Exercise walk-through

Proteins ▪ 2.3

eXercise

You must be able to

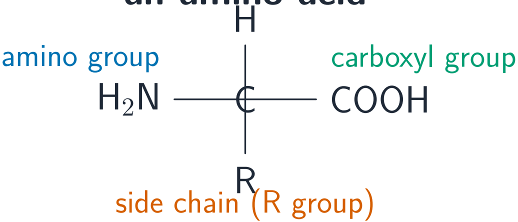
- draw the general structure of an amino acid and the formation of a peptide bond
- explain primary, secondary, tertiary and quaternary structure and the bonds that hold them
- relate the structure of haemoglobin (globular) and collagen (fibrous) to their functions

Method — Amino acids and the peptide bond

Every amino acid has a central carbon bonded to an **amino group** (–NH), 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**.

Method — Amino acids and the peptide bond

an amino acid



—CO—NH—

amino acid 1 — amino acid 2 + H_2O

peptide bond

condensation removes one water for each peptide bond

Method — The four levels of structure

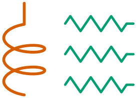
level	meaning
primary 一级	the order of amino acids
secondary 二级	local shapes (α-helix, β-pleated sheet) held by hydrogen bonds
tertiary 三级	the whole chain folded into a precise 3-D shape
quaternary 四级	two or more chains joined into one protein

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**.

Method — The four levels of structure

primary (1°)

order of
amino acids

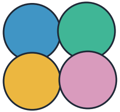


secondary (2°)

α-helix & β-sheet
(hydrogen bonds)

tertiary (3°)

folded into a
precise 3-D shape



quaternary (4°)

two or more
chains together

Method — 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 (so one molecule carries four O). **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.

Practice 2.1 ▪ 2 marks

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

Solution 2.1

Method: Amino acids and the peptide bond

Worked steps

peptide bond **B1**; a water molecule is removed **B1**.

Practice 2.2 ▪ 3 marks

State the level of protein structure described by each:

(a) two or more polypeptide chains joined together

(b) the sequence of amino acids

(c) folding into a precise 3-D shape

Solution 2.2

Method: The four levels of structure

Worked steps

(a) quaternary; (b) primary; (c) tertiary **B1** *each*.

Exam-style 3.1 ▪ 1 mark

Which bond is **not** involved in holding the tertiary structure of a protein?

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

Solution 3.1

Method: The four levels of structure

A disulfide bond

B glycosidic bond ✓

C hydrogen bond

D ionic bond

Worked steps

B. A glycosidic bond joins sugars, not amino acids.

Exam-style 3.2 ▪ 1 mark

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

- **A** 60
- **B** 119
- **C** 120
- **D** 240

Solution 3.2

Method: Amino acids and the peptide bond

A 60

B 119 ✓

C 120

D 240

Worked steps

B. Joining 120 amino acids needs 119 peptide bonds, so 119 water molecules are released.

Exam-style 3.3 ▪ 3 marks

Haemoglobin has a quaternary structure.
(a) Describe what is meant by quaternary structure, using haemoglobin as an example.
(b) Explain the importance of the iron in each haem group.

Solution 3.3

Method: Globular vs fibrous

Worked steps

(a) two or more polypeptide chains joined into one protein **B1**; haemoglobin has four chains — two α and two β **B1** — each with a haem group **B1**.
(b) the iron atom is where one oxygen molecule binds **B1**; four haem groups let one haemoglobin carry four O molecules **B1**.

Exam-style 3.4 ▪ 3 marks

Collagen is a fibrous protein.

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

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

Solution 3.4

Method: Globular vs fibrous

Worked steps

(a) three polypeptide chains wound into a triple helix **B1** held by hydrogen bonds **B1**; many molecules lie side by side, staggered and cross-linked into fibres **B1**.
(b) the triple helix and cross-links make it very strong when pulled **M1**, suiting it to support skin, tendons and bone **A1**.