THERMOREGULATION

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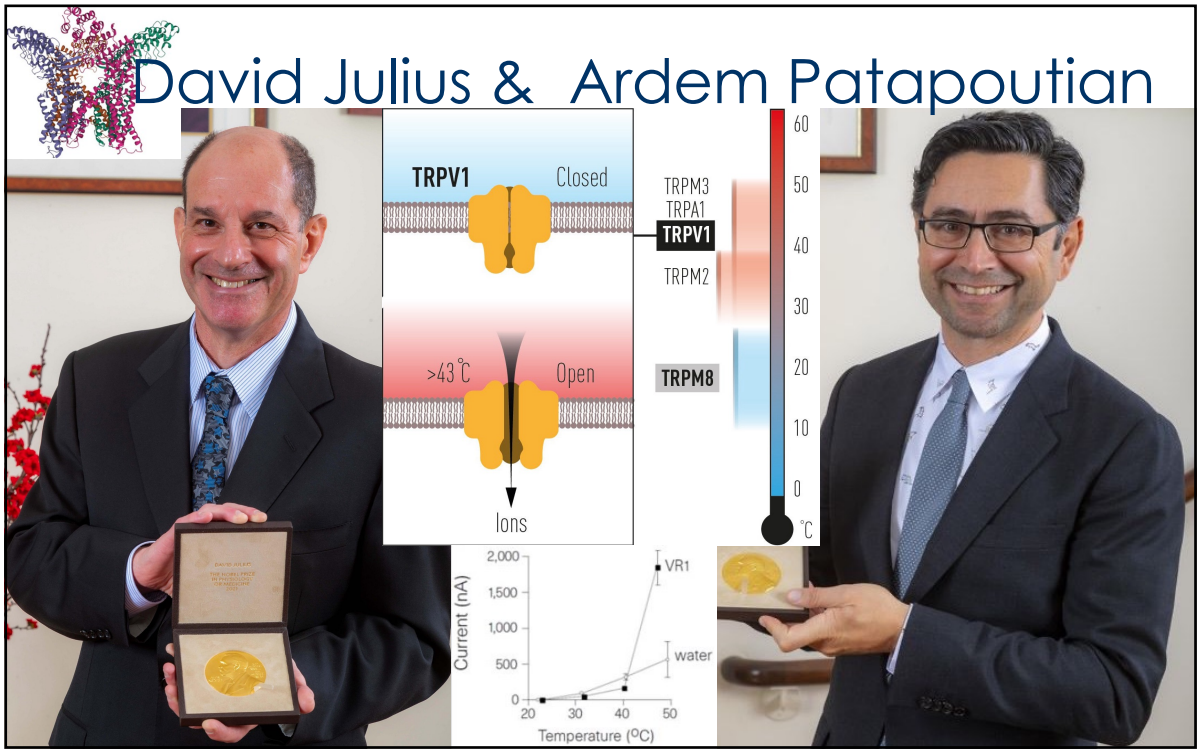


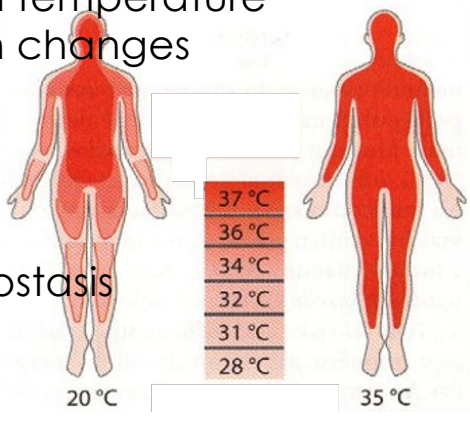
One of the most efficient physiological regulations

body temperature changes by 1 °C
for each 30 °C of ambient temperature

x

What is it?

- maintenance of optimal body temperature
  - independent of external temperature & body heat production changes
  - "core temperature"
  - has limits
  - energy demanding
  - important part of homeostasis



Cold x warm blooded

"cold-blooded"
(nature)

poikilotherms
(lab)

non-living

Core
body
temperature

homoiotherms

behavior
*+ **physiology***

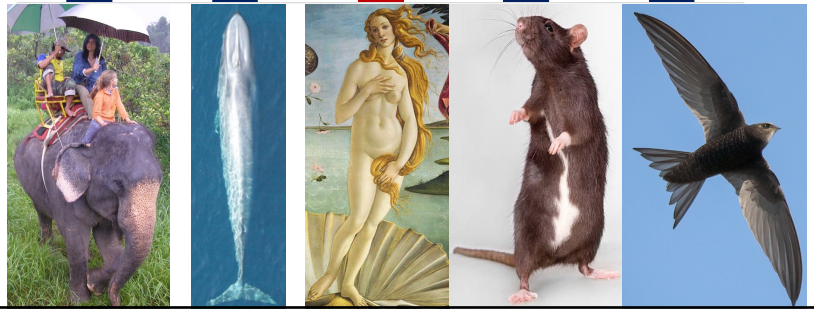
behavior

Ambient temperature

Core body temperature

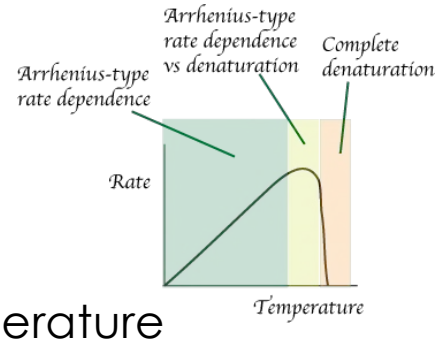
°C

44
42
40
38
36
34
32



Why?

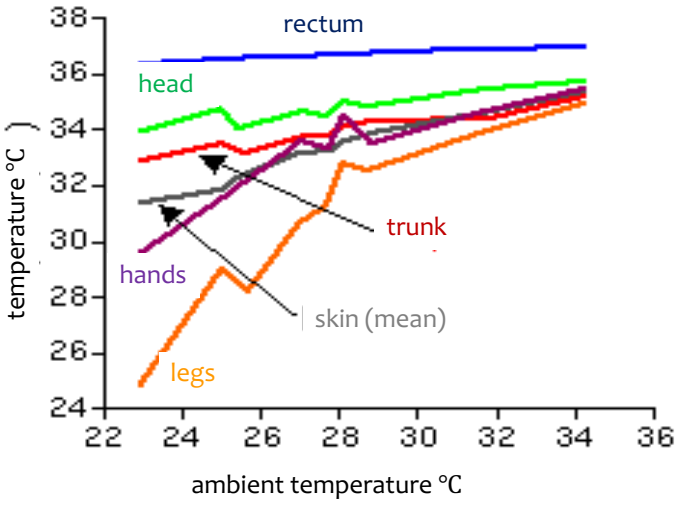
- all enzymes have optimal temperature for activity
  - in mammals ~37-38 °C



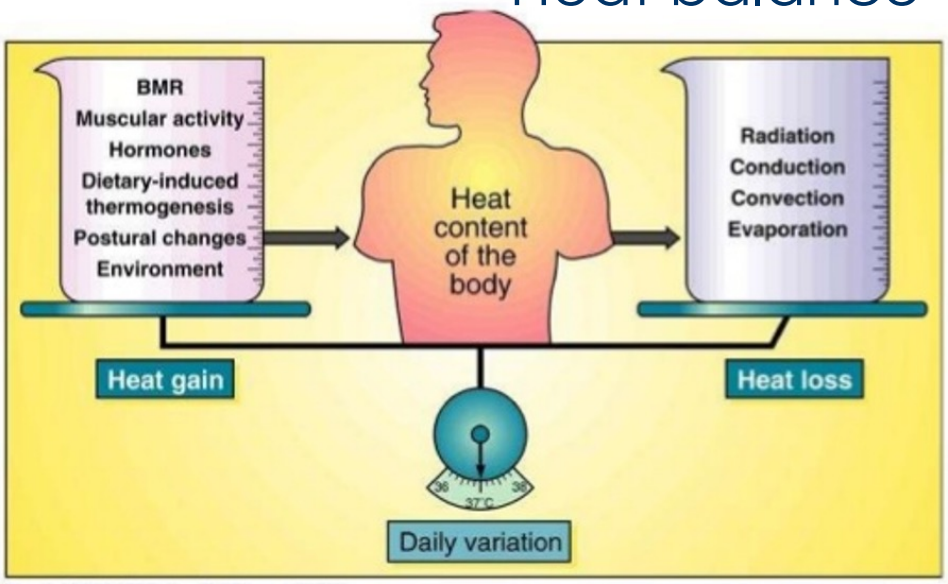
X

- variable external temperature
- variable heat production by the body

Why?



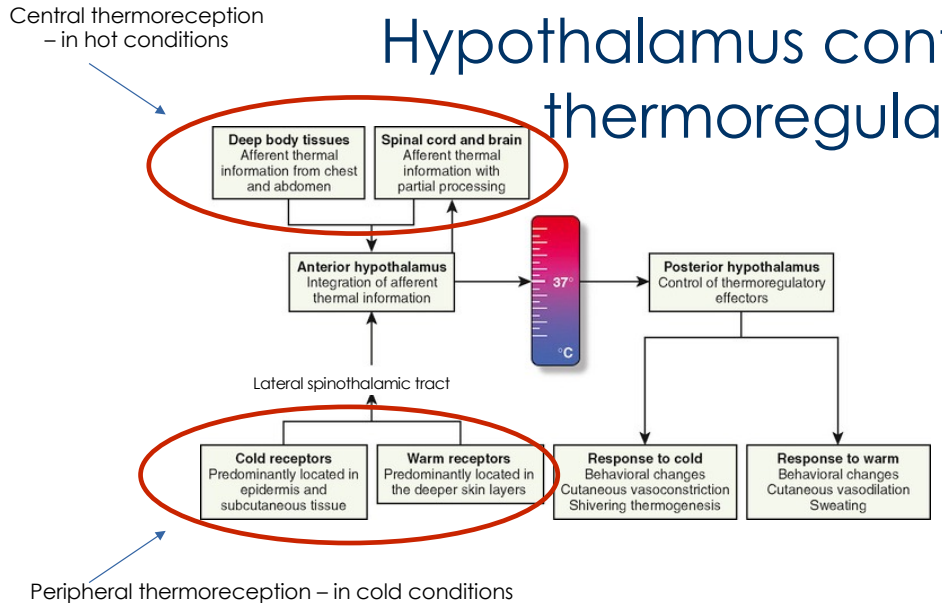
Heat balance



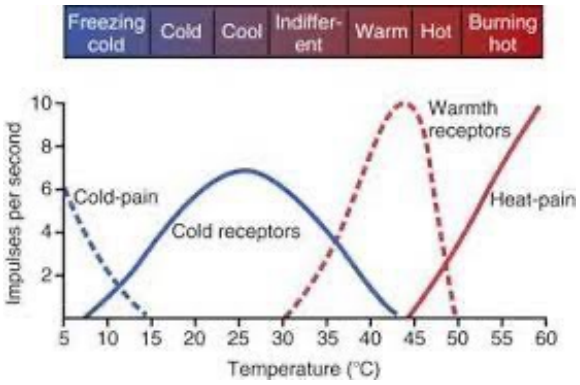
Thermoneutral zone

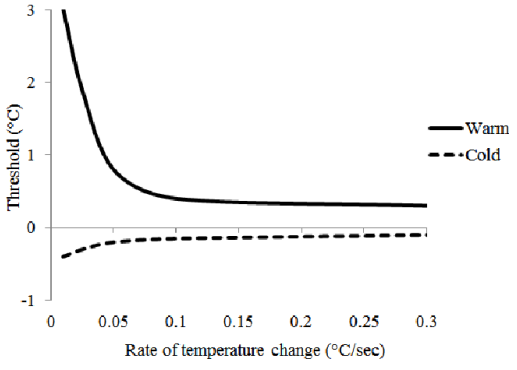
- ambient temperature at which thermoregulatory mechanisms are not needed to maintain body temperature
- lower than body temperature because of BMR
- women > man (25 x 22 °C)

Hypothalamus controls thermoregulation



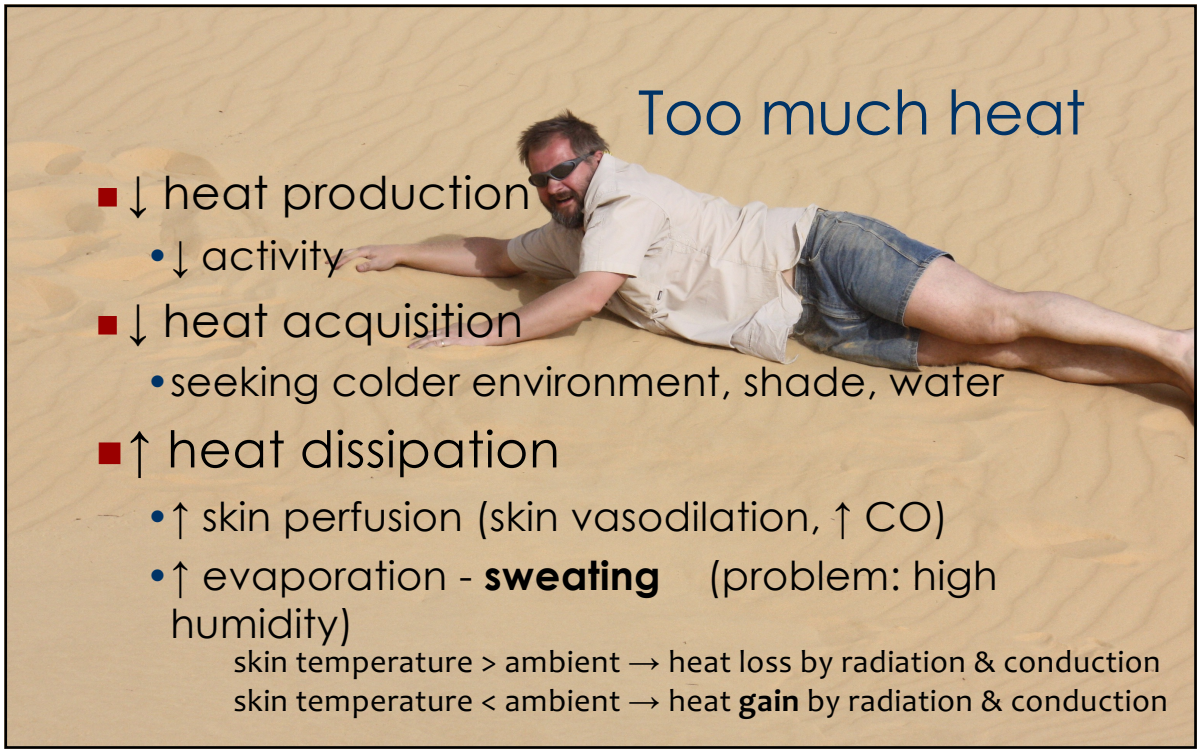
Perception of heat & cold





Too little heat

- ↑ heat production
  - ↑ activity (muscles)
  - shivering
  - non-shivering thermogenesis (BAT; muscles?)
- ↓ heat loss
  - seeking warmer environment
  - more insulation (dress)
  - ↓ skin perfusion (skin vasoconstriction)
  - piloerection(goose bumps)

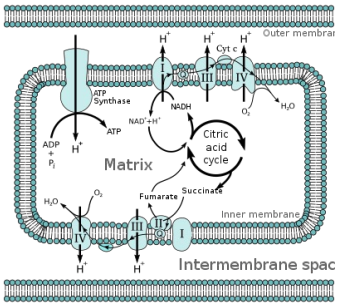


Too much heat

- ↓ heat production
  - ↓ activity
- ↓ heat acquisition
  - seeking colder environment, shade, water
- ↑ heat dissipation
  - ↑ skin perfusion (skin vasodilation, ↑ CO)
  - ↑ evaporation - **sweating** (problem: high humidity)

skin temperature > ambient → heat loss by radiation & conduction
skin temperature < ambient → heat **gain** by radiation & conduction

Non-shivering thermogenesis



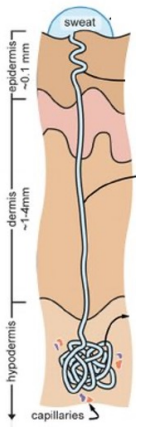
- BAT (+ skeletal muscle?)
  - especially infants
  - still present in most adults in the upper chest and neck (especially paravertebrally)
  - related not to white fat, but to skeletal muscle
- UCP1 (thermogenin)
- regulated mainly by thyroid hormones & SNS

Hypothermia

- 20-30 minutes in ice water fatal (body temperature ↓ to ~25 °C)
- arrhythmia, heart failure
- in mountains, beware of confusion with high altitude brain edema - similar symptoms, without O_2 and descent fatal
- somewhere <28 °C, the ability to regulate temperature and spontaneous return ceases - used perioperatively, organ transport
- COLD ADAPTATION - shift of thermoneutral zone: metabolic, isolation, shift of the threshold of tremor thermogenesis (! Similar in the elderly)
- !!! cold can aggravate problems with coronary heart disease, can provoke angina pectoris development

Sweat glands

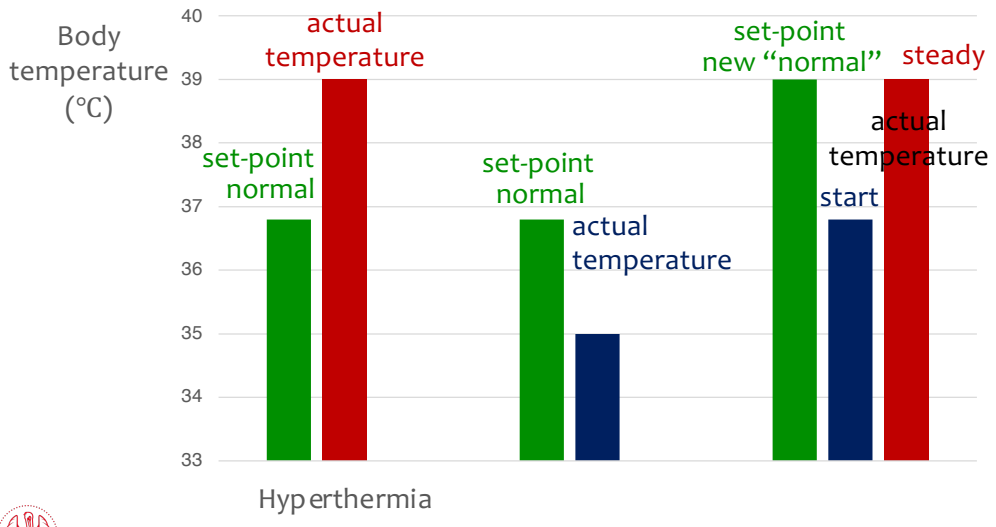
- almost everywhere
- density: palms & soles > head >> trunk & extremities
- mammary glands are their derivatives
- 98–99% water, some electrolytes (Na, Cl), fatty acids, lactic acid, citric acid, ascorbic acid, urea, uric acid
- pH 4 - 6.8 (helps to protect skin from pathogens)
- originally odorless, gains odor upon decomposition by bacteria
- hormonal regulation (sweat: men > women)
- max >3 l/hr



Fever (pyrexia)

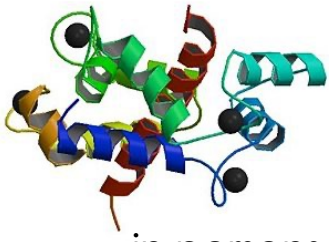
- when the core temperature is set higher, through the action of the pre-optic region of the anterior hypothalamus
- viral, bacterial, and parasitic infections
- Non-infectious - vasculitis, deep vein thrombosis, connective tissue disease, side effects of medication or vaccination, cancer
- Hyperpyrexia = extreme ↑ body temperature (> 40.0 or 41.0 °C)
- Useful (↑ white cell activity → against infection) ???
- pyrogens → PGE_2 release → EP_3 receptors in hypothalamus
- The most common pyrogens: endotoxins = lipopolysaccharides produced by Gram-negative bacteria such as *E. coli*.
- Endogenous pyrogens - cytokines released from monocytes (interleukin 1 (α and β) & IL-6)
- activation of the EP_3 receptor →↓ inhibitory tone of preoptic hypothalamus on thermogenic effector cells in the brain

Fever x hyperthermia



Response to overheating

- ↑ cardiac output - especially ↑ frequency
- heat transport from muscles to surface, possible hypotension
- ↑ blood flow to skin & subcutaneous tissue compensated by ↓ flow tp other areas (GIT)
- heat cramps - caused by loss of fluids and minerals
- heat exhaustion - decrease in performance, slowing pace, thirst, deterioration of movement coordination, feeling tired
- in non-acclimatized or in poor physical condition, this condition can occur even at a body temperature of 39 °C
- adaptation to dry (sweating) x moist heat (changes in the circulatory system, ↑ in heart rate)
- !!! thermoregulation failure above 40 °C, symptoms: cessation of sweating, hot and dry skin, tachycardia with weak pulse and tachypnea, confusion, unconsciousness



Malignant hypertherima

- in persons sensitive to anesthesia, congenital defect of ryanodine receptor 1
- High intracellular Ca 2+ concentration, muscle contractions, heat production persist.

Heat stroke

- generally a lack of sweating in classic heat stroke while sweating is generally present in exertional heatstroke
- life-threatening condition characterized by severe hyperthermia and multiorgan-dysfunction resulting from exposure to heat

Thermoregulation in children

- relatively larger body surface area in relation to body weight
- greater heat loss by conduction, convection and radiation than by sweating
- in extreme heat this means greater heat absorption from the surroundings and in extreme cold greater heat loss
- usually a smaller layer of subcutaneous fat in children is a disadvantage in a cold environment
- children's sweat glands produce less sweat
- children have a relatively higher density of sweat glands than adults, but their glands produce less sweat, perhaps due to lower sensitivity to thermal stimuli
- BAT, NST