Regulation of Body Temperature

Answer the prior knowledge questions, then read the following information about the regulation of body temperature and answer the questions that follow. This reading and the questions that follow will serve as your class notes for Regulation of Body Temperature.

PRIOR KNOWLEDGE QUESTIONS

1. How is heat produced by the human body?

2. How is heat lost from the human body?

3. TRUE/FALSE  Shivering is a useless body movement, as it does not assist in creating heat when the body is exposed to cold environments.

4. TRUE/FALSE  Hypothermia is more dangerous and more life-threatening that hyperthermia.

5. TRUE/FALSE  All fevers over (98.6°F) should be treated immediately with ibuprofen (Advil), acetaminophen (Tylenol), or aspirin.

The regulation of body temperature is vitally important because even slight shifts can disrupt the rates of metabolic reactions. Normally, the temperature of deeper body parts remains close to a set point of 37°C (98.6°F). The maintenance of a stable temperature requires that the amount of heat the body loses be balanced by the amount it produces. The skin plays a key role in the homeostatic mechanism that regulates body temperature.

HEAT PRODUCTION AND LOSS

Heat is a product of cellular metabolism. The major heat producers are the more active cells of the body, such as skeletal and cardiac muscles and cells of the liver.

When body temperature rises about the set point, the nervous system stimulates structures in the skin and other organs to release heat. For example, during physical exercise, active muscles release heat, which the blood carries away. The warmed blood reaches the part of the brain (the hypothalamus) that controls the body’s temperature set point, which signals muscles in the walls of dermal blood vessels to relax. As these vessels dilate (vasodilation), more blood enters them, and some of the heat the blood carries escapes to the outside. At the same time, deeper blood vessels contract (vasoconstriction), diverting blood to the surface, and the skin reddens. The heart is stimulated to beat faster, moving more blood out of the deeper regions.

The primary means of body heat loss is radiation, by which infrared heat rays escape from warmer surfaces to cooler surrounding. These rays radiate in all direction, much like those from the bulb of a heat lamp.
Conduction and convection release less heat than does radiation. In conduction, heat moves from the body directly into the molecules of cooler objects in contact with its surface. For example, heat is lost by conduction into the seat of a chair when a person sits down. The heat loss continues as long as the chair is cooler than the body surface touching it. Heat is also lost by conduction to the air molecules that contact the body. As air becomes heated, it moves away from the body, carrying heat with it, as is replaced by cooler air moved toward the body. This type of continuous circulation of air over a warm surface is convection.

Still another means of body heat loss is evaporation. When the body temperature rises above normal, the nervous system stimulates eccrine sweat glands to release sweat onto the surface of the skin. As this fluid evaporates (changes from a liquid to a gas), it carries heat away from the surface, cooling the skin.

When body temperature drops below the set point, as may occur in a very cold environment, the brain triggers different responses in the skin structures. Muscles in the walls of dermal blood vessels are stimulated to contract. This action decreases the flow of heat-carrying blood through the skin, which loses color, and helps reduce heat loss by radiation, conduction, and convection. At the same time, sweat glands remain inactive, decreasing heat loss by evaporation. If body temperature continues to drop, the nervous system may stimulate muscle cells in the skeletal muscles throughout the body to contract slightly. This action requires an increase in the rate of cellular respiration, which releases heat as a by-product. If this response does not raise the body temperature to normal, small groups of muscles may rhythmically contract with greater force, causing the person to shiver, generating more heat. The figure to the left summarizes the body’s temperature-regulating mechanism; the clinical application at the end of this reading examines two causes of elevated body temperature.

**PROBLEMS WITH TEMPERATURE REGULATION**

The body’s temperature-regulating mechanism does not always operate satisfactorily, and the consequences may be dangerous. For example, air can hold only a limited volume of water vapor, so on a hot, humid day, the air may become nearly saturated with water. At such times, the sweat glands may be active, but the sweat cannot quickly evaporate. The skin becomes wet, but the person remains hot and uncomfortable. In addition, if the air temperature is high, heat loss by radiation is less effective. If the air temperature exceeds body temperature, the person may gain heat from the surroundings, elevating body temperature even higher. Body temperature may rise, in a condition called hyperthermia. Hyperthermia occurs when the core body temperature exceeds 106°F. The skin becomes dry, hot, and flushed. The person becomes weak, dizzy, and nauseous, which headache and rapid, irregular pulse.
Hypothermia, or lowered body temperature, can result from prolonged exposure to cold or as a part of an illness. It can be extremely dangerous. Hypothermia begins with shivering and a feeling of coldness. If not treated, it progresses to mental confusion, lethargy, loss of reflexes and consciousness, and eventually the shutdown of major organs. If the temperature in the body’s core drops just a few degrees, fatal respiratory failure or heart arrhythmia may result. However, the extremities can withstand drops of 20-30°F below normal.

Certain people are at higher risk for developing hypothermia due to less adipose tissue in the subcutaneous layer beneath the skin (less insulation). These include the very old, very thin individuals, and the homeless. The very young with undeveloped nervous system have difficulty regulating their body temperature. Dressing appropriately and staying active in the cold can prevent hypothermia. A person suffering from hyperemia must be warmed gradually so that respirator and cardiovascular functioning remain stable.

Hypothermia is intentionally induced during certain surgical procedures involving the heart, brain, or spinal cord. In heart surgery, body temperature may be lowered between 78°F (26°C) and 89°F (32°C), which lowers the body’s metabolic rate so that less oxygen is required. Hypothermia for surgery is accomplished by packing the patient in ice of by removing blood, cooling it, and returning it.

CLINICAL APPLICATION – ELEVATED BODY TEMPERATURE

It was a warm June morning when the harried and hurried father strapped his five-month-old son, Bryan, into the backseat of his car and headed for work. Tragically, the father forgot to drop his son off at the babysitter’s. When his wife called him at work late that afternoon to inquire why the child was not at the sitter’s, the shocked father realized his mistake and hurried down to his parked car. But it was too late – Bryan had died. Left for ten hours in the car in the sun, all windows shut, the baby’s temperature had quickly soared. Two hours after he was discovered, the child’s temperature still exceeded 41°C (106°F).

Sarah’s case of elevated body temperature was more typical. She awoke with a fever of 40°C (104°F) and a sore throat. At the doctor’s office, a test revealed that Sarah had a Streptococcus infection. The fever was her body’s attempt to fight the infection.

The true cases of Bryan and Sarah illustrate two reasons why body temperature may rise – inability of the temperature homeostatic mechanism to handle an extreme environment and an immune system response to infection. In Bryan’s case, sustained exposure to very high heat overwhelmed his temperature-regulating mechanism, resulting in hyperthermia. Body heat built up faster than it could dissipate, and the temperature rose, even though the set point of the thermostat was normal. His blood vessels dilated so greatly that after a few hours, his cardiovascular system collapsed.

Fever is a special case of hyperthermia in which temperature rises in response to an elevated set point. In fever molecules on the surfaces of the infectious agents (usually bacteria or viruses) stimulate phagocytes to release a substance called interleukin-1 (also called endogenous pyrogen, meaning “fire maker from within”). The bloodstream carries interleukin-1 to the hypothalamus, which it raises the set point controlling temperature. In response, the brain signals skeletal muscles to contract (shivering) and increase heat production, blood flow to the skin to decrease, and sweat glands to decrease secretion. As a result, body temperature rises to the new set point, and fever develops. The increased body temperature helps the immune system kill the pathogens.

Rising body temperature requires different treatments, depending on the degree of elevation. Hyperthermia in response to exposure to intense, sustained heat should be rapidly treated by administering liquids to replace lost body fluids and electrolytes, sponging the skin with water to increase cooling by evaporation, and covering the person with a refrigerated blanket. Fever can be lowered with ibuprofen or acetaminophen, or aspirin in adults. Some health professionals believe that a lightly elevated temperature should not be reduced (with medication or
cold baths) because it may be part of a normal immune response. A high or prolonged fever, however, requires medical attention.

QUESTIONS

1. Explain why regulation of body temperature is so important.

2. Which part of the brain controls body temperature?

3. Define vasodilation.

4. Define vasoconstriction.

5. Explain how vasodilation and vasoconstriction help to release heat from the body.

6. What is the primary way in which body heat is released?

7. Explain the difference between conduction and convection.
8. Explain how sweating helps to lower body temperature.

9. What medical condition can be diagnosed by pale skin, which might result from a cooler body temperature?

10. Explain the processes that help to keep the human body warm when exposed to cold temperatures.

11. TRUE/FALSE Shivering is a useless body movement, as it does not assist in creating heat when the body is exposed to cold environments.

12. What environmental conditions negatively affect the body's efficiency to raise/lower core body temperature?

13. What is another common name for hyperthermia?

14. Why would it be especially dangerous for mountain climbers, such as those who climb Mt. Everest, to suffer from hypothermia?

15. Why are hypothermic conditions useful during certain medical surgeries?

16. Name a common *Streptococcus* infection.

17. What is the significance of interleukin-1?

18. Why would it be a bad idea to use over-the-counter medications to treat a minor fever (99.5°F), which has only been present for 6 hours?