2. Biological Molecules

2.3 Proteins

Paper 2

Question Paper

1 Fig. 2.1 is a photomicrograph of a longitudinal section (LS) through a root tip. Two different regions are visible:

- the root apical meristem
- the root cap.

Cells in the root cap synthesise a gel-like, sticky secretion known as mucilage, which is important in reducing friction between soil and the growing root. It is composed mainly of polysaccharides and also contains some amino acids and enzymes.

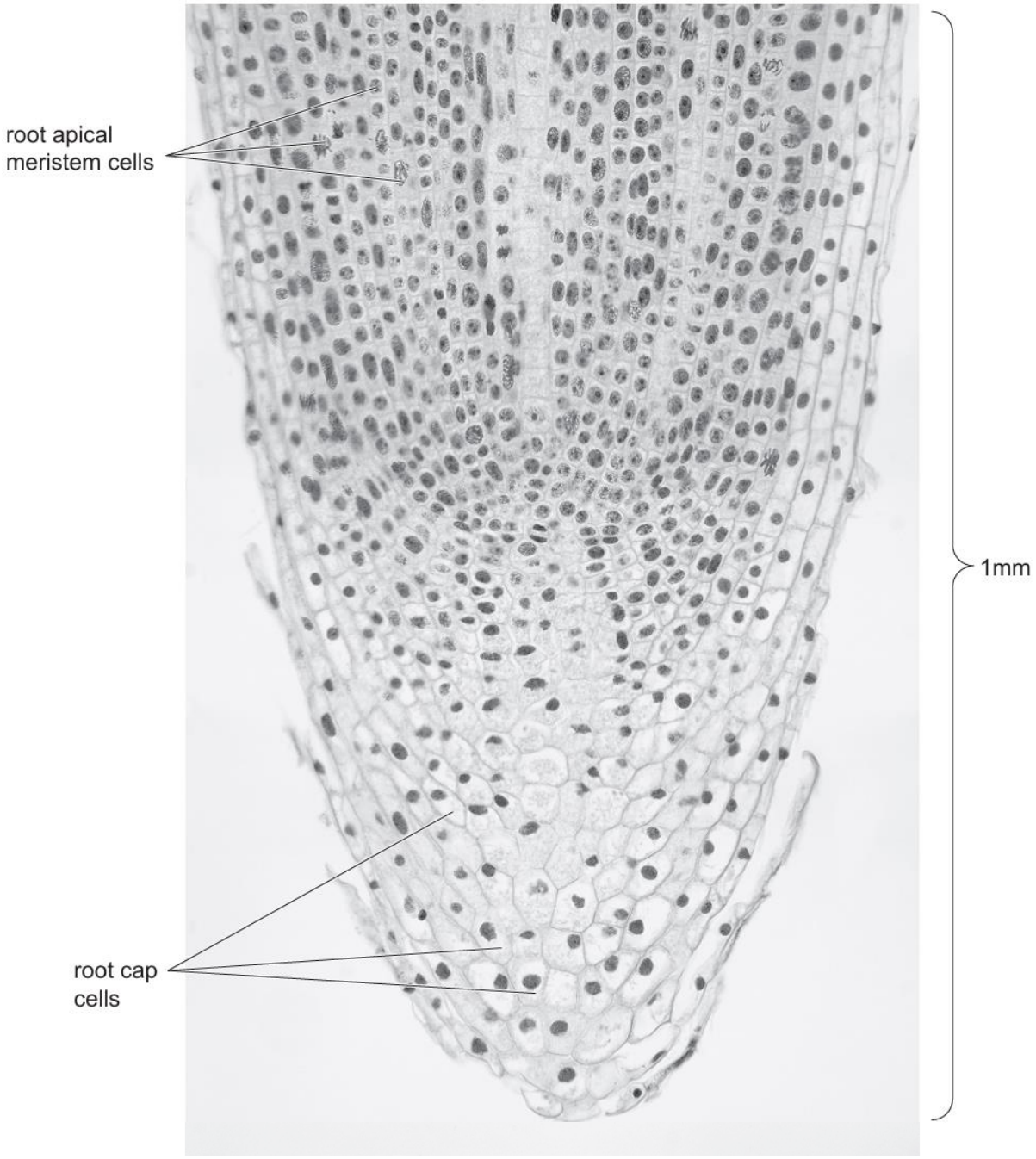


Fig. 2.1

(d) The polysaccharides and amino acids present in the mucilage are a source of nutrients for soil microorganisms that live in the area surrounding the root. Some of these microorganisms can break down soil compounds to release mineral ions.

(ii) The soil microorganisms use amino acids to synthesise proteins. All of the twenty different amino acids that are present in proteins have the same general structure.

Draw the general structure of an amino acid in the space provided **and** use this drawing to explain how it is possible to have many different amino acids.

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..... [2]

2 Keratin is the structural protein in feathers of birds. Keratin polypeptides are composed of a high proportion of cysteine amino acids, which have sulfur-containing R groups.

Keratin polypeptides form filaments. The two main types of keratin in feathers are α-keratin, which consists of many α-helices, and β-keratin, consisting of many β-pleated sheets.

(a) Keratin can be classified as α-keratin or β-keratin based on a study of protein structure.

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

..... [1]

(c) Proteases known as keratinases vary in the extent to which they can hydrolyse keratin.

Feathers are not easily degraded (broken down) because keratin is a very stable protein.

Suggest features of keratin structure that contribute to its stability.

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3 Fig. 2.1 is a transmission electron micrograph showing a section of a specialised epithelial cell found in the lining of the stomach. This cell produces extracellular proteins that are released into the bloodstream.

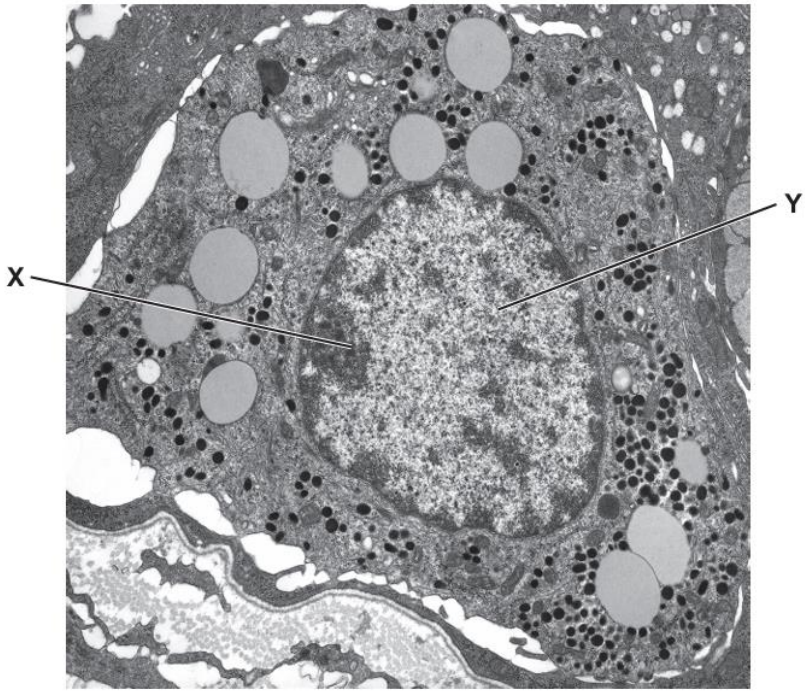


Fig. 2.1

(b) 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.

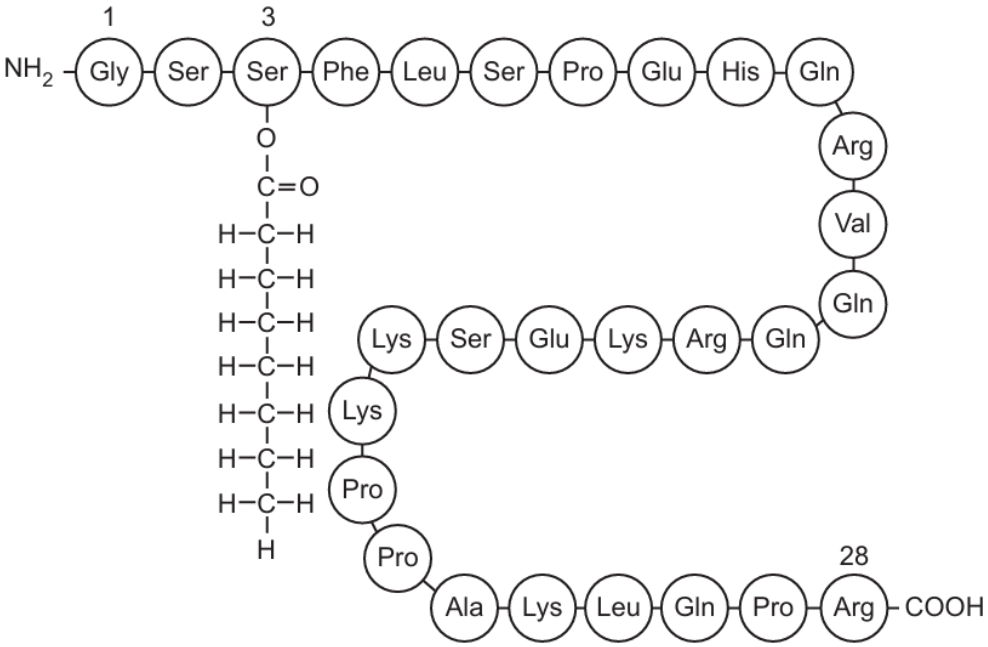


Fig. 2.2

(i) State the level of protein structure shown in Fig. 2.2.

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(ii) State **one** similarity between the structure of a saturated fatty acid molecule and an amino acid molecule.

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..... [1]

4 Fibroblasts are one of the cell types of connective tissue. The cells synthesise and secrete collagen, which forms part of the supporting external cellular environment, known as the extracellular matrix.

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

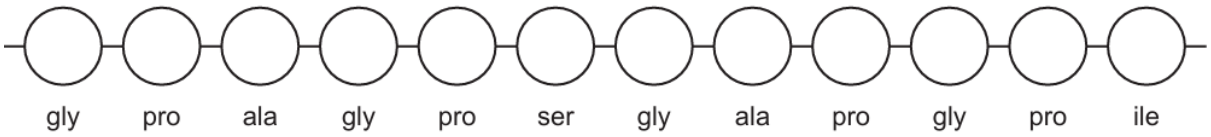


Fig. 5.1

Explain how the primary structure shown in Fig. 5.1 indicates that the structure of the polypeptide is suited to be a component of a collagen molecule.

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5 Fig. 2.1 is a simplified diagram of the human circulatory system.

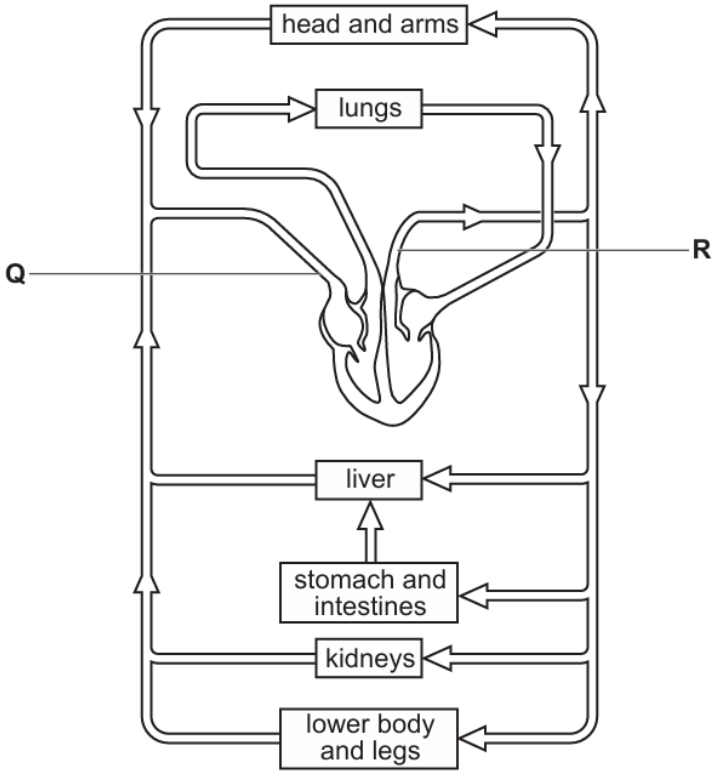


Fig. 2.1

(b) Blood plasma plays an important role in the transport of molecules such as antibodies.

Scientists discovered that some of the antibodies in the blood plasma of sharks have a different structure to the antibodies found in human blood plasma.

Fig. 2.2 shows the structure of an antibody molecule found in the blood plasma of a shark.

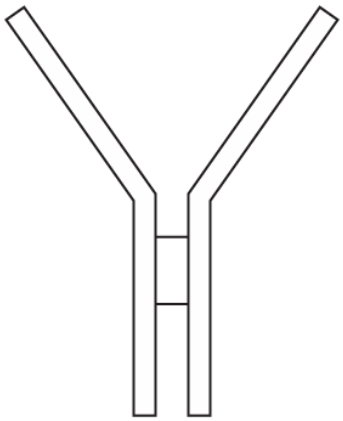


Fig. 2.2

(i) State how the quaternary structure of a human antibody molecule differs from the quaternary structure of the shark antibody molecule shown in Fig. 2.2.

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6 Carbonic anhydrase is a globular protein found in red blood cells.

(a) (i) Explain why this protein is described as globular.

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7 In mammals, some cell signalling molecules are steroid (lipid) hormones. These hormones are transported in the bloodstream to reach capillary networks.

At a capillary network, hormones pass out of the blood into tissue fluid.

(e) Cell signalling by hormone **S** results in the production of a functioning globular protein molecule composed of three identical polypeptide chains.

After the synthesis of these polypeptides, changes need to occur to form the functioning globular protein molecule.

Outline the changes that need to occur to form the functioning globular protein molecule.

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8 Fig. 2.1 shows three molecules of water.

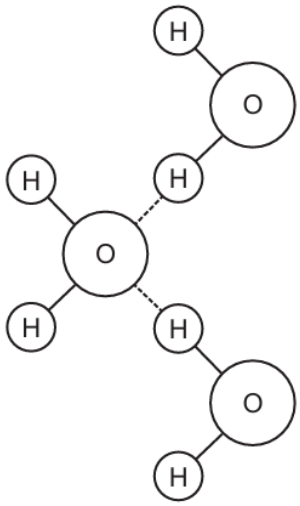


Fig. 2.1

(b) The human enzyme, salivary amylase, is composed of one polypeptide. Fig. 2.2 represents the structure of a molecule of salivary amylase.

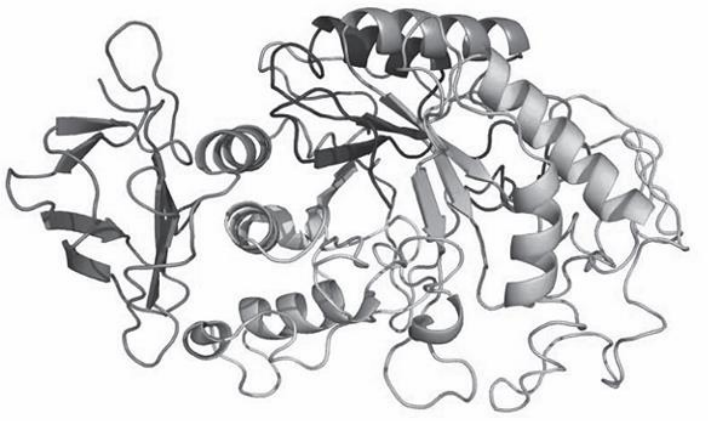


Fig. 2.2

(i) Explain the role of hydrogen bonding in maintaining the secondary structure of proteins, such as salivary amylase.

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..... [1]

(ii) Explain the role of hydrogen bonding in maintaining the tertiary structure of proteins such as salivary amylase.

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9 Baculovirus is a virus that kills some of the insect pests of major crops. When the virus is released to the outside of the insect body, it is contained within stable, protective structures known as polyhedrons.

The main component of the polyhedron is a protein molecule, polyhedrin.

Polyhedrons can be sprayed onto plants as a bioinsecticide. They are ingested by feeding insect larvae and once inside the insect gut they break down to release the virus.

(c) A polyhedrin molecule is composed of three identical polypeptides. Each polypeptide is 245 amino acids long. The first 10 amino acids of the polypeptide are shown in Fig. 3.1.

1	2	3	4	5	6	7	8	9	10
met	**pro**	**asp**	**tyr**	**ser**	**tyr**	**arg**	**pro**	**thr**	**ile**

Fig. 3.1

Fig. 3.2 **A** is a ribbon diagram of a single polypeptide. Fig. 3.2 **B** shows a polyhedrin molecule composed of 3 polypeptides.

The two diagrams are not to the same scale.

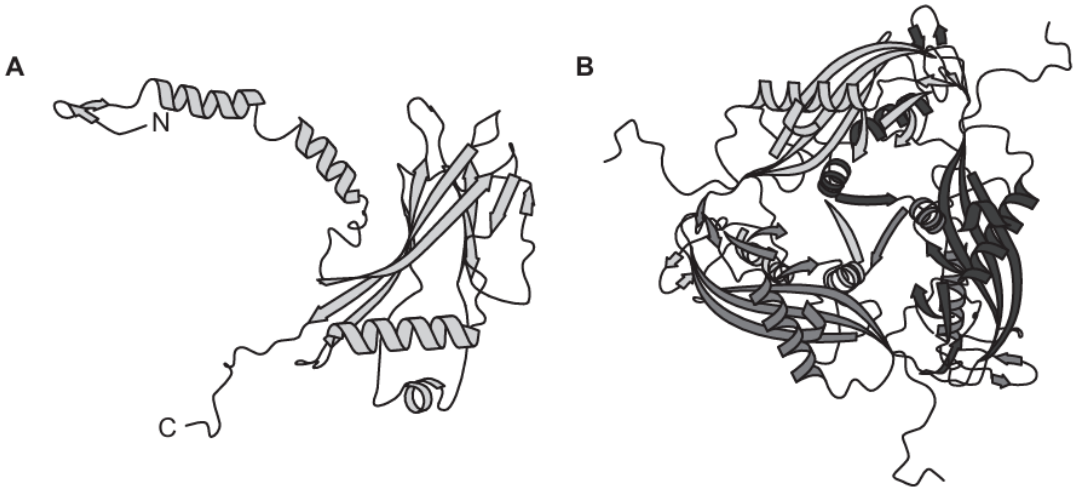


Fig. 3.2

With reference to Fig. 3.1 and Fig. 3.2, describe the structure of a polyhedrin molecule.

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10 Cholera is an infectious disease caused by the bacterial pathogen *Vibrio cholerae*.

V. cholerae releases a toxin called choleragen. Choleragen is a protein molecule made up of six polypeptides (subunits).

(b) Fig. 3.1 is a ribbon diagram of a molecule of choleragen.

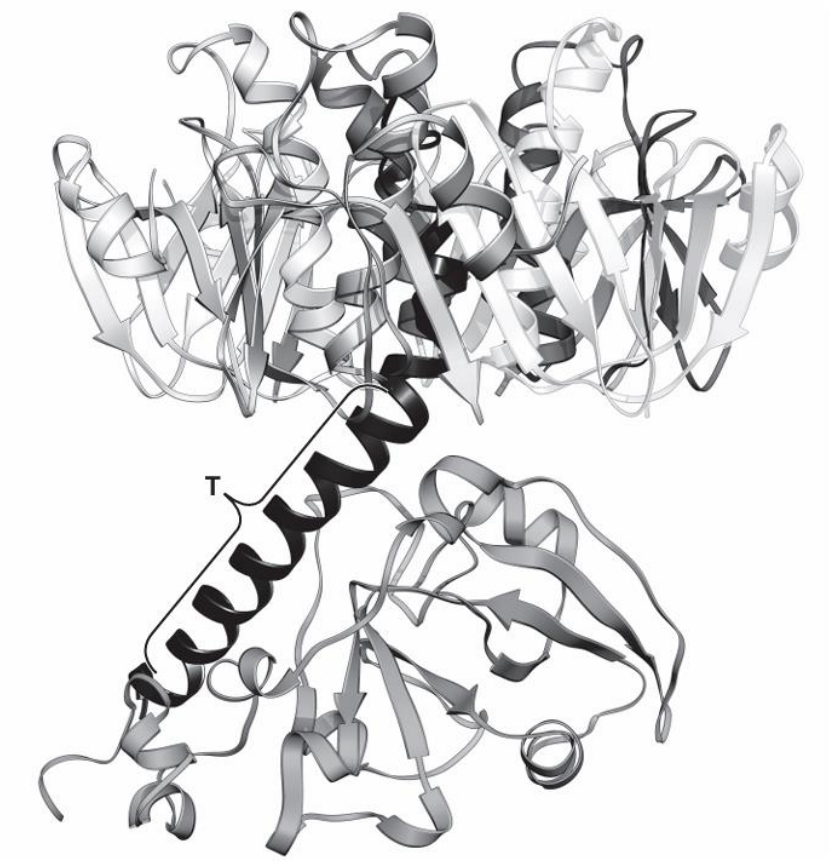


Fig. 3.1

Describe what is shown by the part of the molecule labelled **T**.

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..... [3]

11 Collagen is a major component of the cartilage found in some of the structures of the human gas exchange system. Cells that synthesise and secrete the components of cartilage are known as chondrocytes.

(c) Fig. 4.2 shows part of the primary structure of a collagen polypeptide.

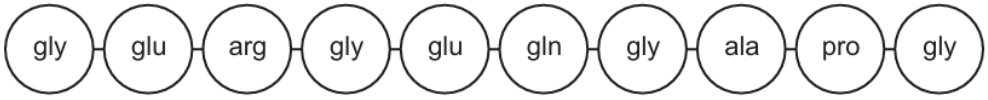


Fig. 4.2

(i) Name the type of covalent bond formed between the amino acids shown in Fig. 4.2.

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(ii) Fig. 4.3 shows the molecular structure of the amino acid glycine (gly).

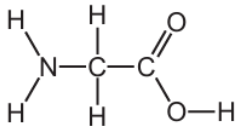


Fig. 4.3

With reference to Fig. 4.2 and Fig. 4.3 and the function of collagen, explain how the structure of a collagen polypeptide makes it suitable to form a collagen molecule.

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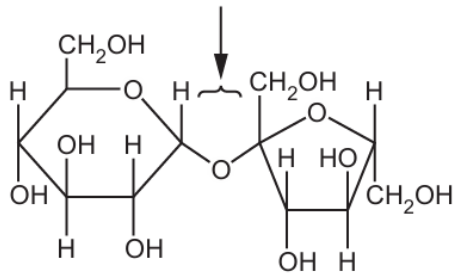
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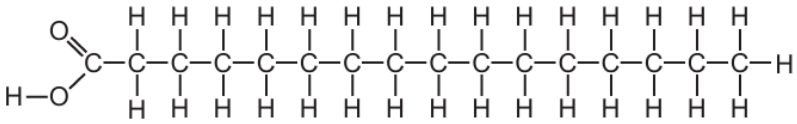
..... [3]

12 Fig. 1.1 shows five biological molecules.

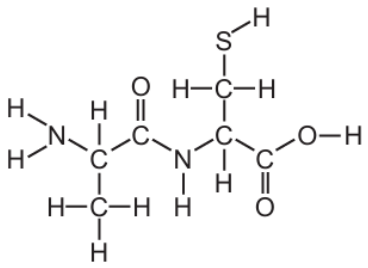
A



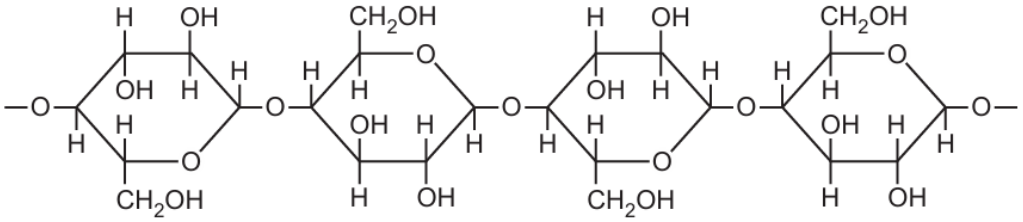
B



C



D



E

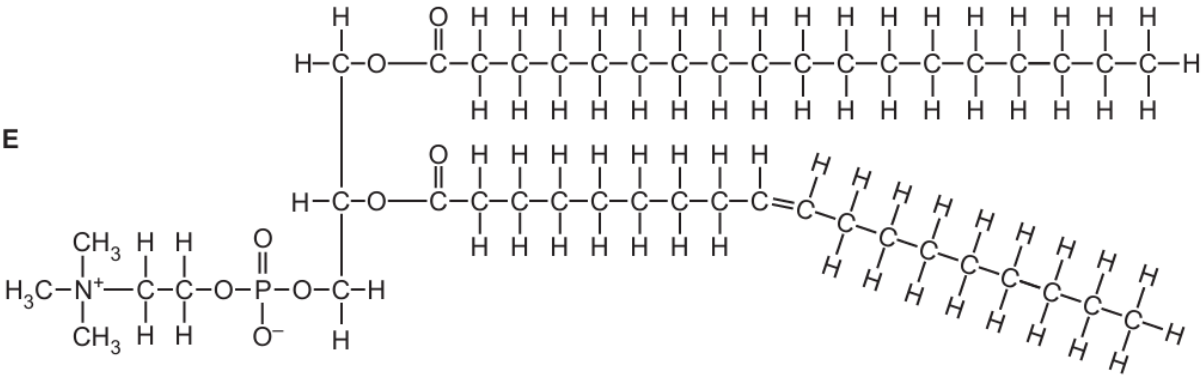


Fig. 1.1

(d) State the letter of the molecule that could be formed during the hydrolysis of a polypeptide.

..... [1]

13 The enzyme glucose 6-phosphate dehydrogenase (G6PD) is composed of two identical polypeptide chains.

(b) In certain conditions, G6PD may also exist as four identical polypeptide chains rather than two identical polypeptide chains.

Explain why both of these types of G6PD have all four levels of protein structure.

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..... [2]

14 **(b)** Fig. 5.2 is a photograph of two African elephants, *Loxodonta africana*.



Fig. 5.2

(iii) The feet of elephants are protected by structures under the skin known as cushions. The cushions are made up of a large number of cells surrounded by connective tissue containing many fibres of collagen. The fibres help to maintain the structure of the cushion.

The collagen fibres are made of collagen molecules.

Describe the structure of a **collagen molecule**.

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..... [4]

(iv) The cushion in the foot is very strong and is able to resist extremely large forces acting on it due to the large mass of the elephant.

Suggest how the structure of a **collagen fibre** can help the cushion resist these large forces.

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..... [1]

15 Fig. 1.1 shows the structure of the amino acid glycine.

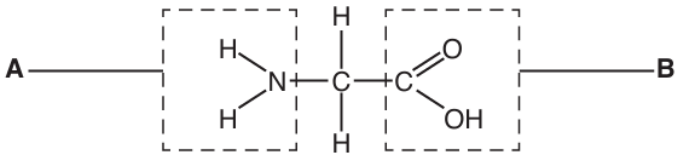


Fig. 1.1

(a) (i) Name the parts of the amino acid molecule labelled **A** and **B** in Fig. 1.1.

A .....

B .....

[2]

(ii) Amino acids are monomers used to build proteins.

Complete Fig. 1.2 by drawing a diagram to show the formation of a peptide bond between two molecules of glycine.



Fig. 1.2 [3]

16 **(a)** Antibody molecules are proteins that show primary structure, secondary structure, tertiary structure and quaternary structure.

Fig. 1.1 shows a ribbon diagram of an antibody molecule.

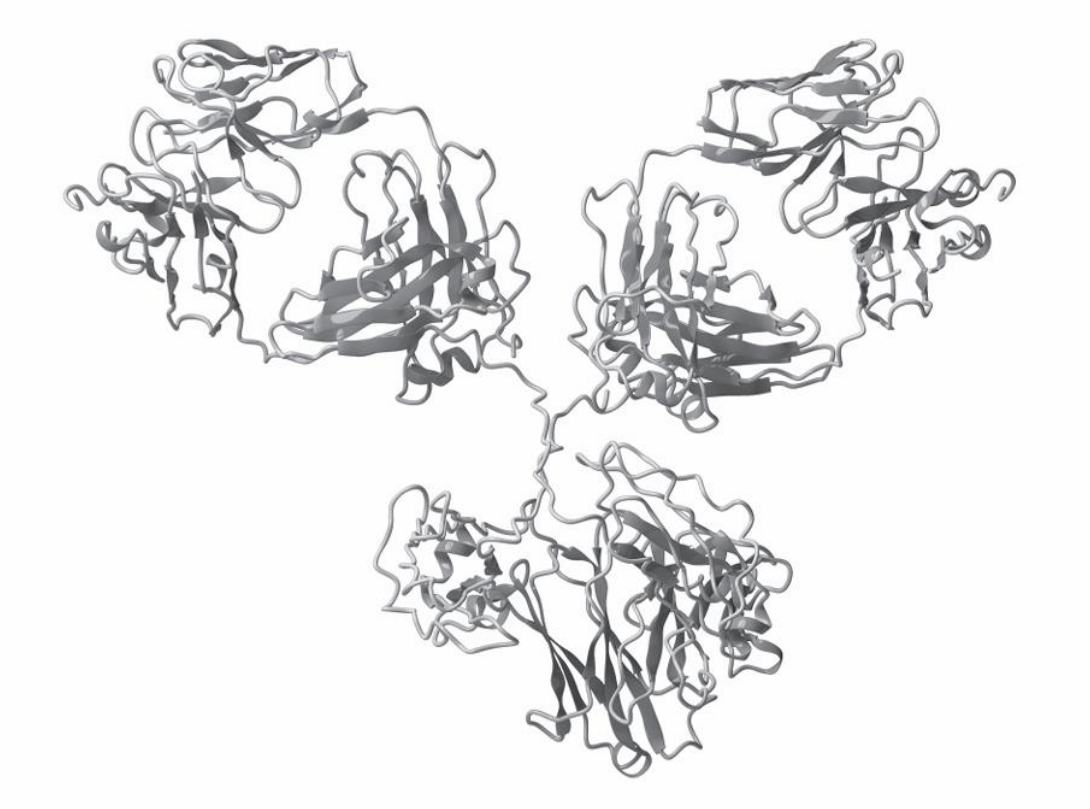


Fig. 1.1

Describe how Fig. 1.1 shows the secondary structure **and** tertiary structure of the antibody molecule.

secondary structure .....

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tertiary structure .....

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[3]

17 In 1953, James Watson and Francis Crick published details about the structure of DNA. They used experimental results from other scientists to help them work out the structure and then built a model of a section of a DNA molecule, using pieces of wire and metal, with clamp stands to hold the model in place. This is shown in Fig. 2.1.

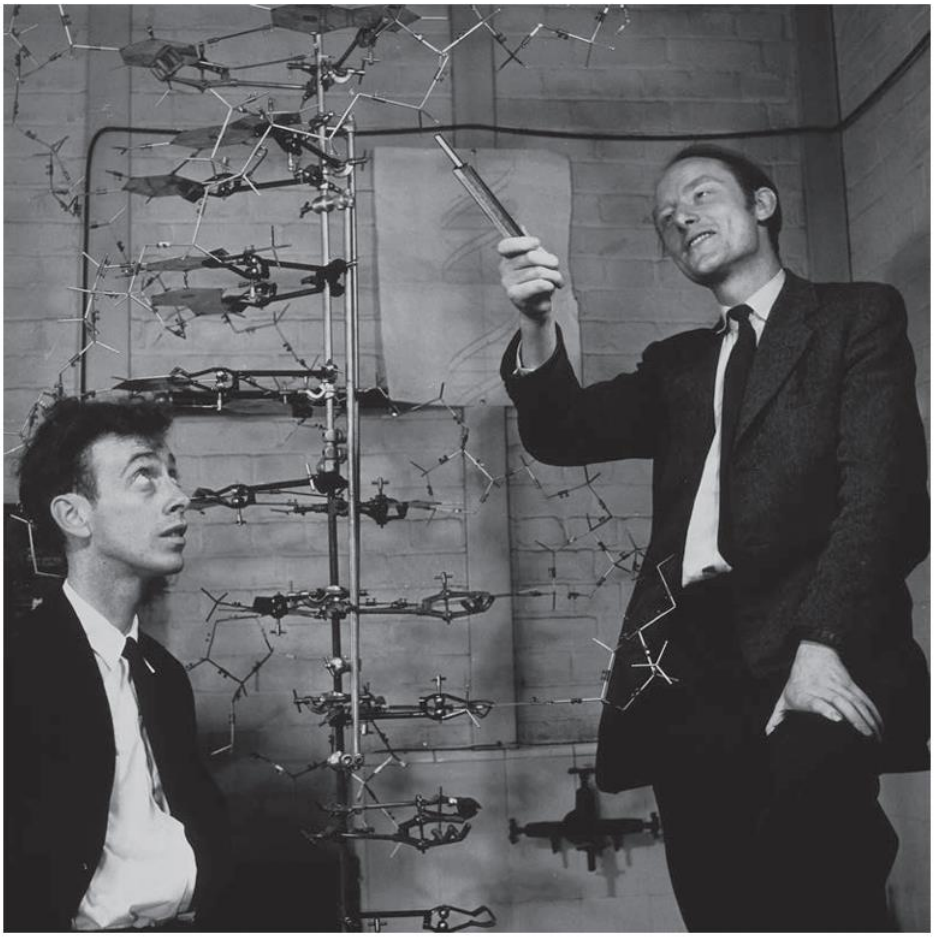


Fig. 2.1

(c) Before the discovery of the structure of DNA as the molecule of inheritance, scientists thought that proteins were most likely to be the molecules that carried information.

Suggest how the structure of proteins made scientists think that these were the molecules that carried information.

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.....[2]

18 Fig. 4.1 is a ribbon model of a molecule of haemoglobin.

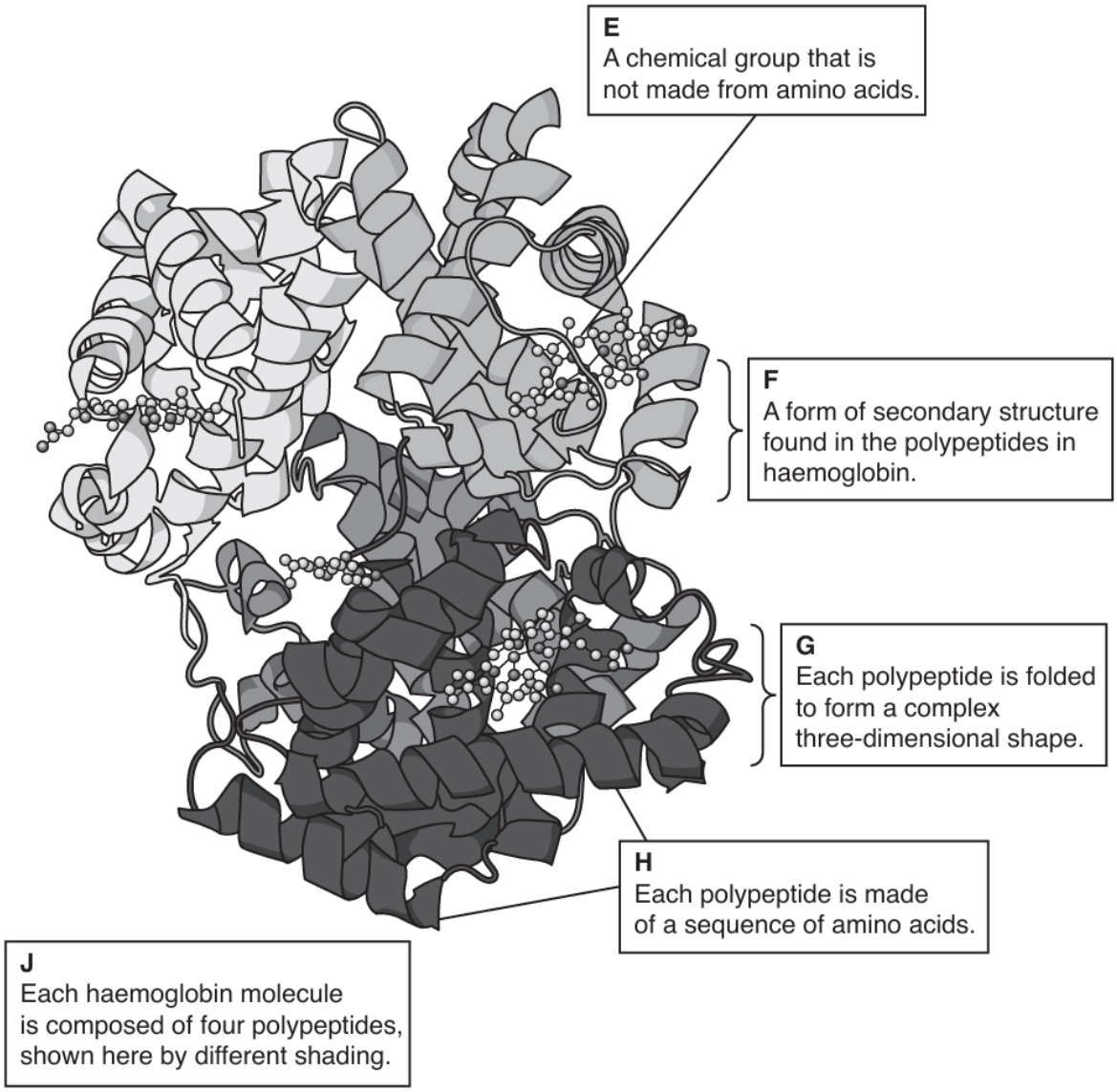


Fig. 4.1

(a) State the term that matches each of the descriptions given in boxes **E**, **F**, **G**, **H** and **J** in Fig. 4.1.

E .....

F .....

G .....

H .....

J .....

[5]

19 **(a)** Haemoglobin is a globular protein which is able to transport oxygen and is soluble in water.

(i) Explain how the structure of a haemoglobin molecule makes it able to transport oxygen efficiently.

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..... [3]

(ii) Explain how the structure of a haemoglobin molecule allows it to be soluble in water.

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..... [2]