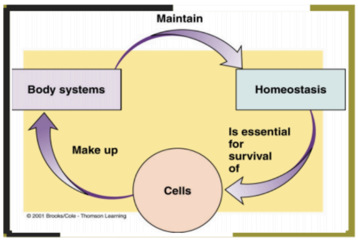
L2 – HOMEOSTASIS

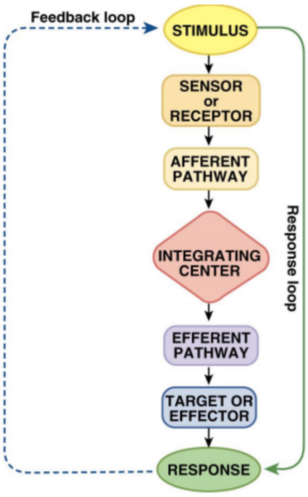
HOMEOSTASIS

- The maintenance of a relatively constant internal environment
- There are always fluctuations of physiological parameters, but the body aims for relatively constant levels
- Essential for survival of the cell and hence the individual



- Set Point = the level of a specific physiological parameter which our body aims for
- The physiological parameters which our body chooses to maintain in preference to others depends on the circumstances we are in, but the relatively constant maintenance of all physiological parameters is important for long term survival

Response/Feedback Loop of Homeostasis



- Receptor detects change triggered by stimulus
- Sensor passes this information, via afferent pathways, to an integrating centre (brain)
- Integrator processes the sensory information, and compares the change to set point
- Integrating centre then sends information, via efferent pathways, to a target/effector organ, to elicit a response which returns the physiological parameter within a desired range (negative feedback)

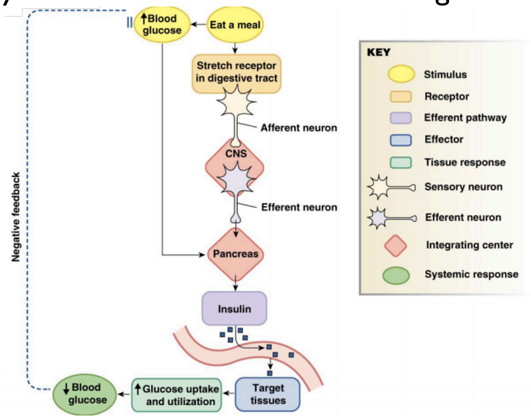
Negative Feedback

- Constant monitoring and adjusting of physiological parameters in order to achieve set point
- These adjustments are subtle and go unnoticed
- Maintains homeostasis

Integration Pathways

There are 2 pathways by which information can be received from a receptor and delivered to the brain, and be delivered from the brain to an effector:

- Endocrine (hormones)
    - Messages sent via the blood stream
    - Can communicate with any part of the body which has a receptor for that hormone
    - Every cell in the body is able to be reaches by a capillary
    - slow
- Neural
    - Fast
    - Direct
    - Targets a specific organ or several organs (can also be disadvantageous)
- In some situations, integration involves the input of both endocrine and nervous systems, such as the sympathetic NS
- e.g. Insulin pathway uses endocrine and neuron integration



Positive Feedback

- Reinforces the stimulus and escalates the response
- Positive feedback loops do not maintain homeostasis
- e.g. birth, ovulation, Na+ channels in APs

DIFFUSION

- The movement of molecules from an area of high concentration to one of low concentration across some sort of membrane
- Results in balanced concentrations on either side of the membrane
- Passive process
- Spontaneous

CELL MEMBRANE

- Separates cell from the environment as the intracellular environment is different to the extracellular environment
- Energy is needed to maintain this separation
- What is able to pass through the cell membrane from ECF to ICF (and vice versa) is controlled
- What can move across a cell membrane freely?
    - Gases (O_2, CO_2)
    - Small lipid soluble molecules
    - Water
- What can't move across a cell membrane freely?

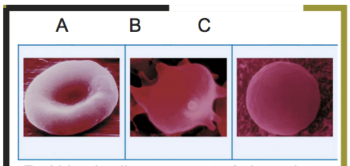
- Large lipid insoluble molecules
    - Proteins
    - Glucose
    - Charges molecules (ions) → this allows us to create electrochemical gradients across membranes
- Intracellular Fluid (ICF) = fluid inside cells
- Extracellular Fluid (ECF) = fluid outside cells
    - Plasma = fluid outside the cell, but inside blood vessels
    - Interstitial Fluid = fluid outside the cell, in between the cell and blood vessel

OSMOLARITY

- Total concentration of solutes (penetrating and non-penetrating) in a particular area
- Normal cell osmolarity is ~300mOsm
- Osmolarity should be equal in ICF and ECF

TONICITY

- Concentration of non-penetrating solutes in ECF in comparison to concentration of non-penetrating solutes in ICF
- Isotonic solutions = have the same concentration of non-penetrating solutes outside the cell as inside the cell (same tonicity)
- Hypertonic solutions = have a higher concentration of non-penetrating solutes compared to inside the cell → water is drawn out of the cell
- Hypotonic solution = have a lower concentration of non-penetrating solutes compared to inside the cell → water flows into the cell



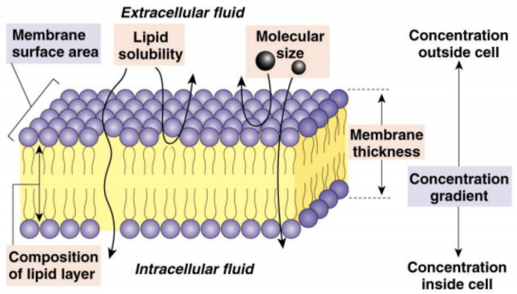
Red blood cell responses to A: isotonic, B: hypertonic and C: hypotonic solutions.

OSMOTIC EQUILIBRIUM

- The body is in osmotic equilibrium
- The total number of particles/concentration of particles in ICF and ECF are the same
- This does not mean the same particles are in ICF and ECF as different molecules predominate in ICF and ECF (chemical disequilibrium)
- At osmotic equilibrium, net water movement stops

FICK'S LAW

- Describes how readily a substance diffuses across a membrane
- Factors affecting rate of diffusion:
    - Membrane permeability = lipid solubility and molecular size
    - Concentration gradient (higher concentration gradient → more force pushing substances across a membrane → higher rate of diffusion)
    - Membrane surface area (larger surface area → higher rate of diffusion; anatomical areas where diffusion occurs have high surface areas such as lungs, capillaries and the small intestine)
    - Cell membrane thickness (thinner membrane → higher rate of diffusion)



Fick's Law of Diffusion says:

$$\text{Rate of diffusion} \propto \frac{\text{surface area} \times \text{concentration gradient} \times \text{membrane permeability}}{\text{membrane thickness}}$$

Membrane permeability

$$\text{Membrane permeability} \propto \frac{\text{lipid solubility}}{\text{molecular size}}$$

Changing the composition of the lipid layer can increase or decrease membrane permeability.

Equation:

$$Q = \frac{\Delta C \times P \times A}{\sqrt{MW} \times \Delta X}$$

Net Rate of diffusion (Q)
Concentration Gradient (ΔC)
Permeability of membrane to substance (P)
Surface Area of membrane (A)
Molecular Weight of substance ($\sqrt{MW}$) ~ Molecular size
Distance (membrane thickness) (ΔX)