

Exercise walk-through

Protein synthesis ■ 6.2

eXercise

You must be able to

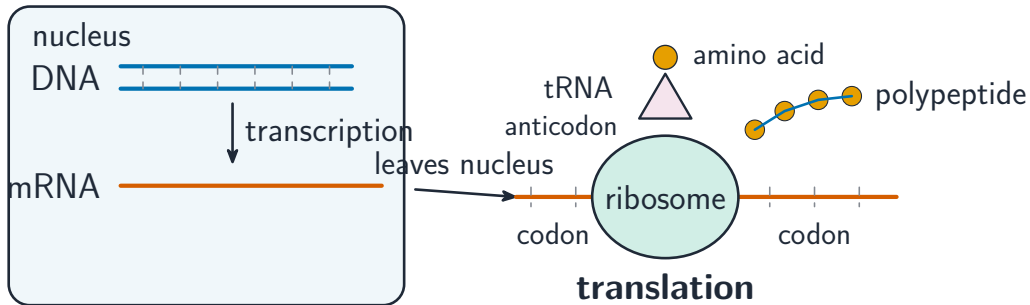
- describe the universal triplet code and the roles of RNA polymerase, mRNA, codons, tRNA, anticodons and ribosomes
- work out an mRNA sequence and amino acids from a DNA template
- explain splicing (introns/exons) and the effects of substitution, deletion and insertion mutations

Method — The genetic code and protein synthesis

A **gene** 基因 is a DNA sequence coding for one **polypeptide** 多肽. The code is read in **triplets** 三联体 (three bases): each codes one amino acid or a start/stop signal. It is **universal**.

- **transcription** — **RNA polymerase** copies the DNA **template strand** 模板链 into mRNA (uracil pairs with adenine).
- **translation** — at the **ribosome** 核糖体, mRNA is read in **codons** 密码子; **tRNA** 转运 RNA brings amino acids whose **anticodon** 反密码子 pairs with the codon; amino acids join by peptide bonds.

Method — The genetic code and protein synthesis



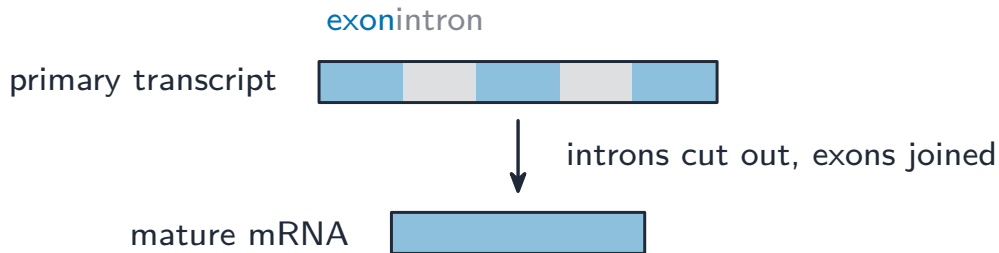
Method — Reading the code from a DNA template

To find the amino acids, copy the template into mRNA ($A \rightarrow U$, $T \rightarrow A$, $C \rightarrow G$, $G \rightarrow C$), then read the mRNA codons. Example: DNA template TAC $\rightarrow$ mRNA codon AUG (the start codon, methionine); the tRNA anticodon is UAC.

Method — Splicing

In eukaryotes the **primary transcript** 初级转录本 has coding **exons** 外显子 and non-coding **introns** 内含子. The introns are removed and exons joined to make the finished mRNA.

Method — Splicing



Method — Mutations

- **substitution** 替换 — one base swapped; changes at most one amino acid (sometimes none).
- **deletion** 缺失 / **insertion** 插入 — shifts how every later triplet is read (a **frameshift**), usually changing many amino acids.

Method — Mutations

original **A****T****G** **C****A****T** **T****A****C**

substitution **A****A****G** **C****A****T** **T****A****C**

deletion **A****T****G** **A****T****T** **A****C**

insertion **A****T****G** **G****C****A** **T****T****A** **C**

red = changed base; shaded = shifted by a frameshift (deletion or insertion)

A sequence read in triplets shown as original, substitution, deletion and insertion

Practice 2.1 ■ 2 marks

Name the molecule that (a) carries the code from the nucleus to the ribosome, and (b) brings amino acids to the ribosome.

Solution 2.1

Method: The genetic code and protein synthesis

Worked steps

(a) messenger RNA (mRNA) **B1**; (b) transfer RNA (tRNA) **B1**.

Practice 2.2 ■ 3 marks

Complete the table for this DNA template strand.

DNA template	mRNA codon	tRNA anticodon
T A C		
C G A		

Solution 2.2

Method: The genetic code and protein synthesis

Worked steps

TAC → mRNA AUG → anticodon UAC; CGA → mRNA GCU → anticodon CGA **B1** **B1**

per correct row, plus for all correct: 3 marks.

Exam-style 3.1 ■ 1 mark

What is a codon?

- A** a triplet of DNA bases on the template strand
- B** a triplet of mRNA bases coding for one amino acid
- C** a tRNA molecule
- D** an enzyme that builds mRNA

Solution 3.1

- A** a triplet of DNA bases on the template strand
- B** a triplet of mRNA bases coding for one amino acid 
- C** a tRNA molecule
- D** an enzyme that builds mRNA

Worked steps

- B.** A codon is a triplet of mRNA bases coding for one amino acid (or stop).

Exam-style 3.2 ■ 1 mark

Which type of mutation is most likely to change **every** amino acid after the point of mutation?

- A** a substitution
- B** a deletion of one base
- C** no mutation changes later amino acids
- D** a substitution at the start codon

Solution 3.2

Method: Mutations

- A a substitution
- B a deletion of one base**
- C no mutation changes later amino acids
- D a substitution at the start codon



Worked steps

- B. A deletion causes a frameshift, changing every later triplet.**

Exam-style 3.3 ■ 3 marks

- (a) Describe what happens during transcription.
- (b) Explain the roles of tRNA and the ribosome during translation.

Solution 3.3

Method: The genetic code and protein synthesis

Worked steps

(a) RNA polymerase binds and the DNA unwinds at the gene **B1**; free RNA nucleotides pair with the template strand (A with U) **B1**; they are joined into mRNA, which leaves the nucleus **B1**.

(b) each tRNA brings a specific amino acid and its anticodon pairs with the matching mRNA codon **B1** **B1**; the ribosome moves along the mRNA and joins the amino acids by peptide bonds in order **B1**.

Exam-style 3.4 ■ 2 marks

- (a) Explain why a substitution mutation sometimes has no effect on the polypeptide.
- (b) Explain why removing introns is necessary before translation.

Solution 3.4

Worked steps

- (a) most amino acids are coded by more than one triplet, so the changed triplet may still code for the same amino acid **M1** **A1**.
- (b) introns are non-coding; if left in they would be translated into wrong/extra amino acids, giving a faulty polypeptide **M1** **A1**.