Temperature of the body

Normal Body Temperature:

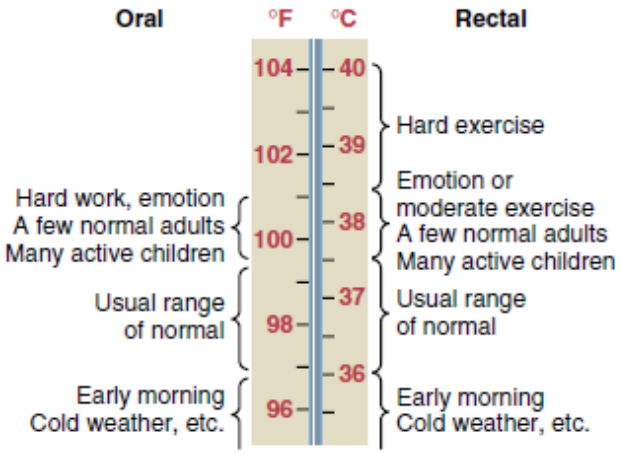
Like all regulated functions of the body, temperature is also not maintained at a fixed level but within a narrow range. Further, the body temperature shows physiological variations beyond the range within which it is ordinarily maintained. Hence, so long as the temperature is within the normal range, or deviates beyond it in association with specific circumstances, the temperature is considered normal.

The core body temperature shows a diurnal variation due to cyclic resetting of the hypothalamic thermostat. The highest temperature occurs at about 6 p.m. and the lowest at about 3 a.m.

In women, body temperature shows cyclic variation synchronous with the menstrual cycle. The basal body temperature shows a rise of about 0.5°C at the time of ovulation and stays at the higher level till the onset of menstruation. There is a small but finite seasonal variation in body temperature, the temperature being higher in summers than in winters. Similarly, the temperature rises a little after a hot water bath and falls a little after a cold water bath.

There may also be a rise in body temperature after meals. Physical exercise and emotional outbursts raise the body temperature.

The temperature of the deep tissues of the body—the "core" of the body—usually remains very constant, within ±0.6°C, except when a person has a febrile illness.
The ***skin temperature***, in contrast to the *core temperature*, rises and falls with the temperature of the surroundings. The skin temperature is important when we refer to the skin's ability to lose heat to the surroundings.
Normal Core Temperature: No single core temperature can be considered normal because measurements in many healthy people have shown a range of normal temperatures measured orally, from less than (36°C) to greater than (37.5°C). The average normal core temperature is generally considered to be between 36.7°C and 37°C when measured orally and about 0.6°C higher when measured rectally.



The body temperature increases during exercise and varies with temperature extremes of the surroundings because the temperature regulatory mechanisms are not perfect. When excessive heat is produced in the body by strenuous exercise, the temperature can rise temporarily to as high as 38.3° C to 40° C. Conversely, when the body is exposed to extreme cold, the temperature can fall below 35.5° C.

Body Temperature is controlled by balancing heat production and heat loss:
When the rate of heat production in the body is greater than the rate at which heat is being lost, heat builds up in the body, and the body temperature rises. Conversely, when heat loss is greater, both body heat and body temperature decrease.

Mechanisms of temperature regulation:
If the core temperature falls below the set point, then the following mechanisms may be induced by the posterior hypothalamus

- Somatic nervous system activation induces shivering. Shivering generates heat by causing adenosine triphosphate (ATP) hydrolysis in the contractile apparatus of skeletal muscle. –
- Thyroid hormones may be released, which generates heat by increasing the activity of Na +−K+ ATPase.
- Sympathetic nervous system activation causes vasoconstriction of blood vessels to the skin, resulting in heat conservation.

If the core temperature rises above the set point, then the following mechanisms may be induced by the anterior hypothalamus:

- Sympathetic cholinergic activation of sweat glands (via muscarinic receptors) increases heat loss by evaporation of water from the skin.
- Lowered sympathetic adrenergic activity causes dilation of blood vessels to the skin, resulting in heat loss by convection and radiation.

Hypothalamic set point for body temperature
All the temperature control mechanisms continually attempt to bring the body temperature back to this set point level.
1. Temperature sensors on the skin and in the hypothalamus “read” the core temperature and relay this information to the anterior hypothalamus.
2. The anterior hypothalamus compares the detected core temperature to the set-point temperature.
a. If the core temperature is below the set point, heat-generating mechanisms (e.g., increased metabolism, shivering, vasoconstriction of cutaneous blood vessels) are activated by the posterior hypothalamus. If the core temperature is above the set point, mechanisms for heat loss (e.g., vasodilation of the cutaneous blood vessels, increased sympathetic outflow to the sweat glands) are activated by the anterior hypothalamus.
3. Pyrogens increase the set-point temperature. Core temperature will be recognized as lower than the new set-point temperature by the anterior hypothalamus. As a result, heatgenerating mechanisms (e.g., shivering) will be initiated.

Fever (Pyrexia): Fever is produced by endogenous pyrogens (e.g., interleukin-1) released by cells of the immune system in response to infective bacteria. These pyrogens act on the anterior hypothalamus to increase prostaglandin synthesis, which in turn stimulates the thermoregulatory center to reset the set point to a higher temperature. Because body temperature is cooler than the set point, body temperature increases (by heat production and conservation of heat loss) until it stabilizes at the new, elevated setpoint temperature. When the fever breaks and the set point returns to 37°C (98.6°F), the patient vasodilates and sweats to lose heat until the body temperature returns to normal.
For suppressing fever, aspirin is effective therapy because it inhibits cyclooxygenase and therefore inhibits prostaglandin synthesis. In doing so, aspirin lowers the set point temperature and will cause activation of the heat loss mechanisms. Steroids may also be used because they block the release of arachidonic acid (the precursor of prostaglandins) from membrane phospholipids.

Heat exhaustion: Heat exhaustion occurs when the body overheats, causing profuse sweating. This may result in a drop in blood pressure and fainting. Treatment for this condition involves rehydration and resting in a cool place.

Heat stroke: Heat stroke represents a failure of heat loss mechanisms but not a change in set point. In this case, a person in a hot environment fails to adequately mobilize cutaneous vasodilation and sweating. People experiencing heat stroke must be drastically cooled (placed in a bathtub of ice water), or the core temperature will continue to rise, resulting in death.

Malignant hyperthermia: is caused in susceptible individuals by inhalation anesthetics. It is characterized by a massive increase in oxygen consumption and heat production by skeletal muscle, which causes a rapid rise in body temperature. Malignant hyperthermia may be treatable if dantrolene (a drug that reduces muscular contraction and the hyper-metabolic state) is given promptly.

Hypothermia: results when the ambient temperature is so low that heat-generating mechanisms (e.g., shivering, metabolism) cannot adequately maintain core temperature near the set point. Death can occur by myocardial fibrillation (uncoordinated, chaotic contractions of cardiac muscle).

Frostbite. When the body is exposed to extremely low temperatures, surface areas can freeze, which is a phenomenon called *frostbite*. Frostbite occurs especially in the lobes of the ears and in the digits of the hands and feet. If the freeze has been sufficient to cause extensive formation of ice crystals in the cells, permanent damage usually results, such as permanent circulatory impairment and local tissue damage. Gangrene often follows thawing, and the frostbitten areas must be removed surgically.

QUESTIONS AND PROBLEMS

1. Why is our urine warm even on a very cold day?
2. Why do we see fog when we breathe out on a cold day?