DNA structure

4.6.1.5 · Inheritance, variation and evolution · revision notes

DNA is a polymer of nucleotides, and the order of its bases codes for the order of amino acids in a protein. Higher tier students also need complementary base pairing, protein synthesis and how mutations can change a protein. This is in GCSE Biology only, not in Combined Science.

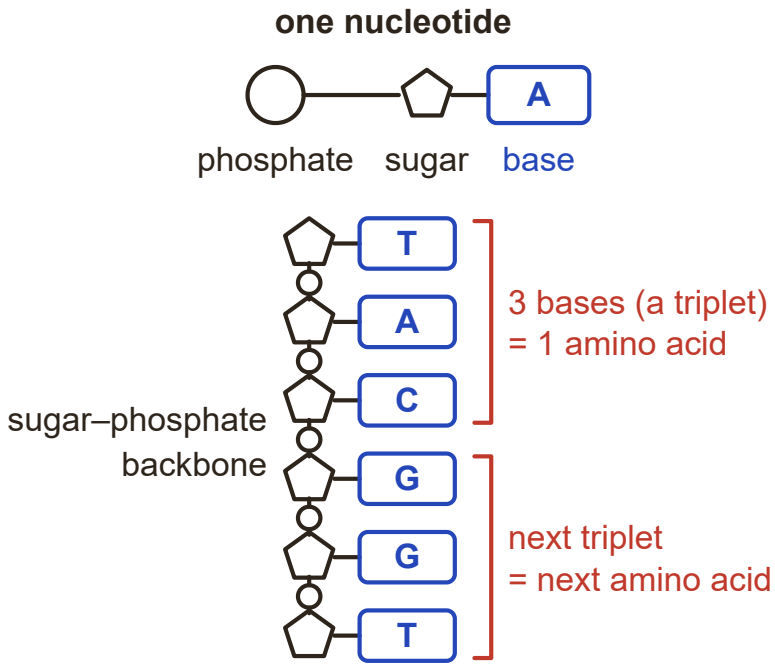
Key facts

- Nucleotide = sugar + phosphate + one base
- DNA strand: alternating sugar and phosphate, with a base on each sugar
- Grade 7+ only Complementary base pairs: A with T, C with G
- Grade 8+ only Mutation → changed amino acid sequence → different shape → protein may not work
- Four bases: A, C, G, T
- 3 bases = the code for 1 amino acid
- Grade 7+ only Protein synthesis: on ribosomes, from a template; carrier molecules bring amino acids in the correct order; chain folds into a unique shape
- Grade 8+ only Non-coding DNA switches genes on and off

Notes

DNA is a polymer of nucleotides

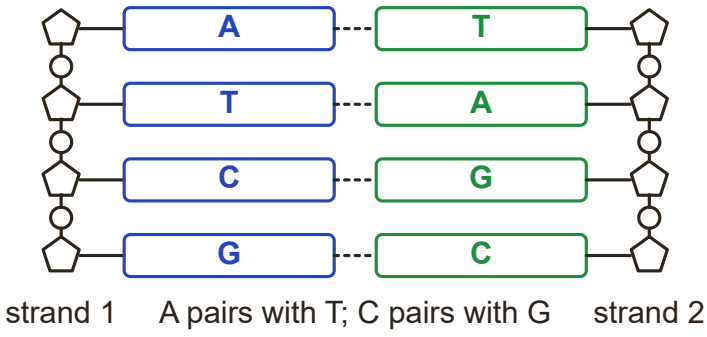
- DNA is a **polymer** made from repeating units called **nucleotides**.
- Each nucleotide is a common **sugar** and a **phosphate** group, with one of **four bases** attached to the sugar.
- The four bases are **A, C, G and T**.
- Each long strand has alternating **sugar and phosphate** sections, with a base attached to each sugar.



DNA is a polymer of nucleotides. Every three bases code for one amino acid.

The genetic code

- A sequence of **three bases** is the code for one particular **amino acid**.
- The order of bases controls the **order in which amino acids are assembled** to make a particular protein.
- The two strands are **complementary**: an A on one strand is always linked to a T on the other, and a C is always linked to a G. Grade 7+ only

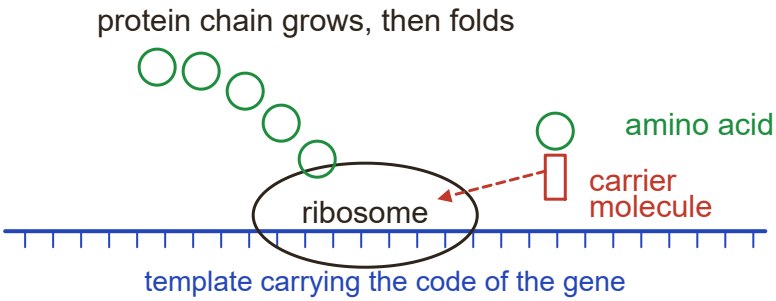


Complementary strands: A–T and C–G.

Grade 7+ only

Protein synthesis Grade 7+ only

- Proteins are made on **ribosomes**, according to a **template** that carries the code of the gene.
- **Carrier molecules** bring specific amino acids to add to the growing protein chain in the correct order.



Protein synthesis on a ribosome.

- When the chain is complete it **folds up** to form a **unique shape**. This shape lets the protein do its job, e.g. as an **enzyme**, a **hormone** or a structural protein such as **collagen**.

Mutations and non-coding DNA Grade 8+ only

- **Mutations** (changes to the DNA base sequence) occur continuously.
- Most mutations do not alter the protein, or only alter it slightly, so its appearance or function is not changed.
- A few mutations code for an **altered protein with a different shape**: an enzyme's active site may no longer fit its substrate, or a structural protein may lose its strength.
- Not all DNA codes for proteins. **Non-coding** parts of DNA can **switch genes on and off**, so variants in them can change **how genes are expressed**.

How to answer each type of question

Describe the structure of DNA 3 to 4 marks **Grade 5**

1. Say DNA is a polymer of repeating nucleotides.
2. Describe a nucleotide: sugar, phosphate and one of four bases (A, C, G, T).
3. Describe the strand: alternating sugar and phosphate, with a base on each sugar.
4. Higher: two strands joined by complementary base pairs, A with T and C with G.

Example. Describe the structure of a DNA molecule. [4 marks]

Model answer. DNA is a polymer made of repeating nucleotides (1). Each nucleotide contains a sugar, a phosphate group and a base (1). There are four different bases: A, C, G and T (1). Each strand has alternating sugar and phosphate sections with a base attached to each sugar / the two strands are joined by complementary base pairs, A with T and C with G (1).

Work out a complementary strand or the number of amino acids

1 to 2 marks | Grade 7

1. Pair each base in turn: A with T, T with A, C with G, G with C.
2. Number of amino acids = number of bases ÷ 3.

Example. One strand of a short section of DNA has the base sequence A T G C C A T T G.
(a) Write the base sequence of the complementary strand.
(b) How many amino acids does this sequence code for? [2 marks]

Model answer.

(a) T A C G G T A A C (1)
(b) 9 ÷ 3 = 3 amino acids (1)

Describe protein synthesis

3 to 4 marks | Grade 7

1. Say where: on ribosomes.
2. The order of amino acids is set by a template carrying the gene's code.
3. Carrier molecules bring specific amino acids and add them to the chain in the correct order.
4. The finished chain folds into a unique shape so it can do its job.

Example. Describe how a protein is made in a cell. [4 marks]

Model answer. Proteins are made on ribosomes (1) according to a template that carries the code of the gene (1). Carrier molecules bring specific amino acids and add them to the growing chain in the correct order (1). When the chain is complete it folds into a unique shape (1).

Explain how a mutation affects a protein

3 to 4 marks | Grade 8

1. A mutation changes the base sequence.
2. This can change the sequence of amino acids (three bases code for each one).
3. The protein folds into a different shape.
4. Apply it: the enzyme's active site no longer fits the substrate, or a structural protein loses its strength.

Example. A mutation changes one base in the gene for an enzyme. The enzyme made from the mutated gene does not work.
Explain why. [4 marks]

Model answer. The mutation changes a sequence of three bases, so a different amino acid is coded for (1). The enzyme has a different sequence of amino acids (1), so it folds into a different shape (1). The active site no longer fits the substrate, so the enzyme cannot catalyse its reaction (1).

Don’t lose marks

- Pairing A with G or C with T. It is always A with T and C with G.

- Saying each base codes for an amino acid. It takes a sequence of three bases.
- Saying a nucleotide contains amino acids. A nucleotide is a sugar, a phosphate and a base.
- Saying every mutation changes a protein. Most have no effect, or only a slight effect.
- Saying a mutated enzyme is 'denatured' or 'killed'. Say that its shape is different, so the active site no longer fits the substrate.

More tips

Memory tricks

- Base pairs: 'Apple Tree' (A with T) and 'Car Garage' (C with G).
- Number of amino acids = number of bases ÷ 3.
- Mutation chain: base → amino acid → shape → function. Each arrow is usually a mark.

Exam technique

- For mutation questions, work through the chain: base sequence → amino acid sequence → shape → function.
- Check a complementary strand letter by letter; one slip loses the mark.
- Write 'a sequence of three bases codes for one amino acid', not 'three bases code for a protein'.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4 — **Name the four bases in DNA**
The four bases are A, C, G and T.

Grade 5 — **Describe the structure of a nucleotide**
A common sugar and a phosphate group, with one of four bases attached to the sugar.

Grade 5 — **Describe DNA as a polymer of nucleotides**
Long strands of alternating sugar and phosphate sections, with a base attached to each sugar.

Grade 5 — **Explain how bases code for amino acids**
A sequence of three bases codes for one amino acid, so the order of bases controls the order of amino acids.

Grade 7 — **Use complementary base pairing**
A always pairs with T, and C always pairs with G, on the opposite strand.

Grade 7 — **Describe protein synthesis simply**
On ribosomes, carrier molecules bring amino acids in the order set by a template; the chain then folds into a unique shape.

Grade 8 — **Explain how a mutation can change a protein**
A changed base sequence can change the amino acid sequence, so the protein has a different shape and may not work.

Grade 9 — **Explain effects of variants in non-coding DNA**
Non-coding DNA switches genes on and off, so variants there can change how genes are expressed.

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