BODY TEMPERATURE AND ITS REGULATION

Learning Objectives

List the factors affecting the body temperature

Understand the mechanism of heat generation and transfer in the body

Understand the mechanism of heat preservation and heat loss in the body

Describe the regulation of body temperature

Understand the physiological basis of hypothermia and hyperthermia

REGULATION OF BODY TEMPERATURE

Body temperature reflects the balance between heat production and heat loss

At rest, the liver, heart, brain, kidneys, and endocrine organs generate most heat

During exercise, heat production from skeletal muscles increases dramatically

REGULATION OF BODY TEMPERATURE

Normal body temperature = 37°C ± 5°C (98.6°F)

Optimal enzyme activity occurs at this temperature

Increased temperature denatures proteins and depresses neurons

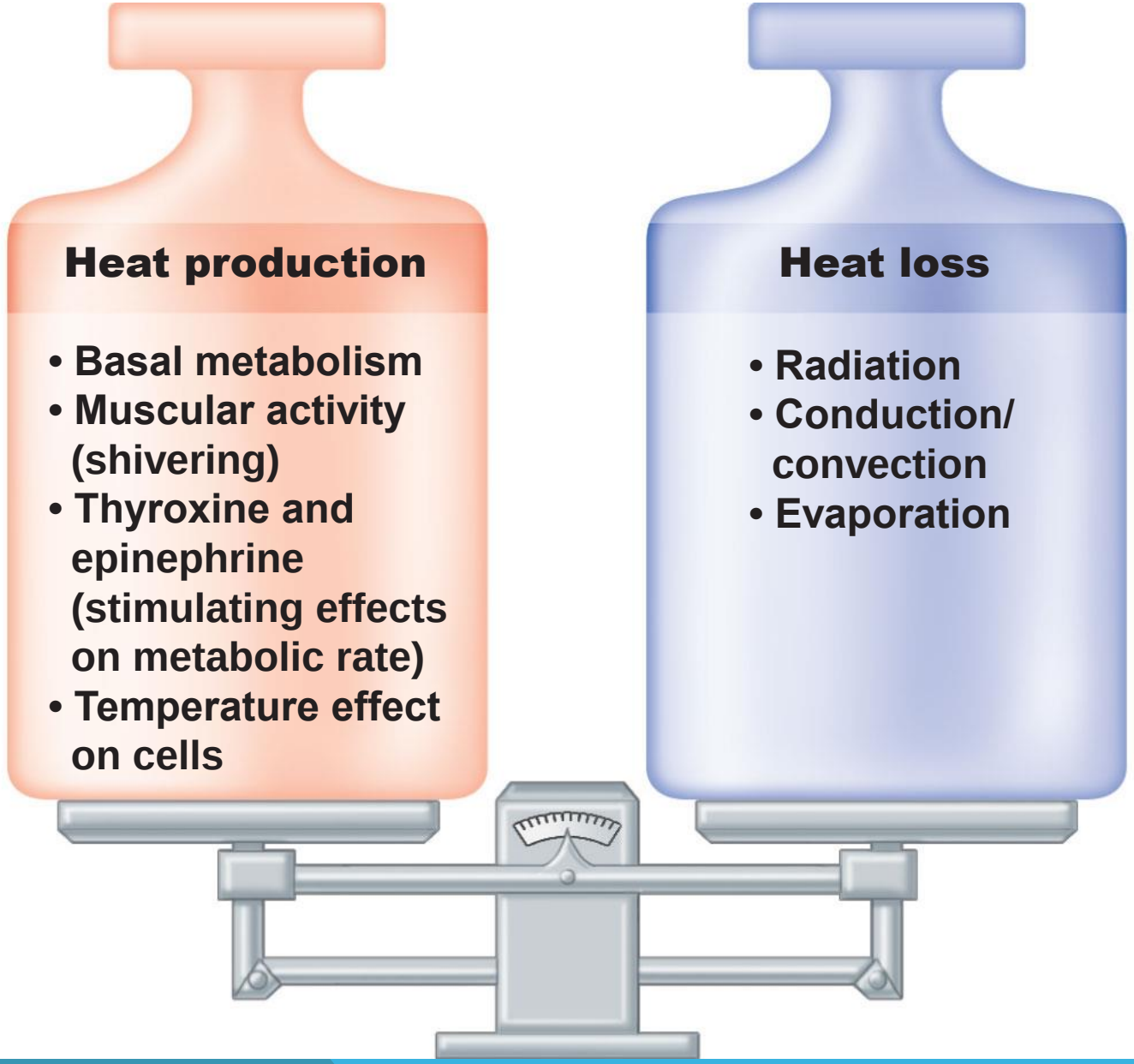
Heat production
• Basal metabolism
• Muscular activity (shivering)
• Thyroxine and epinephrine (stimulating effects on metabolic rate)
• Temperature effect on cells
Heat loss
• Radiation
• Conduction/ convection
• Evaporation

Figure 24.25

CORE AND SHELL TEMPERATURE

Organs in the core have the highest temperature

Blood is the major agent of heat exchange between the core and the shell

Core temperature is regulated

Core temperature remains relatively constant, while shell temperature fluctuates substantially (20°C–40°C)

MECHANISMS OF HEAT EXCHANGE

Four mechanisms

1. Radiation is the loss of heat in the form of infrared rays
2. Conduction is the transfer of heat by direct contact
3. Convection is the transfer of heat to the surrounding air
4. Evaporation is the heat loss due to the evaporation of water from body surfaces

MECHANISMS OF HEAT EXCHANGE

- Insensible heat loss accompanies insensible water loss from lungs, oral mucosa, and skin
- Evaporative heat loss becomes sensible (active) when body temperature rises and sweating increases water vaporization

ROLE OF THE HYPOTHALAMUS

Hypothalamus contains the two thermoregulatory centers

- Anterior Hypothalamus : activates the mechanism that promote Heat-loss .
- Posterior Hypothalamus : activates the mechanism that increase Heat-production and promote heat gain.

ROLE OF THE HYPOTHALAMUS (THERMOSTAT)

The hypothalamus receives afferent input from

- Peripheral thermoreceptors in the skin
- Central thermoreceptors (some in the hypothalamus)

Initiates appropriate heat-loss and heat-promoting activities

Flowchart 156.3: Mechanism of hypothalamic integration following change in set point temperature.

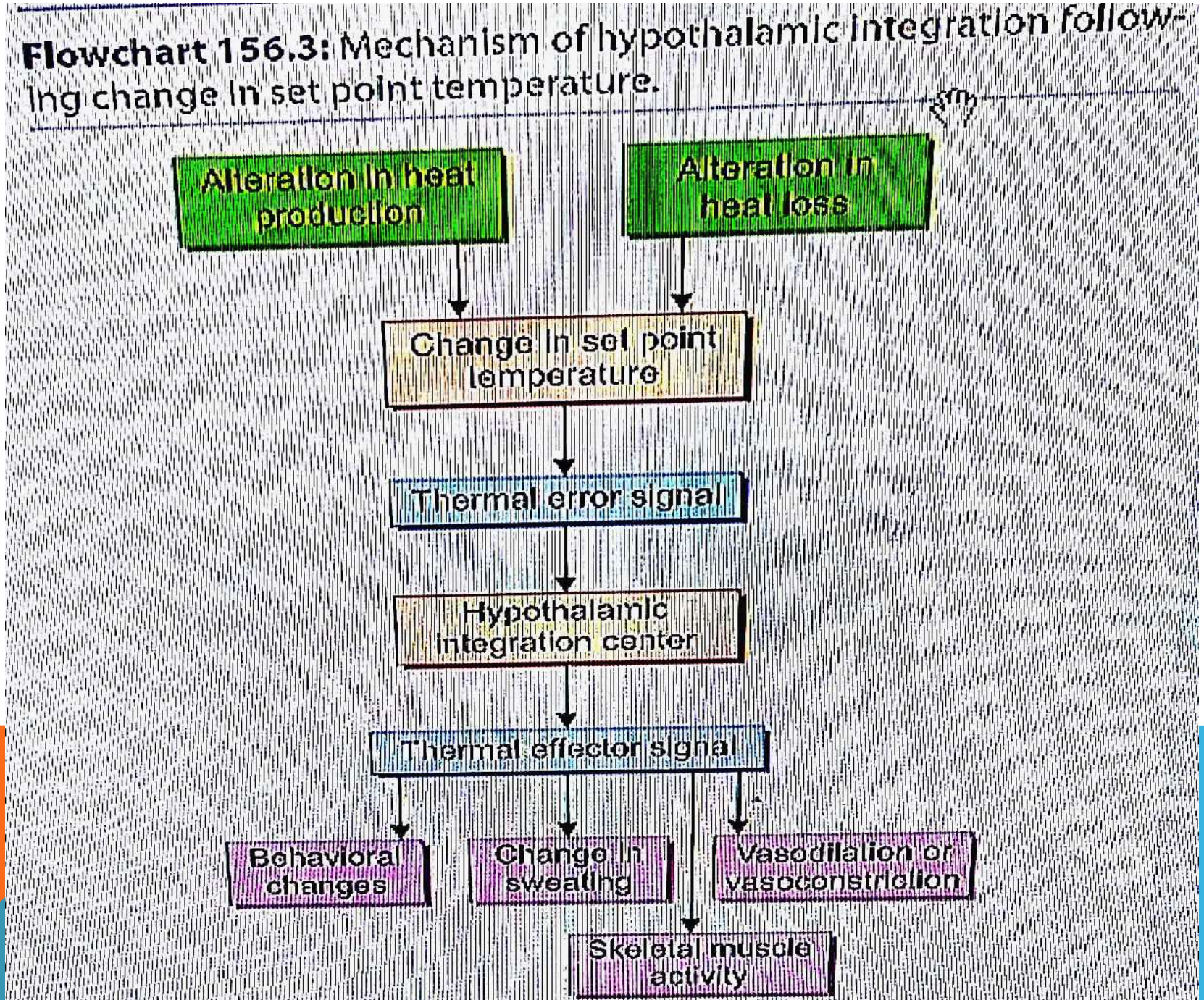

Table 156.4: Responses activated by change in temperature.

A. Responses activated on exposure to heat

1. Responses that promote heat loss
   - Cutaneous vasodilation
   - Sweating
   - Increased respiration or panting
2. Responses that reduce heat production
   - Decreased appetite
   - Decreased physical activity

B. Responses activated on exposure to cold

1. Responses that promote heat gain
   - Shivering (shivering thermogenesis)
   - Increased physical activity
   - Increased secretion of catecholamines (nonshivering thermogenesis)
   - Increased appetite
2. Responses that decrease heat loss
   - Cutaneous vasoconstriction

HEAT-PROMOTING MECHANISMS

- Constriction of cutaneous blood vessels
- Shivering
- Increased metabolic rate via epinephrine and norepinephrine
- Enhanced thyroxine release

HEAT-PROMOTING MECHANISMS

- **Voluntary measures include**
  - Putting on more clothing
  - Drinking hot fluids
  - Changing posture or increasing physical activity

HEAT-LOSS MECHANISMS

- Dilation of cutaneous blood vessels
- Enhanced sweating
- Voluntary measures include

-Reducing activity and seeking a cooler environment

-Wearing light-colored and loose-fitting clothing

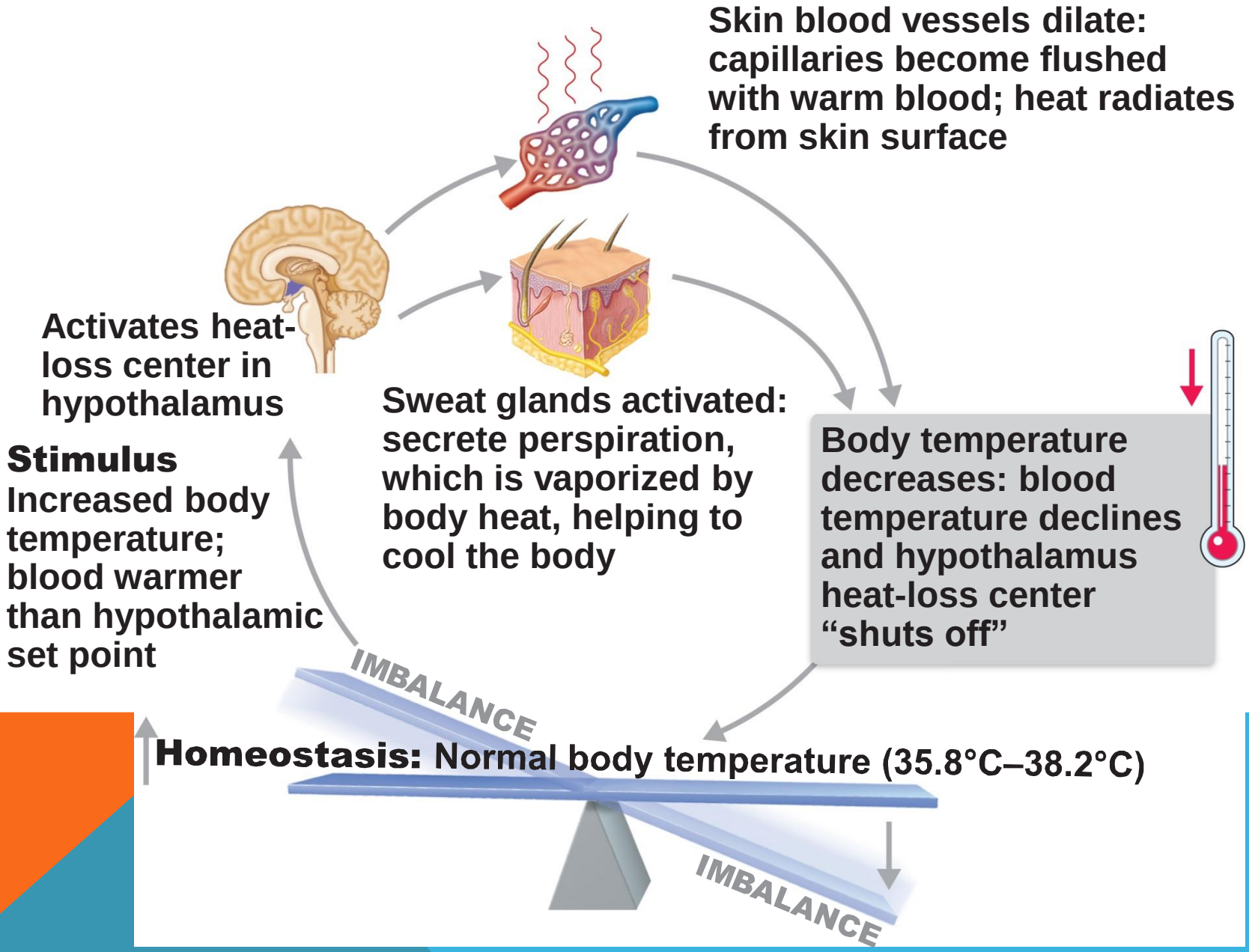

Figure 24.27, step 1

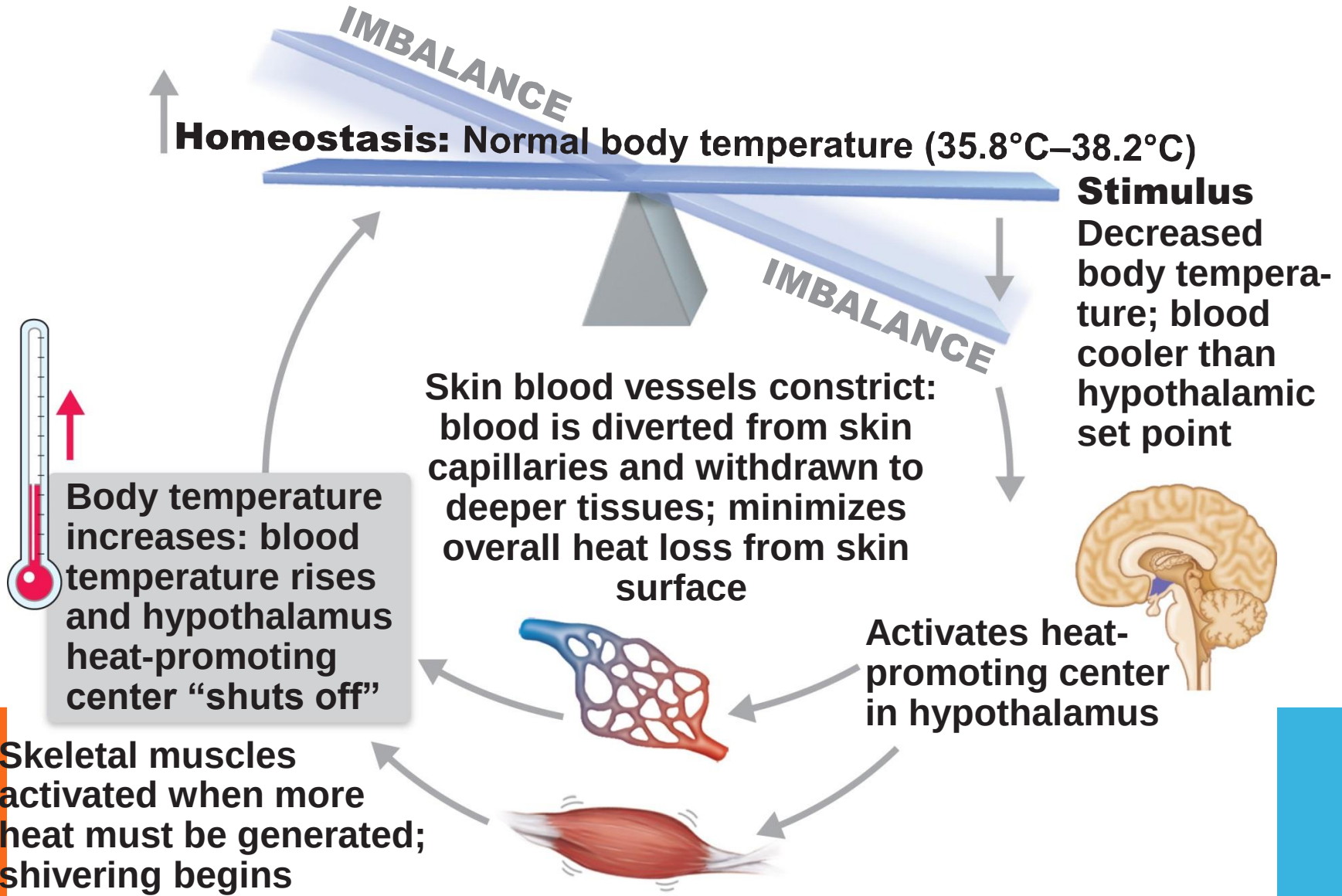

Figure 24.27, step 2

Table 1 Heat Illness: Causes, Signs and Symptoms, and Prevention

CONDITION	CAUSES	SIGNS AND SYMPTOMS	PREVENTION
Heat Cramps	Intense, prolonged exercise in the heat	Tightening, cramps, involuntary spasms of active muscles; low serum Na^+	Cease exercise; rehydrate
Heat Syncope	Peripheal vasodilatation and pooling of venous blood; hypotension; hypohydration	Lightheadedness; syncope, mostly in upright position during rest or exercise; pallor; high rectal temperature	Ensure acclimatization and fluid replenishment; reduce exertion on hot days; avoid standing
Heat Exhaustion	Cumulative negative water balance	Exhaustion; hypohydration, flushed skin; reduced sweating in extreme dehydration syncope, high rectal temperature	Proper hydration before exercise and adequate replenishment during exercise; ensure acclimatization
Heat Stroke	Extreme hyperthermia leads to thermoregulatory failure; aggravated by dehydration	Acute medical emergency; includes hyperpyrexia (rectal temperature >41°C, 105.8°F); lack of sweating and neurologic deficit (disorientation, twitching, seizures, coma)	Ensure acclimatization; identify and exclude individuals at risk; adapt activities to climatic constraints

HOMEOSTATIC IMBALANCE

Hyperthermia

- Elevated body temperature depresses the hypothalamus
- Positive-feedback mechanism (heat stroke) begins at core temperature of 41°C
- Can be fatal if not corrected

HOMEOSTATIC IMBALANCE

Heat exhaustion

- Heat-associated collapse after vigorous exercise
- Due to dehydration and low blood pressure
- Heat-loss mechanisms are still functional
- May progress to heat stroke

HOMEOSTATIC IMBALANCE

Hypothermia

- Low body temperature where vital signs decrease
- Shivering stops at core temperature of 30 - 32°C
- Can progress to coma a death by cardiac arrest at ~ 21°C

FEVER

- Controlled hyperthermia
- Due to infection (also cancer, allergies, or CNS injuries)
- Macrophages release interleukins ("pyrogens") that cause the release of prostaglandins from the hypothalamus

FEVER

- Prostaglandins reset the hypothalamic thermostat higher
- Natural body defenses or antibiotics reverse the disease process; cryogens (e.g., vasopressin) reset the thermostat to a lower (normal) level