# 25.1 Protein synthesis

Name: _____ Class: _____ Date: _____ **Total: 20 marks**

**KEY WORDS** transcription • translation • codon • anticodon • RNA polymerase RNA • degenerate

## Objective

Build the skills to answer exam questions on **protein synthesis** : transcription, translation, the genetic code, and the roles of mRNA, tRNA and ribosomes.

**You must be able to:**

- describe transcription by RNA polymerase, using the template strand
- describe translation: mRNA codons, tRNA anticodons and ribosomes
- use the genetic code to work out an amino acid sequence, and explain why the code is degenerate and universal
- explain how a change in the base sequence can change a protein

## 1 Key knowledge and worked examples

### ■ Protein synthesis

**Transcription** (in the nucleus): **RNA polymerase** separates the DNA strands and joins RNA nucleotides that pair with the **template strand** (A–U, T–A, C–G, G–C). The **mRNA** has the same sequence as the **coding strand**, with **U** instead of T.

**Translation** (at ribosomes): the mRNA binds to a **ribosome**; each **codon** (three bases) pairs with the **anticodon** of a **tRNA** carrying a specific amino acid; the ribosome joins amino acids by **peptide bonds**; translation starts at **AUG** (start) and ends at a **stop codon**.

**The genetic code:** $4^3 = 64$ codons for 20 amino acids, so the code is **degenerate** (several codons per amino acid). It is nearly **universal**: the same codons mean the same amino acids in almost all organisms, which lets genes be transferred between species (e.g. human insulin made by bacteria).

| codon | amino acid | codon | amino acid |
|---|---|---|---|
| AUG | Met (start) | GCU | Ala |
| UUU | Phe | GGC | Gly |
| CAU | His | UAA | stop |



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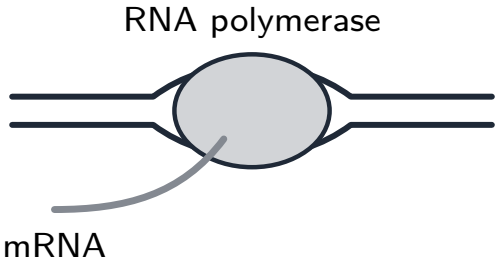
**Mutation link:** changing one base can change one codon, so a different amino acid may be placed, changing the protein's shape (e.g. sickle cell: GAG → GTG gives valine instead of glutamic acid).

**Worked example.** Template DNA TAC AAA GTA → mRNA AUG UUU CAU → Met–Phe–His.

**Answer shapes:** codon (mRNA) and anticodon (tRNA) pair; three bases code for one amino acid.

## 2 Practice

**2.1** State the role of RNA polymerase. [2]



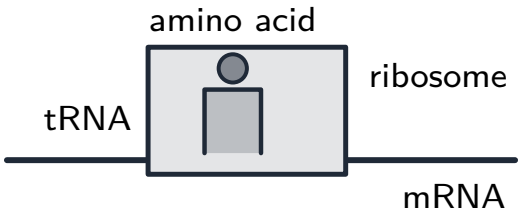

**2.2** A template strand of DNA has the sequence TAC CCG ATT. Write the mRNA sequence and use the table in the key-knowledge panel to give the amino acids. Explain what happens at the last codon. [3]





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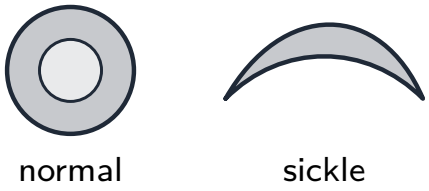
**2.3** Explain the roles of tRNA and ribosomes in translation. [3]




## 3 Exam-style questions

**3.1** Sickle cell anaemia is caused by a change in the gene for the $\beta$-chain of haemoglobin.

| | **DNA coding strand** | **mRNA codon** | **amino acid** |
|---|---|---|---|
| normal | GAG | GAG | glutamic acid |
| sickle | GTG | | valine |




(a) Give the mRNA codon for the sickle allele. [1]

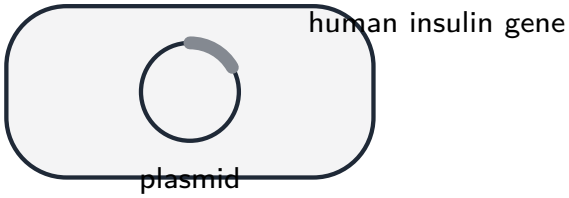
(b) Explain how this change produces a different protein. [3]

(c) Explain why some base changes do not change the protein. [2]



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**3.2** Human insulin is now made by bacteria that contain the human insulin gene.




(a) Explain why bacteria can make a human protein from a human gene. [2]

(b) State where transcription and translation happen in a human cell. [2]

(c) Explain why there are 64 codons but only 20 amino acids. [2]



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