LEARNING OBJECTIVES

1. Learn what is meant by the term homeostasis.
2. Learn the systems and structures that play major roles in maintaining homeostasis.
3. Become familiar with how temperature is regulated in the human.
4. Gain an appreciation for how humans are able to generate heat energy.

INTRODUCTION

Homeostasis comes from the Greek words Homio meaning similar or like and Stasis from states meaning standing. Thus it means standing the same or staying the same. The physiological definition is “The maintenance of a dynamic equilibrium.” Figure 26-1 is an example of values demonstrating homeostasis.

The range is the difference between the largest and smallest values. The means is obtained by dividing the total of all the values by the number of values. This shows that most values fall above or below the means value. If it were not for the tendency of the organism to maintain a steady state, health professionals would have no measuring stick to determine between health and illness. When the values exceed the range, a
General mechanisms involved

Homeostasis is maintained by the action of many regulatory mechanisms. But the two main ones are the endocrine system and the nervous system. Although nerve cells carry electrical messages, both the endocrine system and the nervous system bring about their affect on cells by releasing chemical molecules that bind to receptor sites in the cell membrane. This reaction then sets off a chain of reactions resulting in a specific reaction in the cell. Many of the reactions within the cell are governed by enzymes; therefore, enzymes are also one of the regulatory mechanisms. Negative feedback loops are mechanisms that control a reaction by using a product of the reaction to slowdown or stop the reaction that produced the product (fig. 26-2). The loop requires a sensor to detect significant deviations from the mean value, set point. The information must be sent to an integrating center, usually the brain or spinal cord. The integrating center sends a message to an effector, which is usually a gland or muscle. This causes an increase or decrease in the effector, which in turn increases or decreases the production of the original stimulus.

Figure 26-2. A generalized diagram of a negative feedback loop (from Raven and Johnson 6th edition)
Some parameters under homeostatic control

As stated earlier, without homeostatic controls maintaining certain values, it would very difficulty to have a meaningful physical exam by medical personnel. The doctor usually takes a blood sample, urine sample, blood pressure reading, temperature measurement, and listens to your heart and lungs. The blood sample is used to measure—number of red blood cells, number of white blood cells, number of platelets, concentration of hemoglobin, blood sugar, percent fluid (plasma), concentration or presence of certain enzymes, etc. The urine sample is used to measure—pH, nitrogen content, sugar content, bilirubin content, etc. Without accepted mean values and ranges for these values, the measurements taken by the doctor would have little significance.

Temperature regulation in humans

Organisms are classified as poikilotherms (cold blooded) and homeotherms (warm blooded). Poikilotherms have a body temperature that varies with the environmental temperature. Homeotherms maintain their body temperature at a relatively constant temperature within a range of environmental temperatures. Birds and mammals are the only “true” homeotherms. The temperature of a homeotherm is maintained by a continuous expenditure of energy (fig. 26-3)

Humans have a mean temperature of about 98.6 degrees Fahrenheit (37.5 degrees Centigrade); they expend about 80% of their energy maintaining this temperature. The temperature control center is in the hypothalamus; it acts as both a thermostat and a temperature monitor. Receptor cells in the hypothalamus monitor the temperature of the blood in the internal carotid arteries, which flow in close proximity to the hypothalamus. This temperature is referred to as the core temperature as opposed to the shell temperature, the skin temperature. The temperature control center has both high and low set points. Raising the temperature above or below the set points initiates stimuli from the hypothalamus, which go by way of glands to effectors to lower the temperature or raise the temperature respectively.

A decrease in temperature of the environment, which causes a change in the shell temperature or and the core temperature results in heat gain mechanisms being activated. These mechanisms can be of two types: 1) increasing insulation to conserve body heat; and 2) generating more body heat. There are thermal receptors in the shell (skin) which are classified as heat and cold receptors. They send messages to the CNS, central nervous system (brain). The first response is a behavioral one; a person either moves where it is warmer or puts on warmer clothes. That not working or being sufficient, messages are sent causing constriction of peripheral blood vessels and a decrease in sweating. These cut down on heat loss by reducing radiation and evaporation respectively. These early response are attempts to cut down on heat loss. If they are not successful in controlling the body temperature, the mechanisms of heat production go into action. Shivering and voluntary muscle contraction result in heat production. Shivering increases the metabolic rate 2-5 times. Further stress results in messages from the hypothalamus to the anterior pituitary, which sends hormones to the adrenal cortex and thyroid gland which release hormones that cause the skeletal muscles, heart, liver, and kidney to increase their rate of metabolism, which produces more heat (26-4).
Figure 26-3. Heat production and heat loss as a function of body (head) temperature.
An increase in temperature results in heat dissipating mechanism being activated. Again behavioral responses occur first. Receptors in the skin send messages to the brain, which result in moving to a cooler environment, donning cooler clothes, or/and cutting down on physical activity. Then the hypothalamus sends out messages, which result in an increase in sweating and the dilation of peripheral blood vessels. Dilation increases heat loss by radiation. Increased sweating increases heat loss by evaporation. Most heat loss is from the skin (80% or more) and the rest from membranes of the respiratory, digestive and urinary tracts. At moderate temperatures, evaporation accounts for about ½ as much as radiation, but at higher temperatures it is the main method. Homeostatic organisms exist at a temperature only a few degrees below what can be a very damaging temperature. Proteins are affect by temperatures above 104 degrees Fahrenheit. We have both an insulation mechanism and a heat generating mechanism to compensate for cold environments, but only heat loss mechanisms for a hot environment. In other words, unlike your home, you do not have an active cooling mechanism.
Fever is the result of a resetting of the high set point in the temperature control center in the hypothalamus. The set point is raised and thus the body does not respond to increased temperature by stimulating heat-dissipating mechanisms. Some bacteria produce a pyrogenic substance that works, through prostaglandins (a type of hormone), on the hypothalamus. Aspirin counteracts the effect of the prostaglandins and thus the high set point is reduced to normal and the heat dissipating mechanisms go into effect relieving the fever. Aspirin will not lower the normal body temperature. It should be mentioned that fever is a defense mechanism in itself. Microorganisms multiple best at body temperature; if it is raised, it helps to control the growth of the bacteria and activates the phagocytes in the blood. In many cases it would be best to let the fever run its course rather than taking things to reduce it. It’s a case of providing short-term relief but, in many instances, prolonging the infection.
OBJECTIVE QUESTIONS OVER HOMEOSTASIS

1. Values for a particular parameter are 6.5, 9.3, 7.4, and 10.6. The mean value is (A) 7.4 (B) 33.8 (C) 8.45 (D) 4.1.

2. In the above problem, the range would be (A) 7.4 (B) 3.8 (C) 8.45 (D) 4.1.

3. You are a (A) heterotherm (B) homeotherm (C) poikilotherm.

4. The temperature control center is located in the (A) cerebrum (B) cerebellum (C) hypothalamus (D) pituitary.

5. In addition to mammals, the only other group of organisms that are “true” homeotherms are the (A) fish (B) amphibians (C) birds (D) reptiles.

6. The temperature control center in the brain acts as (A) a thermostat (B) monitor (C) both A and B.

7. You get rid of body heat by two main methods. (A) radiation and conduction (B) radiation and change of state (C) conduction and change of state (D) convection and change of state.

8. The first adjustment made to a cold environment by a human is (A) stop sweating (B) constriction of peripheral blood vessels (C) shiver (D) behavioral changes.

9. Shivering increases the metabolic rate (A) 2-5 times (B) 5-10 times (C) 20+ times.

10. Most of your heat loss is from the (A) respiratory system (B) digestive system (C) excretory system (D) skin.

11. Aspirin can (A) raise one’s body temperature (B) lower a normal body temperature (C) lower a body temperature that is higher than normal (D) two of the preceding (E) all the preceding.

12. You have receptors for (A) cold (B) heat (C) both A and B in your skin.
DISCUSSION QUESTIONS OVER HOMEOSTASIS

1. What is the difference between a dynamic and static equilibrium?

2. It is said that a person’s first response to either a cold or hot environment is a behavioral one. What is meant by this?

3. List another factor, other than temperature, that your body keeps within rather narrow limits. Explain how this is done.

4. List an advantage of being a homeotherm. List a disadvantage.

5. Would you expect an Eskimo to have a higher or lower blood level of thyroxin (hormone from the thyroid gland) than you? Explain.


7. Is there any indication (evidence) that human babies are born without a completely operating temperature control center? Explain.

8. Cold and hot receptors in the skin send messages to the CNS. Is there any evidence that this information reaches the conscious levels of the brain? Explain.