Biological Molecules

Model Answers 3

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Foundations in Biology
Topic	Biological Molecules
Booklet	Model Answers 3

Time allowed: **74 minutes**

Score: **/55**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

Question 1

A number of different biological molecules are represented in Fig. 3.1.

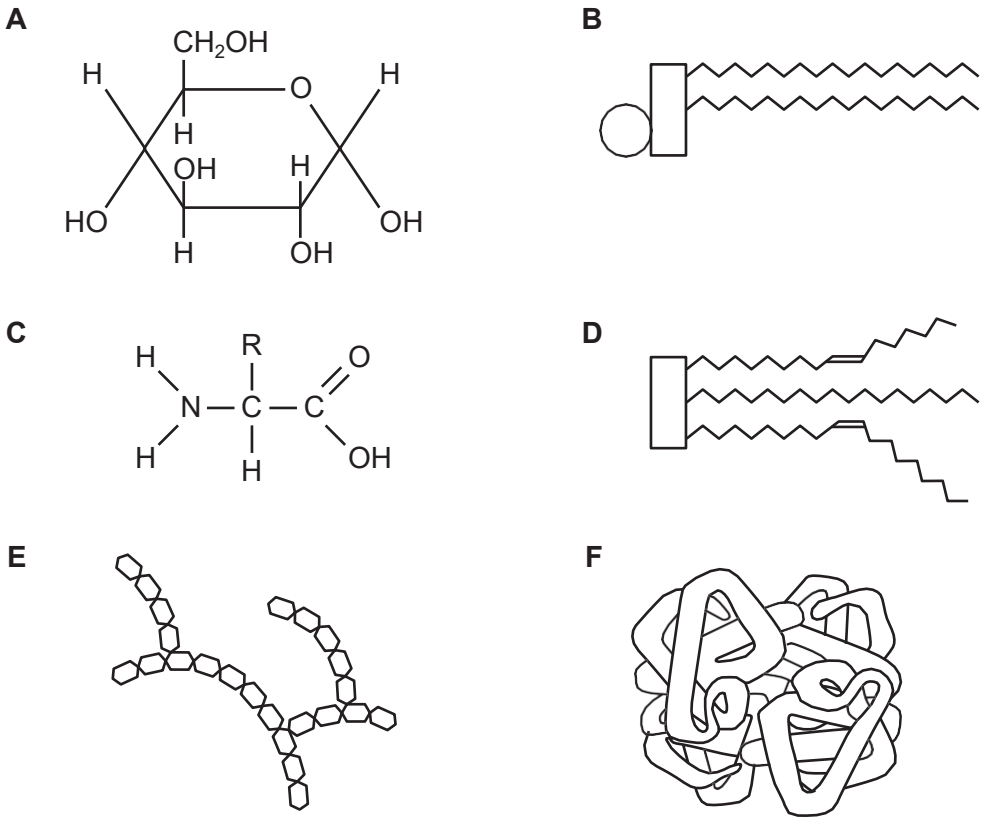


Fig. 3.1

(a) (i) State the letter of the molecule shown in Fig. 3.1 that represents:

a triglyceride ..... D .....

a monosaccharide ..... A .....

a protein ..... F .....

[3]

(ii) State the letter of the molecule shown in Fig. 3.1 that contains:

phosphate ..... B ..... phospholipid

glycosidic bonds ..... E ..... between monosaccharides

peptide bonds ..... F ..... join amino acids together in proteins

disulfide bonds ..... F ..... strong covalent bonds involved with the tertiary structure of proteins

[4]

(b) Molecule **E** shown in Fig. 3.1 is part of the carbohydrate molecule glycogen.

Explain why glycogen makes a good storage molecule. **[3]**

- Glycogen makes a good storage molecule because it is insoluble
- Because it does not dissolve, it does not change the water potential of a cell
- Glycogen can be hydrolysed quickly and easily
- It has lots of branches for enzymes to attach to
- Its shape makes it very compact
- As a result it has a high energy content for such a small mass

Glycogen is stored in the liver and muscle of animals. It is a polysaccharide consisting of alpha glucose molecules connected by 1,4 glycosidic bonds and 1, 6 glycosidic bonds, these make it branched. It is very similar to amylopectin in starch, but glycogen is much more highly branched and more compact.

(c) **(i)** When glycogen is hydrolysed, molecule **A** shown in Fig. 3.1 is produced.

State the **precise name** of molecule **A** ..... **alpha** glucose ..... **[1]**

(ii) State **one** function of molecule **A.** **[1]**

- Alpha glucose is used for energy in respiration or a respiratory substrate

(iii) State the letter of a molecule shown in Fig. 3.1, other than molecule **E**, that is used as a storage molecule. **[1]**

- D is a triglyceride which also used to store energy

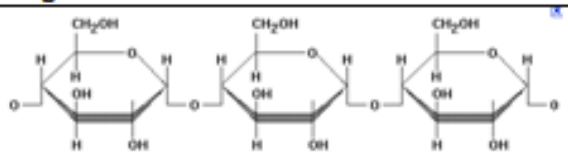
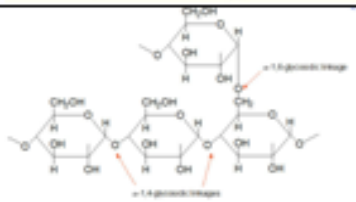
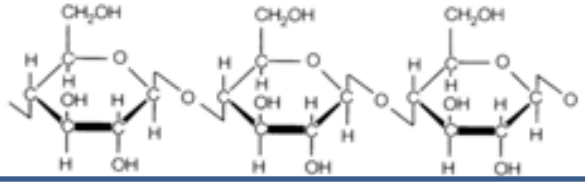
(d) Cellulose is a carbohydrate molecule found in plants.

Complete the table below to give three **differences** in the **structures** of glycogen and cellulose.

One difference has been done for you.

[3]

glycogen	cellulose
no hydrogen bonding	**hydrogen bonding**
α / alpha, glucose	β / beta, glucose
1,4 and 1,6 – glycosidic bonds or 1,6-glycosidic bonds present	1,4-glycosidic bonds (only) or 1,6-glycosidic bonds not present
branched	not branched / linear / straight
No fibres / fibrils	fibres/fibrils
granules	no granules
All glucose units in same orientation	Adjacent glucose units in opposite direction

Polysacc	Monosac	Bonds	Diagram
Starch: Amylose	α - glucose	1-4	
Starch: Amylopectin	α - glucose	1-4 and 1-6	
Glycogen (**NOT starch**!)	α - glucose	1-4 and 1-6 (more 1-6 than amylo-pectin)	
Cellulose	β - glucose	1-4	

[Total: 16]

Question 2

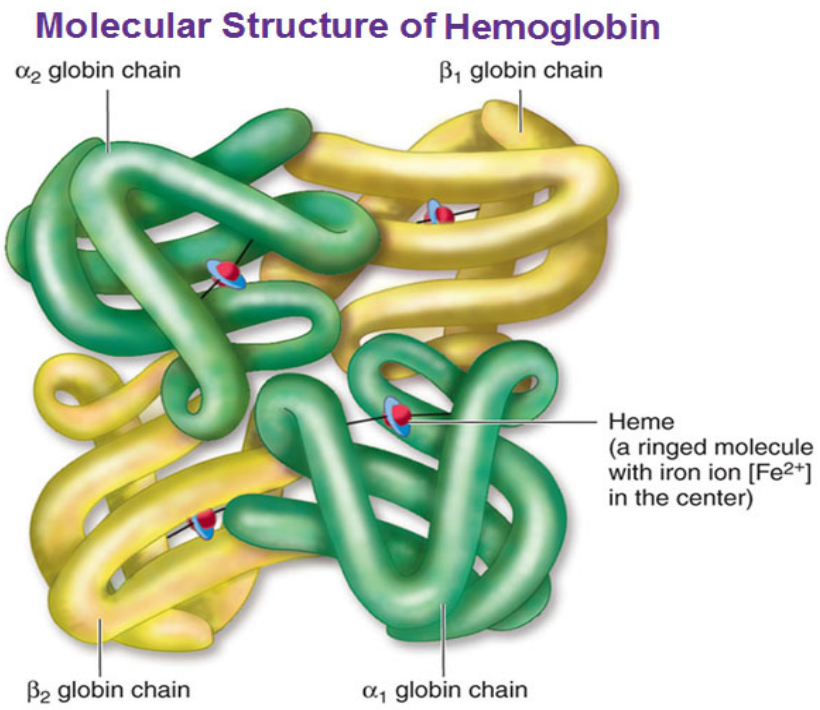
(a) Haemoglobin is a globular protein.

Describe the structure of a haemoglobin molecule.

In your answer, you should include details of the secondary, tertiary and quaternary structure of the molecule. **[7]**

- Haemoglobin is a globular protein and consists of a chain of amino acids
- The amino acids are joined together by peptide bonds
- The secondary structure involves the sequence of amino acids folding into an alpha helix
- The alpha helix is held together by hydrogen bonds
- The polypeptide chain then undergoes **further** folding into the tertiary structure
- Hydrogen bonds, disulphide bridges and ionic bonds help to determine the tertiary structure
- Hydrophilic R groups are arranged on the outside of the molecule which helps it to attract water
- There are four polypeptide chains involved in the quaternary structure of haemoglobin
- The four sub units are made of two alpha chains and two beta chains
- A haem group is found in each polypeptide chain
- This contains a porphyrin ring and an Fe^{2+}

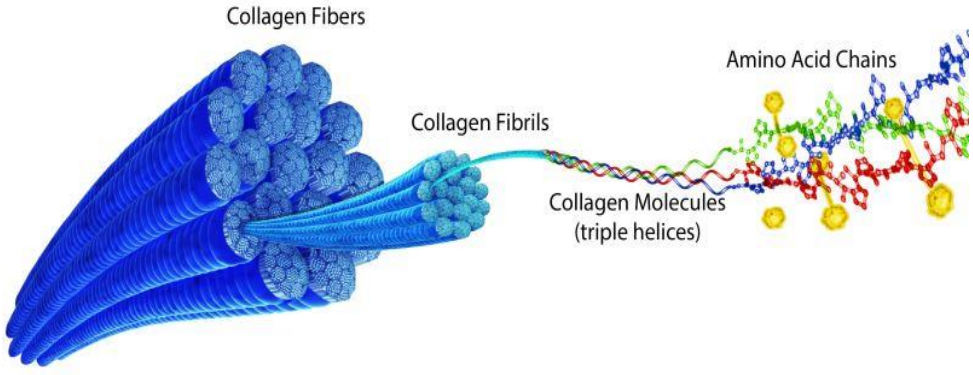
The section of the question in italics refers to the secondary, tertiary and quaternary structure of the molecule. Note that you are told that haemoglobin is a globular protein, this should help you to direct your answer. Proteins are made on the ribosomes then they are folded into the secondary and tertiary structure inside the rough endoplasmic reticulum. Globular proteins are highly folded, the polar R groups on the outside attract water molecules which helps this large molecule to dissolve.



(b) Describe the ways in which the structure of collagen is **similar** to the structure of haemoglobin.

[4]

- Collagen is similar to haemoglobin in that it consists of a chain of amino acids
- The amino acids are held together by peptide bonds
- The collagen molecule is arranged in a helix
- Collagen also has ionic, hydrogen and disulphide bonds
- Collagen has more than one polypeptide chain, in fact it has three



[Total: 11]

Question 3

Fig. 2.1 represents a water molecule.

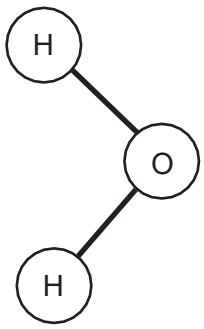


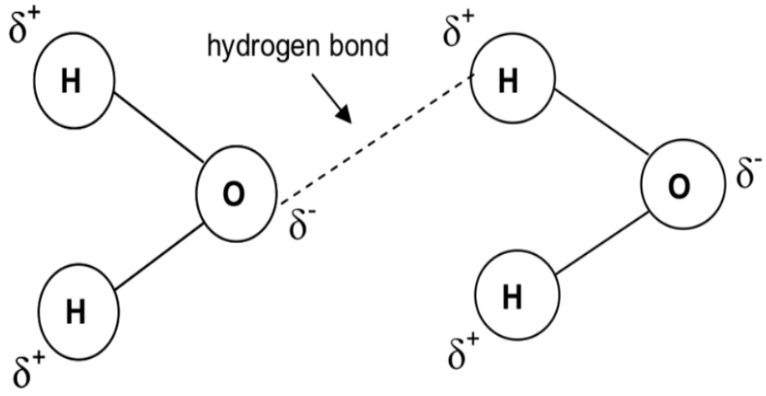
Fig. 2.1

(a) Water molecules are polar. As a result, they attract each other.

Draw a second water molecule on Fig. 2.1.

Your drawing should show:

- the bond(s) between the two molecules
- the name of the bond
- the charges on each atom. **[3]**



To get the marks here you need to:

- Ensure the hydrogen bond line is drawn as a dashed line between an O on one molecule and H on the other
- You have clearly labelled the hydrogen bond line
- You have drawn the delta positive on all H and delta negative on each O
- Ensure you have only drawn one bond between the two molecules

(b) Ponds provide a very stable environment for aquatic organisms.

Three properties of water that contribute to this stability are as follows:

- the density of water decreases as the temperature falls below 4 °C so ice floats on the top of the pond
- it acts as a solvent for ions such as nitrates (NO_3^-)
- a large quantity of energy is required to raise the temperature of water by 1 °C.

Explain how these three properties help organisms survive in the pond.

In your answer you should make clear the links between the behaviour of the water molecules and the survival of the organisms. **[8]**

Ice floats because of the following *properties*:

- Molecules spread out and form a crystal/lattice structure
- Ice forms an insulating layer so that below the water does not freeze

This is linked to organism survival because:

- So that organisms do not freeze
- Animals can still swim/ move
- Currents/nutrients can still circulate

Water makes an excellent solvent because:

- Ions are charged/polar and interact/bind to/are attracted to water molecules

This is linked to organism survival because:

- Organisms can uptake minerals dissolved in the water
- For example, phosphates for ATP or nitrates for amino acids

(not limited to these examples)

Water can be temperature-stable because:

- There are many hydrogen bonds between molecules and it takes a lot of energy to break these bonds
- This means that water has a high specific heat capacity
- This is linked to organism survival because:
- There is only a small variation/little change in temperature
- This is ideal because temperature affects the metabolic rate/enzymes of organisms

***Exam tip**: To gain marks in this question you need to state the properties AND how each is linked to survival*

(c) Water is important in many biological reactions.

Complete Table 2.1 by writing an appropriate term next to each description.

Table 2.1

description	term
the type of reaction that occurs when water is added to break a bond in a molecule	**Hydrolysis** (hydro = water, lysis = to split)
the phosphate group of a phospholipid that readily attracts water molecules	**Hydrophilic** (hydro = water, philic = loving)

[2]

[Total: 13]

Question 4

(a) Amino acids are the basic building blocks for proteins. Fig. 4.1 shows the amino acid cysteine.

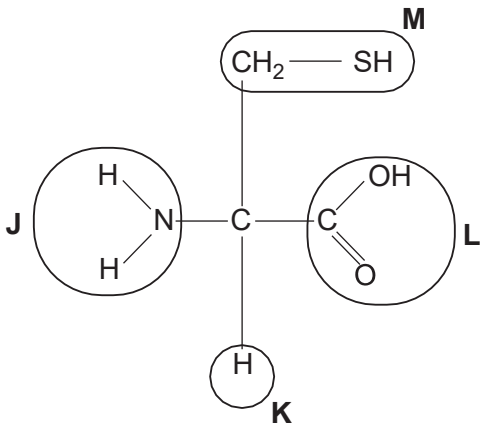


Fig. 4.1

(i) Complete the table by selecting the letter, **J**, **K**, **L** or **M**, that represents the following groups in cysteine.

group	letter
carboxyl	L
R group	M
amine group	J

[3]

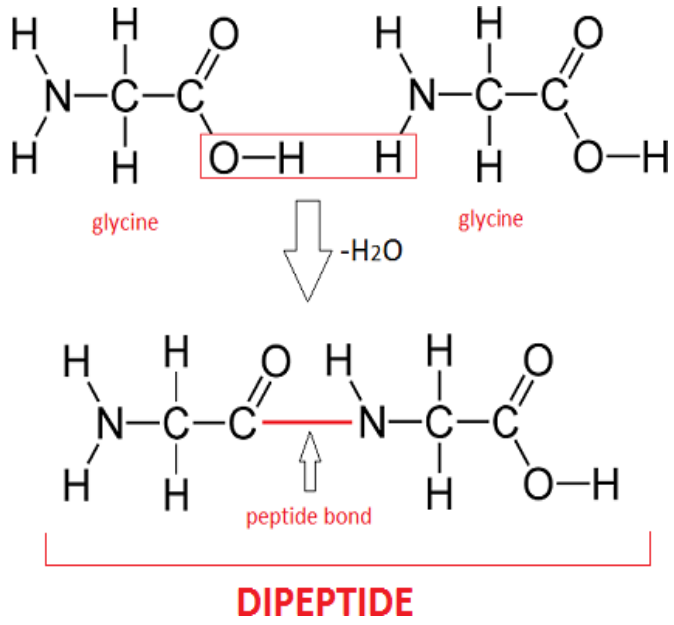
- L (Carboxyl group is a carbon double bonded to an oxygen and an alcohol group)
- M (The R group is variable between amino acids but is always opposite the single hydrogen bonded to the central carbon)
- J (Amine group is a nitrogen bonded to two hydrogens)

(ii) The primary structure of a protein consists of a chain of amino acids.

Describe how a second amino acid would bond to cysteine in forming the primary structure of a protein. **[3]**

- A **peptide** bond would form
- between **carboxyl** group of one amino acid and **amine** group of the other (L to J)
- The H from the amine group combines with the OH from the carboxyl group
- in a **condensation** reaction (creating water, which is lost)
- Resulting peptide bond is **covalent**

Diagrams to show a condensation reaction between two amino acids to form a dipeptide:



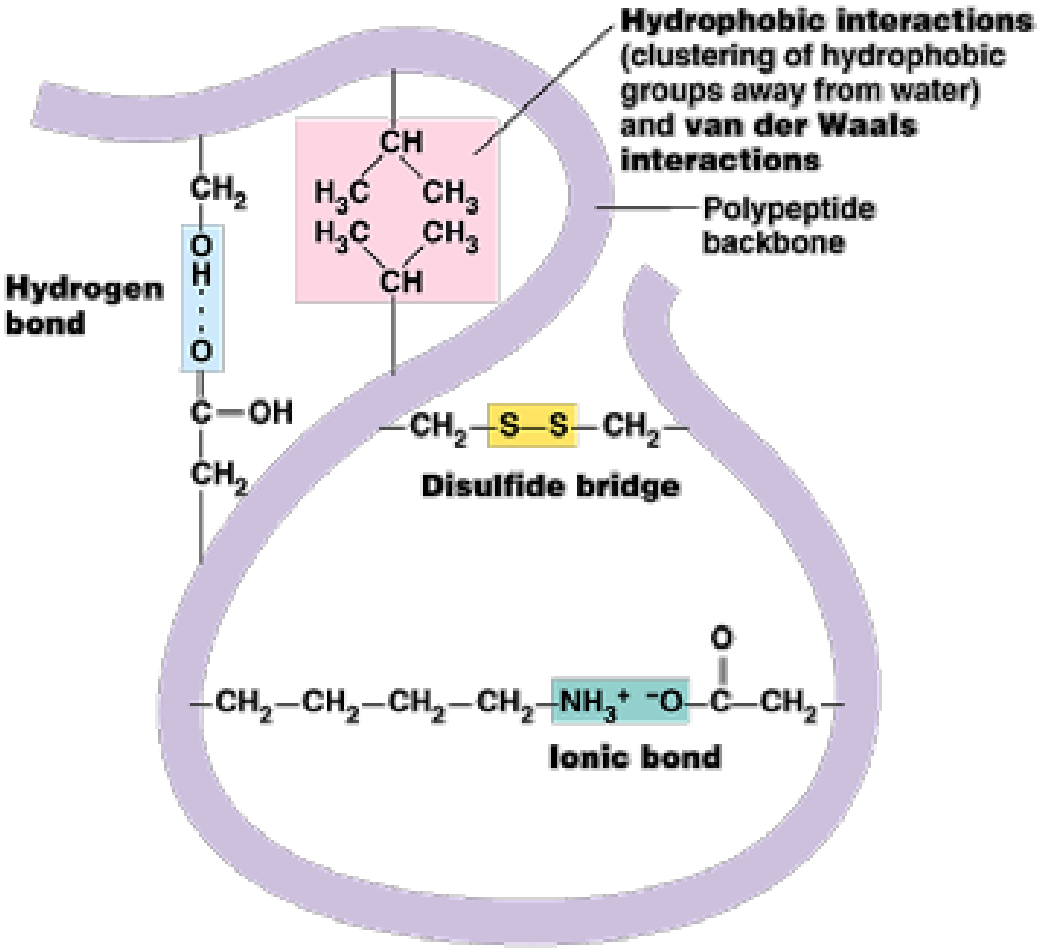
(b) Each amino acid has a different R group.

Describe how these R groups can interact to determine the **tertiary** structure of a protein. **[4]**

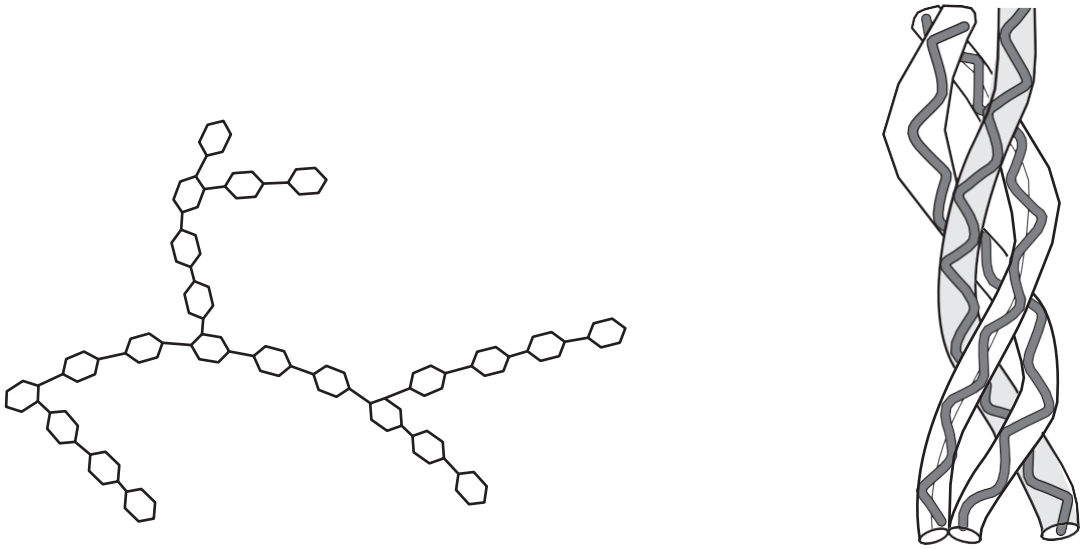
- Some **R groups** attract each other
- **Disulfide bridges** may form between S atoms in R groups
- **Hydrogen bonds** can also form between R groups
- **Ionic bonds** can form if the R groups are oppositely charged

- **Hydrophilic** (‘water-loving’) R groups are found on the outside of the molecule, in contact with water
- whereas **hydrophobic** (‘water-hating’) R groups are on the inside, shielded from water

Diagram to show the bonds present in the tertiary structure of a polypeptide:



(c) Fig. 4.2 shows the structure of two polymers, glycogen and collagen, that are found in mammals.



glycogen collagen

Fig. 4.2

(i) Complete the table below to give three **differences** between the **structure** of glycogen and collagen.

[3]

Glycogen	Collagen
• Carbohydrate Glycogen is a carbohydrate used to store energy, equivalent to starch in plants	• Protein Collagen is a fibrous protein
• Alpha glucose units The monomer of carbohydrates is glucose, in this case alpha glucose	• Amino acid units The monomer of all proteins is an amino acid
• Glycosidic bonds Glucose monomers are joined by glycosidic bonds	• Peptide bonds Amino acids are joined by peptide bonds in condensation reactions between the amino group of one amino acid and the carboxyl group of another
• Branched 1-4 and 1-6 glycosidic bonds	• Unbranched Amino acids can only join by the amino-carboxyl groups, so cannot branch
• One chain per molecule, with no cross links	• Three chains per molecule, with cross links between chains
• Contains C, H and O	• Contains C, H, O and N

(ii) Collagen is found in the ligaments which hold bones together at joints.

State **two** properties of collagen that make it suitable for this purpose. **[2]**

- Strong
- Flexible
- Insoluble
- Is not elastic

[Total: 15]