IB BIOLOGY | B1.2 | SL AND HL

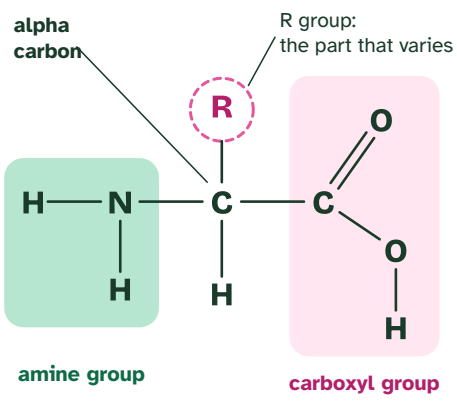
REVISION ON TWO PAGES

Proteins: *endless* chains

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

The sequence of amino acids sets how a protein folds, and its shape sets its job. Lose the shape and the job goes.



Draw it like this. Every atom and bond, the un-ionised form ($-NH_2$ and $-COOH$).

B1.2.1 START HERE

One core: the *amino acid*

- Proteins are polymers; their monomer is the **amino acid**.
- A central **alpha carbon** makes four bonds: to an **amine group** ($-NH_2$), a **carboxyl group** ($-COOH$), **one hydrogen** and an **R group**.
- The **R group is the only part that varies**: twenty R groups, so twenty amino acids. You need not name any at SL.
- **Check your drawing:** four bonds on carbon, three on nitrogen, two on oxygen, one on hydrogen.

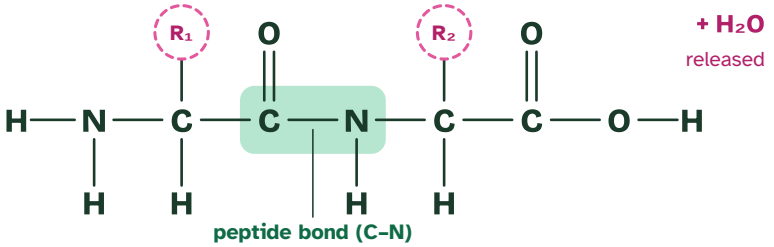
FOUR GROUPS ON THE ALPHA CARBON — *A Cat Has Rhythm*

A Amine $-NH_2$, one side	**C** Carboxyl $-COOH$, other side	**H** Hydrogen one H atom	**R** R group the part that varies

B1.2.2

Condensation makes peptide bonds

- The **OH** of one carboxyl group and an **H** of the next amine group leave as **water**.
- The C–N bond left is a **peptide bond**, a strong covalent bond.
- **Word equation: amino acid + amino acid → dipeptide + water**. Keep adding: a polypeptide.
- A chain of *n* amino acids has ***n* – 1 peptide bonds**; forming it releases *n* – 1 waters.



B1.2.3

Amino acids to *eat*

- All twenty are needed to build your proteins. The body **stores no spare** amino acids.
- Short of one essential amino acid, every protein that needs it **cannot be finished**.
- **Vegan diets need attention: a variety of plant proteins** (rice with lentils) supplies all of them.

Essential nine, for an adult
Cannot be made by the body: must come from food.

Non-essential eleven
Made in the body **from other amino acids**.

B1.2.4

Endless possible chains

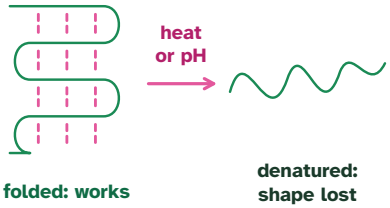
- The genetic code codes for **20 amino acids**. A chain can be **any length**, a few to thousands, in **any order**.
- **Examples:** glucagon 29 amino acids, insulin 51, lysozyme 129, titin about 34,000.
- Twenty amino acids do not mean twenty proteins: **the order is the identity**.

400	**8,000**	**20^n**
dipeptides	tripeptides	*n* long

B1.2.5

Heat and pH *denature*

- A protein works by its precise 3D shape, held by **many weak bonds**.
- **Heat:** atoms vibrate until the weak bonds break. **pH:** H^+ joins or leaves R groups, **changing their charges**.
- The shape and job are lost: **denaturation**, usually permanent. **Peptide bonds stay intact**.



How a chain folds into a *shape*

B1.2.6 HIGHER LEVEL

The *R groups* set the properties

- R groups **decide the properties of the polypeptide**.
- **Hydrophobic:** non-polar. **Hydrophilic:** **polar or charged**.

FOUR KINDS OF R GROUP

Hungry Pandas Ate Bamboo

H Hydrophobic non-polar	**P** Polar δ+, δ–	**A** Acidic $-COO^-$	**B** Basic $-NH_3^+$

B1.2.7 HIGHER LEVEL

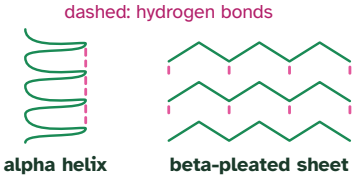
The *sequence* sets the shape

- Primary structure: the **amino acid sequence**.
- The **exact position of each amino acid** sets the shape.
- So proteins are **precise, predictable and repeatable**: one sequence, one shape.
- Change one key amino acid and the shape can change.

B1.2.8 HIGHER LEVEL

Coils and pleats

- **Hydrogen bonds** between backbone **C=O and N–H groups**, in regular positions.
- **Alpha helix:** each C=O bonds to the N–H **four amino acids along**.
- **Beta-pleated sheet:** stretches lie side by side, bonded across.



B1.2.9 HIGHER LEVEL

Four bonds hold the *fold*

- Tertiary structure: the 3D fold of the whole chain, held by **bonds between R groups**.
- Amine and carboxyl R groups **gain or lose H^+** to become charged.

BOND	BETWEEN
Hydrogen	polar R groups
Hydrophobic	non-polar R groups
Ionic	+ to – R groups
Disulfide	**two cysteines** (S–S)

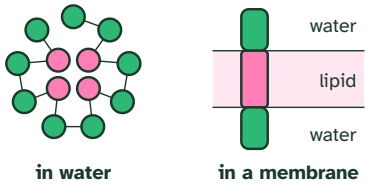
Happy Hippos Ignore Dentists

B1.2.10 HIGHER LEVEL

Oily in, *watery* out

- **Soluble proteins: hydrophobic amino acids cluster in the core**; hydrophilic ones face the water.
- **Integral proteins: hydrophobic regions** sit among the phospholipid tails, in the membrane.

Pink: hydrophobic. **Green:** hydrophilic.



B1.2.11, B1.2.12 HIGHER LEVEL

Three named proteins: *quaternary* structure, form and function

PROTEIN	QUATERNARY STRUCTURE	SHAPE	FORM SUITS FUNCTION
I **Insulin** non-conjugated	**2 chains, 21 and 30.** Joined by disulfide bonds.	**Globular**	Small and soluble, so carried in plasma; its precise shape fits the insulin receptor.
C **Collagen** non-conjugated	**3 chains: a triple helix.** Each about 1,000 amino acids.	**Fibrous**	Insoluble ropes, cross-linked into fibres: **tensile strength** in skin and tendons.
H **Haemoglobin** conjugated	**4 chains, each with haem.** Haem is a **prosthetic group**.	**Globular**	Soluble; each haem binds one O_2, so up to four.

Conjugated: has a non-polypeptide part. **Nature of science:** cryogenic electron microscopy images single protein molecules.

I See Him

WATCH OUT

Six mistakes that *cost marks*

- × **The peptide bond is C–N.** Not between the alpha carbons, not through an oxygen, never an R group.
- × **Denaturing keeps the sequence.** Weak bonds break; peptide bonds hold. Cold does not denature.
- × **Non-essential still matters.** It just need not be eaten.
- × **Secondary structure bonds are in the backbone** (C=O to N–H), not R groups.
- × **A disulfide bond is covalent,** between two cysteines only.
- × **Quaternary means more than one chain, not four.** Conjugated means a non-protein part.

COVER THE SHEET

Can you *answer these?*

1. Draw an amino acid, then a dipeptide made from two.
2. Distinguish essential and non-essential amino acids.
3. Explain why possible polypeptides are endless.
4. Explain how heat or pH denatures a protein.
5. Outline how R groups are classified. HL
6. Explain why proteins have repeatable shapes. HL
7. Describe the bonds that hold an alpha helix. HL
8. State four bonds that hold a tertiary structure. HL
9. Explain how integral proteins embed in membranes. HL
10. Compare insulin, collagen and haemoglobin. HL

IN THE EXAM

Name the weak bonds that break, say **peptide bonds stay**, then link **shape to job**.

GO FURTHER

Animated figures and a game online.