

# *Biothermal physics*

## *Fourth lecture*

### *Thermoregulation in organism*

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## **What is thermoregulation?**

- ✚ **Thermoregulation** is the biological mechanism responsible for maintaining a steady internal body temperature.
- ✚ The thermoregulation system includes the **hypothalamus in the brain**, as well as **the sweat glands**, **skin**, and **circulatory system**.

## **How does thermoregulation work in humans?**

- ✚ The human body uses three mechanisms of thermoregulation:
  - ✓ efferent responses
  - ✓ afferent sensing
  - ✓ central control
- ✚ **Efferent responses** are the behaviors that humans can engage in to regulate their own body temperature.
- ✚ Examples of efferent responses include putting on a coat before going outside on cold days and moving into the shade on hot days.
- ✚ **Afferent sensing** involves a system of temperature receptors around the body to identify whether the core temperature is too hot or cold. The receptors relay the information to the hypothalamus, which is part of the brain.
- ✚ **The hypothalamus acts as the central control**, using the information it receives from afferent sensing to produce hormones that alter body temperature.
- ✚ These hormones send signals to various parts of the body so that it can respond to heat or cold in the following ways:

Response to heat	Response to cold
sweating	shivering, or thermogenesis
dilated blood vessels, known as vasodilation	constricted blood vessels, known as vasoconstriction
decrease in metabolism	increase in metabolism

### **Thermoregulation disorders**

- ✚ The healthy temperature range for the human body is very narrow.
- ✚ If the body cannot maintain a temperature within this range, thermoregulation disorders can develop.

### **Hyperthermia**

- *It is abnormally high body temperature caused by a failure of the heat-regulating mechanisms of the body to deal with the heat coming from the environment*
- There are several types of hyperthermia, including:
  - ✓ **heat cramps**, which present as heavy sweating and muscle cramps during exercise.
  - ✓ **heat exhaustion**, which is more serious and causes a range of symptoms.
  - ✓ **heatstroke**, which is a medical emergency.
- ***The symptoms of heat exhaustion are:***
  - ✓ Sweating
  - ✓ pale, clammy, or cold skin
  - ✓ fast or weak pulse
  - ✓ tiredness, weakness
  - ✓ dizziness, nausea or vomiting
  - ✓ headaches and fainting

➤ **Heatstroke causes similar symptoms, but with some important differences, including:**

- ✓ flushed or hot skin, which may be dry or damp
- ✓ a fast, strong pulse
- ✓ a body temperature of 103°F (39.4°C) or higher

## **Hypothermia**

➤ **Hypothermia occurs when the body loses heat faster than it can produce it. Prolonged exposure to cold temperatures can cause hypothermia.**

➤ **The symptoms include:**

- ✓ Shivering, confusion.
- ✓ exhaustion or feeling very tired.
- ✓ fumbling hands, slurred speech.
- ✓ drowsiness, memory loss

## **What can impair thermoregulation?**

✚ Several factors can affect thermoregulation, including **environmental conditions, diseases, and certain medications**

## **Extreme weather**

- Extreme weather can significantly affect the body's ability to regulate temperature.
- Hypothermia occurs when a person has exposure to extremely cold temperatures for an extended period. In these instances, the body loses heat quickly, and heat production cannot keep up, causing a dip in body temperature.
- In addition to freezing temperatures, hypothermia can also occur in cool temperatures if sweat, rain, or submersion in cold water chills someone.

- On the opposite end of the spectrum, hot weather and extended exposure to the sun can cause the body to overheat. Instead of losing more heat than it can produce, the body heats up faster than it can cool itself down.
- Someone may also develop hyperthermia in warm temperatures as a result of:
  - ✓ drinking insufficient fluids
  - ✓ wearing heavy, insulating clothing
  - ✓ visiting overcrowded places
  - ✓ exerting physically

### **Infections**

- When a person has an infection, harmful microorganisms invade the body and multiply. These pathogens can thrive at typical body temperatures, but an increased temperature makes it more difficult for some of them to survive.
- For this reason, part of the immune response to infections is often a fever. This occurs when the body raises its own temperature in an effort to kill infection-causing organisms.
- However, problems can arise if the body temperature becomes too high, hindering necessary functions. If someone has a fever above 105°F (40.5°C) that does not decrease with medication, they should seek urgent medical attention. A doctor will treat the fever to try to lower the body temperature to a safe level.

### **Age**

- **Infants** and **older** adults have a higher risk of thermoregulation disorders. The reason for this is that these individuals have **a lower muscle mass**, a **decreased shiver reflex**, and **lower immunity**.

**Other diseases can also affect thermoregulation. These include:**

**Endocrine disorders**

- The endocrine system comprises glands and organs that produce hormones, such as the pancreas, thyroid, pituitary gland, and adrenal glands. If something interferes with hormone production, it can affect body temperature.
- For example, an underactive thyroid, or hypothyroidism, can lead to a lower body temperature, while an overactive thyroid, called hyperthyroidism, can cause a higher body temperature.

**Central nervous system (CNS) disorders**

- The CNS includes the brain, spinal cord, and nerves. Conditions that affect the CNS can interfere with thermoregulation by impairing afferent sensing and central control.
- *Some examples of these conditions include:*
  - ✓ brain injuries.
  - ✓ spinal cord injuries.
  - ✓ neurological diseases, such as Parkinson’s or multiple sclerosis.
  - ✓ Tumors.

**Medications**

- Certain medications can disrupt thermoregulation as a side effect, causing a temporary rise in body temperature. Some people refer to this as “drug fever.” Examples of medications that can have this effect include:
  - ✓ Antimicrobials, such as antibiotics.
  - ✓ Nonsteroidal anti-inflammatory drugs (NSAIDs).
  - ✓ First generation anticonvulsants.
  - ✓ Antidepressants.