Week 1: Basic Cell Processes

Physiology: how the body *works.*
How humans adapt to their environment.

Walter Cannon – linked O2, glucose and sodium to physiological change.

Homeostasis – regulation and coordination of systems. All systems respond to environmental change, including mechanical stress

Homeostatic control mechanisms

- **Sensory receptor nerve:** detects change
- **Control centre**: relays information along pathway
- **An effector**: restores homeostasis

Homeostasis operates around a set point at which systems are calibrated.

Feedback loops

Negative feedback (most common): *triggered by conditions exceeding set point.*
- Negative reaction reverses conditions in an attempt to restore homeostasis
e.g. sweating to cool down

Positive feedback: increase disruptive influences
e.g. smell of food → activates digestive system and salivation
- Positive feedback loops are not controlled.
e.g. fever → increases heat to destroy pathogens → death.

Catabolism and anabolism

Anabolism: smaller molecules form larger molecules
e.g. amino acids → proteins
Catabolism: larger molecules break down to form smaller molecules
e.g. digestion – protein → amino acids

Basal metabolic rate

- **65-70%** sustains basal metabolic rates; muscle dependent. For instance, more muscle = more metabolism
- **10%** for digestion and processing food – requires energy for chemical breakdown and food movement
    - e.g. weight loss diets often fail. Low calories → not enough energy to break down food.
- Remainder is used for **physical activity**.

Cell Anatomy and Physiology

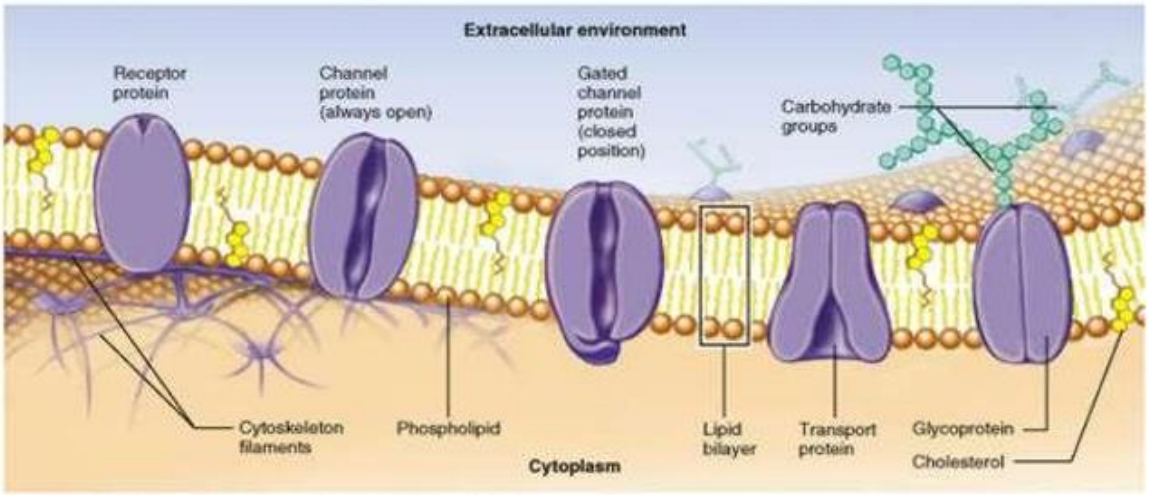
Cell membrane: *selective barrier that controls movement of substances in and out of cell.*

Made of a **phospholipid bilayer**.
- outer: (polar heads face outwards)
- centre of membrane: nonpolar/hydrophobic tails = face inwards

Membrane proteins

Integral/transmembrane proteins go through the membrane.
- Can move; others transmit chemical signals"
- *interact with filaments to control shape

Receptor: signalling molecule (ligand) releases second messenger
Channel protein: retains physiological pH



Nucleolus: contains genes that form ribosomes

Ribosomes: translate mRNA into polypeptides then proteins. Can be found floating in cytoplasm or attached to Rough ER.

Endoplasmic reticulum (ER)
Smooth ER: packages lipids
Rough ER: make and package proteins in **vesicles** to Golgi
Mitochondria: site of ATP production
Cristae (folds) increases surface area for ATP production

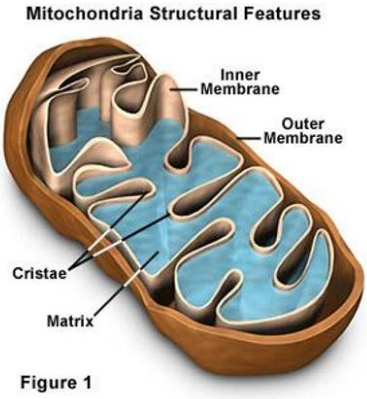
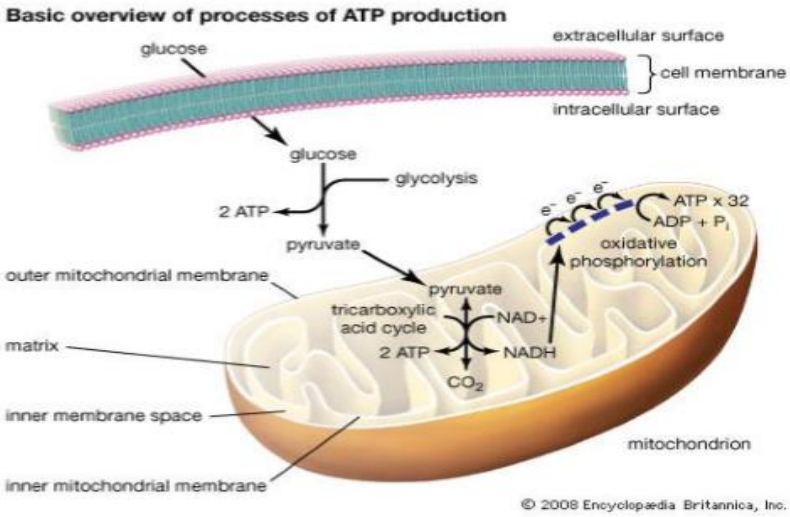


Figure 1

Krebs cycle



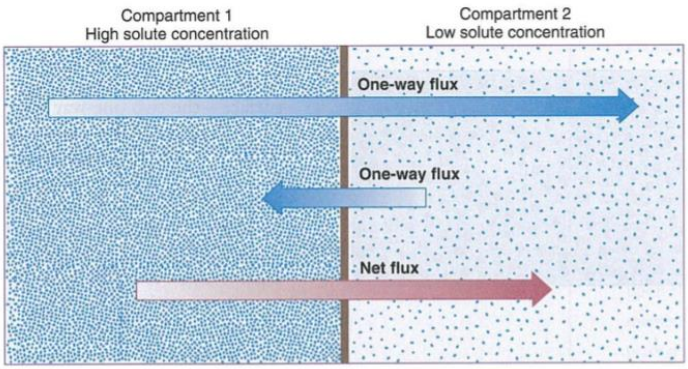
<u>Cytoskeleton components</u>
Microfilaments e.g. actin
Intermediate filaments e.g. keratin
Microtubules- comprise of tubulin, separate and organise chromosomes

Dynamics of diffusion

diffusion equilibrium: point at which solute is at uniform concentration throughout solution

Flux (diffusion) and what affects it

- **Mass and charge (polarity) of solute**
  - Non-polar diffuse faster than polar
- **Temperature**
  - Increased temperature = faster diffusion
- **Surface area**
- **Distance of solute travel**



Channels

1. **Ligand-gated channels: ligand binding affects conformation of channel protein**
2. **Voltage gated channels: movement of charge**
3. **Mechanically-gated channels: membrane can alter shape of some**
   e.g. shape of cell membrane

Membranes

membrane potential: voltage difference between intracellular and extracellular electrical charge

Terms

***concentration difference**
***electrical difference (membrane potential)**
***electrochemical gradient**

Transporters

Integral membrane proteins which move molecules through lipid bilayers

Factors determining rate flux with transporters

1. Extent to which transporter binding sites are saturated
2. Number of transporters
3. Rate at which transporter is able to change its shape and orientation

Mediated: facilitated and active diffusion

Mechanisms of active transporters

1. Direct use of ATP (i.e. *primary active transport)
   e.g. Na+/K+ pump
2. Electrochemical gradient (i.e. *secondary active transport)

Types of transport

Passive: movement of molecules DOWN their concentration gradient (i.e. high → low). Does not require ATP (energy)

Active: movement of molecules AGAINST their concentration gradient. Requires ATP

Secondary active transport

- **co-transport:** ions and other solutes move across membrane in same direction
  e.g. Na+ diffusion generates ATP to transport Glucose
- countertransport: ions and solutes moving across membrane in opposite direction

Osmosis

Osmosis: diffusion of water across a membrane

- aquaporin: group of membrane proteins forming channels for osmosis
- osmolarity: total solute concentration in a solution

Bulk transport

Endocytosis: absorbing matter *into* cell

- Fluid: vesicles takes extracellular fluid
- Absorptive endocytosis: ECF and membrane-bound proteins

- Phagocytosis: consume bacteria and cellular debris

Exocytosis: excreting matter *out* of cell

1. Replaces portions of membrane
2. Impermeable molecules can be released into extracellular fluid (e.g. hormones)

Effector pathways

paracellular pathway: diffusion between adjacent cells

- Limited by tight junctions

transcellular pathway: molecule movement across luminal or basolateral membrane → cytosol → across membrane

- Transcellular: coordination of diffusion and mediated-transport