A-LEVEL BIOLOGY • EXERCISE SHEET

2.3 Proteins

Name: _____ Class: _____ Date: _____ **Total: 31 marks**

KEY WORDS amino acid 氨基酸 • collagen 胶原蛋白 • primary 一级 • primary structure 一级结构 • fibrous 纤维状

Objective

Build the skills to answer exam questions on **proteins** — the structure of **amino acids** 氨基酸 and the **peptide bond** 肽键, the four levels of protein structure, and how the structures of **haemoglobin** 血红蛋白 and **collagen** 胶原蛋白 fit their functions.

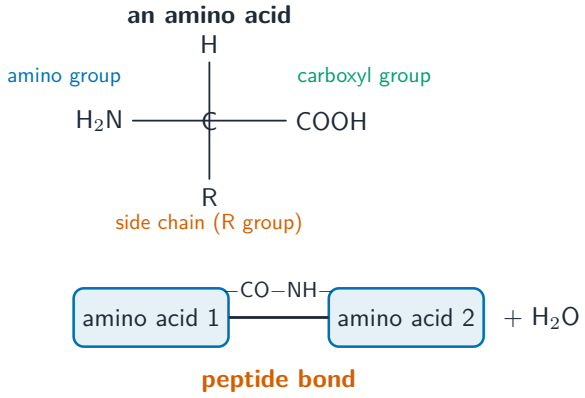
You must be able to:

- draw the general structure of an amino acid and the formation of a peptide bond
- explain primary, secondary, tertiary and quaternary structure and the bonds that hold them
- relate the structure of haemoglobin (globular) and collagen (fibrous) to their functions

1 Worked examples

Amino acids and the peptide bond

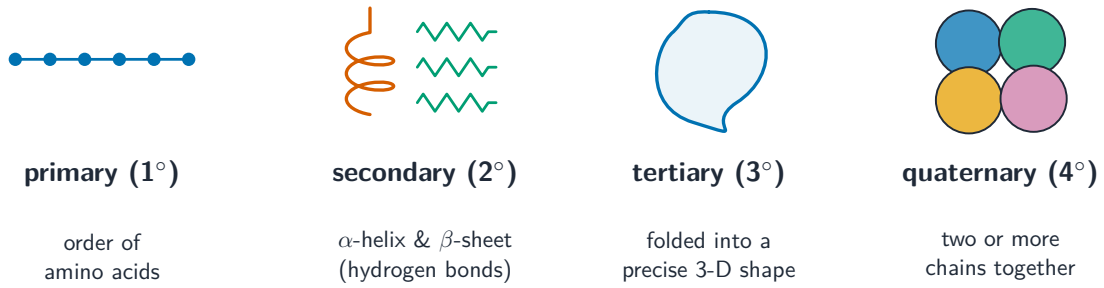
Every amino acid has a central carbon bonded to an **amino group** ($–NH_2$), a **carboxyl group** (–COOH), a hydrogen, and a variable **R group** 侧链. Two amino acids join by **condensation**: a peptide bond forms and **one water molecule is removed**. Many joined this way make a **polypeptide** 多肽.



Two amino acids join by a peptide bond, releasing water

The four levels of structure

level	meaning
primary 一级	the order of amino acids
secondary 二级	local shapes (α-helix, β-pleated sheet) held by hydrogen bonds
tertiary 三级	the whole chain folded into a precise 3-D shape
quaternary 四级	two or more chains joined into one protein



Primary → secondary → tertiary → quaternary structure

The folded shape is held by interactions between R groups: **hydrophobic interactions**, hydrogen bonds, **ionic bonds** 离子键, and strong **disulfide bonds** 二硫键.

Globular vs fibrous

Globular 球状 proteins fold into rounded, usually **soluble** shapes with jobs in the body — e.g. **haemoglobin**, four chains (two α, two β), each with a **haem group** 血红素 holding an iron atom that binds one O_2 (so one molecule carries four O_2). **Fibrous** 纤维状 proteins form long, insoluble strands for support — e.g. **collagen**, three chains wound into a triple helix, cross-linked into strong fibres.

2 Practice

2.1 Name the bond that forms between two amino acids, and state what small molecule is removed. [2]

2.2 State the level of protein structure described by each: [3]

(a) two or more polypeptide chains joined together

(b) the sequence of amino acids

(c) folding into a precise 3-D shape

3 Exam-style questions

3.1 Which bond is **not** involved in holding the tertiary structure of a protein? [1]

A disulfide bond
B glycosidic bond
C hydrogen bond
D ionic bond

3.2 A polypeptide is made from 120 amino acids. How many water molecules were released in forming it? [1]

A 60
B 119
C 120
D 240

3.3 Haemoglobin has a quaternary structure.

(a) Describe what is meant by quaternary structure, using haemoglobin as an example. [3]

(b) Explain the importance of the iron in each haem group. [2]

3.4 Collagen is a fibrous protein.

(a) Describe the structure of a collagen molecule and how collagen molecules form a fibre. [3]

(b) Explain how this structure makes collagen suitable for its function. [2]

3.5 Haemoglobin and collagen are both proteins, but they differ completely in structure and function.

(a) Draw the general structure of an amino acid, and describe how a peptide bond forms between two of them. [4]

(b) Explain what is meant by the primary, secondary, tertiary and quaternary structure of a protein. [4]

(c) Compare haemoglobin and collagen under **three** headings: shape, the level of structure that determines their function, and their solubility in water. [3]

(d) A mutation changes one amino acid in the haemoglobin β chain from glutamate (charged) to valine (non-polar). Explain how a single change can alter the whole molecule's behaviour. [3]