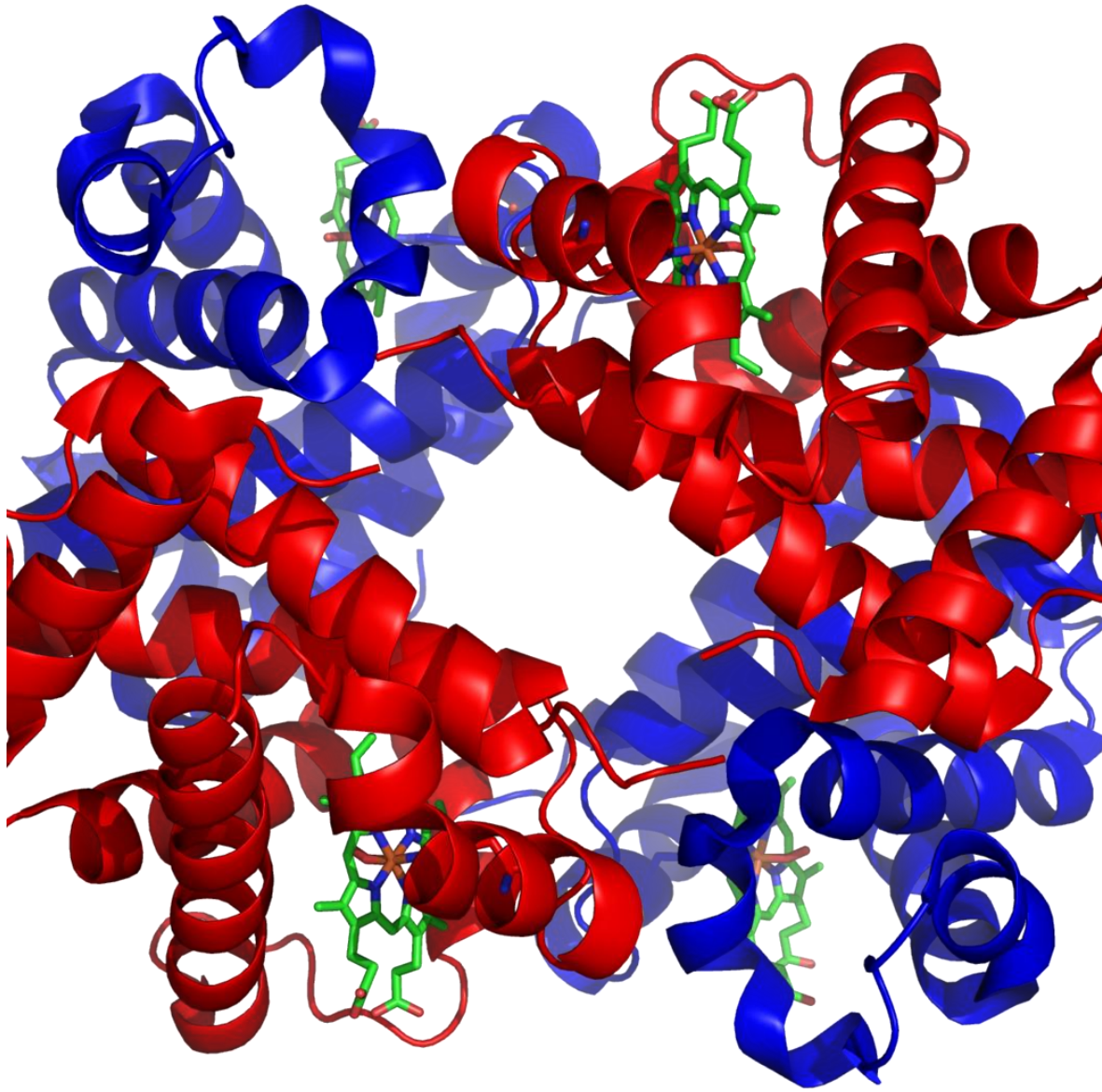
DP Biology – B1.2

Proteins

- How does the order of amino acids produce such a variety of protein forms and functions?
- How do chemical and physical conditions affect protein molecules?



SL statements B1.2.1–5. Textbook pp. 205–210.
Image: model of haemoglobin. Zephyris, CC BY-SA 3.0.

Objectives for each class

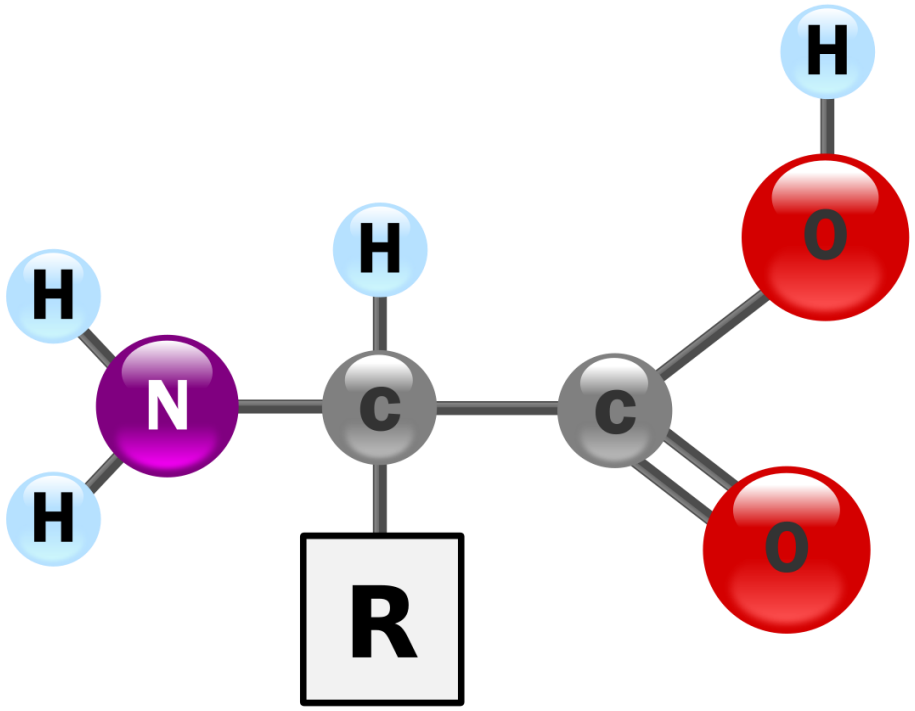
Class	Statements	By the end of the class, you can...
1	B1.2.1–2	Draw an amino acid, and show how condensation forms a dipeptide
2	B1.2.3–4	Explain dietary needs for amino acids, and why the variety of peptide chains is limitless
3	B1.2.5	Explain how pH and temperature can denature a protein

Overview of this chapter

Part	Statements	What it covers
Amino acids	B1.2.1	The general structure
Building chains	B1.2.2	Condensation, peptide bonds and dipeptides
In the diet	B1.2.3	Essential and non-essential amino acids
Variety	B1.2.4	Why so many polypeptides are possible
Stability	B1.2.5	Denaturation by heat and pH

The structure of an amino acid

B1.2.1



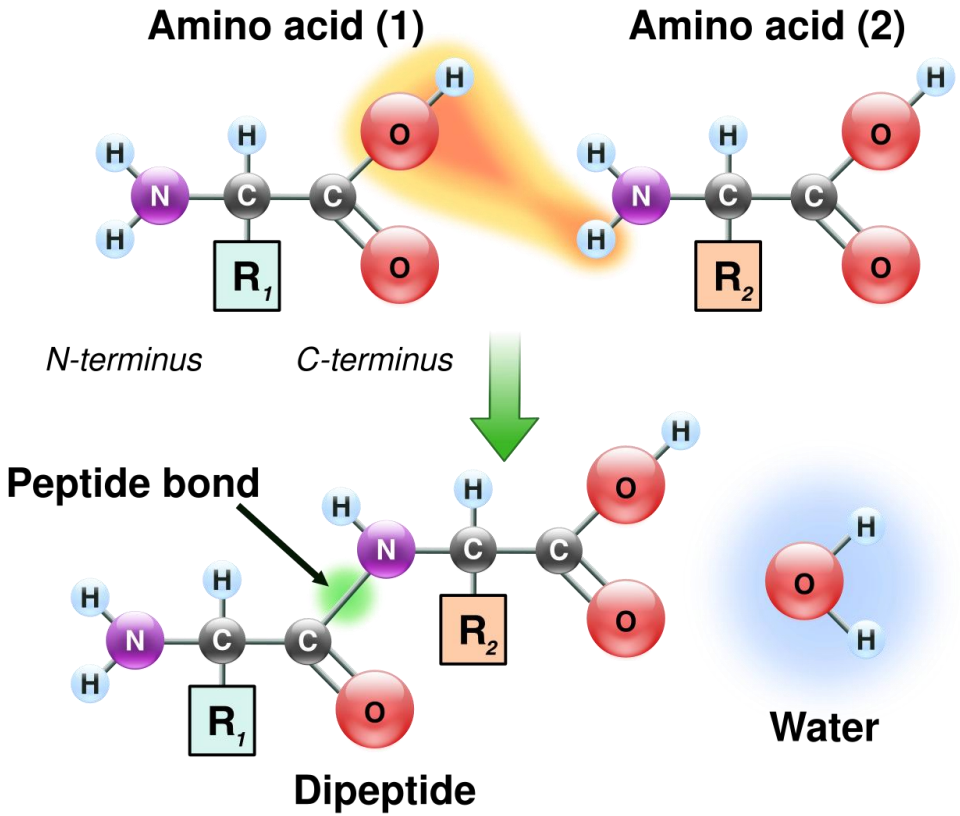
General structure of an amino acid. YassineMrabet, public domain.

Group	Formula or note
Alpha carbon	The central carbon
Amine group	-NH_2
Carboxyl group	-COOH
Hydrogen	-H
R-group	Differs in each amino acid

Exam note

Be ready to draw a generalized amino acid. Four groups are attached to the alpha carbon. You do not need to learn the R-groups of particular amino acids.

Condensation forms a dipeptide



Two amino acids form a dipeptide. YassineMrabet, public domain.

- The -OH of one carboxyl group and an -H of the other amine group form water
- A **peptide bond** links the two amino acids
- The result is a **dipeptide**

Word equation

amino acid + amino acid → dipeptide + water

Activity

Use molecular models to carry out this reaction, then draw the dipeptide. Mark the peptide bond and show where water came from.

From dipeptides to long chains

B1.2.2

Polypeptide	Amino acids	Function
Each chain of insulin	21 and 30	Hormone: controls blood glucose
Each chain of haemoglobin	141 and 146	Transports oxygen
Titin	About 34 000	Gives muscle its elasticity

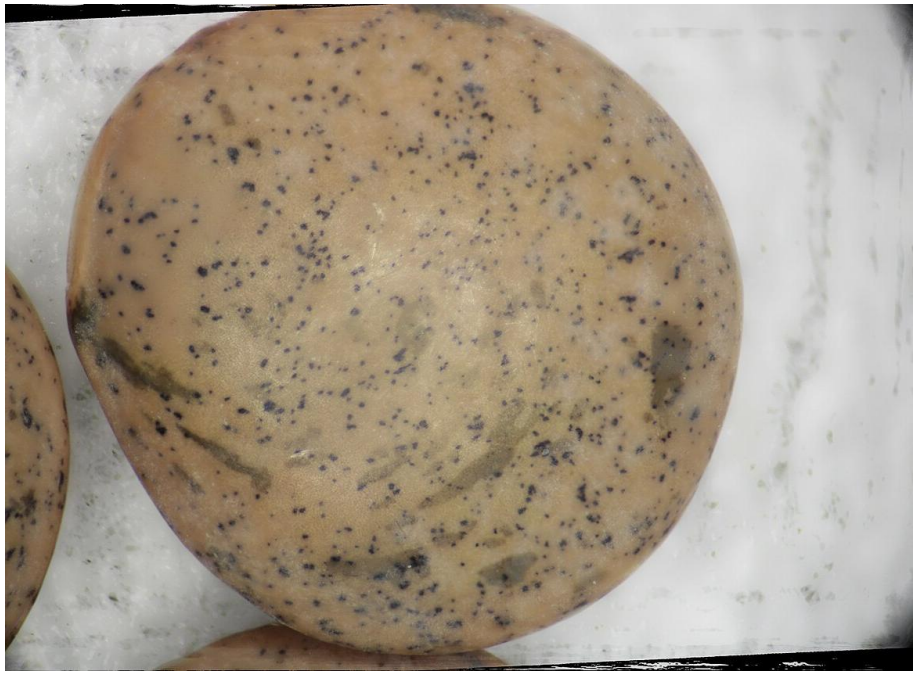
- Repeated condensation reactions add amino acids one at a time
- In cells, this takes place on ribosomes, and it follows the code in mRNA (D1.2)

Common mistake

Polypeptide and protein are not the same. A protein contains one or more polypeptides, folded into a working shape.

Dietary requirements for amino acids

B1.2.3



Lentils: a plant source of protein. Bean appreciator, CC0.

- **Essential** amino acids cannot be made by the body, so they must come from food
- **Non-essential** amino acids can be made from other amino acids
- Meat and dairy often contain all the essential ones
- Vegan diets need attention, and combining plant foods can supply them

Discussion

A vegan needs to think about combining foods such as beans and grains. Why could a shortage of one essential amino acid limit how much protein a person can make, even if plenty of others are available?

The limitless variety of peptide chains

Length of chain	Calculation	Sequences
1	20	20
2	20 × 20	400
3	20 × 20 × 20	8000
4	20 to the power 4	160 000
6	20 to the power 6	64 million

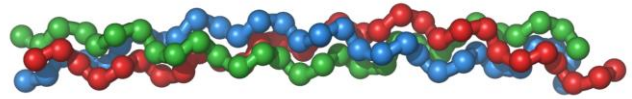
- The genetic code covers **20 amino acids**
- Amino acids can be in **any order**
- Chains can have from a few to thousands of amino acids
- So the possible variety has no real limit

Key idea

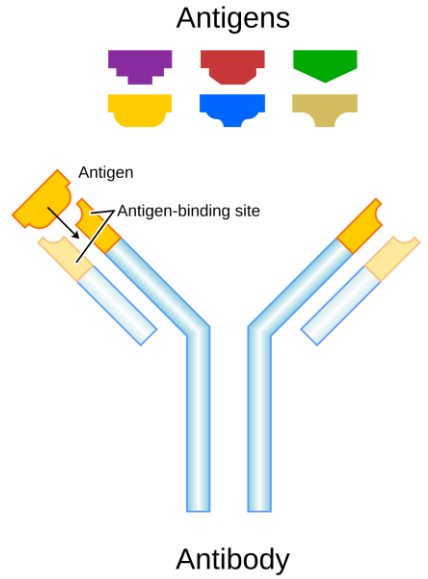
A polypeptide of 400 amino acids could have 20 to the power 400 different sequences. Only a tiny fraction of these has ever been produced by any living organism.

Examples of polypeptides and proteins

Protein	Function
Haemoglobin	Carries oxygen in red blood cells
Immunoglobulin	Antibody that binds to antigens
Rhodopsin	Pigment in the retina, absorbs light
Collagen	Rope-like strength in skin and tendons
Keratin	Structure in hair and nails
Insulin	Hormone that lowers blood glucose
Lipase	Enzyme that digests fats



Collagen. CC BY-SA 3.0.

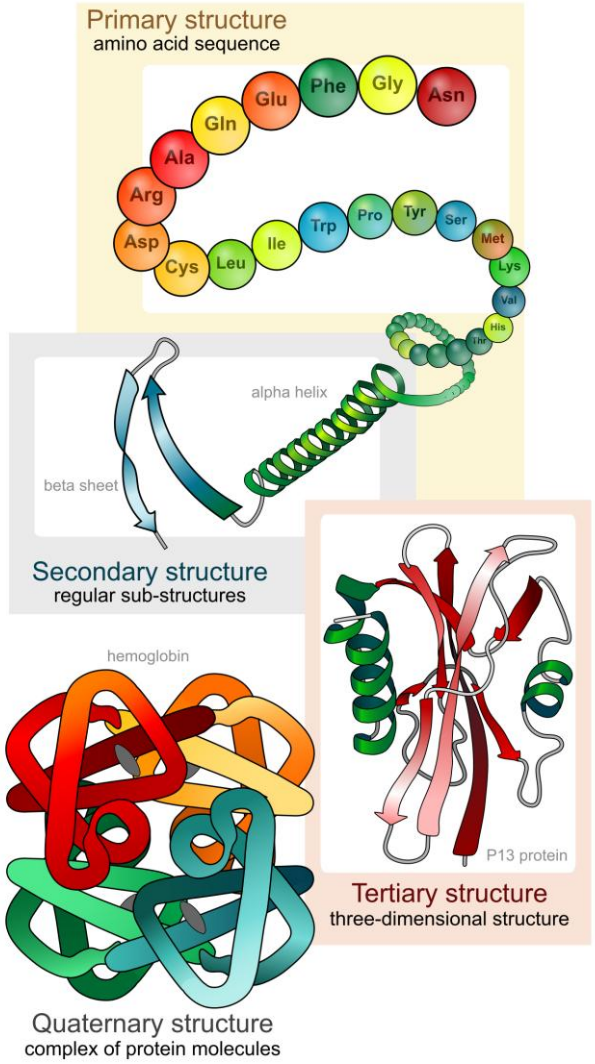


An antibody. Fvasconcellos, public domain.

Each one has a shape that depends on its amino acid sequence, and its function depends on that shape.

Sequence determines shape

B1.2.4



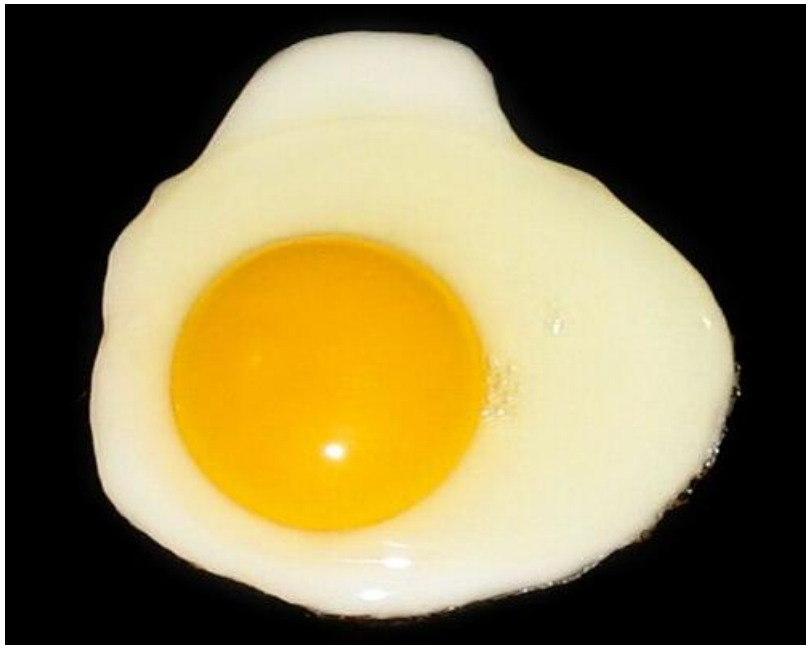
Levels of protein structure. LadyofHats, public domain.

- The sequence of R-groups decides how a chain folds
- R-groups can be charged, polar or non-polar
- Each interacts with others, and with water
- So a particular sequence reliably gives a particular shape

Link

Details of how proteins fold are at HL. For now, remember that sequence determines shape, and shape determines function. This also explains why a mutation can have such an effect (D1.2.11).

Denaturation by heat



Cooked egg: heat has denatured the albumin. David Benbennick, public domain.

- Heat makes molecules vibrate more
- Weak bonds and interactions in the protein break
- The chain unfolds, and the shape changes permanently: **denaturation**
- It can no longer carry out its function

Common mistake

Denaturation does not break the peptide bonds, so the amino acid sequence stays the same. Only the three-dimensional shape is lost. Denaturation is usually irreversible, although some small proteins can refold.

Denaturation by pH

- Some R-groups carry a charge, and attract groups of opposite charge
- A change in pH alters these charges, by adding or removing H^+ ions
- So the attractions break, and the shape changes

Protein	Works best at pH	Why this matters
Pepsin in the stomach	About 2	Strong acid helps digestion there
Salivary amylase	About 7	Denatures in the acid of the stomach

Activity

Plan an experiment using raw egg white to compare the effects of acid, alkali and heat. Which variable will you measure, and how?

Check that you can explain

1. How to draw a generalized amino acid
2. How to draw a dipeptide, with a word equation
3. Essential and non-essential amino acids
4. Why vegans must pay attention to their diet
5. Why peptide chains have limitless variety
6. Examples of proteins and their functions
7. How sequence determines shape
8. How heat and pH cause denaturation

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. Name the four groups attached to the alpha carbon of an amino acid.
2. Calculate the number of possible sequences for a peptide of 3 amino acids.
3. Explain why a boiled egg cannot go back to being raw.

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