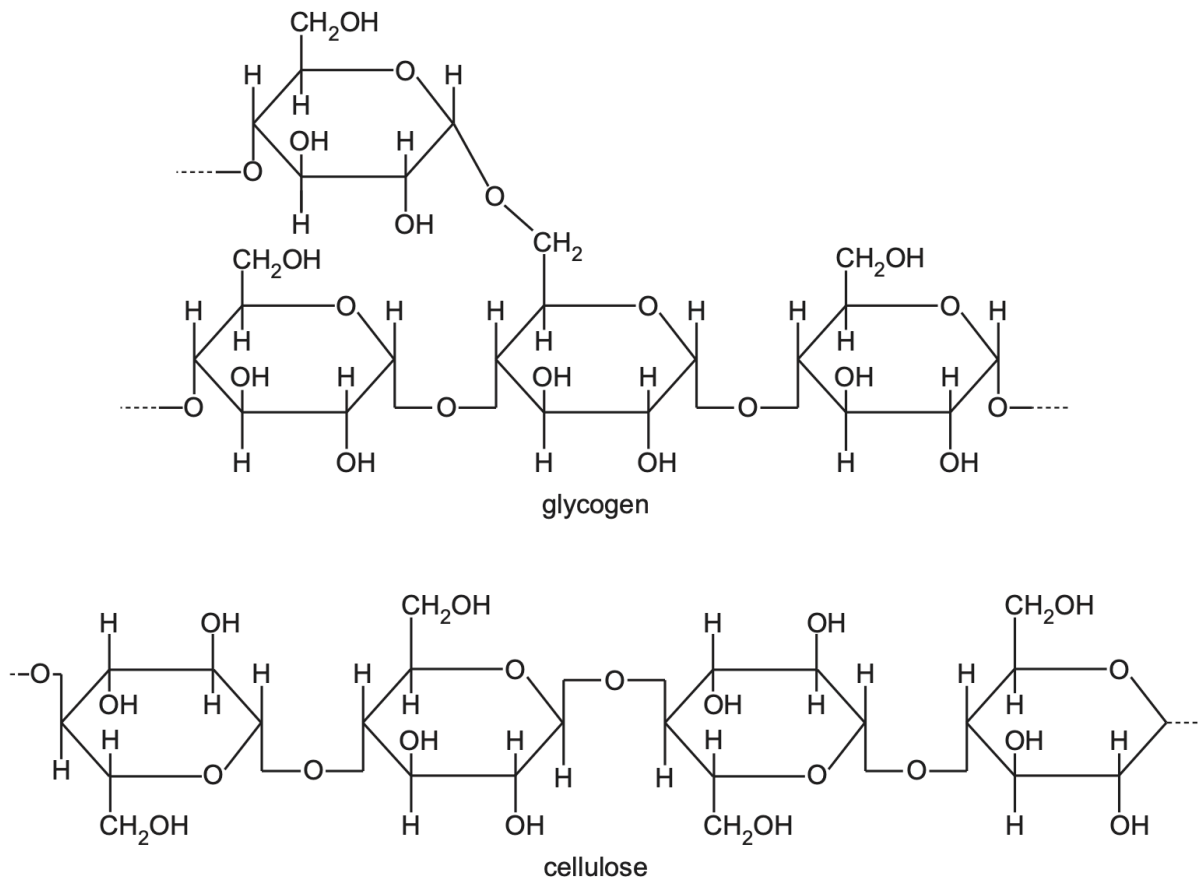


2. Biological molecules

1.

Glycogen and cellulose are polymers.

Fig. 2.1 shows small, representative regions of a glycogen molecule and a cellulose molecule.



Describe three ways, visible in Fig. 2.1, in which the molecule of glycogen differs from the molecule of cellulose.

- Glycogen is branched | cellulose is unbranched.
- Glycogen monomer is alpha-glucose | Cellulose monomer is beta-glucose.
- Glycogen has 1,4- and 1,6-glycosidic bonds | Cellulose has only 1,4-glycosidic bonds.
- In cellulose, alternate monomers are rotated 180° / inverted / flipped

2.

Glycogen is found in the form of granules in mammalian liver and muscle cells. Fig. 2.2 is a diagram of part of a molecule of glycogen isolated from a glycogen granule.

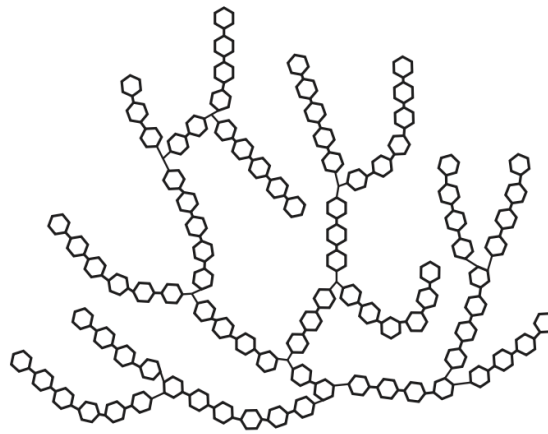
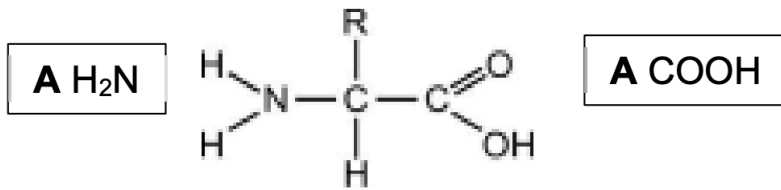


Fig. 2.2

Explain how the structure of glycogen is related to its function in cells.

- glycogen is a store of energy / glucose
 - many branching points / ends / terminals for easy / faster addition & release of glucose
 - compact so stores more glucose / energy in small space
 - insoluble
 - does not lower / change water potential of cell; no osmotic effect
 - chemically inactive so does not take part in cell metabolism
3. Explain how the arrangement of cellulose molecules in plant cell walls is related to their function.
- unbranched polymer / straight chain / linear
 - cellulose molecules are arranged in parallel
 - large number of -OH groups projecting in all directions
 - allows hydrogen bonds / H-bonds to form with water OR makes the molecule hydrophilic
 - many hydrogen bonds between cellulose molecules
 - cellulose molecules form microfibrils
 - hydrogen bonds give high tensile strength to microfibrils / hydrogen bonds help cell walls to resist turgor pressure
4. Explain what is meant by a polysaccharide.
- more than two / three or more / large number of repeating monosaccharides/ sugar monomers/ sugar units
 - joined by glycosidic bonds

5. Draw the general structure of an amino acid and use the drawing to explain how it is possible to have many different amino acids.



- R-group / side chain is variable OR different amino acids have different R-groups / side chains

6.

- (a) (i) Table 4.1 contains descriptions of the structures of glutenin and gliadin.

Complete Table 4.1 by writing the level of protein structure that applies to each description.

Table 4.1

description	level of protein structure
a gliadin protein is a single polypeptide that forms a compact structure	
20% of the amino acids in a glutenin molecule are glycine	
gliadin and glutenin molecules contain regions of β -pleated sheets	

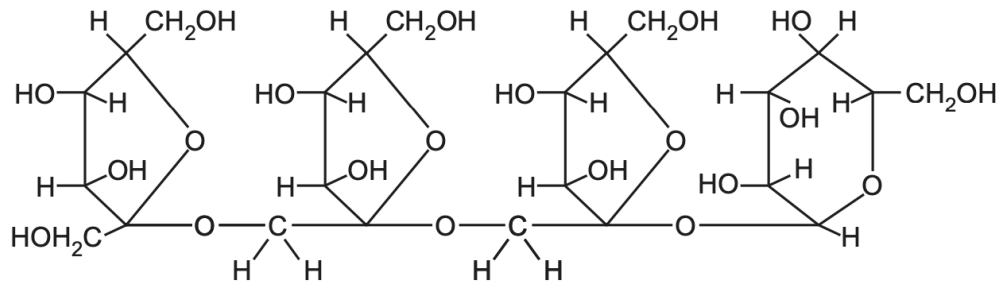
description	level of protein structure
a gliadin protein is a single polypeptide that forms a compact structure	tertiary
20% of the amino acids in a glutenin molecule are glycine	primary
gliadin and glutenin molecules contain regions of β -pleated sheets	secondary

7.

Polysaccharides, such as glycogen, are composed of thousands of monomers.

Oligosaccharides are carbohydrates that contain three to ten monomers in their chain.

(a) Nystose is one example of an oligosaccharide. The structure of nystose is shown in Fig. 6.1.



State three differences between the structures of nystose and glycogen, other than the number of monomers in the molecules.

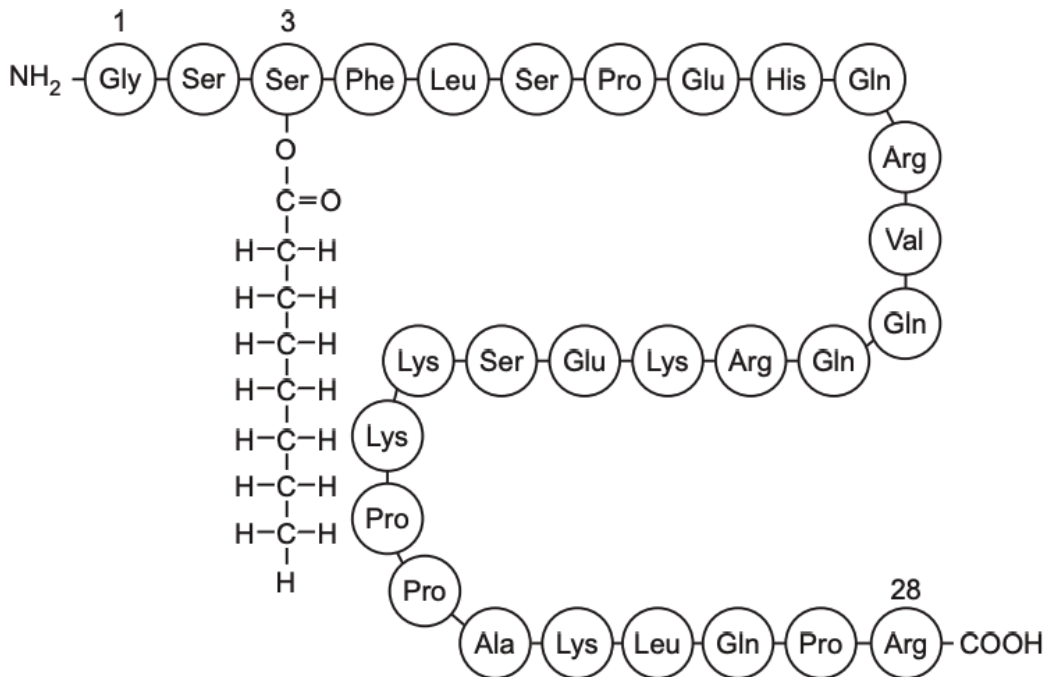
- nystose is not branched / glycogen is branched
- different glycosidic bonds: nystose has one type of glycosidic bond and glycogen has two types – 1-4 and 1-6 glycosidic bonds
- two types of monomer in nystose v only glucose in glycogen
- nystose contains one glucose monomer
- ring shape: glycogen monomers have six-sided rings and nystose has 1 six-sided ring and five-sided rings
- AVP: fructose in nystose and no fructose in glycogen

8.

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.



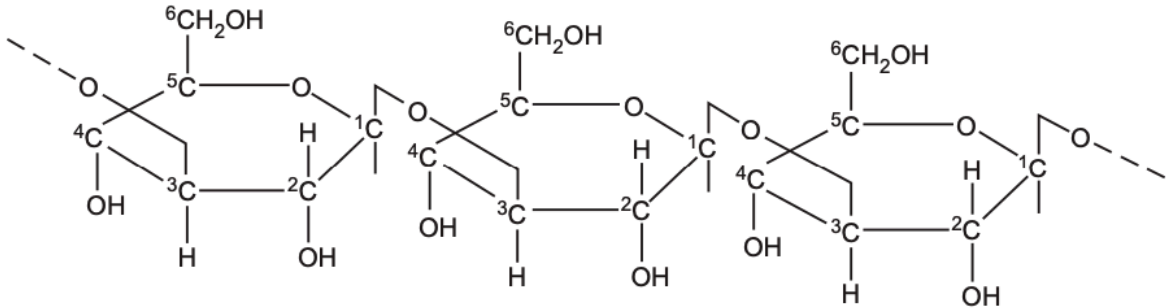
State the level of protein structure shown in Fig. 2.2.

- Primary
9. State one similarity between the structure of a saturated fatty acid molecule and an amino acid molecule.
- both contain carbon/ hydrogen/ oxygen
 - both have / carboxylic acid / carboxyl / C=O group

10.

(b) The polysaccharide callose is found in the cell walls of cells close to plasmodesmata.

Fig. 3.1 is a simplified diagram showing the structure of callose. Not all hydrogen atoms are shown.



Complete Table 3.2 to compare the structure of a callose molecule with a cellulose molecule.

Table 3.2

feature of polysaccharide	callose molecule	cellulose molecule
monosaccharide used to synthesise the polysaccharide	β -glucose	
bond connecting the monomers		1,4 glycosidic bond
shape of molecule	helix	
orientation of monosaccharides in the molecule		alternate glucose molecules are rotated by 180°

feature of polysaccharide	callose molecule	cellulose molecule
monosaccharide used to synthesise the polysaccharide		beta / β , glucose ; R B glucose
bond connecting the monomers	1, 3 glycosidic bond ;	
shape of molecule		straight / linear ;
orientation of monosaccharides in the molecule	adjacent glucose molecules same way up / AW ;	

11.

During research, scientists can use modified nucleotides to prevent elongation of a polynucleotide chain during DNA replication.

Fig. 6.1 shows the structure of a DNA nucleotide found in the nucleus of a cell.

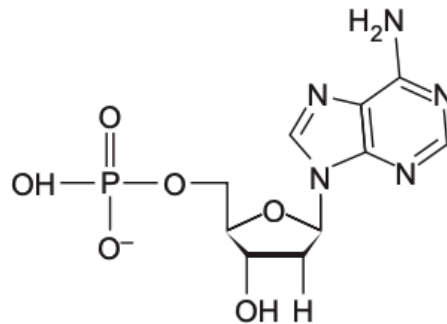


Fig. 6.1

Fig. 6.2 shows the structure of a modified nucleotide.

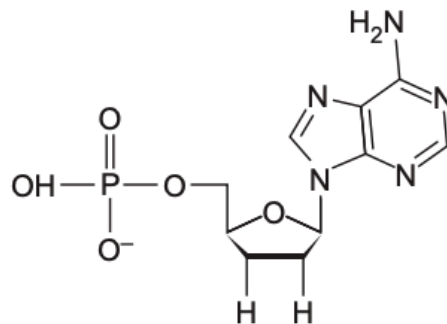


Fig. 6.2

Suggest how the structure of the modified nucleotide prevents DNA polymerase joining it to another nucleotide.

- does not have an OH group so condensation reaction cannot occur
- phosphodiester bond cannot form between deoxyribose and phosphate of adjacent nucleotide
- is a different shape because it has H instead OH on C3
- shape not complementary to the active site of DNA polymerase OR no enzyme substrate complexes

12. Feathers are not easily degraded (broken down) because keratin is a very stable protein. Suggest features of keratin structure that contribute to its stability.

- fibrous / not globular
- insoluble / does not dissolve / does not dissolve easily

- high proportion of disulfide bonds / disulfide bridges / covalent bonds because of cysteines
- high proportion of / many hydrogen bonds between polypeptides
- high proportion of / many hydrophobic interactions due to many amino acids with hydrophobic R-groups
- tight / close packing of chains / polypeptides / molecules
- many amino acids with small R-groups / small amino acids

13.

- (a) Table 1.1 shows some details of the five most common fatty acids found in samples of olive oil produced by olive plants grown in different regions in Portugal.

Table 1.1

Key

C : D = number of carbon atoms : number of double bonds in the hydrocarbon chain

X = missing detail

fatty acid	percentage of total fatty acid content	C : D	chemical structure
oleic acid	55.0–83.0	18 : 1	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{X}$
palmitic acid	7.5–20.0	16 :	$\text{CH}_3(\text{CH}_2)_{14}\text{X}$
linoleic acid	3.5–21.0	18 :	$\text{CH}_3(\text{CH}_2)_4(\text{CH}=\text{CH})\text{CH}_2(\text{CH}=\text{CH})(\text{CH}_2)_7\text{X}$
stearic acid	0.5–5.0	18 :	$\text{CH}_3(\text{CH}_2)_{16}\text{X}$
palmitoleic acid	0.3–3.5	16 :	$\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CH}(\text{CH}_2)_7\text{X}$

- a. State the detail of chemical structure, represented by X, which is missing from Table 1.1.
- COOH / carboxylic acid group
- b. The analysis of the triglycerides present in the different samples of olive oil showed that:
- there are many different triglycerides present in olive oil
 - each olive oil is different in its composition, but the same few triglycerides are present in all olive oils.
- With reference to Table 1.1 and to the structure of triglycerides, suggest explanations for these observations.

- each triglyceride has three fatty acids
- fatty acids can be saturated / with no double bonds or unsaturated / with double bonds
- fatty acids can have different hydrocarbon chain lengths / number of carbons
- detail from Table 1.1 to support these
 - saturated = palmitic / stearic v unsaturated = oleic / linoleic / palmitoleic
 - oleic / linoleic / stearic = 18C v palmitic / palmitoleic = 16C
- idea of a particular fatty acid can be located at a different position in a triglyceride / can form a bond with any one of the 3 hydroxyl groups
- ref. to different environmental conditions of plants grown in different regions : e.g. colder conditions and oils having more triglycerides with higher proportion of unsaturated fatty acids
- shared triglycerides have structures most suited as energy stores: e.g. have fatty acids with longest hydrocarbon chains // easiest to hydrolyse / release hydrogen atoms // have greater energy value than others
- ease of production / synthesis
- shared triglycerides composed of the fatty acids present in highest proportions: e.g. using Table 1.1 to determine the most common 2 or 3 fatty acids = could all have the same fatty acid combination from oleic acid and / or palmitic acid and/or linoleic acid' (any two)

14. Glycerol is soluble in water. Triglycerides are insoluble in water. Explain why water is a good solvent for some substances such as glycerol, but is a poor solvent for substances such as triglycerides.

- water is a polar molecule / polar / dipolar: the O atom has slightly negative charge, and the H atoms have a slightly positive charge
- water can form hydrogen bonds with glycerol / polar substances OR cannot form H-bonds with triglycerides / non-polar substances
- glycerol / polar molecules / ions interact with water molecules / are attracted to water molecules / are hydrophilic

15. State an advantage of using a colorimeter in determining the progress of the reaction.

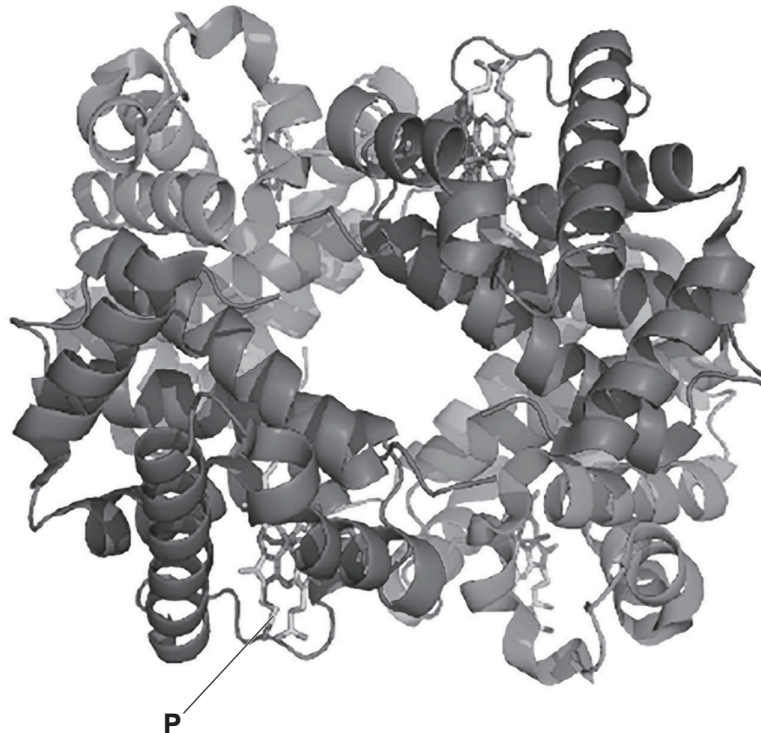
- results are not subjective / no judgements made by eye
- colorimeter gives quantitative / numerical results / readings
- can use values from the colorimeter to plot graphs
- can use calibration curve to determine concentrations
- can take continuous readings / do not have to take samples

16. State the names of the two different polypeptides that form a haemoglobin molecule.

- Alpha globin / alpha chain
- Beta globin / beta chain

17.

Haemoglobin is a complex protein molecule made of four separate subunits, as shown in Fig. 3.1.



Identify the structure labelled P.

- haem/ prosthetic group

18. Describe the structure of a cellulose molecule and a cellulose microfibril.

Cellulose molecule

- monomers of beta-glucose
- glucose joined by glycosidic / 1,4 glycosidic bonds
- adjacent monomers / glucoses rotated through 180°
- straight / linear chain
- unbranched

Cellulose microfibril

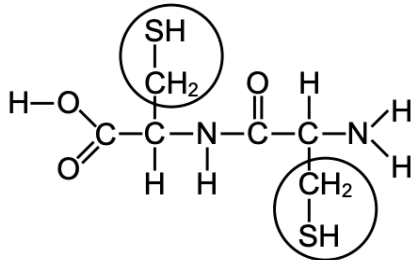
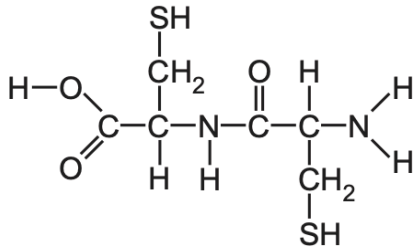
- parallel molecules / chains of cellulose
- hydrogen bonds between molecules / form cross bridges / between OH groups
- staggered starts and ends

19. Explain how water acts as a solvent for sodium chloride.

- water is polar: delta positive hydrogen atom / $H\delta^+$ and delta negative oxygen atom / $O\delta^-$

- attraction between negatively charged chloride ions / Cl^- and $\text{H}\delta^+$, and attraction between positively charged sodium ions / Na^+ and $\text{O}\delta^-$
- water molecules collect around sodium chloride and separate ions
- ionic bond broken between sodium and chloride atom; ions are separated and spread through the water

1. Circle an R-group in this molecule which consists of 2 amino acid molecules joined together:

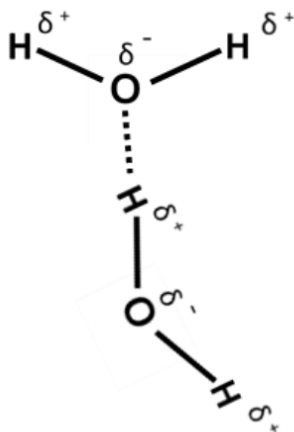


2. Mucin strands are formed by joining the ends of mucin (protein) molecules together through covalent bonds between R-groups. State the name of these covalent bonds.

Disulfide bonds

NOTE: disulfide bonds are covalent links between the sulphur atoms of 2 cysteine amino acids.

3. Explain how hydrogen bonding occurs between two water molecules.



- oxygen has a small negative charge and hydrogen has a small positive charge

- a hydrogen bond forms between the oxygen of one water molecule and the hydrogen of a neighbouring water molecule
 - AVP ; e.g. oxygen is more electronegative than hydrogen
4. Describe the hydrogen bonding that occurs between the water molecules as shown in the diagram
- Diagram shows that hydrogen bond is a weak bond
 - each oxygen (atom) forms 2 hydrogen bonds / each hydrogen (atom) forms 1 hydrogen bond
 - (attraction) between oxygen (atom) of one water molecule and hydrogen (atom) of another (forms a hydrogen bond)
 - water is dipolar
 - Detail:
 - electrons not shared equally between oxygen and hydrogen
 - oxygen is more electronegative (than hydrogen)
 - 2 lone pair(s) (of electrons) on oxygen
 - uneven distribution of, electrons / charge: oxygen has slight, negative charge / δ^- and hydrogen has slight, positive charge / δ^+
5. Explain the role of hydrogen bonding in maintaining the secondary structure of proteins.
- Hydrogen bonds maintain the shape of α -helices / β -pleated sheets.
- NOTE: these H-bonds are NOT between the R groups of amino acids!! They form between the carbonyl O of one amino acid and the amino H of another.
6. Explain the role of hydrogen bonding in maintaining the tertiary structure of proteins.
- hydrogen bonds help to stabilise / enable further folding of polypeptide
 - hydrogen bonds are formed between, R groups with amine and carboxyl groups.
 - hydrogen bonds may be formed between amino acids that are far apart in primary structure
 - helps to maintain / form / globular shape / 3D shape / structure of protein OR maintains / forms / specific shape / structure of active site (if enzyme)
7. Outline how hydrogen bonding is involved in water transport in the xylem of a plant stem.
- ref. to cohesion between water molecules ;
 - ref. to adhesion / hydrogen bonding, between water molecules and, cellulose / hydrophilic parts of lignin (in cell wall) ;
 - formation of continuous column
 - (column) pulled up by, transpiration / evaporation / transpiration pull ;

8. Hydrogen bonding between water molecules gives water a relatively high latent heat of vaporisation. Suggest why it is important to plants that water has a high latent heat of vaporisation.
- ref. to plant leaves heat up, when light absorbed for photosynthesis / at high (ambient) temperatures ;
 - (high latent heat of vaporisation leads to large cooling effect / removal of (large quantities of) heat energy, by evaporation ;
 - reduces, protein / enzyme, denaturation ;
 - reduces rate of water loss by, transpiration / evaporation, at high temperatures
9. Outline the importance of water as a solvent in plants.
- dissolves ions / minerals / salts and (named) polar molecules ;
 - transports solute(s) / named solutes / dissolved substance in xylem / phloem
 - storage of solutes / named solutes in vacuoles
 - metabolic / chemical / cellular, reactions occur in water
 - dissolves carbon dioxide / oxygen, with ref to, respiration / photosynthesis;
10. Explain how the structure of a collagen fibre provides the skin with strength.
- covalent bonds between collagen molecules (between R groups / side-chains)
 - covalent bonds are strong
 - (molecules) staggered / overlapping molecules, so no weak areas (gives greater strength)
 - (in skin) fibres line up in layers, not parallel / running in different directions
 - provides tensile strength / strength in different directions
11. After the synthesis of polypeptides, changes need to occur to form a functioning globular protein molecule composed of 3 identical polypeptide chains. Outline the changes that need to occur to form the functioning globular protein molecule.
- formation of secondary structure with α -helix β -pleated sheets.
 - folding / coiling to form tertiary structure.
 - name 2: hydrogen bonds / ionic or electrostatic bonds / disulfide bonds or bridges / hydrophobic interactions.
 - formation of quaternary structure; polypeptides held together by interactions / hydrogen bonds / ionic bonds / disulfide bonds
 - globular protein has hydrophilic amino acids / R-groups / side chains to the outside and hydrophobic amino acids / R-groups / side chains towards centre
 - Example of other post-translational modification:
 - removal of methionine / met
 - addition sugar group / glycosylation

- addition phosphate group

12. Compare the peptide bond formed during translation with the types of bond made during tertiary structure formation.

Similarity

- peptide bond and disulfide bond are covalent bonds ;

Differences

- tertiary structure bonds are between R groups / side chains of different amino acids.
- peptide bond is between carboxylic acid (COOH) and amine (NH₂) group of the adjacent amino acid ;
- H bond / ionic bond / hydrophobic interaction versus covalent peptide bond ;
- peptide bond stronger / more thermostable than tertiary structure bonds ;
- AVP:
 - hydrophobic interactions between non-polar R groups
 - disulfide bonds between sulfur-containing R groups
 - ionic bonds between carboxyl and amino groups of R groups
 - H-bond between oxygen on –CO groups and H on either the –OH or –NH groups of R groups

13. Define the terms disaccharide and polysaccharide.

- Disaccharide = two, monosaccharides / sugar monomers / sugar units / simple sugars ;
- Polysaccharide = more than two / three or more / many / large number of, monosaccharides / sugar monomers / sugar units / simple sugars

14. Explain why a protein is described as globular.

- spherical / ball shaped ;
- (water-) soluble ;
- amino acids with hydrophilic R groups / hydrophilic amino acids on outside of molecule ; amino acids with hydrophobic R groups in centre of molecule ; physiological / metabolic role ;
- It is an enzyme, and enzymes are globular proteins ;

15.

Human cytomegalovirus (HCMV) is a common virus affecting humans. In people with a fully functioning immune system, infection by HCMV usually causes no, or only mild, symptoms.

Fig. 2.1A is a diagram of a section through HCMV. In Fig. 2.1B, only the outer part of HCMV is sectioned.

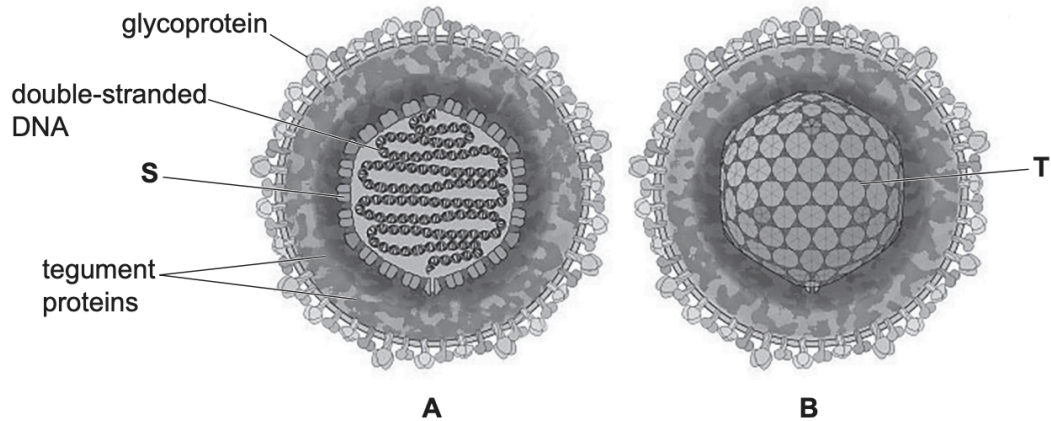


Fig. 2.1

The viral DNA shown in Fig. 2.1 contains genes that code for proteins important in viral replication and viral structure, including viral DNA polymerase and proteins known as tegument proteins.

Viruses can only replicate in host cells as they need to use processes and contents of the host cell. Complete viral particles that are released from the host cell are known as virions.

The virus in Fig. 2.1 is drawn as a spherical shape. Structure T is always the same shape. However, electron micrographs show that HCMV virions are not all the same shape. Suggest how HCMV virions can be of different shapes.

- presence of (viral) envelope / (outer) membrane / phospholipid bilayer ;
- ref. fluid / flexible ;
- ref. to preparation (for electron microscopy) ; e.g. distortion / squashed / artefact
- AVP ; suggestion of variation in tegument protein, number / arrangement / organisation

16.

(a) Fig. 5.1 shows the primary structure of a section of a polypeptide chain of collagen.

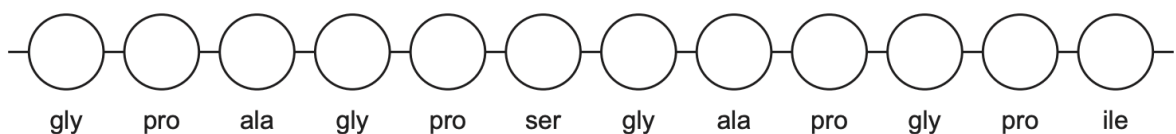


Fig. 5.1

- b. similarities between structure of a saturated fatty acid molecule and an amino acid molecule.
- Both contain carbon, hydrogen and oxygen atoms
 - Carboxylic acid / carboxyl, group ; both have C=O
- c. Addition of fatty acid chain allows ghrelin to function as a cell signalling molecule. Suggest how.
- forms part of overall 3D shape; tertiary / quaternary structure; 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) ;
 - suggested detail ; e.g. interacts with hydrophobic region of the receptor molecule (for binding)
 - AVP
 - helps 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.
 - Suggestion that fatty acid chain allowed incorporation into / attachment to a transport molecule in plasma to reach target cell
 - ref. to effect of binding triggering reactions inside the cell ;

1.

feature of polysaccharide	callose molecule	cellulose molecule
monosaccharide used to synthesise the polysaccharide	β -glucose	
bond connecting the monomers		1,4 glycosidic bond
shape of molecule	helix	
orientation of monosaccharides in the molecule		alternate glucose molecules are rotated by 180°

feature of polysaccharide	callose molecule	cellulose molecule
monosaccharide used to synthesise the polysaccharide		beta / β , glucose ; R B glucose
bond connecting the monomers	1, 3 glycosidic bond ;	
shape of molecule		straight / linear ;
orientation of monosaccharides in the molecule	adjacent glucose molecules same way up / AW ;	

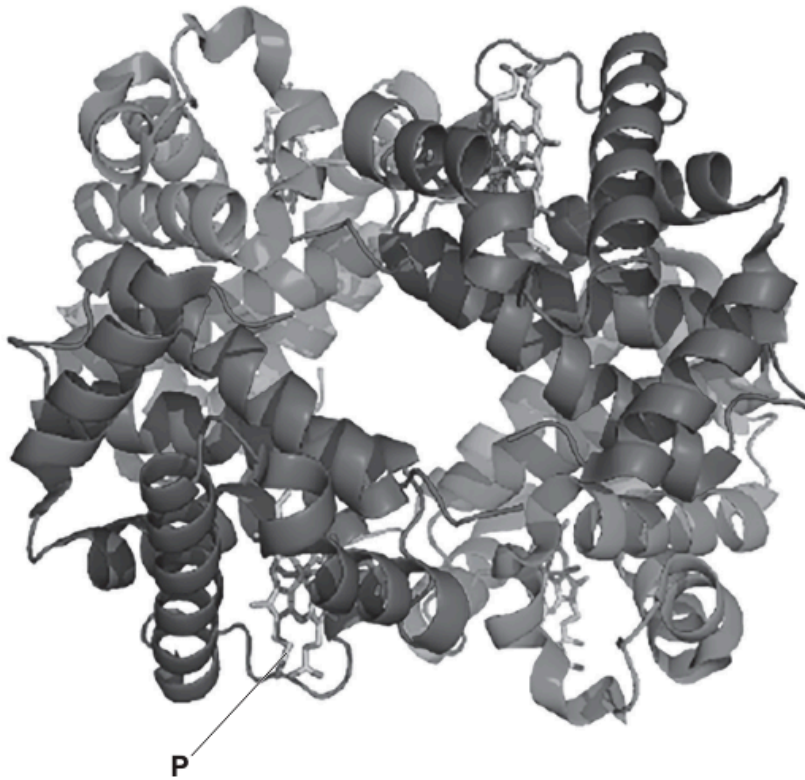
2. roles of hydrogen bonding in the movement of water through xylem vessels.
 - (hydrogen bonding) gives adhesion between water molecules and cellulose / hydrophilic parts of lignin (in xylem wall) ;
 - (hydrogen bonding) gives cohesion between water molecules ;
 - formation of continuous column / adhesion, prevents column of water collapsing
 - transpiration pull ; water, drawn up / pulled up by transpiration / pulled up by evaporation
 - detail ; e.g. water evaporating from spongy mesophyll surfaces // water vapour lost from, leaf / plant, during transpiration
 - idea of creates tension

3. With reference to hydrogen bonding, suggest why cooling of the leaf occurs as a result of evaporation of water during transpiration.
 - hydrogen bonds between water molecules must break for water, to change state / evaporate / AW ;
 - loss of, heat / energy for, evaporation / transpiration (will cool the, leaf / plant) ;

4. Suggest the level of protein structure used to classify a protein as α -keratin or β -keratin.
Secondary

5. Suggest features of keratin structure that contribute to its stability.
 - fibrous/ structural ; not globular
 - insoluble / does not dissolve / does not dissolve easily ;
 - (high proportion of) disulfide bonds / disulfide bridges / covalent bonds (because of cysteines) ;
 - high proportion of / many / hydrogen bonds (between polypeptides) ;
 - high proportion of / many hydrophobic interactions ; many, amino acids with hydrophobic R-groups / hydrophobic R-Groups
 - tight / close, packing, of, chains / polypeptides / molecules ; triple helix
 - AVP ; e.g. arranged so peptide bonds are not accessible; parts of molecule needing to bind to active site not accessible; many amino acids with small R-groups / small amino acids
 - details specific to collagen e.g. gly every third amino acid

6.



State the names of the two different polypeptides.

- Alpha-chain
- Beta-chain

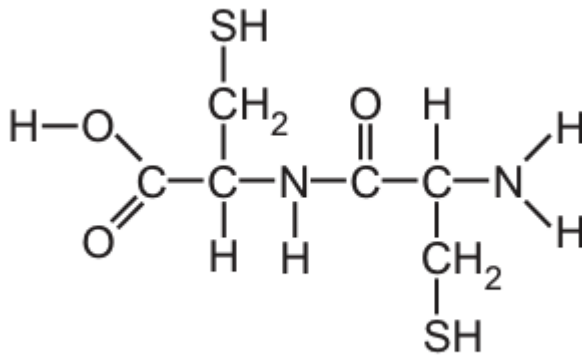
Identify the structure labelled P

Haem

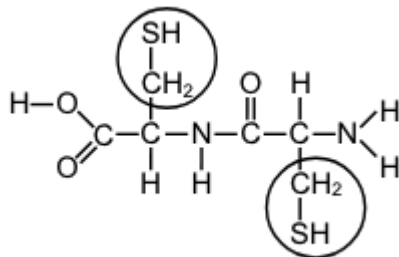
Haemoglobin is involved in the transport of carbon dioxide. Molecules of carbon dioxide enter red blood cells as the cells travel in capillaries through muscle tissue. Some of these molecules are converted to carbonic acid. Explain how haemoglobin is involved in the transport of carbon dioxide molecules that are not converted to carbonic acid.

- haemoglobin, combines with / binds to / reacts with, carbon dioxide ;
- carbon dioxide reacts with (terminal) amine group(s) / $-NH_2$ / $-NH$, of (each), chain / globin / polypeptide ; forms a bond with to for carbaminohaemoglobin
- carbon dioxide is bound to Hb until in, region of low pCO_2 or high pO_2 / pulmonary circulation / lungs / alveoli ;

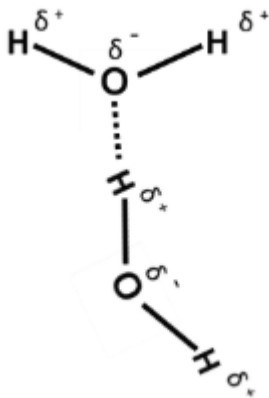
7.



Label the R groups.



8. Explain how hydrogen bonding occurs between two water molecules.



- oxygen has a small negative charge and hydrogen has a small positive charge; oxygen is more electronegative than hydrogen
 - hydrogen bond forms between the oxygen of one water molecule and the hydrogen of a neighbouring water molecule
9. Suggest why it is important to plants that water has a high latent heat of vaporisation.
- plant leaves heat up when light absorbed for photosynthesis / at high (ambient) temperatures
 - (high latent heat of vaporisation leads to large cooling effect / removal of (large quantities of) heat energy, by evaporation
 - reduces, protein / enzyme, denaturation

- reduces rate of water loss by, transpiration / evaporation, at high temperatures

10. Explain how the structure of a collagen fibre provides the skin with strength.

- covalent bonds between collagen molecules (between R groups / side-chains)
- covalent bonds are strong ;
- (molecules) staggered / overlapping molecules, so no weak areas (gives greater strength) ;
- (in skin) fibres line up in layers, not parallel / running in different directions ;
- provides tensile strength / strength in different directions ;