survival and reproduction, natural selection results in more favourable genes becoming more frequent in a population over time. We call this process **adaptation**. **Adaptations are genetic changes that give their carriers a better chance to survive and reproduce than individuals without the genetic change who live in the same environment.** It is environment that favours the reproductive success of certain traits rather than others.

How adaptive a gene or trait is dependent on specific environment. What is adaptive in one environment may not be adaptive in other. For example, dark moths had advantage over light moths when certain areas of England became industrialized. Predators could not easily see the darker moths against the newly darkened trees and these moths soon outnumbered the lighter variety.

Adaptations through natural selection does not account for variation in frequencies of neutral traits- that is, traits do not confer any advantages or disadvantages on their carriers.

Variation in Adaptations

Humans have settled in places from the hottest deserts and rain forests to the coldest reaches above the Arctic Circle. No matter how much we may sweat, shiver, increase our metabolic rate, and change the shape of our blood vessels, it may not be enough to deal with some environmental extremes. Thus, populations have undergone natural selection for genetic and phenotypic variation in response to certain environmental variables. Here are some classic examples.

Climate Populations that inhabit hot climates tend to be linear in build, and those in cold areas tend to be stockier the linear individual has a greater surface area and so loses heat more rapidly, whereas the stockier person has a smaller surface area and so retains heat better. A similar relationship holds true for head shape, which was a popular measure of racial affiliation in the nineteenth and early twentieth centuries. As it turns out, there is a correlation between head shape and climate. Simply put, populations in cold climates tend to have wider heads relative to their length. Rounded heads lose heat more slowly.

Nose shape is another example. The mucous membranes inside our noses serve to warm and moisten air. Cold and dry air is detrimental to the lungs and to the mucous membranes themselves. Thus, long, narrow noses are found in populations in cold and/or dry climates. Short, wide noses are more common in hot and/or moist areas, where the air does not need to be adjusted as we breathe in.

Sunlight Ultraviolet radiation varies with latitude. Sunlight strikes the earth more directly at the equator and at an increasingly greater angle the farther one gets from the equator. The greater the angle, the more atmosphere the solar radiation must travel through. Thus, more UV radiation is absorbed by ozone in northern latitudes. Not only do humans have the ability to tan in response to increased UV levels, but, as is obvious to us all, populations are genetically programmed for differences in skin color, and these differences also vary by latitude. In general, populations closer to the equator have darker skin, and those farther away from the equator have lighter skin. It is generally agreed that the relationship between dark skin and high levels of UV radiation is an example of an adaptive response. Because of the damaging effects of UV radiation, particularly destruction of folic acid necessary for embryo development and sperm production, populations at or near the equator have undergone selection for permanently higher levels of melanin production. Darker-skinned people do not have more melanocytes than lighter-skinned ones, just more melanin production. An implication of this, of course, is that dark skin was the original human skin color, since our species first evolved in equatorial Africa. Moreover, the African great apes, our closest relatives, have darkly pigmented skin, so it could be a shared trait inherited from a common ancestor. The adaptation would have become even more important when hominids lost their protective covering of hair.

The question then becomes, Why did populations who moved away from the equator evolve lower melanin production and therefore lighter skin? It is easiest to say that since dark skin was no longer needed, it became light. Evolution, however, doesn't really work this way. More likely, there was an adaptive reason why lighter skin was actively selected *for*.

The explanation has to do with vitamin D production. Vitamin D can be synthesized by the body in the lower layers of skin when a precursor of the vitamin is activated by UV radiation. This vitamin is important in regulating the absorption of calcium and its inclusion in the manufacture of bone. This is especially important during pregnancy and lactation, possibly accounting for the fact that in all populations females tend to be more lightly pigmented than males (Jablonski and Chaplin 2000, 2002).

Deficiency in vitamin D can lead to a condition of skeletal deformity in children known as rickets. (There is an adult version of the abnormality as well.) Bones with rickets are also more prone to breakage, and the disease can cause a deformity of the pelvis that can make childbirth difficult. Vitamin D is also important for the normal functioning of the immune system. As populations moved away from the equator, those with darker skin could not manufacture sufficient vitamin D for normal bone growth and maintenance and immune-system functioning. Those with lighter skin, therefore, were at an adaptive and, thus, a reproductive advantage. Over time, lighter skin became the normal, inherited condition in these groups. Skin color is thus seen as a balancing act — dark enough to protect from the damaging effects of UV radiation and light enough to allow the beneficial effects.

Diet Culture is part of our environment, and thus natural selection can take place in response to cultural practices. One example involves variation in the body's ability to produce lactase, an enzyme necessary for the digestion of lactose, a sugar found in milk. For the majority of people, the ability to digest milk decreases after childhood. For them, ingesting dairy products can result in digestive problems such as diarrhea and cramps. Populations with long histories of extensive reliance on dairy farming, however, have high frequencies of *lactase persistence,* the ability to produce lactase beyond childhood. The dominant allele of a single gene that codes for lactase persistence has been selected for because those possessing that allele had an advantage — the ability to use an important dietary resource throughout their lives. This gene is common in Europeans and among the Fulani, cattle herders of West Africa, who rely heavily on milk in their diet. Analysis has indicated that this selection has taken place over the last 5,000 to 10,000 years, which is consistent with estimates of the origin of dairy farming.

There is also evidence of some relationship between lactase persistence and latitude. Recall the information about vitamin D and latitude just discussed. Perhaps increased ability to digest lactose in northerly latitudes is advantageous because lactose aids in calcium absorption. This might help explain the high frequencies of lactase persistence in Europeans (as much as 96 percent in Sweden), but it doesn't account for high frequencies in the Fulani.

All adaptations have one purpose: **maintenance of internal homeostasis**, or **maintenance of the normal functioning of all organs and physiological systems**. Not to maintain homeostasis in body temperature, for example, or in oxygen accessibility, or in strength of the bones of the skeleton has severe consequences for the individual, including work impairment and loss of productivity, decline in quality of life, and even death. The maintenance of homeostasis involves all levels of any organism's biology, from biochemical pathways to cells, tissues, organs, and ultimately the entire organism.

ACCLIMATIZATION

Acclimatization is another kind of physiological response to environmental conditions, and it can be short-term, long-term, or even permanent. The physiological responses to environmental factors are influenced by genes, but also affected by the duration and severity of the exposure, technological buffers (such as shelter or clothing), and individual behaviour, weight, and overall body size. Individual develop them during their lifetime rather than being born with them. The simplest type of acclimatization is a temporary and rapid adjustment to an environmental change (Hanna, 1999). **Tanning**, which can occur in everyone (except people with albinism), is one example. Another, which you may have unknowingly experienced, is the very rapid increase in haemoglobin production that occurs when people who live at low elevations travel to higher ones. This increase provides the body with more oxygen in an environment where oxygen is less available. In both of these situations, the physiological change is temporary. Tans fade once exposure to sunlight is reduced, and haemoglobin production drops to original levels following a return to a lower elevation.

Many of our acclimatization are simple physiological changes. For example, when we are chilled our bodies try to create heat by making our muscles work, a physiological response to environment that we experience as shivering. Longer exposure to cold weather leads or bodies to increase our metabolic rates so that we generate more internal heat. Both these physiological changes are short term (shivering) and one long term (metabolic rate).

On the other hand, *developmental acclimatization* is irreversible and results from exposure to an environmental challenge during growth and development. Lifelong residents of high altitude exhibit certain expressions of developmental acclimatization.

Some long-term acclimatization are difficult to distinguish from adaptations because they become established as normal operating processes, and they may persist even after the individual moves into environment that is different from one that originally fostered the acclimatization.

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MAN'S PHYSIOLOGICAL RESPONSES TO ENVIRONMENTAL STRESSES

HEAT/HOT DESERTS

Like all other mammals, humans are **homoeothermic,** meaning they maintain a constant body temperature. A constant core temperature is essential for normal physiology, including brain function, limb function, and general body mobility. Humans can tolerate a body temperature higher than their normal 98.6 °F, but a body temperature above 104–107 °F for an extended period leads to organ failure and eventually death. Extremely hot weather can thus result in many deaths, such as in the summer of 2003, when at least 35,000 and perhaps as many as 50,000 people died in Europe during one of the hottest seasons ever recorded. Severe heat stress is experienced mostly in tropical settings, where it is hot much of the year, and during hot spells in temperate regions.

A body experiencing heat stress attempts to rid itself of internally and externally derived heat sources. Internal heat is produced by the body's metabolism, especially during activities involving movement, such as physical labour, walking, and running. External heat is derived from the air temperature. The initial physiological response to an elevated temperature is **vasodilation,** the dilation (expansion) of the blood vessels near the body's surface. By increasing blood vessels' diameter, the body is able to move more blood (and associated heat) away from the body's core to the body's surface. The red face of a person who is in a hot environment is the visible expression of vasodilation.

Sweating is another response to heat. Sweat is mostly water produced by the eccrine glands, which are located over the entire body's surface. Evaporation of the thin layer of water on the skin results in cooling of the surface. Humans can sweat a remarkably high volume of water, and this physiological process is central to humans' long-term functional adaptation to heat. Sweating is less effective in areas of the body having a dense hair cover than in areas of the body having little or no hair. This relationship suggests that **sweating evolved as a thermoregulatory adaptation in association with the general loss of body hair**. Humans' loss of body hair is unique among the primates, indicating that the thermoregulatory adaptation of hair loss and sweating occurred in human evolution only.

Humans have a strong capacity to adapt to excessive heat. Individuals who have not often experienced such heat are less able to conduct heat away from their cores and less able to sweat than are individuals living in hot climates. Individuals exposed for the first time to a hot climate, however, rapidly adjust over a period of 10 to 14 days. This adjustment involves a lowering of the body's core temperature, a lowering of the threshold for when vasodilation and sweating begin, and a reduction of the heart rate and metabolic rate**. Overall, women are less able to tolerate heat than are men, in part due to a relatively reduced ability to move blood to the skin through vasodilation and the presence of greater body fat.**

Human populations who have lived in hot climates for most of their history— such as native equatorial Africans and South Americans—have the same number of sweat glands as other populations. However, heat-adapted populations sweat less and perform their jobs and other physical functions better in conditions involving excessive heat than do non-heat-adapted populations.

BODY SHAPE AND ADAPTATION TO HEAT STRESS The relationship between body shape and temperature adaptation was first described in the 1800s by a combination of two biogeographic rules, one developed by the German biologist Carl Bergmann (1814–1865) and the other developed by the American zoologist Joel Allen (1838–1921).

Bergmann's Rule states that **heat-adapted mammal populations** will have smaller (in weight and size it means lean body) bodies than will **cold-adapted mammal populations**. Relative to body volume, small bodies have more surface area, facilitating more-rapid climates. Consequently, human populations adapted to hot climates tend to have small and narrow bodies.

Allen's Rule states that **heat-adapted mammal populations will have long limbs**, which maximize the body's surface area and thus promote heat dissipation, whereas cold-adapted mammal populations will have short limbs, which minimize the body's surface area and thus promote heat conservation.

Exceptions exist to Bergmann's and Allen's rules, but by and large these rules explain variation in human shapes that goes back at least 1,500,000 years. Populations living in hot climates tend to have small, narrow bodies and long limbs. Populations living in cold climates tend to have large, wide bodies and short limbs. This long-term association between body shape and climate means that body shape is mostly a genetic adaptation. However, body shape also involves childhood developmental processes that respond to climatic and other stressors, such as poor nutrition. For example, poor nutrition during early childhood can retard limb growth, especially of the forearm and lower leg, resulting in shorter arms and legs. Ultimately, then, body shape and morphology reflect both evolutionary and developmental processes.

Cultural adaptation

It pertains to the creation and maintenance of favourable environmental conditions near the individual - microclimate, different from those in the general area. The ideal microclimate involves lowered skin temperature, a vapour pressure gradient favouring evaporative heat loss, and protection from conductive, convective and radiation heat gain. It is within the extrasomatic zone that behavioural and social adaptations play a major role by maintaining a favourable microclimate within a larger and more stressful macro-environment. (Hanna, 1983).

Material Culture as habitations and clothing establish a favourable microclimate while behavioural adaptation centre's largely upon avoidance. Houses are constructed of high heat capacity materials such as adobe and stone, to delay entry of heat. These materials absorb large amount of heat before passing it into the interior and the stored heat is lost at night by radiation and convection. The net effect is to dampen temperature fluctuation so that interior temperature remains moderate. **Pueblo Indians, Middle Eastern communities construct their house several meters beneath the surfaces** as the mean temperature of subsoil is more comfortable that the surface with its extreme variation. In habitation above the ground, compact geometry minimizing surface area to internal volume reduces solar heat gain as well as convention heat gain from desert winds.

Clothing, another aspect of material culture reduces abrasions, prevents sunburn and reduces solar heat gain. This in turn reduces level of perspiration required to maintain equilibrium. It has been proposed that well-acclimatized individual wearing clothes perspire 30% less than unclothed men at rest which reduces the heat load of about 165 kcal/hr. (Henschel and Hanson, 1959)

Chaamba Arabs, tribal population of Sahara Desert wear clothing that minimises conductive and radiant heat gains from the environment. The insulative effects of trapped air reduce heat transmission to the skin surface. However, clothing is less advantageous at work than at rest as it hinders the loss of internally generated heat and loose fitting, baggy clothing is desirable. Such cases, favours ventilation and evaporates from the skin surface. Furthermore, a light-coloured external garment may reflect radiation reducing heat gain.

COLD

Severe cold stress is experienced mostly in places close to Earth's magnetic poles, such as the Arctic; at altitudes higher than 10,000 feet (3 km); and during cold spells in temperate settings. **Hypothermia,** or low body temperature, occurs in excessively cold air or immersion in cold water. During the great *Titanic* disaster, in 1912, many hundreds of passengers and ship's crew members escaped the sinking vessel but died from hypothermia after floating in the northern Atlantic Ocean (28 °F) for two hours before rescue ships arrived.

Maintaining homeostasis against cold stress involves heat conservation and heat production. The human body's first response to cold stress is **vasoconstriction,** the constriction of the blood vessels beneath the skin. Decreasing the diameter of the blood vessels reduces blood flow and heat loss, from the body's core to the skin. The chief mechanism for producing heat is **shivering**.

Humans adapt to cold, but the adaptation includes cultural and behavioural factors, practices that societies living in extremely cold settings pass from one generation to the next. That is, people teach their children how to avoid situations involving heat loss. They teach them what clothing to wear, what kinds of shelters to build, and how to keep the interiors of shelters warm. Cold-adapted cultures also know that alcohol consumption contributes to the loss of body heat, increasing the chances of hypothermia and death. After being exposed to survivable cold for more than a few days, humans shiver less, produce more heat, and have higher skin temperatures. Overall, adjusting to cold means becoming able to tolerate lower temperatures—simply, feeling better in the cold.

To measure heat production, anthropologists take a specific kind of measurement called the **basal metabolic rate (BMR).** Indigenous people living in cold settings, such as the Indians at high altitudes in the Peruvian Andes, have **significantly higher BMR** than do other human populations. Eskimos are among the most studied populations on Earth, owing to their adaptation to the very cold, dry conditions in the Arctic Circle, where average winter temperatures range from –50 °F to –35 °F and even summer temperatures usually do not climb above 46 °F. In part, the Eskimos' high BMR is produced by their diet, which is high in animal protein and fat (about 9 calories per gram) and low in carbohydrates (about 3 cal/gm). Like most cold-adapted populations, however, the Eskimos have adapted physiologically by developing a capacity for tolerating excessive cold. For example, their peripheral body temperatures, in the hands and feet, are higher than other peoples' because of a higher rate of blood flow from the body's core to the skin.

Himalayan population of India wear several layers of cloth to combat cold, but extremities remain exposed to cold stress. However, they are characterised by elevated resting metabolic rate and high level of blood flow to the extremity to maintain warm surface temperature during local exposure to cold (Little et al, 1977).

Body size and proportions are also important in regulating body temperature. In general, within a species, body size increase with the distance from the equator. Two rules that pertain to such relationship between body size, body proportion and climate are:

1) **Bergman rule**
In mammalian species, **body size tends to be greater(fatter)** in population inhabiting colder climates. Increased mass thereby decreased surface area allows greater heat retention and reduced heat loss eg. Arctic region

2) **Allen's Rule**
In colder climates, **shorter appendages**, with increased mass-to-surface ratios are effective at preventive heat loss. Conversely longer appendages with increased surface area relative to mass permit heat loss eg. Sub Saharan Africans.

Eskimos conform to Bergmann's and Allen's rules, having large, wide bodies and short limbs. Moreover, they have developed a technology that conserves heat: their traditional housing focuses on insulation, so that even the walls of ice constructed "igloos" include whale rib rafters that are covered with alternating layers of seal skin and moss. Heat conductivity from a fire built beneath the main Floor of the house serves to warm cold air as it rises, which is a simple but highly efficient way to heat a small interior environment.

Cultural adaptation
The diurnal-nocturnal variation in the temperature exposes the Aborigines of Australia to heat stress during day and moderate cold stress during night. As they wore no clothing and did not built shelters, the heat against the cold stress is provided by sleeping fires. They also experience continuous vasoconstriction throughout the night which prevents them from excessive internal heat loss with no threat of frostbite.

The Bushman of Kalahari Desert, like the Australian Aborigines are exposed to moderate chronic cold stress during night. They have been able to create a microclimate around their bodies that is close to the thermoneutral temperature of 25°C through efficient use of fires and skin cloaks during cold nights (Frisancho, 1993). They sleep in a group of three or four in families or in single sex groups. The heat made up of grass and boughs are placed in a half-circle as wind breakers.

Eskimos occupy the northwestern coast of North America and across the Bering Strait into Asia. They have well insulated housing known as 'Igloo'. Their wall made of whole rib rafters are covered with a double layer of seal skin attired with moss. They place the source of heat usually an oil, blubber or coal lamp at a lower level than the main floor; where by cold air is warmed before it reaches the area where people live. The housing structure permits trapping of air which in turn further provides insulation. Such an efficient heat exchange system maintains between 10ºC to 21ºC for coastal Eskimos despite sub-zero environmental temperature. Their clothing is made of caribou which provides higher insulation as compared to seal skin. Although Eskimo wear snowshoes and short skin mittens at times, during their daily activities such as fishing, their hands and feet are continuously subject to cold stress. They experience intermittent periods of vasoconstriction and vasodilation which prevent frost bite in below freezing temperatures. At the same time, because vasodilation is intermittent, energy loss is restricted, with more heat retained at body's core. The high peripheral temperatures of extremities and high tolerance to cold of Eskimos and highland Quenchas appear to reflect the influence of developmental acclimatisation. Traditionally they have the highest animal protein and fat diet than any other human population. Such a diet, necessitated by the available resources base, served to maintain the high metabolic rates required by exposures to chronic cold.

Humans, and some other animals, also have a subcutaneous (beneath the skin) fat layer that provides insulation throughout the body. In many overfed populations today, this fat layer is an annoyance to many and a major health issue for others. But in the not-too-distant past, our hunting and gathering.
ancestors relied on it not only for some protection against the cold but also as a source of nutrients when food was scarce.

These examples illustrate some of the ways adaptations to cold vary among human populations. Obviously, winter conditions exceed our ability to adapt physiologically in many parts of the world. If our ancestors hadn't developed cultural innovations, they would have remained in the tropics and
the history of humanity, and the planet, would have been entirely different.

HIGH ALTITUDE

Studies of high-altitude residents have greatly contributed to our understanding of physiological adaptation. As you would expect, altitude studies have focused on inhabited mountainous regions, particularly in the Himalayas, Andes, and Rocky Mountains. Of these three areas, permanent human habitation probably has the longest history in the Himalayas (Moore et al.,1998). Today, perhaps as many as 25 million people live at altitudes above 10,000 feet. In Tibet, permanent settlements exist above 15,000 feet, and in the Andes, they can be found as high as 17,000 feet.

Because the mechanisms that maintain homeostasis in humans evolved at lower altitudes, we're compromised by conditions at higher elevations. At high altitudes, humans face numerous environmental challenges. These include **hypoxia, more intense solar radiation, cold, low humidity, wind, a reduced nutritional base, and rough terrain.** Of these, hypoxia causes the greatest amount of stress for human physiological systems, especially the heart, lungs, and brain.

Hypoxia results from reduced barometric pressure. It isn't that there is less oxygen in the atmosphere at high altitudes, it's just less concentrated. Therefore, to obtain the same amount of oxygen at 9,000 feet as at sea level, people must make physiological alterations that increase the body's ability to transport and efficiently use the oxygen that's available. These challenges with oxygen supply at high altitudes affect reproduction through increased infant mortality rates, miscarriage, low birth weights, and premature birth. In general, the problems related to childbearing are attributed to issues that compromise the vascular supply (and thus oxygen transport) to the foetus.

One cause of foetal and maternal death is preeclampsia, a severe elevation of blood pressure in pregnant women. Palmer and colleagues (1999) reported that among pregnant women living at elevations over 10,000 feet in Colorado, the prevalence of preeclampsia was 16 percent, compared to 3 percent at around 4,000 feet.

People born at lower altitudes and high-altitude natives differ somewhat in how they adapt to hypoxia. When people born at low elevations travel to higher ones, the process of acclimatization begins within a day or two. These changes include **an increase in respiration rate, heart rate, and production of red blood cells.** (Red blood cells contain haemoglobin, the protein responsible for transporting oxygen to organs and tissues.)

Developmental acclimatization occurs in high-altitude natives during growth and development. This type of acclimatization is present only in people who grow up in high-altitude areas, not in those o move there as adults. **Lifelong residents of high elevations have**

greater heart and lung capacity than do people from lower elevations. They are also more efficient than migrants at diffusing oxygen from
blood to body tissues, and geneticists are beginning to identify the genes that regulate this ability. Developmental acclimatization to high-altitude hypoxia is an excellent example of physiological flexibility that illustrates how, within the limits set by genetic factors, development can be influenced by environmental factors. **The best evidence for permanent high-altitude adaptation is provided by the indigenous peoples of Tibet**. These people have inhabited regions higher than 12,000 feet for at least 7,000 years (Simonson et al., 2010) and perhaps as long as 25,000 years.

Altitude doesn't affect reproduction in high altitude Tibetans to the degree it does in other populations. Infants have birth weights as high as those of lowland Tibetan groups and higher than those of recent Chinese immigrants. This disparity in birth weights may be the result of alterations in maternal blood flow to the uterus during pregnancy (Moore et al., 2001; 2006). Another line of evidence concerns how the body processes glucose (blood sugar). Glucose is critical because it's the only source of energy used by the brain, and it's also used, although not exclusively, by the heart. Both highland Tibetans and the Quechua (inhabitants of high-altitude regions of the Peruvian Andes) burn glucose in a way that permits more efficient use of oxygen. This implies the presence of genetic mutations in the mitochondrial DNA because mtDNA directs how cells use glucose. We now have firm evidence that natural selection has acted strongly and rapidly to increase the frequency of certain alleles that have produced adaptive responses to altitude in Tibetans. Ninety percent of Tibetan highlanders possess a mutation in a gene involved in red blood cell production. In effect, this mutation inhibits the increased red blood cell production normally seen in high-altitude inhabitants. Tibetan highlanders have red cell counts similar to those of populations living at sea level. Interestingly, the Quechua and other high-altitude residents of the Andes do not have this mutation and have higher red cell counts than lowland inhabitants. But if increased red blood cell production is advantageous at high altitude, why would selection favour a mutation that acts against it in Tibetans? The answer is that beyond certain levels, elevated numbers of red cells can actually "thicken" the blood and lead to increased risk of stroke, blood clots, and heart attack. In pregnant women, they can also lead to impaired foetal growth and even foetal death. Thus, although the mechanisms aren't yet understood, Tibetans have acquired a number of genetically influenced adaptations to hypoxic conditions while still producing the same amount of haemoglobin we would expect at sea level.

Because the mutation is believed to have appeared only around 4,000 ya, its presence throughout most high-altitude Tibetan populations is the strongest and most rapid example of natural selection documented for humans (Yi et al., 2010).

The Spitians who inhabit high altitudes in the North West Himalayas showed large chest size in relation to stature indicating developmental adaptation to low oxygen pressure of high altitude (Singh et al. 1986). The larger chest circumference of the Bods of Ladakh as compared to lowland Indians also suggests a structural response to the greater lung function capacity and adaptation to high altitude hypoxia (Kapoor & Kapoor, 2005; Bhasin et al. 2008;). Rajis, a hunter-gatherer tribal population of Uttaranchal showed lower chest circumferences comparable to the mid-altitude population but lung functions comparable to those of other high-altitude populations. This leads to the conclusion that indigenous high-altitude populations may possess different genetic potential for thorax growth compared to low-altitude populations, possible related to ethnic differences in the rate of growth of thorax related to stature at high (Kapoor et al., 2009).

BERGMANN'S RULE AND ALLEN'S RULE

In the nineteenth century, two biologists, Carl Bergmann (1814–1865) and Joel Asaph Allen (1838–1921), looked at the relationship between body size and climate in a wide range of mammals. They found that within polytypic species, there were predictable relationships between body form and proportions and temperature.

Bergmann's rule (1847) focuses on body size. This rule was named after a German Biologist Carl Bergmann, who described the physiological differences in Organism according to their climatic conditions in 1847. According to Bergmann's rule, geographic races of a species possessing smaller body size are found in the warmer regions and race of larger body size are found in cooler regions (Timofeev, 2001; Tarraga et al., 2006). Endothermic animals like Birds and Mammals of colder areas are found to have less surface area: volume ratio i.e. heavier body as compared with warmer areas. Evidence to support the rule can be found in Polar bears who are much larger size than the spectacled bears living closer to the equator. Another example can be cited for Penguins, Penguins living in Arctic areas are generally 1m long in length as compared to the 0.5m long penguins of Galapagos Island. This makes geometric sense in that as volume increases, surface area decreases as a proportion of the volume. This would decrease the rate of heat dissipation through the surface, which helps to maintain a higher core temperature.

Bergmann's Principle in Human

Human population living near the arctic poles like Inuit, Aleut, Sami people are on average heavier than populations from mid-latitudes is consistent with Bergmann's rule. They also tend to have shorter limbs and trunks which validate the Allen's rule (Holliday et al., 2010). Marshall T Newman in his report in the Journal of American Anthropologist in 1953, mentioned that Native American populations are generally consistent with Bergmann's rule and he also added that populations of Eurasia also holds with Bergmann's rule (Marshall, 1953).

Allen's rule (1877) focuses on the appendages of the body. In endothermic animals from hot climates usually have long and thin ears, tails, limbs, snout etc. whereas equivalent endotherms from cold climates usually have shorter and thicker ears, tails and limbs. For example, limbs should be longer relative to body size in warmer climates because that would help to dissipate heat, whereas shorter limbs in colder climates would conserve body heat.

Does this rule hold true with modern Humans?

Allen's rule in practice can be found with Eskimos who have stockier body build and shorter limbs in comparison to East African tribes like Masai who have long and linear body build. In Peru, individuals of the same population who lived at higher altitude tended to have shorter limbs whereas those who inhibited more low-lying coastal areas generally had longer limbs and larger trunks (Weinstein and Karen, 2005). Katzmarzyk and Leonard in 1998 similarly noted that indigenous human population living in colder regions have proportionately shorter legs and people who have their origin in the hotter region have proportionately longer legs for their height.

An example of Bergman's and Allen's rules can be found in comparing snowshoe and desert hares. The ears of the desert hare are much longer than those of the arctic hare and the body much leaner and rangier; both are features that dissipate heat.

Body forms of peoples living in some extreme environments are consistent with the rules. If we look at the Inuit in the Arctic and Nilotic peoples from East Africa, we see that the stocky, short-limbed Inuit body seems to be structured to conserve heat, whereas the long-limbed Nilotic body is designed to dissipate heat. Looking at a broad range of populations, there is a general trend among humans for larger body size and greater sitting height (that is, body length) to be associated with colder climates, whereas relative span (fingertip to fingertip length divided by height) tends to be greater in warmer temperatures (that is, longer appendages relative to body size) (Roberts, 1978).

Because it seems unlikely that an Inuit person raised in East Africa would grow up with drastically modified limb and body proportions, should we assume that the associations between body form and climate in humans always result from genetic differences? The evidence that body-size proportions reflect developmental adaptability is not particularly strong. The results of a classic study conducted in the 1950s on U.S. soldiers showed a relationship between state of origin (that is, warmer or colder) and body proportions (Newman & Munroe, 1955) and was interpreted to represent an example of adaptability or acclimatization rather than adaptation. However, a recent analysis of updated Army data shows that if one takes into account whether the soldiers are of African or European ancestry, the climate association disappears (Steegman, 2007). European-Americans have shorter legs and longer trunks than African Americans, and warmer (that is, southern) states may have had a higher representation of African-Americans than the colder states in these Army data.

One study shows that climate change may affect primate phenotypes in accordance with Allen's and Bergmann's rules (Paterson, 1996). In the 1960s, two troops of Japanese macaques (*Macaca fuscata*) were transferred from one location in Japan to an Oregon primate center. Subsequently, one of the troops was moved to a facility in Texas. Analysis of long-term records (more than 20 years) on body size and proportions in the troops showed that by the 1990s, the Oregon monkeys were significantly larger than their Texas cousins, whereas the Texas monkeys had significantly longer limbs. The Oregon monkeys lived at latitude 45° N, whereas the Texas troop was at 28° N; the Texas site was substantially warmer. Thus, the results were in accordance with predictions based on Allen's and Bergmann's rules. Although natural selection could have been responsible for the body changes, it would be surprising to see such effects after only two generations and in the absence of any obvious differences in fertility.

GLOGER'S RULE

This rule was remarked after the name of zoologist Constantin Wilhelm Lambert Gloger, who put forward the rule in the year 1833 based on covariation of climate and avian plumage color. According to this rule skin pigmentation is higher in animals living in warm and humid habitats in comparison to animals living in cold and dry places. During his study, Gloger found that birds in more humid habitats are darker than their relatives living in the regions with higher aridity (Gloger, 1833). More than 90% of 52 North American bird species has been observed to confirm this rule. For example, the song sparrow (Melospiza melodia) living in high humid regions shows darkly coloured wings and furs comparison to pale coloured living in low humid regions (Stresemann et al., 1975). Edward H. Burtt in a report in 2004 suggested that dark coloured feathers are also resistant to bacterial degradation, which is a major problem in humid habitats as bacteria thrives less in arid habitats.

Gloger's rule in Human

Mammalian species including humans also showed the tendency to have a darker skin color living in equatorial and tropical regions. This can be explained in terms of better adaptation against excessive solar ultraviolet (UV) radiations at lower latitudes. Some exception have been observed among Tibetans who have darker skin color living in the colder region and in their native latitude far away from the equator. This is apparently an adaptation towards the extremely high UV irradiation due to ice crystal on the Tibetan Plateau.