1 Cell biology

1.1 Introduction to cells

Testing the cell theory

- three atypical examples are striated muscle, giant algae, aseptate fungal hyphae
- striated muscle tissue is formed by division of pre-existing muscle fibre cells; they are much larger than most animal cells; instead of one nucleus they have many
- fungi consist of narrow thread-like structures called hyphae; in some fungi hyphae are divided by cross walls (septa); aseptate fungi have no septa and each hypha is an uninterrupted tube-like structure with many nuclei
- many algae are unicellular; giant algae grow to a much larger size but are still one cell (10cm)

Functions of life in unicellular organisms

- paramecium to investigate functions of life
- nucleus that divides for reproduction (asexual)
- food vacuoles containing consumed organisms which are gradually digested (provide energy)
- cell membrane controls chemicals entering and leaving; waste products simply diffuse out
- contractile vacuoles fill up with water, expel it through membrane: keeping same water content
- enzymes in cytoplasm catalyze metabolic reactions
- beating of cilia moves the paramecium through water

Therapeutic uses of stem cells

- few current uses of stem cells to cure diseases
- Stargardt's disease: genetic disease causing photoreceptive cells in retina degenerate, vision becomes progressively worse; researchers developed method for making embryonic stem cells develop into retina cells; cells are injected into eyes, they attach to retina and vision improved
- Leukemia: type of cancer; production of large numbers of white blood cells; they are produced in the bone marrow; stem cells are killed by chemotherapy put the patient needs them; fluid is removed from bone marrow, stem cells extracted from fluid, stored by freezing, chemotherapy drugs are given to patient, bone marrow loses ability to produce white blood cells, stem cells are returned to patient which re-establish themselves, produce white blood cells

Sources of stem cells and the ethics of using them

- stem cells from deliberately created embryos: unlimited growth potential, differentiate into any type in body, higher risk of becoming tumour, less chance of genetic damage, likely to be genetically different form patient, removal of cells kills the embryo
- blood from umbilical cord with stem cells: easily obtained, commercial collection available, fully compatible with patient, limited capacity to differentiate, limited quantities, cord is discarded
- adult stem cells from bone marrow: difficult to obtain, less growth potential, less chance of tumour formation, limited differentiation capacity, fully compatible with patient, removal of stem cells does not kill the adult
- most ethical objections are with embryonic stem cells as it kills the embryo: question of when human life begins; though in vitro fertilization (IVF) is purposefully made, the egg cells must be obtained for money (vulnerable groups can be exploited)
- potential to allow methods of treatment of diseases as argument in favor

1.2 Ultrastructure of cells

Exocrine gland cells of the pancreas

- gland cells secrete substances through plasma membrane
- two types of gland cells in pancreas: endocrine (secrete hormones into bloodstream), exocrine (secrete digestive enzymes into duct that carries them into small intestine)
- enzymes are proteins so exocrine gland cells have organelles needed to synthesize proteins in large quantities

Palisade mesophyll cells

- cell type carrying out most of photosynthesis in leaf is palisade cells

- shape of cells is roughly cylindrical

1.3 Membrane structure

The role of cholesterol in membranes

- hydrophobic hydrocarbon tails usually behave as liquids but hydrophilic phosphate heads act as solids; overall membrane is fluid as components are free to move
- fluidity of animal cell membranes needs to be carefully controlled
- cholesterol restricts regular packing of hydrocarbon tails of phospholipids so prevents them crystallizing and behaving as solid
- cholesterol restricts molecular motion and therefore fluidity of membrane
- reduces permeability to hydrophilic substances such as sodium ions and hydrogen ions
- helps membranes to curve into concave shape which helps in formation of vesicles

1.4 Membrane transport

Active transport of sodium and potassium in axons

- axon is part of neuron (nerve cell) and consists of tubular membrane
- function of axons is to convey messages rapidly form one part of body to another in an electrical form (nerve impulse)
- nerve impulse involves rapid movements of sodium, then potassium ions across axon membrane: occur by facilitated diffusion due to concentration gradients built up by active transport (sodium-potassium pump protein)
- pump follows cycle resulting in three sodium ions being pumped out and two potassium in; interior of pump is open to inside of axon and three sodium ions enter, ATP transfers phosphate form itself to pump causing pump to change and close interior, interior opens to outside of axon and three sodium ions are released, two potassium ions form outside enter, binding of potassium cause release of phosphate group and pump changes shape again and opens inwards, potassium ions are released and sodium ions can enter again
- with each cycle the pump uses one ATP

Facilitated diffusion of potassium in axons

- rapid movements occur by facilitated diffusion across sodium and potassium channels
- potassium channels as special example of facilitated diffusion: each channel consists of four protein subunits with narrow pore allowing potassium to pass, dissolved potassium becomes bonded to shell of water molecules making it too big to pass, to pass the bonds are broken and bonds temporarily form between water and series of amino acids at narrowest point of protein, after potassium ion passes it is associated with shell again
- specificity of pump: other positively charged ions are either too large to fit or too small to form bonds with amino acids at narrowest point
- potassium channels in axons are voltage gated: if axon has relatively more positive charges outside than inside channel is closed
- at one stage in nerve impulse there are relatively more positively charges inside: channels open and potassium passes through
- channel rapidly closes again with extra globular subunit/protein attached by flexible chain of amino acids; ball remains in place until potassium channel returns to original closed state

Preventing osmosis in excised tissues and organs

- animal cells can be damaged by osmosis
- solution with higher osmolarity is hypertonic; water leaves cells by osmosis so cytoplasms shrinks in volume, plasma membrane does not change so indentations (crenellations) appear
- solution with lower osmolarity is hypotonic; cells take in water by osmosis and swell up, cells may burst leaving ruptured plasma membranes (red cell ghosts)
- solution with same osmolarity is isotonic; water molecules leave and enter at same rate so cell remains healthy; important for any human tissue and organs to be bathed in isotonic solution
- normal saline: isotonic sodium chloride solution is usually used with osmolarity at 300mOsm
- normal saline can be introduced safely to patient's blood system, used to rinse wounds, used as basis for eye drops, frozen to ‚slush' for packing donor organs

1.5 Origin of cells

Spontaneous generation and Pasteur's experiments

- Louis Pasteur made nutrient broth by boiling water containing yeast and sugar
- shows that if broth is kept in sealed flask it remains unchanged
- famous experiment with swan-necked flasks bent into variety of shapes: boiled broth in some flasks and unboiled as control: organisms soon appear in unboiled flasks while others remain clean; broth in flasks was in contact with air which was needed for spontaneous generation: organisms only appear after necks are snapped off
- Pasteur concludes that no organisms appear spontaneously

1.6 Cell division

Smoking and cancer

- correlation: relationship between two variable factors; positive correlation (when one increases the other does as well), negative correlation (when one increases the other decreases)
- there is a positive correlation between cigarette smoking and death rate due to cancer
- smokers are several times more likely to die from all cancers than non-smokers
- important to distinguish between correlation and cause; correlation does not prove a cause; in this case causal links are well established
- 20 of chemical substances cause tumours in experiments and at least 40 are carcinogenic