TEMPERATURE REGULATION

- In the body, heat is produced by:
  - Muscular exercise
  - All the vital processes that contribute to the BMR
  - Assimilation of food
- Heat is lost by:
  - Radiation
  - Conduction
  - Vaporisation of water in the respiratory passages and on the skin
- The balance between heat production and heat loss determines the body temperature
- Normal body function depends on a relatively constant body temperature
- In "warm blooded" animals, a group of reflex responses that are primarily integrated in the HYPOTHALAMUS operate to maintain body temperature within a narrow range in spite of wide fluctuations in environmental temperature

NORMAL BODY TEMPERATURE:

- In normal young adults, the morning oral temperature averaged 36.7C with a standard deviation of 0.2C
  - Thus 95% of all young adults would be expected to have a morning oral temperature of 36.1-37.1
- The normal human core temperature undergoes a regular circadian fluctuation of 0.5-0.7C
  - **Lowest at 6am and highest in the evenings**
  - Lowest during sleep and rises during activity

HEAT PRODUCTION:

- A variety of basic chemical reactions contribute to body heat production at all times
  - Ingestion of food leads to the specific dynamic action of the food
  - Major source of heat is the contraction of skeletal muscle
- Heat production can be varied by endocrine mechanisms in the absence of food intake or muscular exertion
- A source of considerable heat, particularly in infants, is BROWN FAT
  - This fat has a high rate of metabolism and its thermogenic function has been likened to that of an electric blanket

HEAT LOSS:

- CONDUCTION:
  - **Transfer of heat down a thermal gradient between two surfaces in contact with one another**

- RADIATION:
  - **The transfer of heat by infrared electromagnetic radiation from one object to another at a different temperature with which it is not in contact**
  - When an individual is in a cold environment, heat is lost by CONDUCTION to the surrounding air and by RADIATION to cool objects in the vicinity
- CONVECTION:
  - Aids conduction as this is the movement of molecules away from the area of contact
- VAPORISATION:
  - Vaporisation of 1g of water removes about 0.6Kcal of heat
  - A certain amount of water is vaporised at all times
  - This INSENSIBLE WATER LOSS is important in heat loss
  - The degree to which sweat vaporises depends on the humidity of the environment
    - Hence one feels hotter on a humid day as less sweat is vaporised

TEMPERATURE-REGULATING MECHANISMS:

- MECHANISMS ACTIVATED BY COLD:
  - INCREASED HEAT PRODUCTION:
    - Shivering
    - Hunger
    - Increased voluntary activity
    - Increased secretion of noradrenaline and adrenaline
  - DECREASED HEAT LOSS:
    - Cutaneous vasoconstriction
    - Curling up (thus decreasing surface area for heat loss)
    - Horripilation (piloerection)
- MECHANISMS ACTIVATED BY HEAT:
  - INCREASED HEAT LOSS:
    - Cutaneous vasodilation
    - Sweating
    - Increased respiration
  - DECREASED HEAT PRODUCTION:
    - Anorexia
    - Apathy and inertia
- Thermoregulatory adjustments involve local responses as well as more general reflex responses
  - When cutaneous blood vessels are cooled, they become more sensitive to catecholamines and the arterioles and venules constrict and directs blood away from the skin
    - The deep veins (VENAE COMITANTES) run alongside the arteries supplying the limbs

- Heat is transferred from the warm arterial blood going to the limbs to the cold venous blood coming from the extremities (COUNTER-CURRENT EXCHANGE)
- This keeps the extremities cold but conserves body heat

- Hypothalamic reflexes:
  - Activated by **cold** - **POSTERIOR HYPOTHALAMUS**
  - Activated by **warmth** - **ANTERIOR HYPOTHALAMUS**
    - Stimulation of the anterior hypothalamus causes cutaneous vasodilation and sweating
    - Lesions of this area can cause hyperthermia

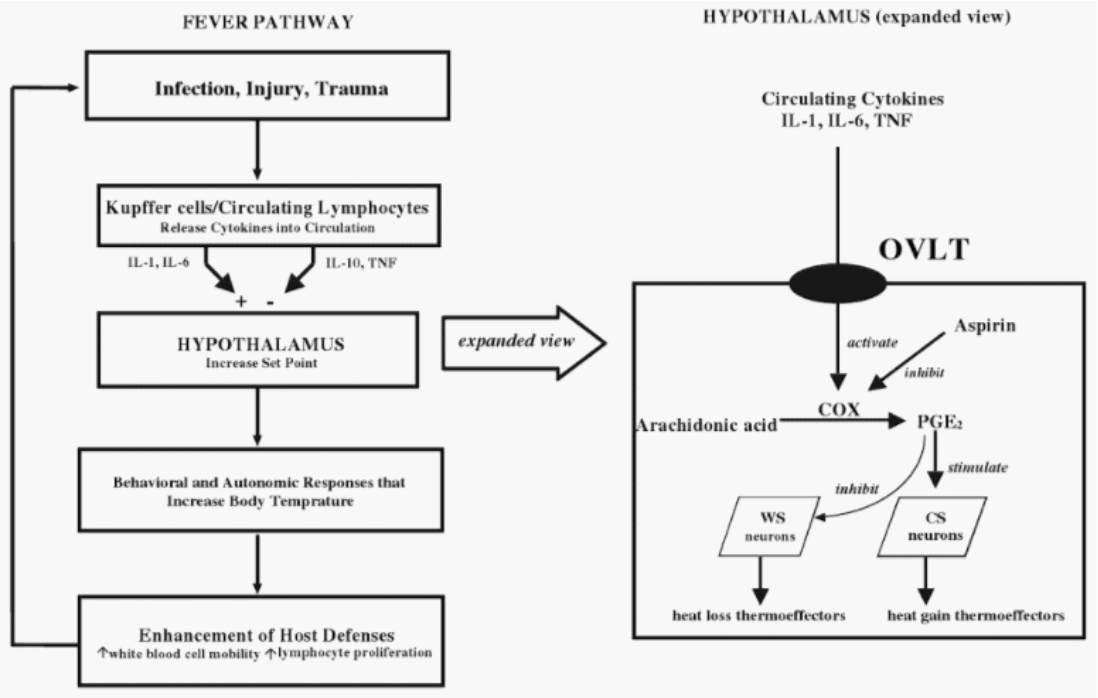
AFFERENTS:

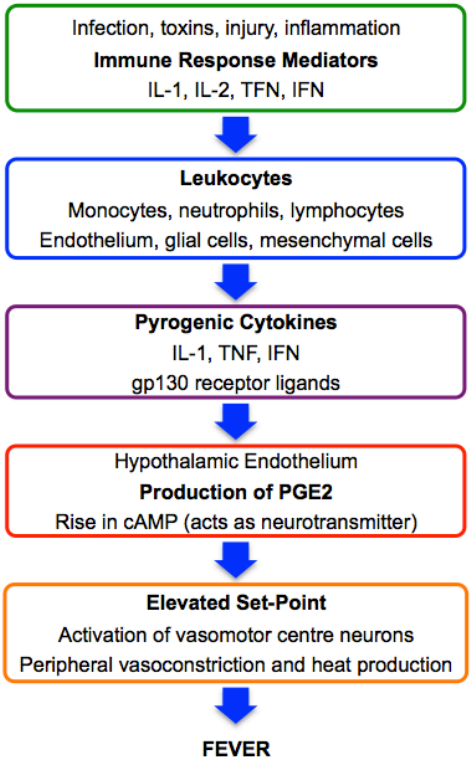
- The hypothalamus is said to integrate body temperature information from sensory receptors in the skin, deep tissues, spinal cord and extrahypothalamic portions of the brain and the hypothalamus itself

FEVER:

- When fever occurs, the thermoregulatory mechanisms behave as if they were adjusted to maintain body temperature at a higher than normal level
  - I.e. “as if the thermostat had been reset”
  - The temperature receptors then signal that the actual temperature is below the new set point
  - This usually produces chilly sensations due to cutaneous vasoconstriction and occasionally enough shivering to produce a shaking chill
- PATHOGENESIS:
  - Toxins from bacteria such as ENDOTOXIN act on monocytes, macrophages and Kupffer cells to produce cytokines that act as ENDOGENOUS PYROGENS:
    - IL1, IL6
    - TNFα
    - IFN-Y
  - These act on the OVLT (organum vasculosum of the lamina terminalis), one of the circumventricular organs, which in turn activates the PREOPTIC AREA OF THE HYPOTHALAMUS
  - The fever produced is probably due to local release of PROSTAGLANDINS in the hypothalamus
    - PGE2 is one of the prostaglandins that causes fever, hence the antipyretic affect of aspirin
- Fever is presumably beneficial
  - A rise in temperature may inhibit the growth of the organisms
  - Antibody production is enhanced when body temperature is elevated
  - However, very high temperatures are harmful and can cause permanent brain damage

- **Endogenous pyrogens → activation of OVLT → activation of preoptic hypothalamus → secretion of PGE2 → reset thermostat**





HYPOTHERMIA:

- In hibernating mammals, body temperature drops to low levels without causing any demonstrable ill effects
- Metabolic and physiologic processes slow down
    - Respiration and heart rate are very slow and blood pressure is low
    - At rectal temperatures of about 28C, the ability to spontaneously return the temperature to normal is lost, but the individual continues to survive and if rewarmed with external heat, returns to a normal state