Homeostasis

Draw a Block Diagram of a Homeostatic System.
Homeostasis

Draw a Block Diagram of a Homeostatic System.
Homeostasis

Input → Set Point → Comparator

Difference → Control Center → Change Signal → Effector → Output

Internal Measure of Output → Output Sensor
Homeostasis

Input → Set Point

Comparator: Difference → +/−

+ → Control Center: Increase effort
− → Maintain effort

Control Center: Decrease effort

Change Signal

Effector → Output

Internal Measure of Output
Which grouping represents the Nervous System?
Homeostasis

Sensory Systems

Input → Set Point → Comparator → Difference

Central Nervous System

Control Center → Change Signal → Effector

Internal Measure of Output

Motor Systems

Output
Homeostasis of thermoregulation

Goals:
- To keep internal conditions constant
- Prevent the body from harmful effects of overheating or hypothermia
- Fever is part of the innate, non-specific immune response, that helps to create a hostile environment for microbial pathogens
Homeostasis of thermoregulation

Heat transfer from body

Radiation – emission of the electromagnetic waves, all matter possesses that have temperature above absolute zero
Convection – energy transfer between objects that are in physical contact (a body and a chair)
Conduction – energy transfer between body and its environment, due to fluid motion
Evaporation – most effective. In hot weather (x humidity of the environment)

Heat production

Most produced in deep organs: liver, brain, heart (heat is the byproduct of metabolic reactions) and in contraction of muscles
Th. in the periphery are different from the homeostatic thermoreceptors in the hypothalamus, that provide feedback to body temp. Homeostatic temp. center in HTH is separated from the temperature sensation – we can feel the temp. of the periphery (receptors in the skin), not from the body core or from the brain. \( TH = \) thalamus, \( HTH = \) hypothalamus.
Homeostasis of thermoregulation

Hot weather
Intensive physical activity
Homeostasis of thermoregulation

Hot weather
Intensive physical activity
Homeostasis of thermoregulation

Heat loss mechanisms in humans:

**Vasodilatation** – incr. blood flow to skin capillaries. Heat loss due to incr. convection, conduction

**Sweating** – evaporative cooling

**Behavioral** – finding shade, weating light cotton clothes, pervious to sweat, impervious to sun heat radiation

**Metabolic** - reactions decreased
Homeostasis of thermoregulation

Input: Th. receptors, HTH

Set Point: HTH

Comparator: HTH

Difference: Body temp. < Set Point

HTH and its projections to various brain regions

Control Center

Change Signal

Effector

Output: Heat Prod.

Internal Measure of Output

Th. receptors: body core, periphery

Output Sensor

Cold weather
Homeostasis of thermoregulation

- **Input**
  - Th. receptors
  - HTH

- **Comparator**
  - HTH

- **Set Point**
  - HTH

- **Difference**
  - Body temp. < Set Point

- **Control Center**
  - Change Signal

- **Effector**
  - Output

- **Output Sensor**
  - Output
  - Heat Prod.

- **Internal Measure of Output**
  - Th. receptors: body core, periphery

- **HTH and its projections to various brain regions**

- **Vasoconstriction**
- **Piloerection**
- **Muscle shivering**
- **Metabolic shift**
- **Behavioral**

Cold weather
Homeostasis of thermoregulation

Thermogenesis in humans

**Piloerection** (goose bumps) – insulating layer of staning hair, trapping heat

**Vasoconstriction** of superficial arterioles – blood rerouted to body core (numbness and pale skin)

**Muscle shivering** – heat production

**Mitochondria metabolism shift** – transforming fat directly into energy (brown fat, norepinephrine induced)

**Metabolic rate increase** – epinephrine and thyroxine induced glycolysis (glucose – energy, heat as a byproduct)

**Behavioral** – curl-up position (body surface), warm clothing, shelter
**Homeostasis of thermoregulation**

- **Input**
  - Pyrogens: production of PGE2
  - Comparator HTH
  - Input

- **Set Point**
  - HTH

- **Difference**
  - Body temp. < Set Point

- **Control Center**
  - HTH and its projections to various brain regions
  - Change Signal

- **Effector**
  - Vasoconstriction
  - Muscle shivering
  - Metabolic rate, HR
  - Behav. (curl up)

- **Output**
  - Body temp.
  - Output Sensor

- **Internal Measure of Output**
  - Th. receptors: HTH, body core, periphery
  - Feeling chills

**Fever** = change of the Set Point

*Feeling chills and muscle shivering until the Body temp. = Set Point Temp.*
**Pyrogens** = substances that induce fever

Exogenous: microbial particles, antigen-antibody-complexes

Produced internally: e.g. Interleukins, interferons

Tissue damage (microbial infection) → Immune cells activation → Cytokine release, production of endogenous pyrogens: Interleukins (IL1), interferons, TNF → Stimulation of PGE2 production → Direct stimulation of receptors in anterior HTH (preoptic area)

Anti-inflammatory drugs (Tylenol): Decrease PGE2 production
Other actions during fever

➢ Decrease in production of anti-diuretic hormone (pituitary) – increase fluid loss – decreased body fluid = less energy needed to maintain the body core temp.

➢ Behavioral – feeling cold (set point temp. > body temp.), wrap up warm, curl up.

Attempts to cool the periphery would result in an increase of the metabolic rate and effort to conserve the body temp. from the febrile body!
Homeostasis of thermoregulation

FEVER in most instances is self-limited reaction
Homeostasis of thermoregulation

Benefits of fever

- Increase in metabolic rate in body temp. 37.5-40°C allow more efficient immune response (quicker enzyme reactions rate, cellular immune system mobilization, accelerated tissue repair,...)
- Metabolism shift from glucose metab. to one based on lipolysis and proteolysis (reduced free glucose available to invading pathogens, acute phase proteins produces in liver used for energy and tissue repair, binding minerals (Fe, Cu, Zn) needed for bacterial and viral replication.
- Most bacterias heat sensitive – with temp. elevated, their growth rate, mobility is decreased, cell walls become damaged. Viruses slow down their replication.

Harmful effects of fever

- Febrile convulsions (mainly in children) – linked with rapid T elevation or decreas, self-limiting
- Prolonged elevation over 40°C – risk of cell damage
- Neuronal damage – T > 43°C
Homeostasis of thermoregulation

Literature:


http://en.wikipedia.org/wiki/Thermoregulation

http://www.docstoc.com/docs/48160243/Physiology-of-fever