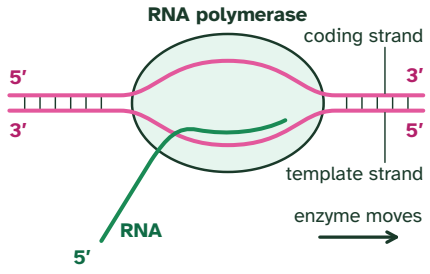
From gene to *protein*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

DNA to RNA to protein: a gene is transcribed into mRNA, and a ribosome translates its codons into a polypeptide.



Worked example. Template 3′ CAT GGC 5′ gives RNA 5′ GUA CCG 3′. The coding strand reads 5′ GTA CCG 3′.

6.3.A START HERE

Transcription copies one strand into *RNA*

- **RNA polymerase** binds at the start of a gene and separates the two DNA strands. It uses one, the **template strand**, to set the order of bases in the RNA.
- RNA nucleotides pair with the template: A takes U, T takes A, C takes G, G takes C. Each joins the 3′ end of the RNA, so the enzyme **reads the template 3′ to 5′** and **builds RNA 5′ to 3′**.
- The RNA is **complementary** to the template, so it matches the other strand, the **coding strand**, with U in place of T. Behind the enzyme the DNA closes up, unchanged.

PAIRING IN TRANSCRIPTION — *Apples Under Cars Garage*

A	**Apples** A on the template	**U**	**Under** takes U in the RNA	**C**	**Cars** C on the template	**G**	**Garage** takes G in the RNA

6.3.A 6.4.A THE FLOW OF INFORMATION

DNA to RNA to *protein*

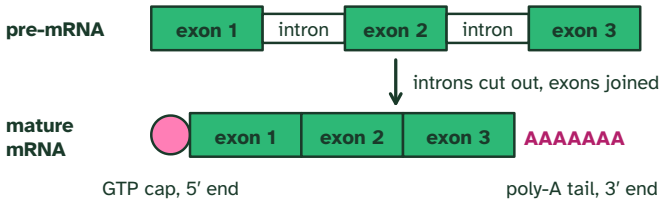
- A gene is a sequence of bases in DNA. Reading it and making its product is **gene expression**.
- The DNA is **copied, never used up**. In a eukaryote it stays in the nucleus, and mRNA carries the message out.
- Proteins do the work of the cell, so **genotype determines phenotype** through the proteins made.
- **Example:** one gene codes for the enzyme tyrosinase, which makes the dark pigment melanin.

Transcription DNA to RNA
The base sequence of a gene is copied into RNA.

Translation RNA to polypeptide
A ribosome reads the mRNA and joins amino acids in the order it sets.

6.3.A CAPPED, TAILED AND SPLICED

A eukaryotic transcript is *processed*



- Enzymes change the new transcript (pre-mRNA) in the nucleus. Only **mature mRNA** leaves.
- **Introns** are transcribed, then cut out of the RNA; the **exons** are joined and expressed.
- **Alternative splicing**: keeping different sets of exons gives different mature mRNAs, and so different polypeptides, from one gene.

THREE CHANGES — *Cats Take Showers*

C	**Cap** a GTP cap on the 5′ end helps a ribosome recognize the mRNA	**T**	**Tail** a poly-A tail on the 3′ end makes the mRNA more stable	**S**	**Splice** introns are cut out and the exons joined

6.3.A STRUCTURE FITS FUNCTION

Three RNAs meet at the *ribosome*

	SHAPE	JOB	WHY THE SHAPE FITS
mRNA messenger	One open strand.	Carries the information from the DNA to a ribosome.	A message has to be read in order, from one end to the other.
tRNA transfer	A short strand folded back on itself.	Each kind binds **one specific amino acid**. Its **anticodon** pairs with one codon of the mRNA.	A three-base tip matches one codon and nothing else.
rRNA ribosomal	Large folded strands, with proteins.	The **working building block of the ribosome**: it holds the mRNA and tRNAs, and joins the amino acids.	A big scaffold can grip several molecules at once.

All three are made by transcription. Only mRNA is translated.

Sequence sets the shape; shape sets the job

Translation: *codons*, ribosomes and a special case

6.4.A THE GENETIC CODE

A code read in *threes*

- mRNA is read three bases at a time. Each **codon** names one amino acid: read it from a genetic code chart.
- **Redundant**: most amino acids have several codons. Never ambiguous: no codon names two.
- **AUG** is the start codon and codes for methionine. UAA, UAG and UGA mean stop.
- Nearly all organisms use the same code: evidence of **common ancestry**.

64	61	3
codons	amino acids	stop

6.4.A PLACE AND TIMING

Where *ribosomes* work

- Translation happens on ribosomes in the **cytoplasm** of every cell, prokaryotic or eukaryotic.
- In eukaryotes some ribosomes sit on the cytoplasmic surface of the **rough endoplasmic reticulum**.

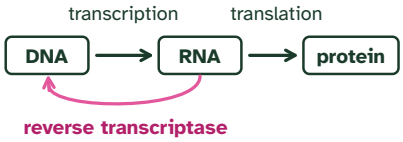
Prokaryote no nucleus
Ribosomes begin translating an mRNA **while it is still being transcribed**.

Eukaryote a nucleus
An mRNA is translated only after it is finished, processed and out of the nucleus.

6.4.A A SPECIAL CASE

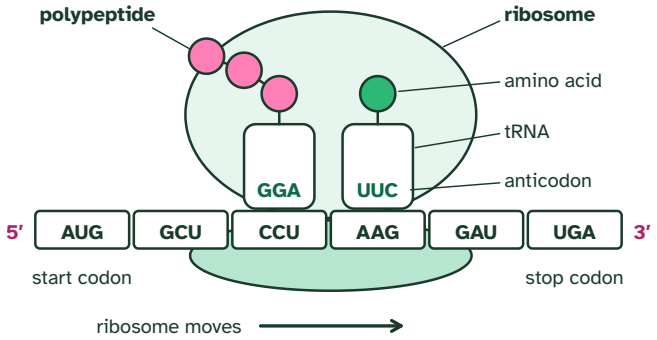
Retroviruses

- A retrovirus carries its genes as **RNA**. Its enzyme **reverse transcriptase** copies that RNA into DNA: information flows from **RNA to DNA**.
- The DNA copy **integrates into the host genome**. The host cell then transcribes and translates the viral genes, and new viruses are assembled.



6.4.A THREE STAGES: IN EVERY TALE

Translation: *start, grow, stop*



The order of codons sets the order of amino acids: the primary structure of the protein.

1 INITIATION
At the start codon
The rRNA of the ribosome interacts with the mRNA at AUG. A tRNA carrying methionine pairs with it.

2 ELONGATION
Codon by codon
A tRNA whose **anticodon pairs with the codon** brings the amino acid it names. It is joined to the chain, and the ribosome moves one codon on, 5′ to 3′.

3 TERMINATION
At a stop codon
No amino acid is added. The new polypeptide is released.

WATCH OUT

Five mistakes that *cost points*

- ✕ **mRNA is not a copy of the template.** It is complementary to it, and matches the coding strand with U for T.
- ✕ **Introns are cut out of the RNA, never the DNA.** They lie inside a gene and are transcribed every time.
- ✕ **The anticodon is on the tRNA; the codon is on the mRNA.** The chart is always in codons.
- ✕ **Redundant is not ambiguous.** One codon never names two amino acids.
- ✕ **A mutation does not denature a protein.** Denaturing is heat or pH unfolding a protein built correctly.

COVER THE SHEET

Can you *answer these?*

1. Describe the direction in which RNA is built.
2. Identify the mRNA made from 3′ TAC CGA ATT 5′.
3. Describe three changes made to a eukaryotic transcript.
4. Explain how one gene can give several polypeptides.
5. Describe the jobs of mRNA, tRNA and rRNA.
6. Explain why a shared code suggests common ancestry.
7. Predict the effect of a drug that blocks RNA polymerase.
8. Describe the flow of information in a retrovirus.

IN THE EXAM

Predicting the effect of a change? Three steps, in order. The molecule: what differs in the DNA, the mRNA or the machinery. The protein: a different polypeptide (or the same, as the code is redundant), less of it, or none. Then the phenotype.

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.