PHSI2005

Contents

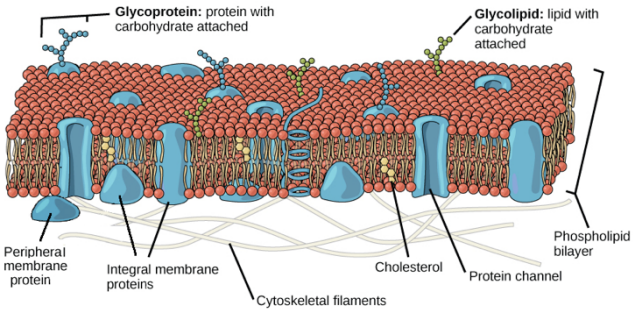
Concepts in Physiology

Homeostasis

- A set of steady states in which an organism operates comfortably
- Constant energy input and losses to maintain

The plasma membrane

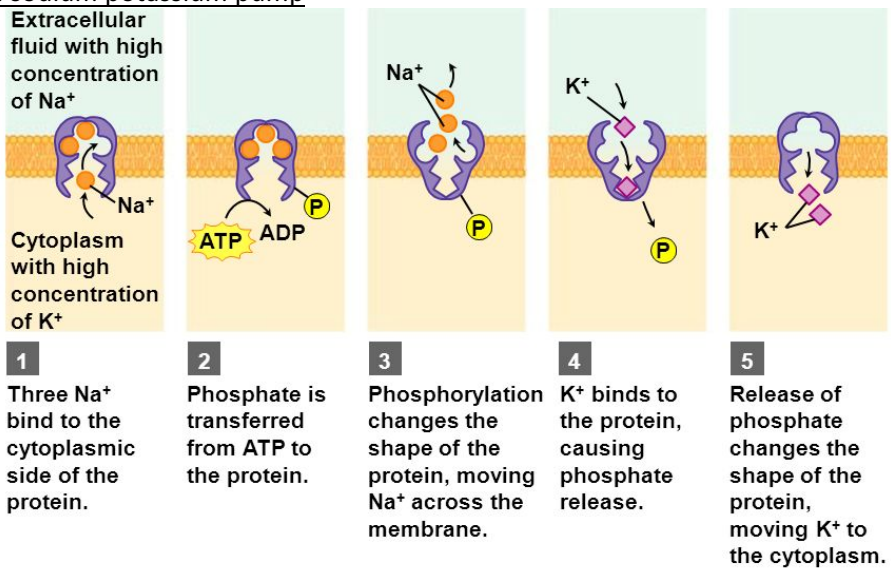
- Cytoskeletal filaments allow for stability, contraction and relaxation, motility and shape change
  - Example: RBC squish to pump the blood around (reduces viscosity)
- Transmembrane proteins allow selectively entry of molecules that can't pass through the membrane normally
- Receptor proteins receive and interpret signals
- Specialised lipids alter permeability to small, hydrophobic molecules
- Permeable to small, hydrophobic molecules
- Barrier to large hydrophobic molecules, atomic ions, charged molecules, polar molecules



Transport

- Diffusion = spread of molecules from areas of higher concentration to areas of lower concentration
  - Simple: straight through the plasma membrane
  - Carrier-mediated: substrate binding causes shape change in transport so molecule can move through
    (1) Uniport: one kind of substrate
    (2) Symport: two plus substrates in same direction
    (3) Antiport: substances in opposite directions
  - Channel-mediated: molecules move through a channel protein
- Osmosis = molecules of a solvent pass through a semipermeable membrane from a less concentrated solution into a more concentrated one
  - Through a specific channel protein (aquaporin) or through lipid bilayer (much slower)

Active transport: sodium potassium pump



Facilitated diffusion of glucose

- Glucose is brought into the cell down its concentration using GLUT transporter
- Diffusion reaches equilibrium when concentration inside = concentration outside
- Conversion of imported glucose into G6P keeps intracellular glucose concentration low so that diffusion never reaches equilibrium

RBC's in solution

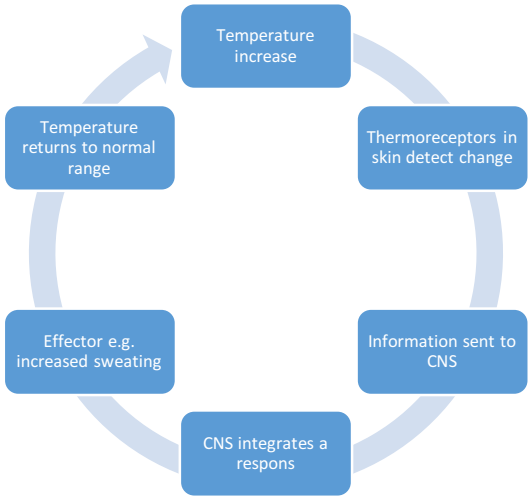
- Isotonic: concentration same inside and outside RBC
- Hyperosmostic: low solutes inside the cell, water moves out and cell shrivels
- Hypoosmotic: low solutes outside the cell, water rushes in and the cell swells and bursts

Secondary transport: SGLT transporter

- Na binds to carrier
- Na binding creates high affinity for glucose
- Glucose binding changes carrier conformation so binding sites now face ICF
- Na released into cytosol where [Na] is low
- Release changes glucose binding site to low affinity and glucose is released

Negative feedback: feedback used to decrease size of input

(1) Stimulus produces change
(2) Receptor detects change
(3) Input information sent (afferent) to control centre
(4) Output information sent (efferent) to effector
(5) Response of effector feeds back to reduce the effect of stimulus and returns variable to homeostatic level



Positive feedforward: to change a variable in anticipation of a process

- Anticipation of eating food so we salivate more

Positive feedback: feedback used to increase size of input

- Baby drops lower in uterus to initiate labour
- Cervical stretch
- Stimulates oxytocin release
- Causes uterine contractions
- Push baby against cervix
- More cervical stretch

Chemical signalling

- Needs a signal input (ligand) to bind to a receptor
- This changes conformation, amplifying the signal
- Cell takes this information and decides how to respond
- Ligand-receptor interactions
  - Signal molecule acts as a ligand, binding with specific proteins on the membrane
  - This induces a change in shape of a receptor protein, inducing a cellular response
- Signal amplification

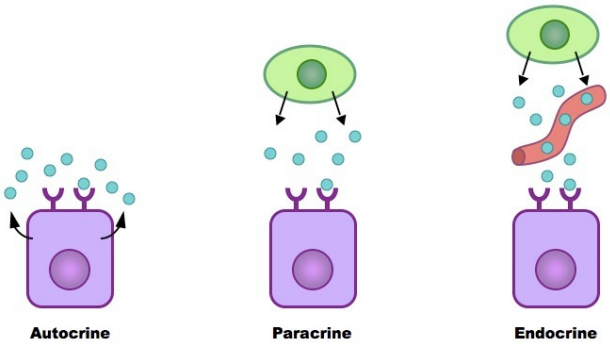
    - Receptor activates stage 1 protein which activates stage 2 protein … stage 3
    - Stimulation of a cascade of protein kinases to amplify the signal produces a strong response inside the cell
- Phosphorylation
    - Signal transduction pathways involve phosphorylation cascades – series of kinases successively add phosphate groups to next one in line, activating them
- Signal transduction converts cell signal on cellular surface into a specific response

Emergent properties of the cell

- Type of cell
- State of cell
- Type of ligand
- Concentration of ligand
- Receptor and receptor subtype
- Receptor concentration
- Number of different ligands

Types of signalling

- Endocrine: cells respond to factors produced by distant cells (hormones)
- Paracrine: cells respond to secretion of nearby cells
- Autocrine: cells have receptors for their own secreted factors



Types of membrane receptors

- Receptor channel: ligand binds to open or close channel
- Receptor-enzyme: ligand binds to a receptor and enzyme activates an intracellular enzyme
- G protein coupled receptor: ligand binds to receptor, G protein coupled receptor alters the enzyme activity or opens an ion channel
- Integrin receptor: ligand binds to integrin receptor to alter the cytoskeleton

Oxygen transport and use

- Oxygen binds to haemoglobin
- Oxygen is small, uncharged and non-polar – easily crosses cell membranes, diffuses rapidly
- High oxygen partial pressure in lungs
- 2% oxygen dissolved in plasma, 98% attached to haemoglobin
- Low oxygen partial pressure at tissues (increases concentration gradient)