Lectures 1,2,3: Cells and Organelles

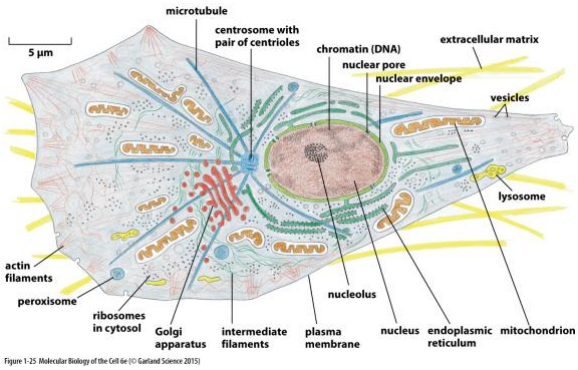
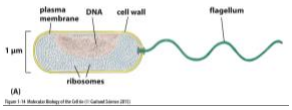


Figure 1-25 Molecular Biology of the Cell 6e (© Garland Science 2015)

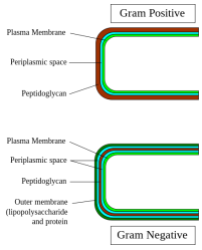
Cells

Cells

Cell	Description
Eukaryotes	-have a true nucleus -have internal organelles with specialised functions -the types of cells in humans -much bigger than Prokaryotes
Prokaryotes 	-no organisation of internal structure -DNA is just concentrated in one region -cell wall different to Eukaryotes -example: Bacteria

Bacteria

- Two types of bacteria
  - Gram positive: thicker layer of peptidoglycan
  - Gram negative: thinner layer of peptidoglycan
    - Peptidoglycan provides structural integrity
    - Made up of sugar moieties cross-linked by peptides
    - Beta-lactam antibiotics can inhibit cross0linking
    - Makes the cell wall structurally weak and disintegrates when the cell divides



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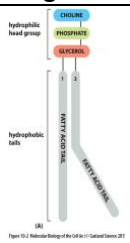
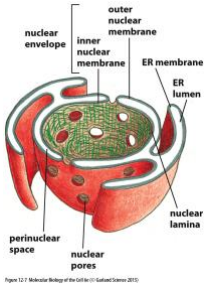
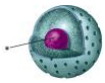
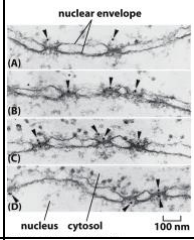
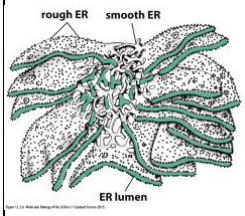
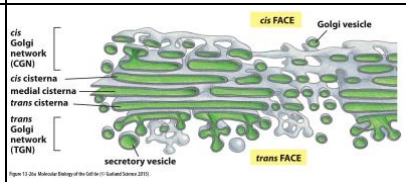
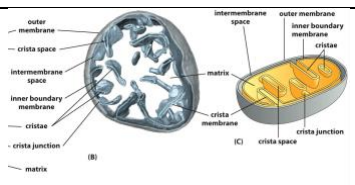
Structure	Diagram	Description
Plasma Membrane		-50% lipid, 50% protein -amphiphilic (hydrophobic tail, with a hydrophilic head) -carbon tail length and structure can vary, 14-24 carbons, and single/double bonds -phospholipids spontaneously form the lipid bilayer -defines the boundary of the cell and maintains the intra/extracellular environment -proteins in the membrane allows controlled movement of molecules
Nucleus		-contains DNA -defined by a nuclear envelope -lipid bilayer membrane (inner/outer membrane) -connected to ER
Nucleolus		-major structure in nucleus -not membrane bound associated with assembly of ribosomes
Nuclear Pore		-diagram shos visualisation of transport through nuclear pore -controls movement between the nucleus and cytosol -each nucleus contains around 4000 pores -small molecules can freely move through, though larger molecules (such as proteins) cannot → gated transport proteins required in nucleus have specific signals to let them into the nucleus
Endoplasmic Reticulum		-largest membrane in the cell -made from tubules and flattened sacs which are interconnected, which is connected to the outer nuclear membrane Rough ER: has ribosomes on the outside involved in synthesis of secreted proteins Smooth ER: No bound ribosomes Involved in transport of proteins from ER to Golgi Helps with lipid transport Detoxification: prevents build-up of toxic levels
Golgi Apparatus		-flattened vesicles in three regions: cis, medial, trans -receives proteins from rough ER and modifies them
Mitochondria		-generation of ATP: high energy bonds in ATP provide primary chemical energy -outer membrane is permeable to small molecules -inner membrane is much less permeable has a large number of folds (cistae) that protrude into the centre -because it's involved in energy production, the amount of mitochondria in a cell depends on it's location in the body (so cells that need more energy, such as cardiac muscle → more mitochondria)

Organelles and associated diseases: Lysosome and Peroxisome

Lysosome

- Degrades
  - membranes and organelles no longer required by the cell (unwanted components)
  - proteins and particles taken up by the cell
- does this by 40 different types of enzymes: such as proteases, nucleases, phosphates
- structure:
  - low pH 4.5-5
    - this is maintained by hydrogen ion pump (uses ATP)
    - the pH activates the acid hydrolases (an enzyme)
      - works best with a low pH, and becomes inactive at neutral pH
    - also helps with degradation by denaturing proteins
- organelle degradation
  - macromolecules: enter through endocytosis and mature into lysosomes
  - obsolete organelles: fuses with lysosome for digestion/differentiation
  - large particles and microorganisms: fuse with lysosome for digestion

Lysosomes and cholesterol:

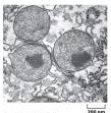
- LDL is responsible for carrying cholesterol in the body, and it carries cholesterol to the lysosome, where the LDL protein component is digested and cholesterol is released into the cell

Tay Sachs Disease: Lysosome organelle disease

- Gangliosides are a sugar containing lipid which is degraded in the lysosome by the sequential removal of terminal sugar
- In Tay Sachs disease there is a loss on an enzyme leading to the build-up of Gangliosides and neurons becomes swollen with lipid filled lysosomes
- Nerve damage begins while the baby is in the womb, the child is usually dead b/w 3-5 yrs

Peroxisome

- Major site of Oxygen utilisation
- High conc. Of oxidative enzymes such as catalase and urate oxidase
  - These can form a crystalline core (dark part)
- Function: degrade fatty acid and amino acids
  - Does this through a frist reaction to produce hyrogen peroxide



Peroxisome

$$RH_2 + O_2 \xrightarrow{\text{Peroxisome Enzymes}} R + H_2O_2$$

  - the hydrogen peroxide is then used in a reaction to oxidize substrates (which is hand is detoxifying them)
  - this is extremely important in the liver where a lot of detoxification is required
  - though it must be controlled because hydrogen peroxide is a hgighly reactive molecule that can do oxidative damage to the cell
    - if there is excess hydrogen peroxide it is converted to water
  - peroxisomes also form lasmalogens: an important phosholipin in myelin

Peroxisome linked disease: X-ALD

- Genetic disorder due to peroxisomal storage disease
- Very Long Chain fatty acids (VLCFA) accumulate in the tissue of the body
  - Particularly in the brain/adrenal gland
- This starts to affect neural function → the myelin sheath is destroyed
- This is because patients have defective peroxisomes so they cannot convert the LCFA
- Treatments: there have been many attempts
  - Lorenzo's oil: modified diet to reduce plasma levels of VLCFA this showed no disease progression
  - Phenylketonuria: provides contract to Lorenzo's oil: a diet which has a lack of enzyme that breaks down the amino acid phenylalanine, which prevented symptom development

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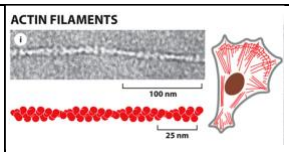
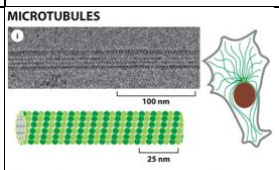
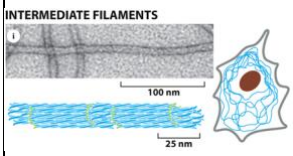
Cytoskeleton

Cytoskeleton

- Function: to provide the cell with
  - Shape, robustness and ability to rearrange internal organelles
- Types

Actin	-determines the shape of the cell -involved in whole cell locomotion -structure two stranded helical polymers of the protein actin flexible structure -location dispersed through the cell but concentrated in the cortex, just below the plasma membrane	
Microtubules	-determines position of membrane enclosed organelles -directs intracellular transport -structure low hollow cylinders made up of tubulin more rigid than actin long and straight -location have one end attached to a centrosome	
Intermediate filaments (IF)	-provides mechanical strength -one type of IF forms the nuclear lamina -structure fibres made of intermediate filament proteins -location extend across cytoplasm giving mechanical strength	

Dynamic changes in cytoskeleton

- the movement that can happen in the cell due to the cytoskeleton
- dynamic changes
  - cell division
    - actin and microtubule separate the cell into two daughter cells
  - neutrophils: the cytoskeleton moves the cell so it can change the bacteria
    - the actin moves the cell towards the bacteria
    - allows the cell to change orientation and direction of movement within seconds
  - microtubule movement
    - extremely dynamic structures
    - they grow and shrink (but from one end only)
    - microtubules grow out of the centrosome
  - centrosome
    - microtubules grow out of a specific intracellular location knows the microtubule-organiser centre
    - most microtubules have their negative end linked to the centrosome and grow out from there
  - centriole
    - during cell replication the two centrioles separate and replicate
    - this provides the organisational sites for two new centrosomes that in turn will separate the duplicated chromosome in cell division
- cytoskeleton in polarised epithelium: a stable structure, completed by
  - actin filaments: contribute to tight junctions to prevent intestinal fluid leaking into the body
    - also have microvilli → increase SA
  - intermediate filaments: are anchored to desmosomes which link epithelial cells → strength
  - microtubules: run vertically from top to bottom to provide a system to allow newly synthesised components to get to the proper location