

MUNI
MED

THERMOREGULATION

Heat vs. temperature

- **Heat [J]** – (heat) energy transmitted/shared among the objects (passed or received)
- **Temperature [K, °C, °F]** – degree of heat energy content; mean kinetic energy of particles (molecules, ions)

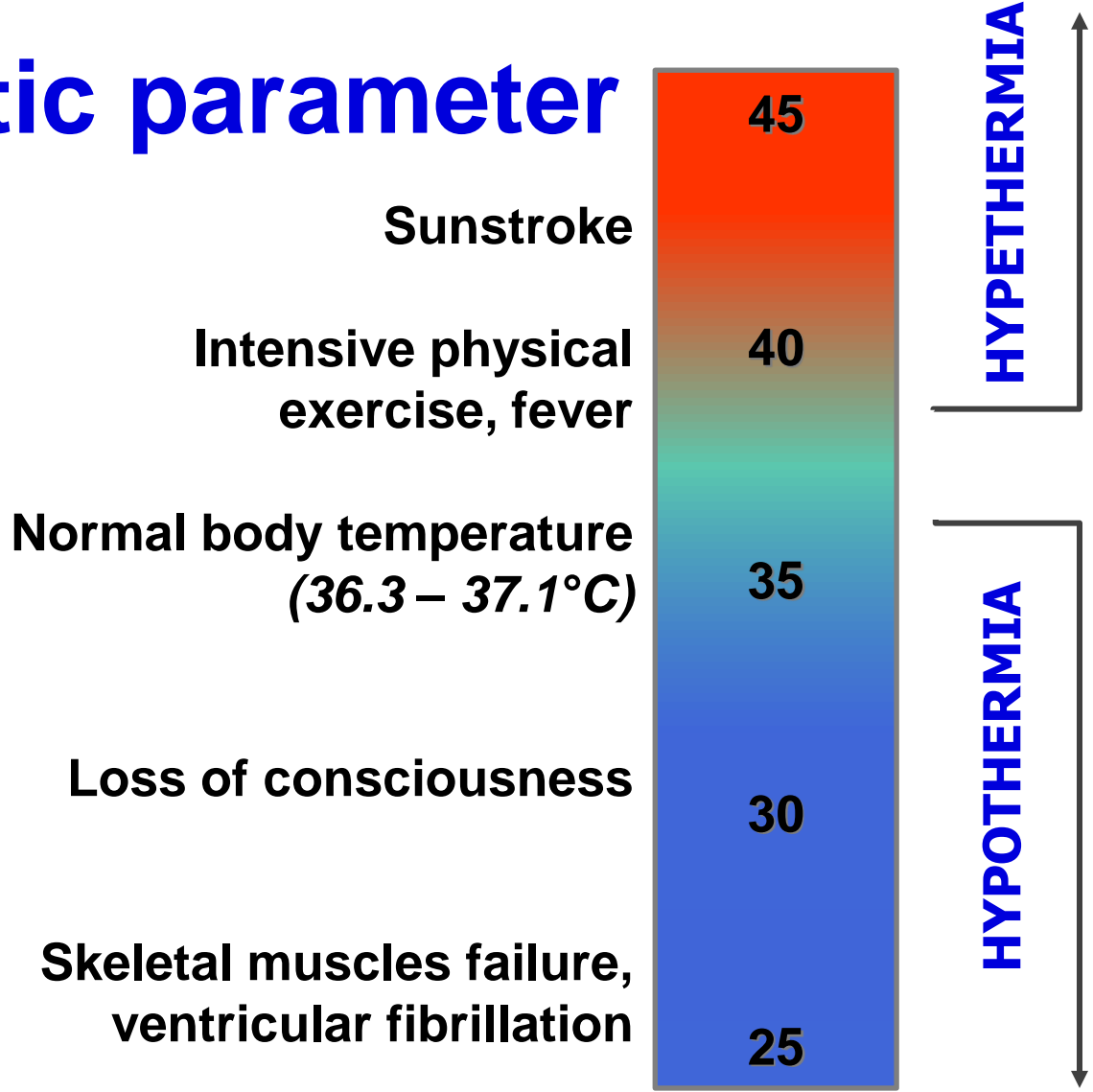


Endothermic („warm-blooded“) *vs.* ectothermic („cold-blooded“) species

Arctic (20° - 40°C) *vs.* tropic (22° - 27°C water, 32° - 35°C) animals

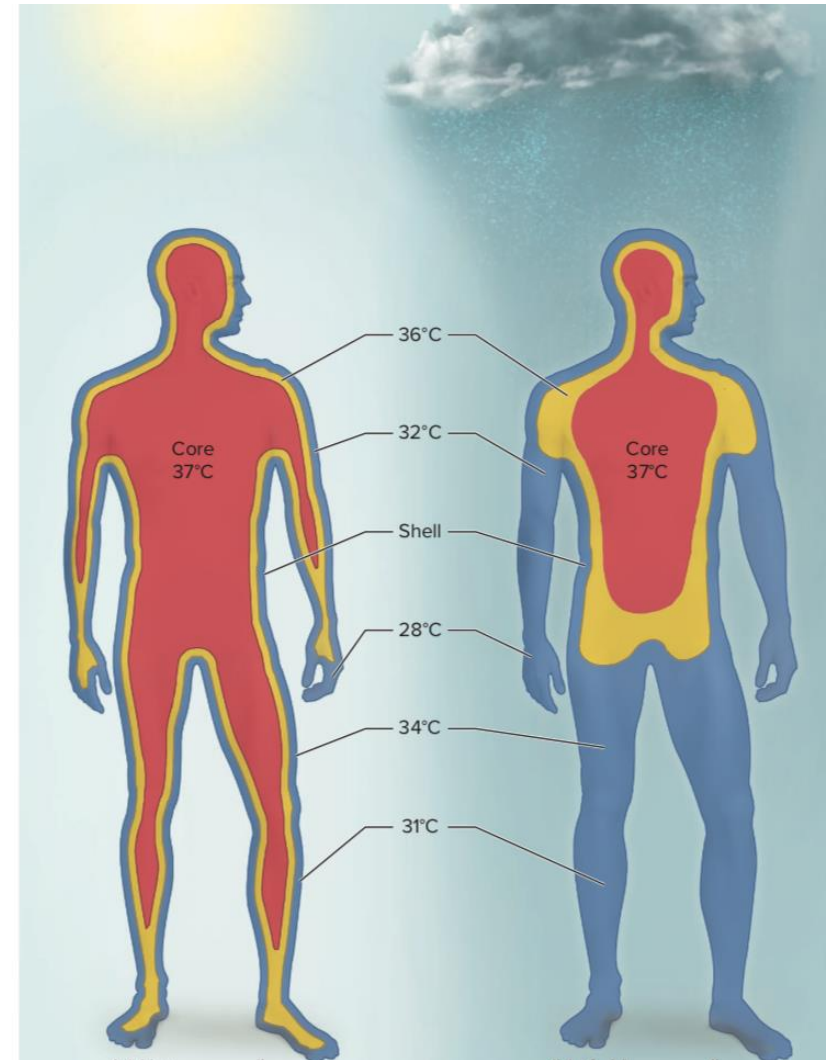
Temperature – homeostatic parameter

Temperature (C)	Symptoms
28	muscle failure
30	loss of body temperature control
33	loss of consciousness
37	normal
42	central nervous system breakdown
44	death



Core vs. Periphery (Shell)

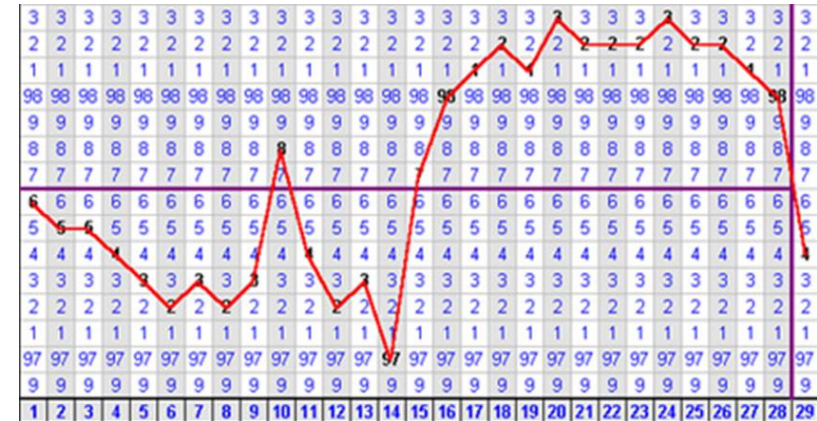
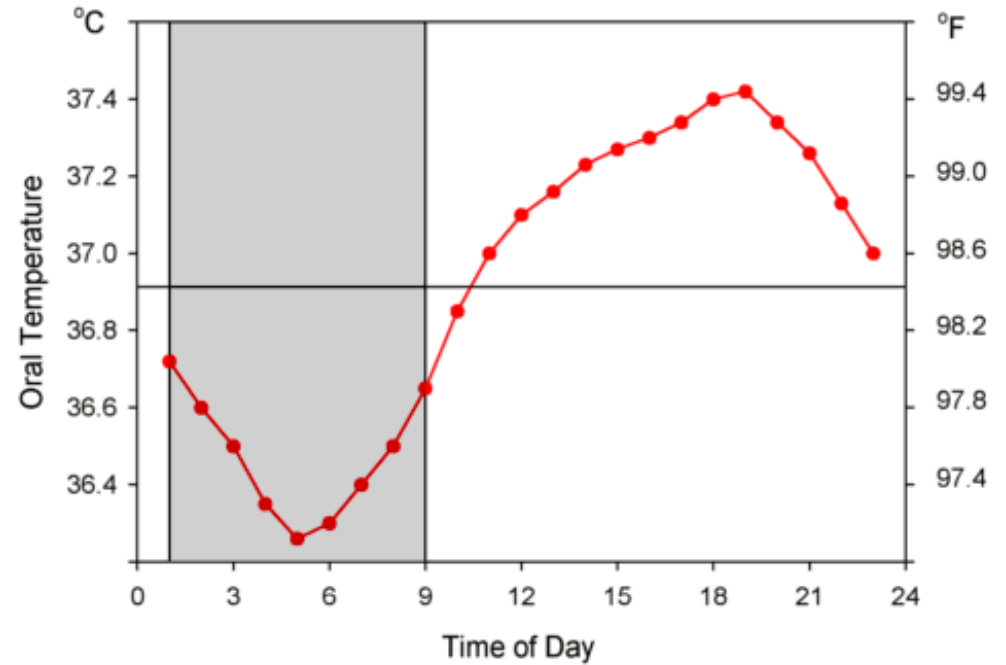
- homeothermic vs. poikilothermic
- Core temperature – kept within (narrow) range
- Skin temperature (periphery, shell) – changing (depends on core and ambient temperatures)



Variability of core temperature

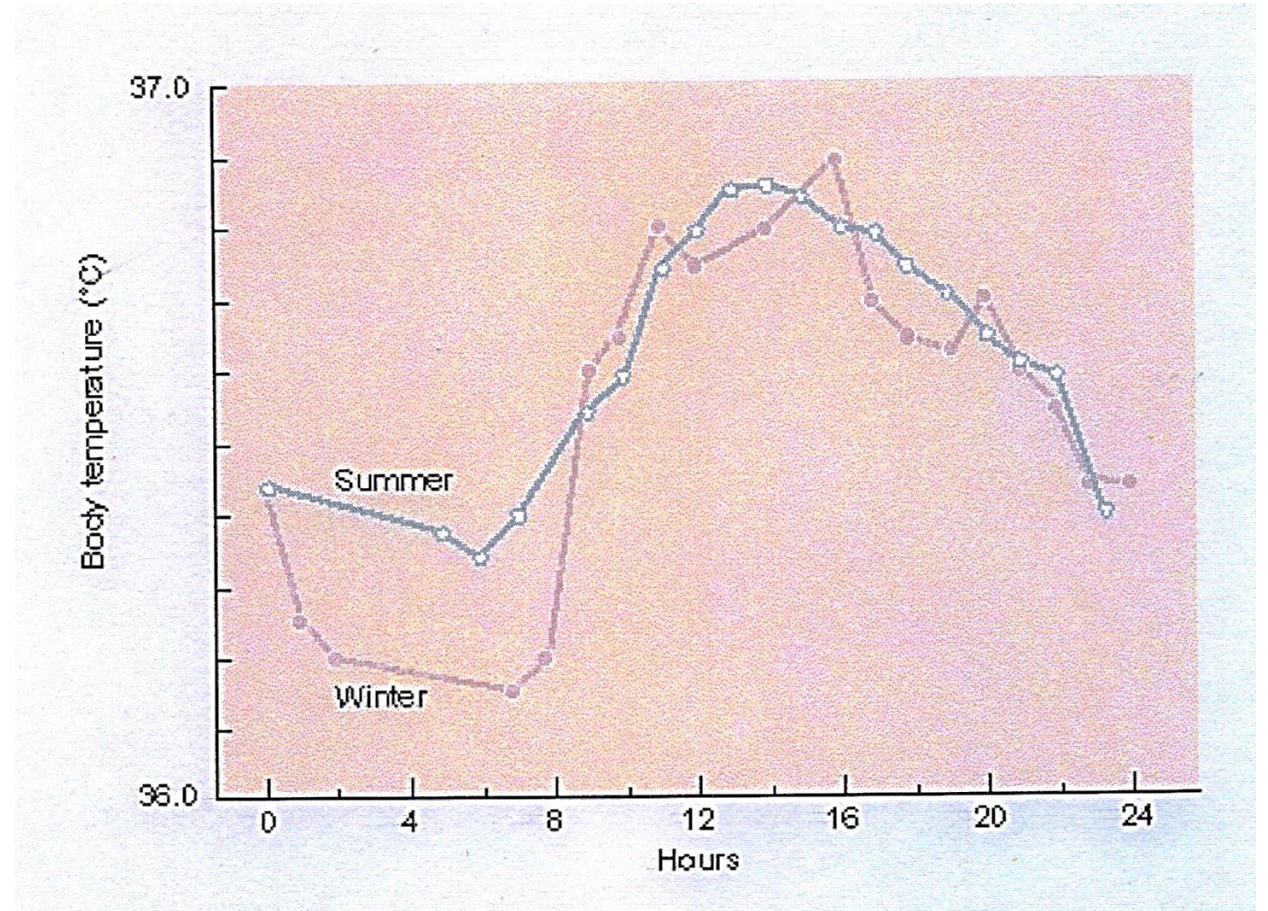
– Circadian rhythm

– Circamensal rhythm (women from puberty to menopause)

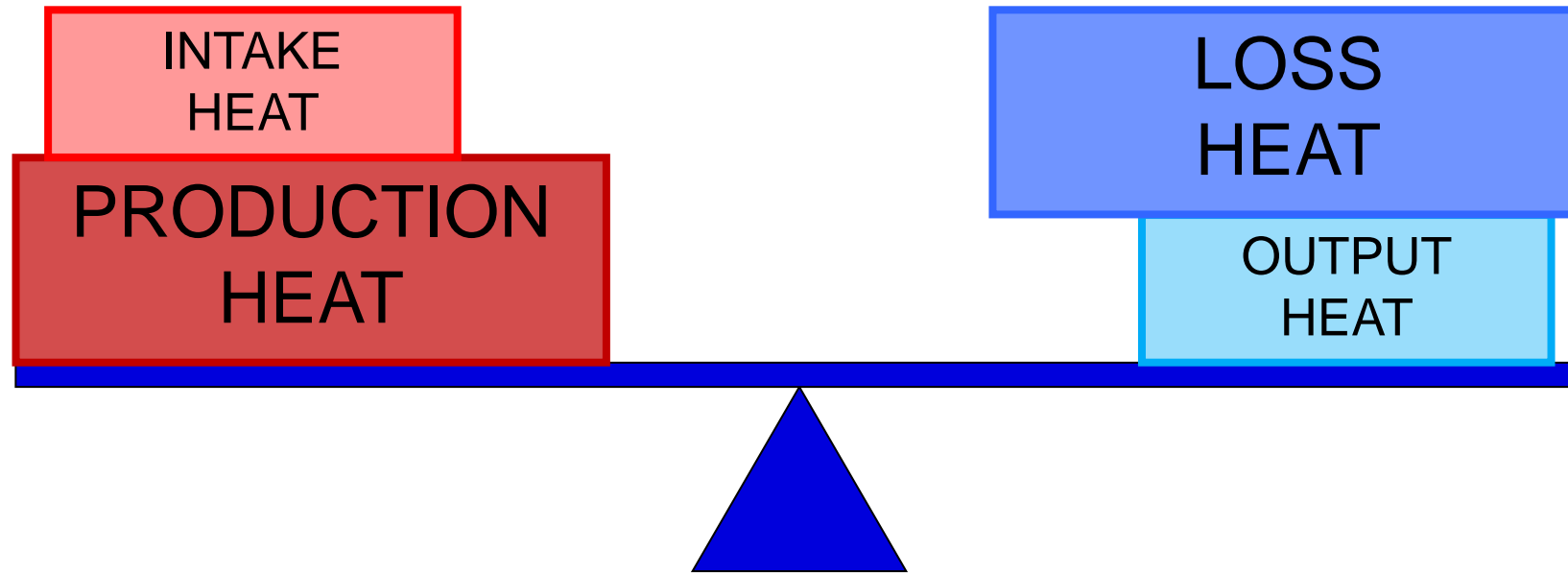


Variability of core temperature

- Seasonal variability (circannual rhythm)
- Aging



Fine equilibrium of core temperature



Transfer of heat in the organism

- primarily **CONVECTION**
- medium = blood

- to lower extent **CONDUCTION**
 - Inner heat convection (between inner organs and skin)
 - Outer heat convection – heat output

Heat production

- Metabolism: metabolic turnover ~ heat production (+10% BM ~ +1°C)
- Physical activity (muscle contractions) – rest vs. exercise (exercising muscles produce up to 70-90% of actual total heat production)
- Postprandial thermogenesis (food intake)
- Shivering thermogenesis (voluntary and non-voluntary shivering thermogenesis)
- Non-shivering thermogenesis (brown adipose tissue)

Heat intake and loss

- „passive“ processes
 - RADIATION (irradiation, IR, „touchless“ heat sharing)
 - CONVECTION
 - CONDUCTION (touch)
- Dependent on temperature gradient shell (skin) – surrounding environment

Heat output (active loss)

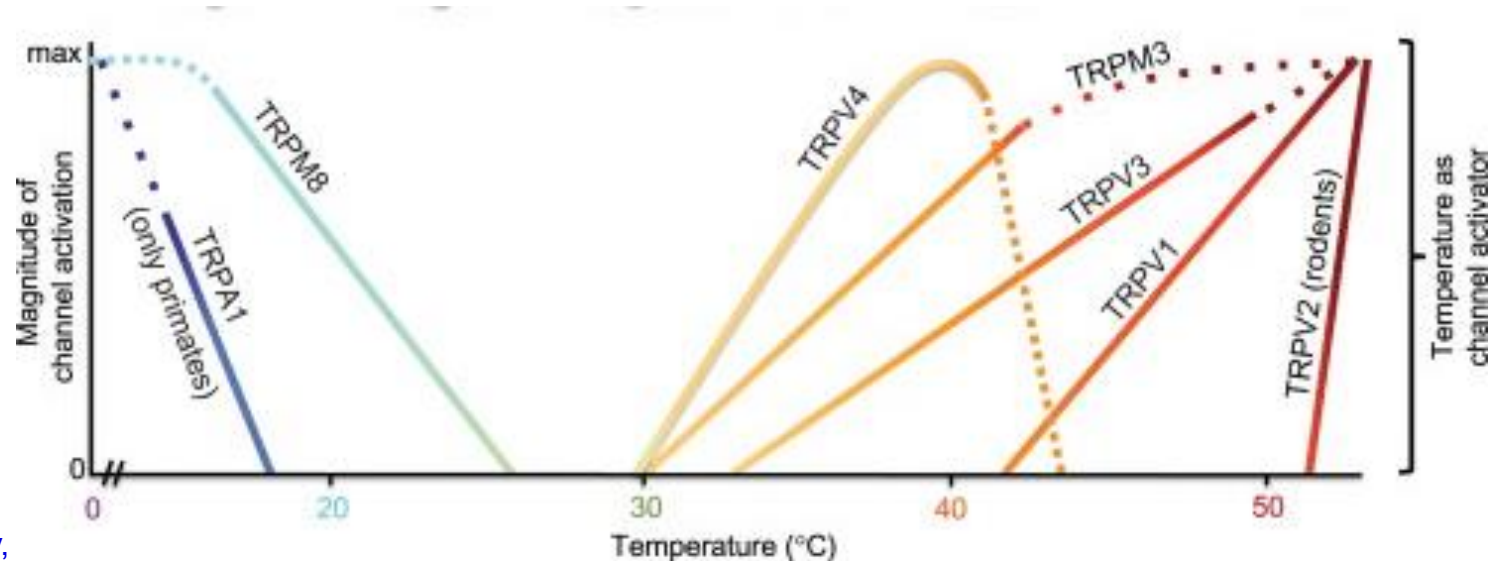
- EVAPORATION
 - perspiratio sensibilis = sweat production (1 l of evaporated sweat = - 2 428 kJ)
 - perspiratio insensibilis = diffusion of water through skin and mucosa
- (RADIATION)
- (CONDUCTION)
- (CONVECTION)

Thermoregulation

- All processes aiming to keep core temperature within desired range
- Thermoregulatory behavior
- Social thermoregulation

Afferentation

- Central thermoreceptors – brain (core) temperature
- Temperature-sensitive neurons in anterior hypothalamus (area preoptica)
- Peripheral thermoreceptors – skin (shell) temperature
- TRP channels



Thermoregulatory center

- Anterior HYPOTHALAMUS (area preoptica)
- Integration of afferent information
- Modification of efferent pathways (vegetative, somatic) – impact on effector systems
- „set-point“ vs. threshold temperature for effector systems

Effector systems of thermoregulation

- Behavior
- Skin circulation
- Sweat glands
- Skeletal muscles (voluntary movements, shivering thermogenesis)
- Horripilation (piloerection)
- Brown adipose tissue (non-shivering thermogenesis)

Cold-induced mechanisms

- Strategy: minimize heat loss
 - Behavior: decrease body surface, dress up properly
 - Vasoconstriction in skin, horripilation
 - Inhibition of sweating
- Strategy: increase heat production
 - Skeletal muscle: more frequent voluntary movements (behavior), shivering
 - Non-shivering thermogenesis (brown adipose tissue, NA, β_3 R, lipolysis, lipoprotein lipase and thermogenin expression, mitochondrial uncoupling - UCP1)
 - Increased appetite (increased food intake)

Heat-induced mechanisms

- Strategy: increase heat loss/output
 - Skin vasodilation
 - Increase sweating (evaporation)
 - Increase ventilation
- Strategy: decrease heat production
 - Behavior: search for shadow, light dress
 - Inactivity, apathy
 - Loss of appetite (decreased food intake)