Body temperature regulation

Objective learning

1. Recognize the normal body temperature.
2. Describe the mechanism available to the body to maintain a stable temperature
3. Define the fever, hypothermia and how can treatment

TEMPERATURE REGULATION:

- **Normal body function depends upon a constant body temperature:**

1. Speed of chemical reaction varies with temp.
2. Enzymes system of the body have a narrow temp ranges in which their function is optimal.

- The normal human temp by mouth is 36.6-37.2°C.

  Febrile temp is > 37.2°C.

  Hyperpyyrexia is > 41.6°C.

  Subnormal temp < 36.6°C.

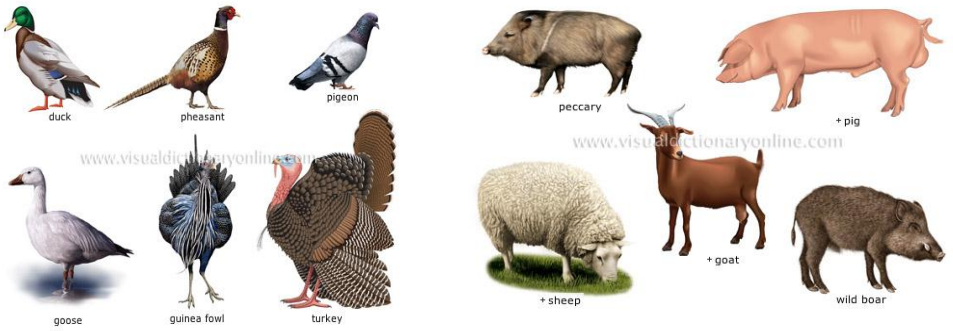
- The core temp: remains almost exactly constant, within ± 0.6°C, except when a person develops a febrile illness.

- The surface temperature rises and falls with the temp of the surrounding.

- Oral temp < rectal temp 0.5 °C affected by:
  1. Hot and cold drinks.
  2. Gum chewing.
  3. Smoking.
  4. Mouth breathing

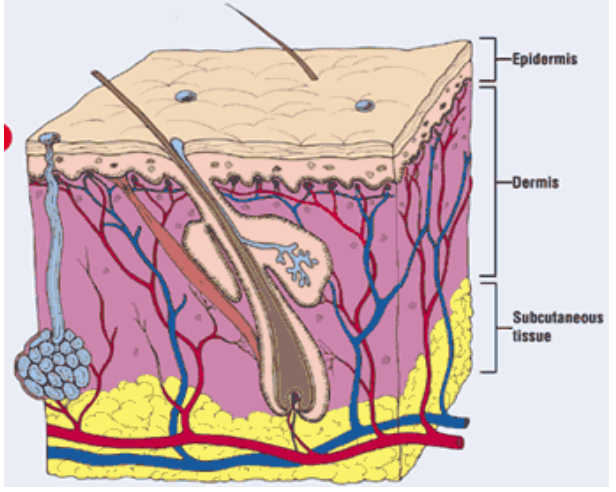
- Internal body temperature varies:
  1. Activity pattern.
  2. External temperature.
  3. Diurnal fluctuation.
  4. Women (menstrual cycle).

- ***Homeothermic animals*** **(birds and mammals) maintain body temperature within a narrow range in spite of wide fluctuation in environmental temp.**



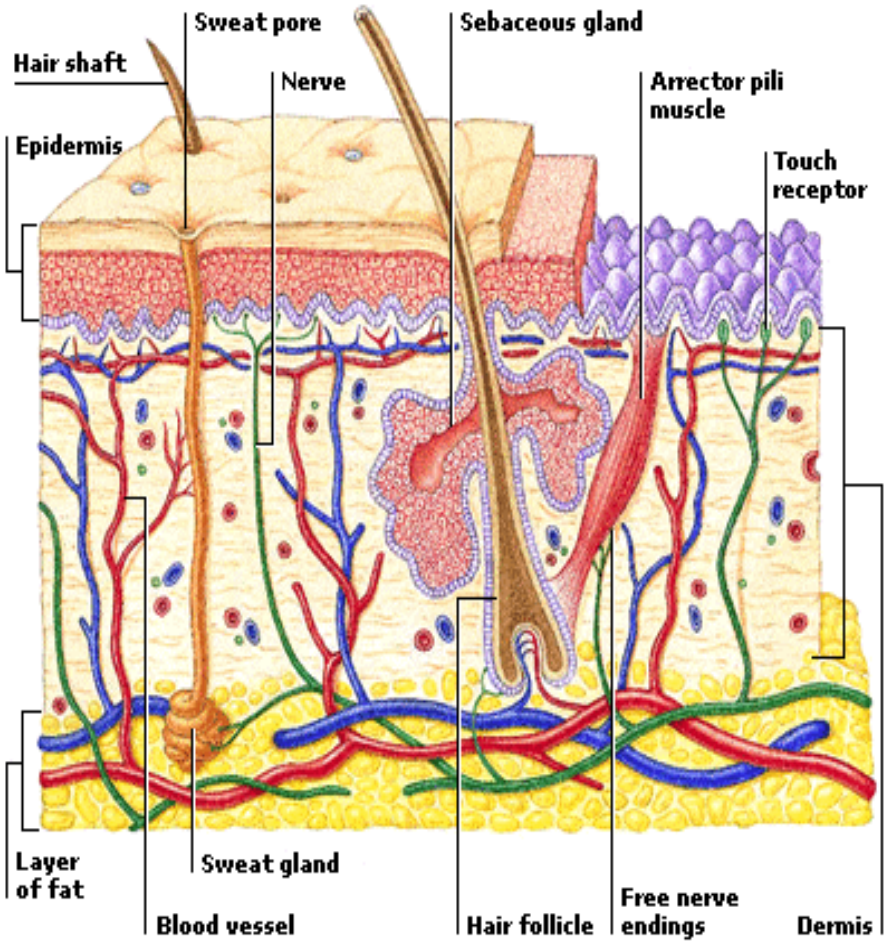
- ***Poikilothermic animals*** **(reptiles, amphibian, & fish): Their body temperature fluctuate over a considerable range.**

- **The skin, SC, and the fat of the SC are a heat insulator for the body. In women this insulation is still better because of the thickness of the SC.**



Flow of blood to the skin and heat transfer from the body core:

- Blood vessels penetrates the SC insulator tissues and are distributed in the subpappilary portion of the skin.
- Beneath the skin is a venous plexus.



- Heat conduction to the skin by the blood is controlled by the degree of vasoconstriction (sympathetic NS).

- **Balance between heat production and heat loss:**
  Heat production = heat loss ➪ heat balance.
  Heat production ≠ heat loss ➪ body heat (temp) ➪ increasing or decreasing.

Factors determining the rate of heat production:

1. **Basal rate of metabolism of all cells of the body. BMR (2000 Kcal/day)**
2. **↑Metabolism by ↑ muscle activity (shivering).**
3. **↑Metabolism caused by effect of thyroxine, Ad, Nad, & sympathetic stimulation on cells.**
4. **↑Metabolism caused by ↑ body temp.**
5. **Heat gained by hot foods & drinks & by high environmental temp.**

Thermoregulation in Heat Stress: Heat Loss

The body's thermoregulatory mechanisms primarily protect against overheating.

Body heat loss occurs in three ways:

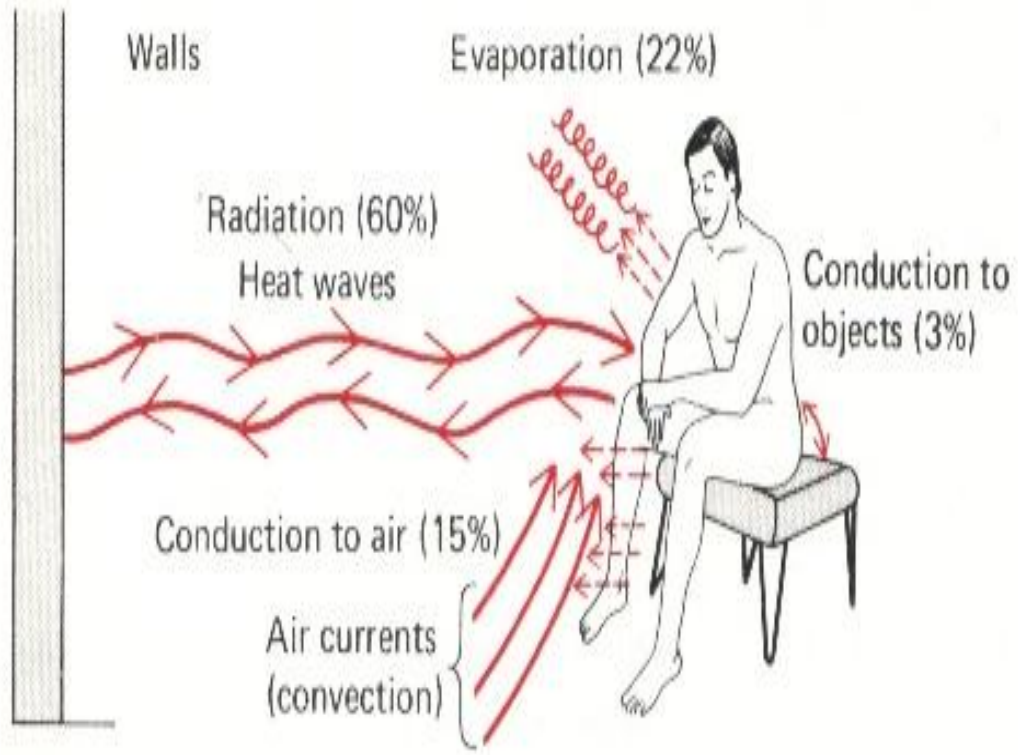
- **radiation**
- **conduction,**
- **evaporation**

Heat is lost from the body by:

1. Radiation (60%):
- **infrared heat rays.**

2. Conduction(18%):
- **To air (15 %)**
- **To objects(3%)**

Conduction is aided by convection



3. Evaporation(22%):

Evaporation of 1 gm of H_2O ⇨ 0.6 Calorie lost body.
- **Uncontrolled: insensibe evaporation of water from the skin & lung (600ml/ day).**
- **Controlled: evaporation of sweat.**

4. Small amount of heat is lost in urine and feces:

Heat Loss by Radiation

- **Our bodies are usually warmer than the environment, so the air and the objects around us absorb our body heat.**

Heat Loss by Conduction

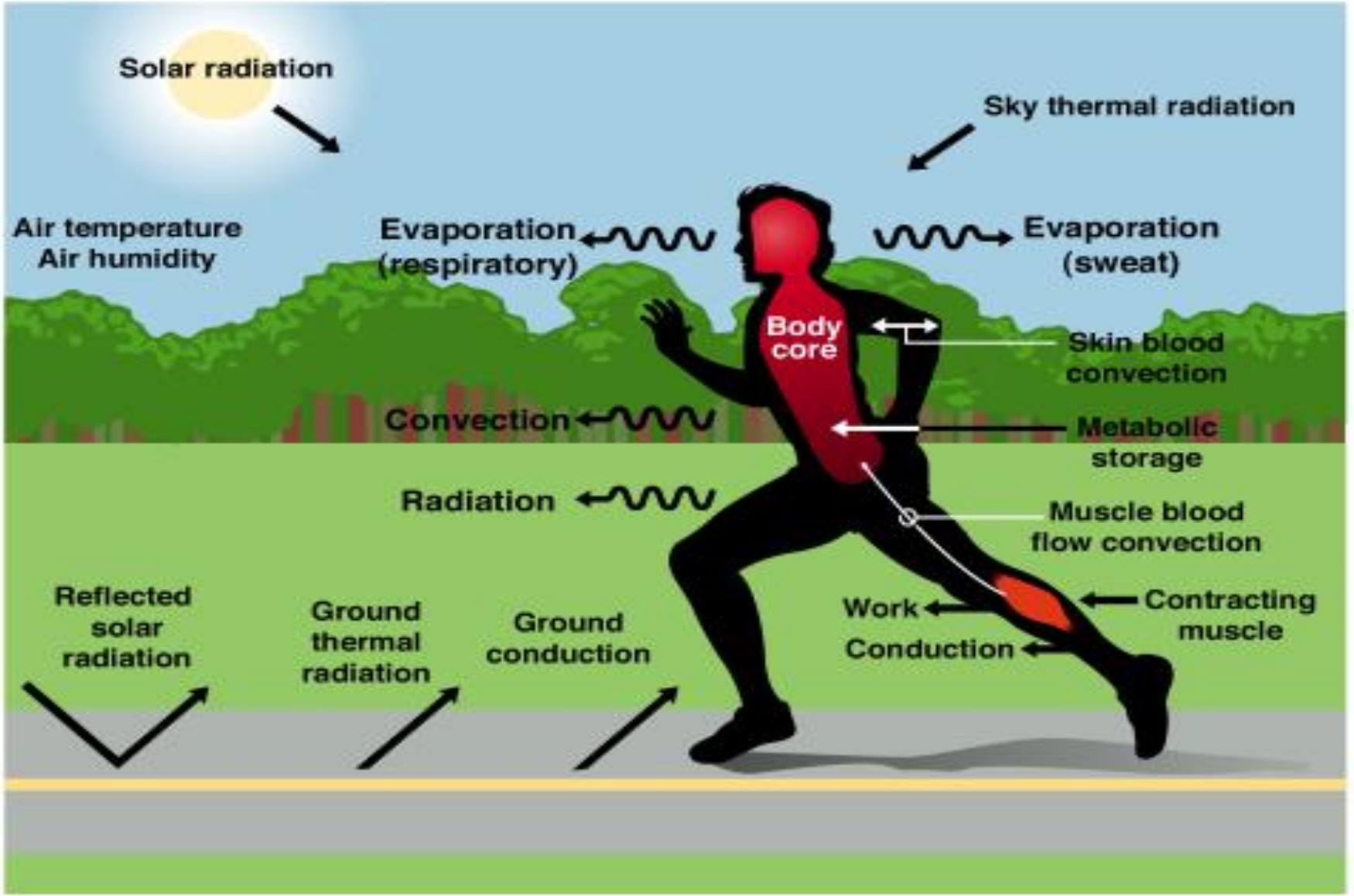
- **Heat loss by conduction involves the direct transfer of heat through a liquid, solid, or gas from one molecule to another.**

- **The rate of conductive heat loss depends on the temperature gradient between the skin and surrounding surfaces and their thermal qualities**

Heat Loss by Evaporation

- **Water vaporization from the respiratory passages and skin surface continually transfers heat to the environment**

9.2. Heat production within active muscle.



BRAIN CENTERS INVOLVED IN TEMP REGULATION:

- Body temp is regulated by nervous feedbacks mechanisms

- Temp regulating centers (hypothalamus).

- Receptors:
  1. Peripheral thermoreceptots (skin)
  2. Central thermoreceptors (hypothalamus, spinal cord, abdominal organs, and other internal location).

- Receptors (information) ➪ afferent neurons & ascending pathways ➪ hypothalamus ➪ efferent output.

- Cold ➪ posterior hypothalamus ➪ shivering
  Warmth ➪ anterior hypothalamus ➪ cutaneous vasodilatation and sweating.

Hypothalamic Regulation of Core Temperature

- **The hypothalamus contains the central coordination center for temperature regulation. It initiates the responses that keep the body from overheating or overcooling**
- **Heat-regulating mechanisms are activated by either:**

  Thermal receptors in the skin or,

  Temperature changes in the blood

  Free nerve endings in the skin respond to heat and cold and relay the senses to the hypothalamus and cerebral cortex.

Mechanisms activated by cold (temp ⇑ mechanisms):

a. ↑Heat production:

1. **Shivering.**
2. **↑Voluntary activity.**
3. **↑Secretion of Ad & Nad (↑chemical thermogenesis).**
4. **↑Secretion of thyroxine.**
5. **Hunger.**

b. ↓ Heat loss:

1. **Cutaneous vasoconstriction.**
2. **Curling up in a ball.** ⟶
3. **Horripulation (piloerection).**

Mechanisms activated by heat (temperature ⇓ mechanisms):

1. ⇑ Heat loss :
   a. Cutaneous vasodilatation:
   b. Sweating:
   c. Increased respiration (panting)

2. ⇓ Heat production:
   a. Anorexia → (↓food intake).
   b. Apathy and inertia.

Definition of fever

- **Fever is an elevation of body temperature mediated by an increase of the hypothalamic heat regulatory set-point.**

What common causes of fever?

- Infectious
- Inflammatory
- Oncologic
- Other: CNS dysfunction, drug fever
- Life-threatening conditions

Infectious

- Systemic
  - Bacteremia, sepsis, meningitis,
- Respiratory
  - URI, sinusitis, otitis media, pharyngitis, pneumonia, bronchiolitis
- Abdominal
  - Urinary tract infection, abscess (liver, kidney, pelvis)
- Bone/joint infection

Inflammatory

- Kawasaki disease
- Juvenile inflammatory arthritis
- Lupus
- Inflammatory bowel disease
- Others
- CNS dysfunction
- Drug fever

Pathogenesis of fever

- **Various infectious, immunologic or toxin-related agents (exogenous pyrogens) induced the production of endogenous pyrogens by host inflammatory cells.**

- **These endogenous pyrogens are cytokines, such as interleukins (IL-1β, IL-1α, IL-6), tumor necrosis factors (TNF-α, TNF-β), and interferon-α (INF).**

- **Endogenous pyrogenic cytokines directly stimulate to hypothalamus to produce prostoglandin which then resets the temperature regulatory set point.**

- **Endogenous pyrogens induce fever within 10-15 min. Whereas the febril response to exogenous pyrogens has a delayed onset requiring the synthesis and release of pyrogenic cytokines (60-90 min).**

Pathogenesis of fever:

Toxin from bacteria (endotoxin)

⇓

monocytes, macrophages, and Kuppfer cells

⇓

cytokines (polypeptides)
endogenous pyrogens
(EPs)

⇓

Hypothalamus

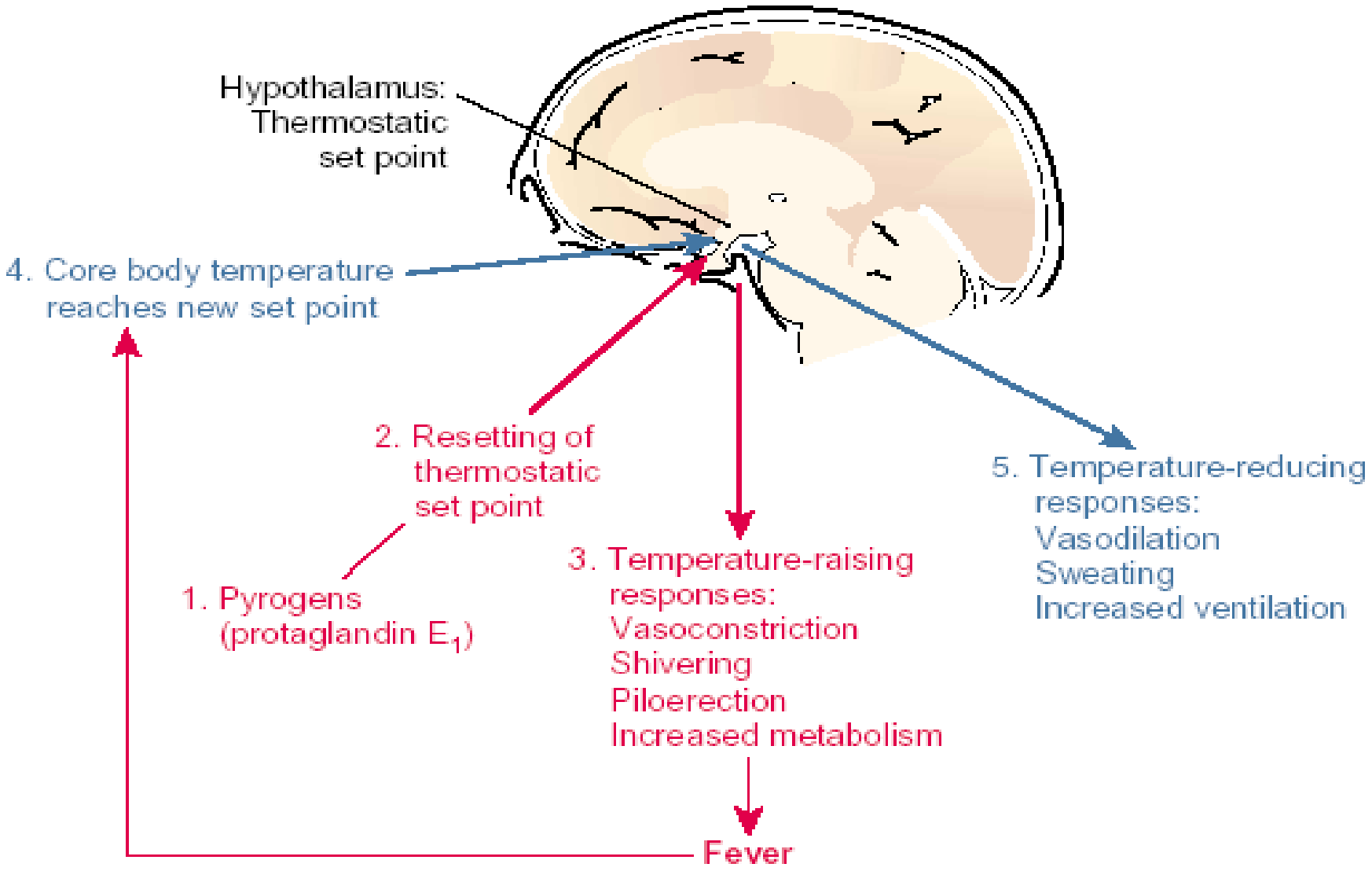
⇓

prostaglandins

⇓

fever

Mechanisms of fever



Neurogenic fever

- It usually is caused by damage to the hypothalamus caused by:
  - central nervous system trauma;
  - intracerebral bleeding;
  - an increase in intracranial pressure
  - drugs (e.g. anesthetics)
- Neurogenic fevers are characterized by a high temperature that is ***resistant to antipyretic therapy*** and is ***not associated with sweating*****.**

The effects of fever

- **It enhance immune function;**
  - **Increases motility and activity of the white blood cells;**
  - **Stimulates the interferon production and activation of T cells;**
- **Inhibits growth of some microbial agents:**
  - **Many of the microbial agents that cause infection grow best at normal body temperatures, and their growth is inhibited by temperatures in the fever range (the rhinoviruses responsible for the common cold are cultured best at 33°C);**
- **Dehydration occurs because of sweating.**

- Metabolic effects:
  - Increased need for oxygen;
    - Increases the heart rate
    - Increases the respiration rate
  - Increased use of body proteins as an energy source;
  - During fever the body switches from using glucose (an excellent medium for bacterial growth)

Fever of unknown origin

- It is defined as a temperature elevation of 38.3°C or higher that is present for 3 weeks or longer.
- Among the causes are:
  - malignancies (lymphomas, metastases to the liver and central nervous system);
  - infections such as human immunodeficiency virus or tuberculosis, or abscessed infections;
  - cirrhosis of the liver.

- **Previously fever were artificially induced for the treatments of neurosyphlis.**

- **Very high temp are harmful. When the rectal temperature is over 41°C for prolonged periods, some permanent brain damage results.**

- **When its over 43°C, heat stroke develops and death is common.**

Hypothermia

Mild: Core temp. 32 to 35ºC

-

Moderate: Core temp. 28 to 32ºC

Severe: Core temp. below 28ºC

Hypothermia:

- When the skin or blood is cooled to lower the body temp :-
  1. Metabolic and physiologic processes slow down,
  2. RR, HR, & B.pr is slow.
  3. consciousness is lost.
- Rectal temp (28°C)→ ability to return the temp to normal spontaneously is lost.
- Human tolerate temp of 21 – 24°C and induced hypothermia has been used extensively in surgery.