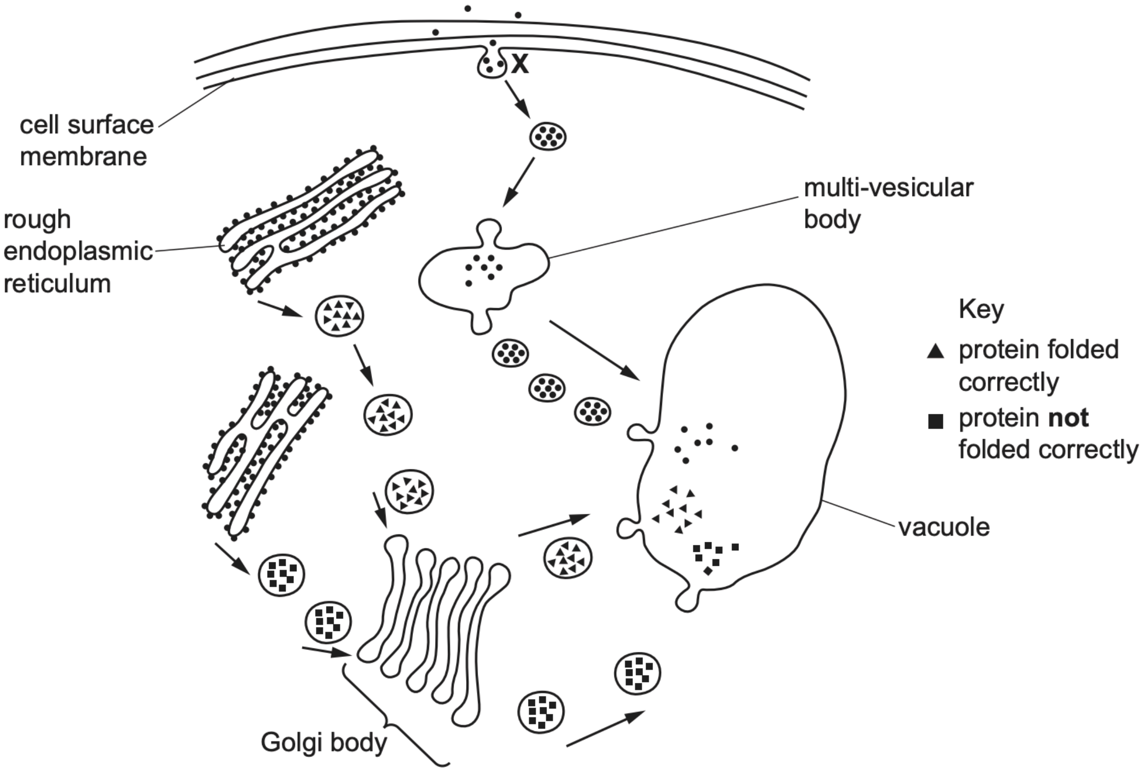
4. Cell membranes and transport

1.

(b) Plant vacuoles develop when vesicles fuse together. The vacuoles increase in size as more vesicles fuse.

Fig. 1.2 shows the movement of vesicles within a plant cell during the development of a vacuole.



Name the process occurring at X

- Endocytosis

Some of the vesicles formed by the Golgi body pass to the vacuole. These vesicles contain proteins that have been folded correctly and some that have not folded into their correct shapes. The proteins that have not folded correctly pass to the vacuole where they are broken down.

Explain how proteins that have not folded correctly are broken down in the vacuole.

- hydrolysis / use water to break bonds; ref. to hydrolytic enzymes
- action of proteases / peptidases / proteolytic enzymes
- peptide bonds broken
- to form peptides / amino acids

2. State why membrane proteins are required for the movement of molecules, such as glucose, across cell surface membranes into cells.
   - polar / water soluble / hydrophilic substances cannot pass through the phospholipid bilayer / hydrophobic core in cell surface membranes

3.

Researchers investigated one type of hexose transporter, known as VvHT1, which is found in the fruit cells of *V. vinifera*. They used a mutant strain of yeast that has very few hexose transporters in its cell surface membranes to investigate the properties of VvHT1. The researchers inserted molecules of VvHT1 into the cell surface membranes of the mutant strain of yeast.

- Equal volumes of mutant yeast cells with VvHT1 were kept in eight different concentrations of glucose solution.
- The rate of uptake of glucose by the yeast cells in each solution was determined.
- All the solutions were kept at the same temperature and pH.

The results are shown in Fig. 3.2.

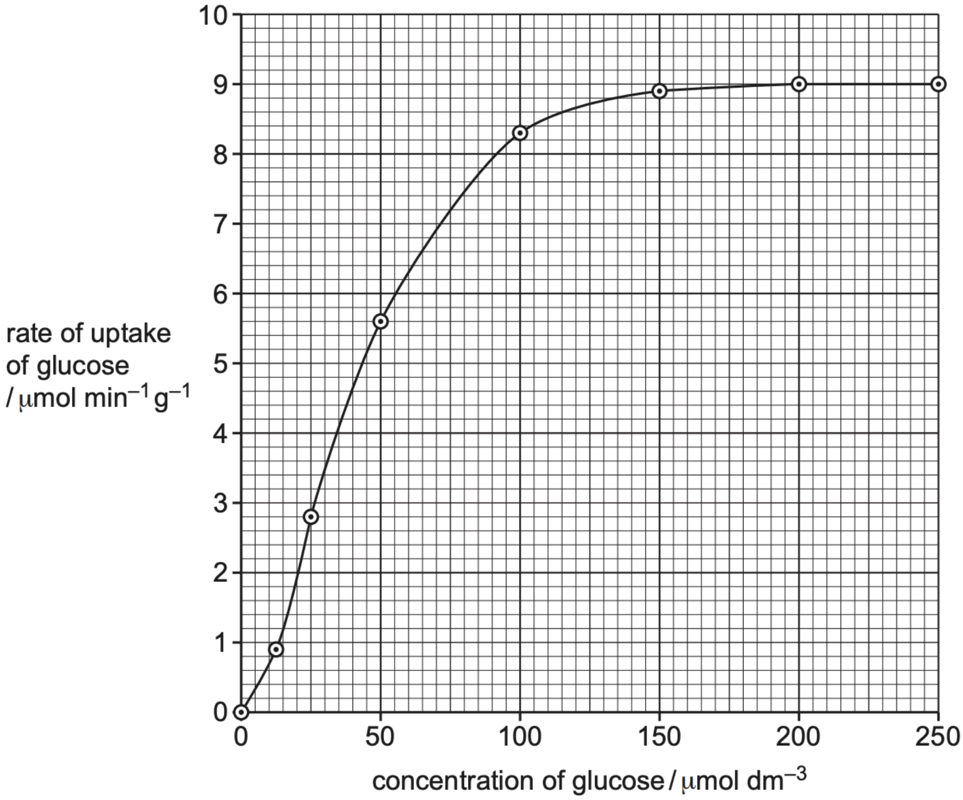


Fig. 3.2

(b) (i) The researchers concluded that VvHT1 is responsible for the facilitated diffusion of glucose into the cells.

Explain how the results in Fig. 3.2 provide evidence to support this conclusion.

- rate of uptake becomes constant / reaches a plateau OR at high concentrations / concentrations of > 150 mol dm−3 rate of uptake remains constant/ levels off

- protein carriers / hexose transporters / VvHT1s are working at their highest rate / are saturated OR the number of protein carriers is limiting factor OR Vmax is reached in context of transporters

The researchers thought that grapevines could be modified to have more hexose transporters to increase the size and quality of grapes. Explain why increasing the number of hexose transporters could be commercially important to growers of grapevines.

- grapes will be sweeter / have improved taste
- concentration of sugars in grapes determines uptake of water by osmosis
- more energy for growth of the grapes
- larger yield
- increased profit / income for farmers
- AVP: producing grapes in shorter time

4. Mineral ions are usually present in the soil in very low concentrations. The action of mucilage enzymes and soil microorganisms can help to increase the presence of mineral ions. Root hair cells are specialised for the uptake of these mineral ions and for the absorption of water from the soil. Suggest and explain how the presence of mineral ions in the root hair cell can increase the absorption of water by the root hair cells.
    - mineral ions are solutes / dissolve in water
    - these solutes decrease / lower the water potential within cell
    - this increases the water potential gradient / makes it steeper
    - water follows osmotically / water enters by osmosis from high to low water potential

5. Coeliac disease is a condition in which the immune system of a person responds to gluten in their diet. In coeliac disease, there is a response to the presence of peptides (short chains of amino acids) that are produced as a result of gliadin digestion (gliadin = a protein found in gluten).

    The gliadin peptides produced as a result of digestion are often as large as 33 amino acids in length. Intestinal cells take up large numbers of these peptides at the same time. Suggest and explain how gliadin peptides are transported into intestinal cells.
    - endocytosis / pinocytosis
    - Details:
        - invagination of membrane
        - formation of (endocytotic / pinocytotic) vesicle
        - use of ATP / active process / energy needed

6. State one role of glycoproteins in the cell surface membrane.
   - cell signalling OR receptors/binding sites for chemicals / hormones / molecules
   - cell recognition OR (cell surface) antigens OR cell-cell interactions

7.

Scientists measured the concentration of sodium ions and potassium ions in the red blood cells and in the blood plasma of a group of people. The results are shown in Table 1.1.

Table 1.1

	mean concentration of sodium ions / $mmol\,dm^{-3}$	**mean concentration of potassium ions / $mmol\,dm^{-3}$**
red blood cells	10	100
blood plasma	100	4

(a) (i) Use the information in Table 1.1 to identify **and** describe the process by which potassium ions enter red blood cells from the blood plasma.

....

....

....

....

....

.... [3]

Use the information in Table 1.1 to identify and describe the process by which potassium ions enter red blood cells from the blood plasma.
- active transport
- against the concentration gradient
- using energy / ATP
- conformational change of protein carrier / described
- ref. to specific binding site

8. Sodium ions and oxygen molecules enter red blood cells. State one similarity and one difference between the processes used by sodium ions and oxygen molecules to enter red blood cells.

   <u>Similarities</u>
   - diffusion / movement down concentration gradient
   - Passive OR no energy / ATP required

   <u>Differences</u>

- sodium ions enter by facilitated diffusion and oxygen molecules enter by simple diffusion
- sodium ions use a carrier / channel / transport protein OR sodium ions do not pass through the phospholipid bilayer / cross the hydrophobic core of the bilayer

9. Scientists studied the uptake of a substance, F, by human red blood cells. The red blood cells were immersed in a solution of substance F for 30 minutes. After this time the scientists recorded two observations:
    • the cell surface membrane of the red blood cells showed infoldings (invaginations)
    • an increase in the number of vesicles in the cytoplasm.

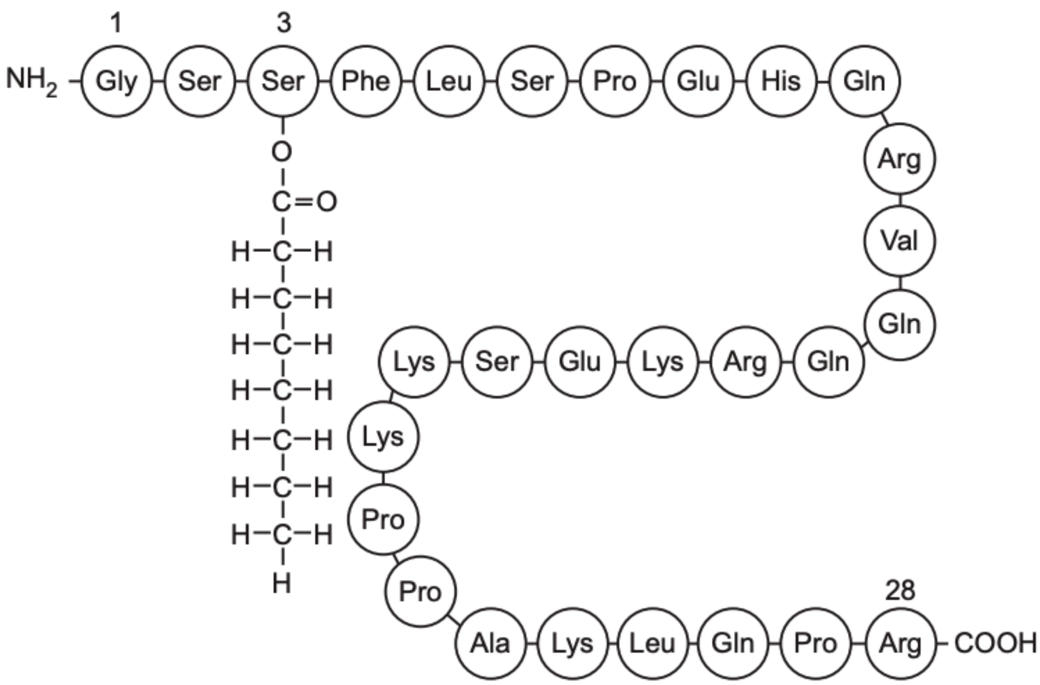
    Identify the process by which substance F entered the red blood cells.
    - Endocytosis/ pinocytosis

10.

The cell in Fig. 2.1 releases ghrelin, a small protein that acts as a cell signalling molecule.

Fig. 2.2 shows the sequence of amino acids in a ghrelin molecule.

The amino acid serine (Ser) in position 3 in Fig. 2.2 has been modified by the addition of a saturated fatty acid chain.



The addition of the fatty acid chain allows ghrelin to function as a cell signalling molecule. Suggest how the addition of this fatty acid chain allows a ghrelin molecule to act as a cell signalling molecule.

- Fatty acid chain forms part of overall 3D shape / tertiary / quaternary structure OR forms part of hydrophobic region of ghrelin
- allows ghrelin to bind to receptor
- allows ghrelin / part of ghrelin to have a complementary shape / be complementary to the receptor
- Detail: e.g. interacts with hydrophobic region of the receptor molecule for binding
- ref. to effect of binding triggering reactions inside the cell
- AVP: e.g. help interaction with / embeds in hydrophobic portion of the cell surface membrane in context of bringing a complementary part of the molecule closer to receptor for binding OR suggestion that fatty acid chain allowed incorporation into / attachment to a transport molecule in plasma to reach target cell

11. Each lamellar body is surrounded by a single membrane. Draw a diagram to show the arrangement of phospholipid molecules in the membrane surrounding each lamellar body.
    - phospholipid with a head and two tails ;
    - bilayer shown ;

12.

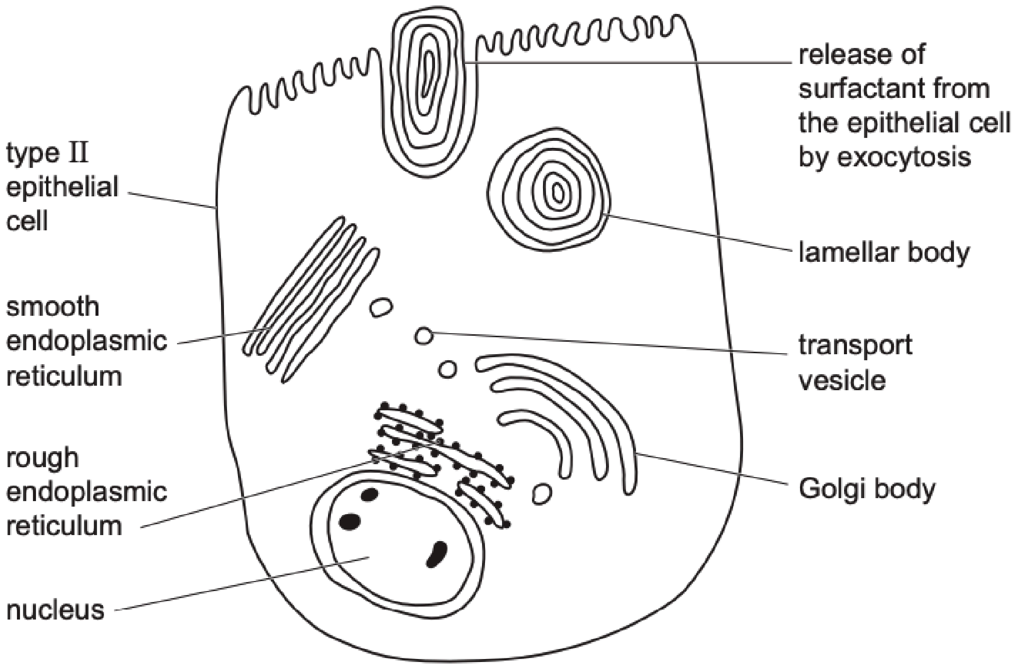
The walls of alveoli contain some specialised epithelial cells called type II epithelial cells. These cells secrete surfactant. Surfactant helps to prevent the alveoli collapsing during breathing.

Surfactant contains phospholipid, cholesterol and protein.

The components of surfactant are synthesised in the rough endoplasmic reticulum and smooth endoplasmic reticulum and then passed to the Golgi body.

The surfactant that is produced is stored in secretory organelles called lamellar bodies.

The surfactant in the lamellar bodies is released onto the surface of the alveolar epithelium by exocytosis, as shown in Fig. 5.2.



Scientists studying the production and secretion of lung surfactant have discovered that a reduction in cholesterol in the cell surface membrane of type II epithelial cells reduces the secretion of surfactant. Suggest why secretion of surfactant is affected by a reduction in cholesterol in the cell surface membranes of type II epithelial cells.

- cholesterol regulates the fluidity of the membrane
- membrane less able to fuse with the lamellar body

Lung surfactant is engulfed by macrophages that are in close contact with the type II epithelial cells. Suggest why macrophages engulf surfactant.

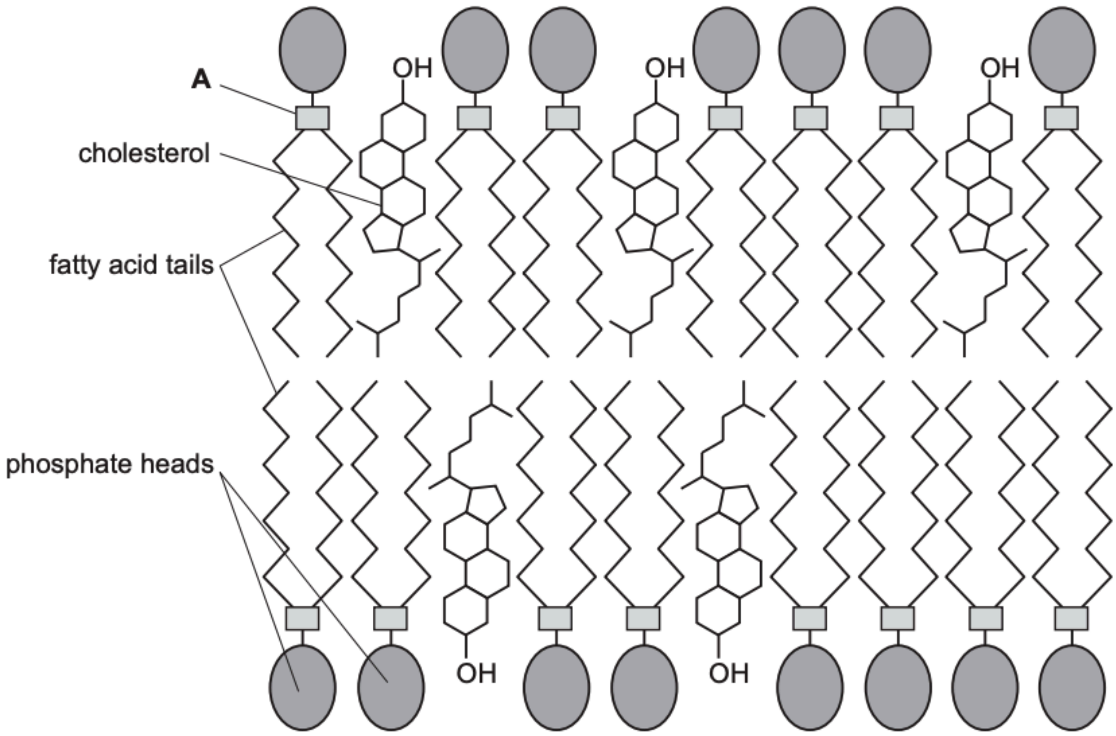
- prevents too much surfactant building up in the lungs
- digest surfactant to recycle / reuse molecules in surfactant
- macrophages use protein / phospholipid / cholesterol in surfactant
- engulf pathogens / microbes trapped in surfactant

13. Kupffer cells are able to remove bacteria present in the blood. They can also remove old or damaged red blood cells. Describe the mode of action of a Kupffer cell in removing and breaking down a damaged red blood cell.
    - endocytosis / phagocytosis
    - Description: red blood cell engulfed / enveloped OR pseudopodia surround red blood cell
    - forms phagocytic vacuole / phagocytic vesicle / phagosome
    - lysosome fuses with phagosome to form phagolysosome
    - lysosome contains hydrolytic / digestive enzymes
    - digestion to produce haem and globin
    - AVP: suggestion of detection / recognition of red blood cell

14. A protein known as ATP-binding cassette transporter A3 (ABCA3) is needed to move surfactant phospholipids into lamellar bodies from the surrounding cytosol (fluid part of cytoplasm). Suggest and explain the features of protein ABCA3 that make it suited to its function.
    - membrane / carrier / transport protein move phospholipids across into lamellar body
    - has binding sites specific for surfactant phospholipids
    - able to carry out conformational change
    - ATP used / hydrolysed / needed for active transport / to provide energy for transport
    - surfactant phospholipids move against a concentration gradient / from a lower to a higher concentration

15.

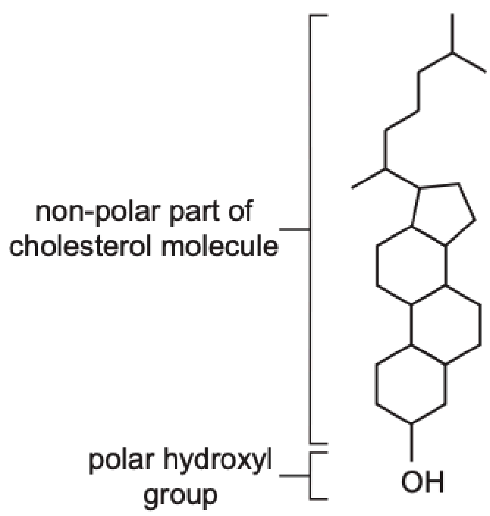
(a) Fig. 1.1 is a diagram representing part of the phospholipid bilayer of a cell surface membrane.



16. Identify the part of a phospholipid molecule, labelled A in Fig. 1.1, that forms bonds with the phosphate heads and with the fatty acid tails.
   - Glycerol

17.

Cholesterol is an important lipid component of many cell surface membranes. Fig. 1.2 shows the structure of a cholesterol molecule.



Using the information in Fig. 1.2, explain the orientation (positioning) of cholesterol molecules in the phospholipid bilayer, as shown in Fig. 1.1.

- hydroxyl / polar group interacts with phosphate heads as both are polar / hydrophilic OR hydroxyl group faces aqueous environment as it is polar / hydrophilic
- non-polar part in region of fatty acid tails as both are non-polar / hydrophobic OR non-polar part is hydrophobic so, in centre of membrane / away from aqueous environment

18. State the role of cholesterol in phospholipid bilayers.
    - maintains / regulates fluidity of membrane: reduces fluidity at high temperature & increases fluidity at low temperature
    - maintains / regulates mechanical stability of membrane
    - prevents entry of hydrophilic substances / polar substances / ions
    - without cholesterol membranes would easily rupture
    - flat ring structure interferes with the movement of fatty acid tails
    - reduces lateral movement of phospholipids

19. Explain why sodium ions cannot cross phospholipid bilayers by simple diffusion.
    - sodium ions are positively charged so repelled by the hydrophobic tails / hydrophobic core

20. Similarities and differences between facilitated diffusion and active transport

    <u>Similarities</u>
    - both occur through / involve a membrane / transport protein
    - both can be specific to the molecule / ion passing through: ref. to binding site on protein
    - both involve conformational change of carrier protein

    <u>Differences</u>
    - Facilitated diffusion: substances transported down the concentration gradient
      Active transport: substances transported against a concentration gradient
    - Facilitated diffusion: passive // does not require ATP / energy
      Active transport: active // requires ATP / energy
    - Facilitated diffusion: involves channel and carrier proteins
      Active transport: does not involve channel proteins / only involves carrier proteins

21. Prostaglandins are examples of cell-signalling molecules. Outline the process of cell signalling that leads to a response by cells.
    - ligands / prostaglandins are secreted / released by cells OR prostaglandins are transported to target cells

- prostaglandins bind to receptors on target cell surface membranes
- example of events triggered leading to a response: e.g. activation of secondary messenger // enzyme cascade/ activation // phosphorylation events // signal transduction

22. P. jirovecii (a fungi) can adhere (attach) to squamous epithelial cells of the alveoli and to the network of fibrous proteins that support the alveolar wall, known as the extracellular matrix (ECM). Examples of proteins in the ECM are elastin and collagen.
Adhesion (attachment) of P. jirovecii to alveolar epithelial cells and the ECM stimulates the growth of its population.
Cell surface glycoproteins known as gpA glycoproteins are essential in allowing P. jirovecii cells to adhere to alveolar epithelial cells and ECM proteins. Suggest how a gpA glycoprotein is able to adhere to alveolar epithelial cells and ECM proteins.
- gpA glycoprotein binds to a receptor / protein / glycoprotein on (surface of) alveolar cell (ECM proteins are on surface of / interacting with cell surface membrane of alveolar cells OR receptor / protein / glycoprotein on surface of alveolar cell is a binding site for gpA)
- gpA complementary shape to attach / bind / adhere to alveolar cell / ECM
- adhering by attractive charges / (named) bonds between gpA and proteins / glycoproteins on surface of alveolar cell
- AVP : gpA acts as a ligand

23.

(b) Researchers investigated the mechanism of transport used for the uptake of potassium ions (K^+) into root epidermal cells at different concentrations of K^+ in the soil solution.

Complete Table 6.1 to provide information about the two different transport mechanisms that were identified by the researchers.

Table 6.1

net movement of K^+	membrane protein needed (yes or no)	ATP used (yes or no)	name of transport mechanism
against the concentration gradient			
down the concentration gradient			

net movement of K^+	membrane protein needed (yes or no)	ATP used (yes or no)	name of transport mechanism
against the concentration gradient	yes	yes	active, transport / uptake
down the concentration gradient	yes	no	facilitated diffusion

24.

A student carried out an experiment to investigate osmosis using Visking tubing. An outline of the investigation is shown in Fig. 3.1.

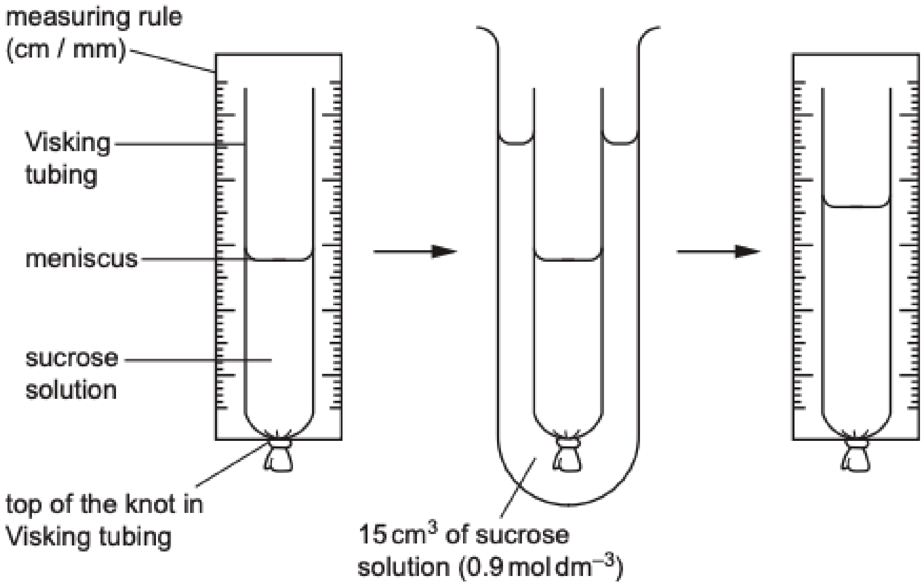


Fig. 3.1

- Six pieces of Visking tubing were filled with 10 cm^3 of different concentrations of sucrose solution: 0.0, 0.4, 0.8, 1.2, 1.6 and 2.0 $mol\,dm^{-3}$.
- The height of the meniscus of each solution in the Visking tubing was measured.
- The pieces of Visking tubing were put into test-tubes containing 15 cm^3 of 0.9 $mol\,dm^{-3}$ sucrose solution.
- After 20 minutes, the pieces of Visking tubing were removed from the test-tubes and the height of the meniscus in each was measured.

The results are shown in Table 3.1.

Table 3.1

concentration of sucrose solution inside Visking tubing / $mol\,dm^{-3}$	difference in height of meniscus after 20 minutes / mm
0.0	–12
0.4	–4
0.8	–2
1.2	+1
1.6	+6
2.0	+11

The Visking tubing used by the student was not permeable to sucrose. Explain the results shown in Table 3.1.

- differences in height show that concentrations of sucrose 0, 0.4 and 0.8 mol dm–3, water moves out of Visking tubing
- concentrations of sucrose 1.2, 1.6, 2.0 (mol dm-3), water moves into Visking tubing
- ref. to net water movement ;
- external solution has higher water potential (than contents of Visking tubing)
- water moves down water potential gradient

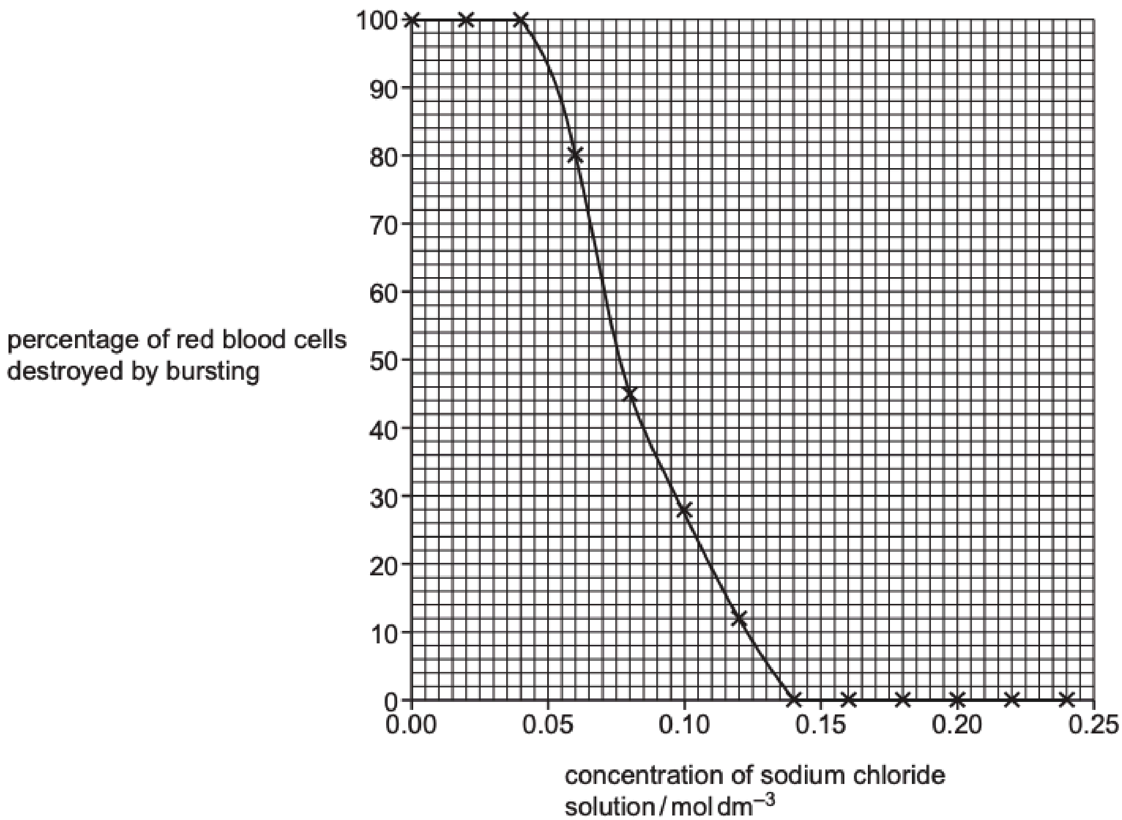
25.

(b) When red blood cells are placed in water they are destroyed by bursting.

The student also investigated how red blood cells are affected by immersion in solutions of sodium chloride of different concentration. Blood samples of the same volume were added to solutions of sodium chloride in separate test-tubes.

After 10 minutes, the student took 0.1 cm^3 of the blood samples from the test-tubes and estimated the percentage of red blood cells that had burst in each blood sample.

Fig. 3.2 shows the student's results.



Describe and explain the effects on red blood cells of immersion in different concentrations of sodium chloride as shown in Fig. 3.2.

- at concentrations ⩽ 0.04 mol dm–3 all cells burst
- at concentrations between 0.04 and 0.14 mol dm–3 decreasing percentage of cells burst
- at concentrations ⩾ 0.14 mol dm–3 no cells burst

- in low concentrations of sodium chloride water moves into cells down water potential gradient / from high to low
- cells increase in volume / size / internal pressure
- cell membranes are not strong enough to withstand increase in volume / pressure OR red blood cells burst because they have no cell wall
- between 0.04 and 0.14 (mol dm–3) water potential gradient into cells decreases / becomes less steep
- above 0.14 (mol dm–3) / in high concentrations water potential inside cells is the same or higher than the sodium chloride solution
- at high concentration ⩾ 0.14 water leaves cells / cells shrink / cells shrivel / cells show crenation

26. Mitochondrial DNA codes for some polypeptides of proteins used within the mitochondrion. Some of the proteins allow movement of ions into and out of the mitochondria. Outline the ways in which ions can move into mitochondria.
    - active transport – uses ATP / moves ions against concentration gradient
    - facilitated diffusion – passive / no ATP / no energy / with the gradient / down concentration gradient
    - protein carrier / pump changes shape / conformation change / has binding sites
    - channel protein / pore protein for facilitated diffusion
    - AVP: ref. to ionophore(s) / hydrophilic pore in channel proteins / specificity of carrier or channel proteins

27. Protoplasts are plant cells that have had their cell walls removed by treatment with enzymes. Scientists often use protoplasts when researching ways to improve the yield of crop plants. Explain why scientists keep the protoplasts in a solution that has the same water potential as the cell.
    - to prevent lysis / bursting / shrinking / shrivelling
    - ref. to no net movement of water
    - otherwise movement of water by osmosis / down a water potential gradient

28. Organic anions (negatively charged organic compounds) are released into the soil by rootlets. The concentration of these organic anions can become higher in the soil solution than in the rootlet cells. Suggest and explain how the concentration of organic anions in the soil solution can become higher than in the rootlet cells.
    - active transport occurring
    - pumped / moved out against their concentration gradient
    - move out through carrier / pump protein
    - using ATP / energy
    - AVP: membrane impermeable to entry of anions

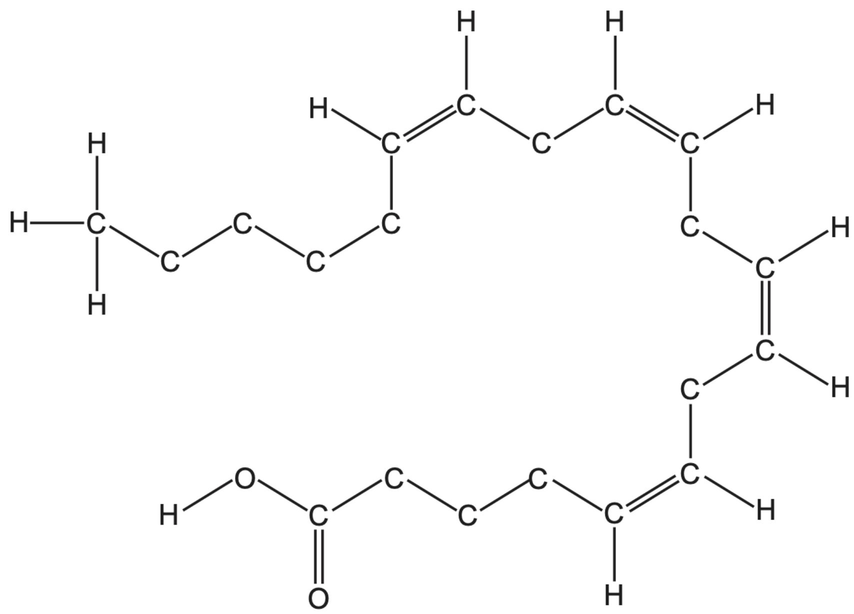
29. When the availability of phosphate ions and other soil nutrients is limited, root clusters are formed. A root cluster is a dense arrangement of tiny side roots known as rootlets. Most of the epidermal cells of the rootlets are root hair cells. Rootlets release compounds into the soil that make phosphates and other mineral ions more soluble for uptake. Uptake of phosphate ions and the absorption of water from the soil increases.

Explain how the formation of root clusters can lead to an increase in the uptake of phosphate ions and absorption of water from the soil solution.

- increased surface area
- because many / more root hairs / root hair cells
- increase in carrier proteins / channel proteins (for ion uptake)
- AVP: increase in water uptake osmotically to follow ion uptake

30.

Fig. 5.3 shows the molecular structure of arachidonic acid. Not all hydrogen atoms are shown.



With reference to Fig. 5.3, explain why increasing the proportion of phospholipids with arachidonic acid in a cell will increase the fluidity of the cell surface membrane of the cell.

- phospholipids may be used in / added to the cell surface membrane
- arachidonic acid is unsaturated / polyunsaturated
- has C=C / carbon-carbon double bonds
- unsaturated fatty acid tails have kinks / not linear OR double bonds produce kinks
- increased distance between, phospholipids / other fatty acid tails OR phospholipids cannot pack closely together
- less hydrophobic interactions between phospholipid (molecules)

31.

(ii) Complete Table 1.1 to show:

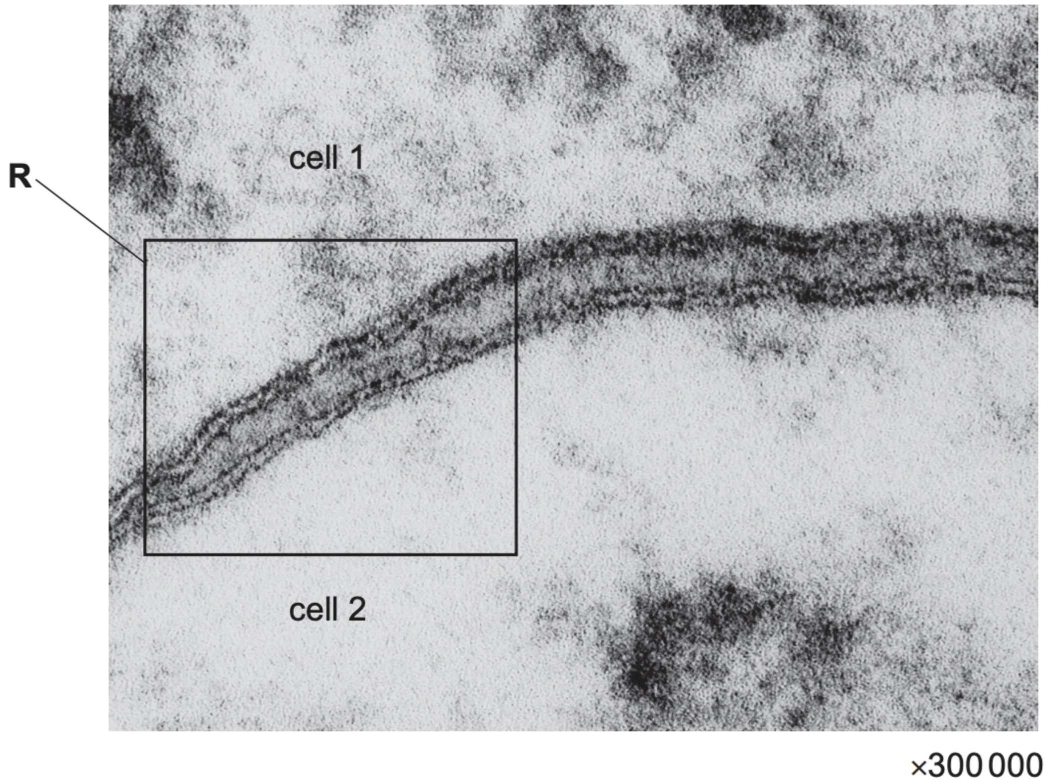
- the names and functions of the components of the cell surface membrane
- the letters of the labels in Fig. 1.1 that identify each component.

Table 1.1

component	function	letter on Fig. 1.1
channel protein		
phospholipid		
	receptor for cell signalling	
		F

component	function	letter on Fig.1.1	
channel protein	facilitated diffusion **or** transport of, water / ions / water soluble substances / polar molecules / charged substances / hydrophilic substances **I** named examples of each category	**A**	;
phospholipid	forms a bilayer **or** a role within bilayer e.g. barrier to, water soluble / polar substances / ions allows diffusion of, fat soluble / non-polar, substances allows fluidity / provides stability / forms a hydrophobic core / AW	**E**	;
glycoprotein **A** glycolipid	receptor for cell signalling	**B** **D**	;
cholesterol	gives (mechanical) stability / maintains fluidity / regulates fluidity / barrier to water soluble substances **or** at low temperatures, maintains or increases fluidity / prevents close packing **A** prevents hydrophobic 'tails' interacting at low temperatures **or** at high temperatures, stabilises the membrane / decreases fluidity	**F**	;

1.



(transmission electron micrograph of part of two adjacent animal cells)

- dark lines = phosphate heads
- clear area between pairs of dark lines = fatty acid tails / hydrophobic core
- clear area between the two cell surface membranes = interstitial fluid / tissue fluid / extracellular matrix / intercellular space

2. Suggest and explain how proteins (mucin strands) are transported out of cells.
   - Exocytosis
   - Any 2 from:
     - vesicles will be large enough to contain many mucins / ref. to bulk transport
     - vesicles forming from Golgi body / apparatus
     - vesicles moved by microtubules / cytoskeleton (to cell surface membrane)
     - vesicles fuse with cell surface membrane
     - active process / requires ATP
     - AVP: mucins are polar / hydrophilic so cannot cross phospholipid bilayer / hydrophobic core of membrane

     OR any 2 from:
     - mucin molecules are hydrophilic
     - can exit via protein channels
     - by facilitated diffusion

3. Some Golgi vesicles contain secretory proteins for release from the cell. Describe the sequence of events that occurs following the packaging of a secretory protein into a Golgi vesicle to its release from the cell.
   - vesicle moves to cell surface membrane ;
   - movement of vesicle via cytoskeleton / microtubules ;
   - vesicle fuses with (cell surface) membrane (and protein released) ;
   - vesicle makes contact with membrane and becomes part of it
   - exocytosis ;

4. Describe the structure of a phospholipid molecule.
   - phosphate (group) and 2 fatty acid chains / tails / residues
   - attachment of phosphate / fatty acids to glycerol
   - AVP:
     - ref. ester bond for attachment of phosphate group to glycerol
     - ref. to additional group e.g. choline-containing - modify the phosphate group
     - ref. to saturated / unsaturated (fatty acid tails)

5. Outline the role of glycolipids in the cell surface membrane.
   acts as (self-)antigen / recognition site / cellular recognition / receptor / membrane stability / cell adhesion ;

6. After final processing in the Golgi body, collagen is released to the outer surface of the cell by exocytosis. Complete the passage to describe the process of exocytosis:

   After final processing in the Golgi body…
   - (Golgi /secretory) vesicles – detail ;
     - e.g. packaging of / containing collagen
     - vesicles bud off from Golgi body
   - movement to surface (not movement to other areas within cell) by microtubules / cytoskeleton (to cell surface membrane) ;
   - ATP required ; active process ;
   - fuse / merge / combine with the cell surface membrane ;
   - AVP: budding from trans face of Golgi