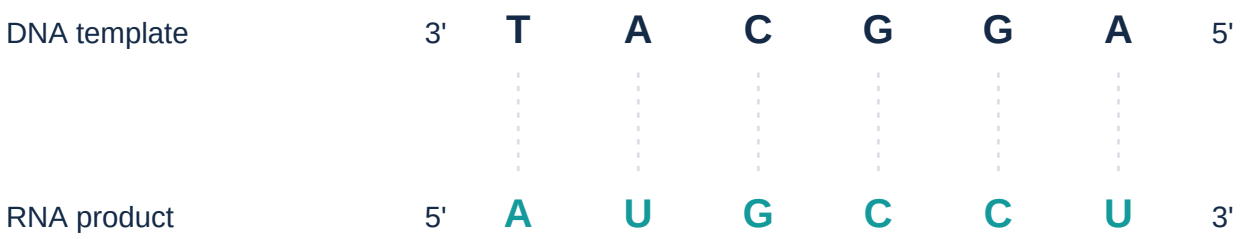
Transcription: DNA information to RNA

For a protein-coding gene, transcription produces an RNA copy of the information. In eukaryotes, nuclear genes are transcribed in the nucleus; the DNA stays there.

1. EXPOSE ONE DNA TEMPLATE

RNA polymerase binds at the gene's promoter region with the transcription machinery. A short region of DNA unwinds and the strands separate. One strand provides the template for the RNA sequence.

2. MATCH BASES AND BUILD THE RNA



RNA polymerase reads the template 3' to 5' and joins RNA nucleotides 5' to 3'. Pairing: DNA A with RNA U; T with A; C with G; G with C.

3. RELEASE THE TRANSCRIPT

RNA polymerase forms phosphodiester bonds in the RNA backbone. The RNA separates from the template and DNA rewinds behind the enzyme. Transcription ends at termination signals; the RNA transcript is released.

In eukaryotes, the primary transcript is processed to form mature mRNA, which can pass through a nuclear pore to the cytoplasm. RNA processing is covered in a later lesson. The alignment above is a sequence model, not a full transcription bubble.

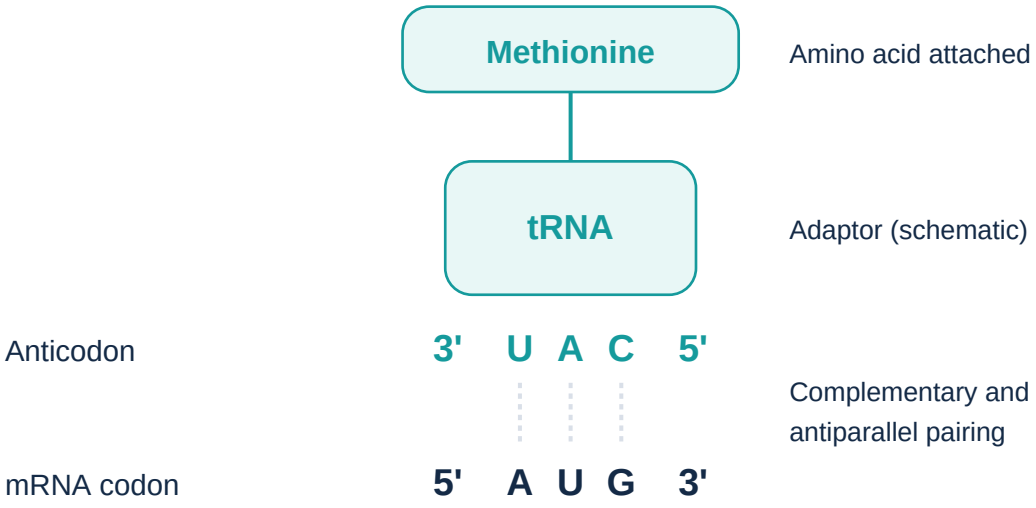
RNA copying and nucleus-to-cytoplasm transfer: NHGRI, Transcription.
Template pairing and polymerase direction: OpenStax Biology 2e, section 15.2.

Scope: Cambridge Biology 9700 syllabus, section 6.2, outcome 3, p. 25.

Translation: codons to a polypeptide

A ribosome reads mRNA codons in sequence. tRNA molecules act as adaptors: each carries a specific amino acid and has an anticodon that pairs with an mRNA codon.

1. MATCH THE ANTICODON TO THE CODON



The ribosome holds mRNA and tRNAs in position. Only one matched codon-anticodon pair is shown; the ribosome itself is omitted for clarity.

2. START AT THE CORRECT CODON

The initiation complex assembles at the start codon, usually AUG. A tRNA carrying methionine pairs with it. This establishes the reading frame for successive groups of three bases.

3. EXTEND, MOVE AND RELEASE

Further matching tRNAs deliver amino acids. The ribosome catalyses peptide bonds and moves along mRNA 5' to 3', one codon at a time. Empty tRNAs leave and can be reused. At a stop codon, a release factor releases the polypeptide.

A stop codon has no corresponding amino acid and is not matched by a normal amino-acid-carrying tRNA. The completed chain can fold and may undergo further processing.

tRNA as an adaptor: NHGRI, Transfer RNA (tRNA).
Ribosome action and termination: OpenStax Biology 2e, section 15.5.

Scope: Cambridge Biology 9700 syllabus, section 6.2, outcome 3, p. 25.

Trace one message from DNA to product

Use the template strand for complementary pairing, then read the mRNA codons. The coding strand is a useful check: its sequence matches mRNA except that DNA has T instead of U.

1. WORKED SEQUENCE - NO INTRONS SHOWN

DNA coding	5'	ATG	GCT	TTT	TAA	3'
DNA template	3'	TAC	CGA	AAA	ATT	5'
mRNA	5'	AUG	GCU	UUU	UAA	3'
Product		Met	Ala	Phe	STOP	

Met = methionine; Ala = alanine; Phe = phenylalanine. Four codons give three amino-acid residues: the stop signal adds no residue. This deliberately short example is not a real complete gene.

2. KEEP THE TWO PROCESSES DISTINCT

FEATURE	TRANSCRIPTION	TRANSLATION
Reads	DNA template	mRNA codons
Builds	RNA	Polypeptide
Main machinery	RNA polymerase	Ribosome + tRNAs
New covalent bonds	Phosphodiester	Peptide

In eukaryotes, translation occurs on cytoplasmic ribosomes, free or attached to rough ER. mRNA carries the instructions; tRNA carries amino acids. Neither DNA nor RNA is physically converted into the polypeptide.

Information flow: NHGRI, Transcription and Translation.
Sequence interpretation and machinery: OpenStax Biology 2e, section 15.5.

Scope: Cambridge Biology 9700 syllabus, section 6.2, outcome 3, p. 25.