Biocultural Model
Refer to Chapter 1 lecture notes

Overview
• This chapter provides a brief review of the study of human adaptation.
  o Following a brief discussion of stress and adaptation, the chapter looks at different levels of adaptation—genetic, physiologic, and cultural.
  o These different levels of adaptation are examined for three types of environmental stress—cold stress, heat stress, and high-altitude stress.
  o This chapter continues many of the themes discussed throughout the text, such as the interrelationship of biology and culture.
• Remember that adaptation is the successful interaction of a population with its environment.
  o Different levels of adaptation—genetic, physiologic, and cultural.
  o Previously talked to genetic adaptation, but adaptation, as a topic, is broader. It includes:
    ▪ Stress: Any factor which interferes with the normal limits of operation of an organism
    ▪ Homeostasis: The maintenance of normal limits of body functioning
    ▪ Homeostasis, then, is how we maintain limits when stress occurs.
  o There are three types of physiological adaptations:
    ▪ Acclimation: Short-term changes that occur very quickly after exposure to a stress.
    ▪ Acclimatization: Physiologic changes that take longer, from days to months.
    ▪ Developmental acclimatization: An adaptive change that occurs during the physical growth of any organism.
  o The ability of organisms to respond physiologically developmentally is called plasticity.

Climate and Human Adaptation 1
• **Physiologic responses to temperature stress**
  o The body reacts to cold stress or rapid heat loss
  o **Cold stress**
    ▪ One response is to produce more heat.
      ▪ This is produced through shivering, but it is not very effective and is very costly
      ▪ Another heat producer is to digest food. Not only does the digestion process itself produce heat, but the energy from the food can be used to produce more heat. Very short-term less useful.
    ▪ A more efficient response to cold is to reduce blood flow to the extremities. This is accomplished by a process of vasoconstriction and vasodilation:
      ▪ Vasoconstriction (narrowing of blood vessels) is the reducing of blood flow and heat loss from the body to the extremities (hands, feet, and face).
      ▪ Vasodilation is the opening of blood vessels, increasing blood flow and heat loss. The body increases blood flow to the extremities for short periods of about 2 minutes at about 20 minute intervals, which helps keep the extremities from freezing.
    ▪ The third response is to shut down all bodily systems that are not required for survival on a moment to moment basis.
      ▪ This means that the person goes to sleep, and the body goes into energy conservation mode, trying to maintain the core temperature.
      ▪ At this point the body can not recover by itself without some input of external heat.

Climate and Human Adaptation 2
• **Physiologic responses to temperature stress (continued)**
  o Heat stress is caused by the inability to remove heat quickly enough
    ▪ The body reacts to heat stress, or rapid heat gain.
    ▪ This can come from four mechanisms: radiation, convection, conduction, or evaporation.
      ▪ Radiation is the heat flow from objects in the form of electromagnetic radiation.
      ▪ Convection is the removal or gain of heat through air molecules.
      ▪ Conduction is heat exchange through physical contact.
Evaporation is the loss of heat through conversion of water to vapor.

- The amount of heat loss from these four mechanisms varies according to temperature and humidity.
  - Role of evaporation
    - At more comfortable temperatures, radiation accounts for more of heat loss and so evaporation accounts for 23% of the total heat loss.
    - At high temperatures, (above 95 degrees), evaporation accounts for 90% of heat loss. As the temperature increases the only way to cool down is by evaporation.
  - Drawbacks of evaporation
    - Loss of water can be fatal
    - Efficiency of evaporation is affected by humidity. In hot, humid conditions are less ideal than hot, dry conditions.

Climate and Human Adaptation 3

- Climate and morphological variation
  - Human populations in colder climates tend to be heavier than those in hotter climates.
    - Not everyone is equally heavier or lighter, some of the variation is due to diet.
    - There is a genetic component to body size, though. This is expressed as the Bergmann and Allen rules.
  - This is related to the fact that heat is lost at the surface of the body.
    - Bergmann’s Rule states that if two mammals have similar shapes but different sizes, the smaller animal will lose heat more rapidly and will be better adapted to warmer climates.
    - Larger mammals lose heat more slowly and will be better adapted to cold climates. Why?
    - The reason is the ratio of body mass to surface area.
    - While a larger animal has both a larger surface area and mass, the ratio between the two is smaller.
    - Allen’s Rule predicts that mammals in cold climates should have shorter, bulkier limbs, and mammals in hot climates should have longer, narrower ones.
  - So remember Bergmann’s Rule is about body shape and Allen’s rule is about appendages

Climate and Human Adaptation 4

- Climate and morphological variation (continued)
  - Body size and shape
    - The Bergmann and Allen Rules apply to adult human body size and shape.
      - Remember these are always average values.
      - But, look at Inuit and Massai as classic example.
    - Evidence to date suggests that both genetic and environmental factors influence the relationship among climate, growth, body size, and body shape.
     - What happens when we move an infant from one environment to another?
      - They tend to grow in ways the indigenous children do, but the results are complex.
       - Katzmarzyk and Leonard examined the relationship between body size and shape with average annual temperature on data collected between 1953-1996.
       - They did find that the Bergmann and Allen rules did have an effect, but the recent changes in nutrition and health care have obscured the relationship between climate and morphology to some extent.
       - Allen’s Rule predicts that mammals in cold climates should have shorter, bulkier limbs, and mammals in hot climates should have longer, narrower ones.
      - So remember Bergmann’s Rule is about body shape and Allen’s rule is about appendages

Box 16.1: Cranial Plasticity

- Cranial Plasticity -- Did Boas Get it Right?
  - As a part of his efforts to challenge the eugenics movement and others who adhered to environmental determinism, Franz Boas collected cranial data on new European immigrants.
  - He was looking to see if there is cranial plasticity as the result of developmental acclimatization.
  - He compared the cephalic index of children from 7 countries, comparing these ethnic groups in Europe and the US.
  - He argued he found differences.
  - There has been a recent debate over these findings that were addressed as a part of a celebration of Boas’ work
    - Sparks and Jantz (2003) argued that Boas’ data only showed a minimum amount of plasticity
Gravlee and others (2003) stated that Boas got it right.
- The results are that both got part of it correct.
  - For 3 groups there was no real differences
  - For the other 4 groups there was.
- Even for those where there are differences, the differences are minor, they were statistical.
- Lesson to take away: Biological determinism is not supportable.

Climate and Human Adaptation 5
- Climate and morphological variation (continued)
  - Cranial size and shape
    - The size and shape of the human head is measured by the cephalic index.
    - This is the total length of the head and the maximum width of the head.
    - There were 3 different categories of head shape recognized:
      - An index of <75 means that the skull is long/narrow and are called dolichocephalic and are typical of Australian aborigines and native southern Africans.
      - An index 75 to 80 means that the skull is rounder and are called mesocephalic
      - An index of >80 is broad/short, and is called brachycephalic
    - These shapes were once used to determine ‘race’. This is obviously not done today,
    - Kenneth Beals (my professor) determined that there is a relationship between cephalic index and climate and that the shape of the upper part of the skull is related to heat loss.
    - Head shape changes as human populations moved into colder climates, a finding that holds up even in fossils dating to 1.5 mya
      - Narrow heads lose heat more quickly and advantageous in hot climates.
      - Rounded heads lose heat more slowing and are advantageous in cold climates.

Climate and Human Adaptation 6
- Climate and morphological variation (continued)
  - Nasal size and shape
    - The size and shape of the human nose is measured by the nasal index.
    - The nasal index is measured by the width of the nose divided by the height of the nasal opening multiplied by 100.
    - Typical values range from 64-104%
    - Populations in cold climates tend to have narrow noses, and those in hot climates tend to have wide ones.
    - Populations in dry climates tend to have narrow noses, and those in wet climates tend to have wide ones.
    - Why?
      - High, narrow noses can warm the air more than low, wide noses
      - High, narrow noses have greater internal surface area and so can moisten the air in dry climates.
    - Recently, there has been found a unique nasal structure in Neandertal noses
      - Two triangular-shaped bone projections (sinuses) are found to protrude into the front of the nasal cavity.
      - One suggestion is that the increased surface area afforded by these projections was adaptive to the cold.
      - Others challenge this research.

Climate and Human Adaptation 7
- Cultural adaptations
  - Cold stress
    - The Inuit of the Arctic have realized effective cultural adaptations to cold stress in terms of clothing and shelter.
    - They wear layered clothing, trapping air between layers to act as an insulator.
    - They also construct temporary shelters and use snow as an excellent insulator.
    - Permanent housing uses underground entrances and higher living areas.
  - Heat stress
• Human populations in dry, hot environments have realized effective cultural adaptations to heat stress using clothing and shelter designs to reduce heat production, reduce heat gain from radiation and conduction, and increase evaporation.
• Typical clothing is light and loose.
• Shelters are frequently built compactly.
• Light colors reflect the sun, and doors and windows are kept closed during the day.
• Building materials are also adaptive.

High-Altitude Adaptation
• High altitude stresses
  o Hypoxia
    • Hypoxia or oxygen starvation or hypoxia is more common in high altitudes due to the relationship of barometric pressure and altitude causing oxygen content to be less concentrated.
    • It is NOT a lack of oxygen in the general sense we mean it.
  o Other stresses
    • Ultraviolet radiation is greater at high altitudes.
    • Thinner air also causes considerable heat loss, and conditions are extremely dry.
    • Greater physical exertion as these are mountainous regions.
    • The wind is stronger in these environments.
    • Food resources are less plentiful.
• Physiologic responses to hypoxia
  o Temporary increase in respiration rate
  o Red blood cell production increases for roughly 3 months.
  o Higher hemoglobin concentration in the blood
  o Loss of appetite and weight loss are common
  o Memory and sensory abilities can be affected
  o Most physiologic adaptations are the result of developmental acclimatization.
• Physical growth in high-altitude populations
  o Chest dimensions and lung volume are greater at all ages in high-latitude Peruvian populations. The changes are a direct result of hypoxic stress, rather than genetics.
  o People are also shorter, related to delayed maturation. Increased chest growth is a functional adaptation to hypoxia, but smaller body size is not.

Figure 16.5: Distance curves (not pictured)

Nutritional Adaptation 1
• Basic nutritional needs
  o Adaptation can be affected by nutritional needs and differences in the availability of food resources.
    • Too little nutrient energy can result in a reduction in overall size and speed of maturation.
    • Too much nutrient energy can result in the accumulation of fat and acceleration of maturation.
    • Lack of certain critical nutrients can also affect basic biological process, such as vitamin deficiencies.
  o Ingested energy (measured in calories) comes from carbohydrates, proteins, and fats.
    • Proteins provide amino acids, of which 20 are needed for synthesis and repair of body tissues.
    • Eight of the amino acids are only available through food.
    • Lack of these amino acids can result in growth retardation, illness, and death.
  o Dietary requirements are referred to as Dietary Reference Intakes (DRIs).
    • They vary by sex, height, weight and average level of activity.
    • They also vary by age

Nutritional Adaptation 2
• Variation in human diet
  o Hunting and gathering
    • Understanding the diet of hunting and gathering societies is important because most of our biological evolution took place in this type of environment.
Early studies of living hunter-gatherer societies suggest that the bulk of their caloric intake came from gathering, rather than animal proteins.

- Recent work has shown this to not be the case for all HG groups
- A study of HG groups found that 73% of the groups acquired >50% of energy needs from animal foods and only 14% from plant foods
- There is variation between populations, with 1/5 groups almost entirely dependent on animal foods.
  - Why is this?
  - Could represent ancestral diet OR could reflect the marginalization of HG groups to regions where there are fewer options.

**Agriculture**
- Variation also exists among agricultural populations, depending on available food resources and the level of technology (i.e.; slash-and-burn, horticulture (extensive agriculture), intensive agriculture (plow agriculture), or industrial agriculture).
- Specific food crops are exploited, depending upon the environment.
- Different ways of processing can improve the quality (or decrease the quality)
  - Adding ash (lime) to corn brings in the 2 amino acids missing in corn
  - Processed foods in the US increase the number of cases of diverticulitis.

**Nutritional Adaptation 3**
- *Malnutrition* is defined as poor nutrition.
  - It can include too much or too little food.
    - Throughout the world, the major nutritional problem is the lack of food or of a balanced diet.
    - It slows growth or leads to obesity.
  - Protein-calorie malnutrition is a result of an inadequate amount of protein and/or calories.
    - **Kwashiorkor** is the most severe form and involves a severe deficit of protein only.
      - It occurs most often in infants and young children who are weaned from their mother’s breast
      - Results in growth retardation, muscle wasting, and lowered disease resistance.
    - **Marasmus** is a severe deficiency of both protein and calories.
      - It is also prevalent during infancy and leads to growth retardation.
      - The child generally looks emaciated.
  - Worldwide, 26% of children under 5 years are moderately to severely undernourished (160 million people).
    About 5.5 million die for malnutrition-linked reasons.

**Nutritional Adaptation 4**
- *Biological costs of modernization and dietary change*
  - Modernization and obesity
    - Modernization leads to increased height and weight in populations, including high rates of obesity due to a more settled lifestyle.
    - Studies of the biological impact of modernization conclude that modernization has led to a rapid increase in obesity.
      - The classic example is the Samoan study
      - Bindon and Baker (as well as my professor Joel Hanna) noted that a Western diet adversely affected the Samoans.
      - They also illustrate how quickly some aspects of human biology can change in response to a changing environment.
  - Modernization and blood pressure
    - Blood pressure tends to be higher in modernized societies and increases with age in these populations.
    - In traditional societies, blood pressure tends to be lower and does not increase with age.
    - Blood pressure changes in modernized societies reflect change in diet, lifestyle, physical activity, and overall stress.