From gene to trait, and the switches

60 minutes • D2.2.1 to D2.2.3, D2.2.5 • Chapters 1, 2, 3, 4

Gene expression from transcription to protein function, regulation of transcription by promoters, enhancers and transcription factors, genome, transcriptome and proteome, and mRNA lifetime

TIMING

0–7	7 min	**Do now: back to D1.2**
7–17	10 min	**Gene to trait**
17–31	14 min	**Switches on the DNA**
31–44	13 min	**One genome, three cells**
44–54	10 min	**How long a message lasts**
54–60	6 min	**Exit**
	60 min	**One lesson**

STARTER

7 min

Do now: back to D1.2

The retrieval grid below: six quick questions on transcription and translation, answered without notes, then marked in pairs.

ON THE BOARD, FROM THE GUIDE

Open the guide on the projector at each chapter (the links work in this PDF). Every figure plays from its own buttons, and the lesson's slides have the same figures, step by step, in the order of this plan.

01 From gene to trait

CHAPTER 01 IN THE SLIDES

Step through the figure (4 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. The **gene**: a length of DNA coding for the enzyme tyrosinase.
2. **Transcription**: RNA polymerase copies the gene into mRNA.
3. **Translation**: ribosomes make a polypeptide, which folds into the enzyme.
4. The **function**: tyrosinase turns tyrosine into melanin, the dark pigment.

Play the animation, From promoter to mature mRNA. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. Transcription factors bind the promoter. Only then can RNA polymerase bind and begin.
2. The RNA grows 5′ to 3′: every new nucleotide joins its 3′ end.
3. In a eukaryote the first RNA is pre-mRNA: exons, with introns between them.
4. A 5′ cap and a poly-A tail are added. The introns are cut out and the exons spliced together.
5. Spliced another way, the same gene gives a different polypeptide.
6. Capped, tailed and spliced, the mature mRNA leaves the nucleus.

> **Predict box:** A mutation stops a pigment cell's tyrosinase from working, but the cell still makes plenty of tyrosinase mRNA. What happens to the colour of the skin around it? Hands up or mini whiteboards first.
>
> **Answer B: It goes pale, because the protein made from that mRNA cannot make melanin**

02 Switches on the DNA

CHAPTER 02 IN THE SLIDES

Step through the figure (4 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. A gene with its **promoter**, and an **enhancer** further along the DNA.
2. **Transcription factors** bind the promoter and RNA polymerase joins them.
3. An **activator** binds the enhancer and helps: far more mRNA.
4. A **repressor** binds near the promoter: RNA polymerase is kept off.

> **Predict box:** A cell stops making one activator protein. What happens to a gene whose enhancer that activator binds? Hands up or mini whiteboards first.
>
> **Answer B: It is transcribed more slowly, as long as its promoter can still be bound**

03 One genome, many cells

CHAPTER 03 IN THE SLIDES

Step through the figure (3 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. A **beta cell** of the pancreas: the same eight genes as every other cell, but it transcribes only three, insulin among them.
2. A **red blood cell precursor**: the same genome, a different transcriptome. Haemoglobin is on, insulin is off.
3. A **skin cell**: keratin on. The genes every cell needs are on in all three; the genes that are off carry methyl tags on their promoter.

> **Predict box:** Which of these is likely to be the most alike in a skin cell and a beta cell from the same person? Hands up or mini whiteboards first.
>
> **Answer A: Their genomes, since nearly every cell in one body carries the same DNA**

04 How long a message lasts

CHAPTER 04 IN THE SLIDES

Step through the figure (2 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. After the gene is switched off, one **mRNA** is half gone in 30 minutes, the other only after 12 hours.
2. Protein is made the whole time an mRNA lasts: far more from the **long-lived** one.

Play the animation, Start, then A, P and E. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. The small subunit attaches to the mRNA at its 5′ end.
2. It moves towards the 3′ end until it reaches the start codon, AUG. The initiator tRNA pairs with it.
3. The large subunit joins. The initiator tRNA sits in the P site.
4. Another tRNA arrives in the A site. A peptide bond joins methionine to its amino acid.
5. The ribosome moves one codon. The empty tRNA leaves from the E site; the chain's tRNA is now in P.
6. At the stop codon the chain is released and the subunits come apart.

> **Predict box:** Two genes are transcribed at the same rate, but one gene's mRNA lasts ten times longer. What is the result? Hands up or mini whiteboards first.
>
> **Answer B: Much more of the protein from the longer-lasting mRNA, read for longer**

THE LESSON

10 min

Gene to trait

Chapter 1 and its figure, stopping on each caption. Students write the three stages for the tyrosinase gene in their own words, then the predict box.

14 min

Switches on the DNA

Chapter 2 and its figure. The match-up below: proteins on one side, DNA sequences on the other. Then the predict box on losing an activator.

13 min

One genome, three cells

Chapter 3 and its tool. Pairs work through the four tasks, then write a definition of genome, transcriptome and proteome that a younger student would follow.

10 min

How long a message lasts

Chapter 4 and its graph. The sketch task below: predict and draw the protein made from each mRNA over a day.

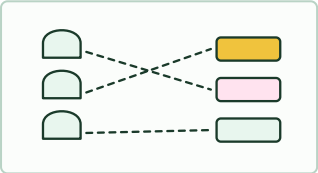
ACTIVITIES

STARTER

Retrieval grid

Six questions on the board, answered in silence: what is made in transcription, where does it happen in a eukaryote, which strand is copied, what is a codon, what does a ribosome do, and what is meant by the code being degenerate. Pairs swap and mark, and the class fixes the most missed one together.

Needs: the board; D1.2 for the answers.



MATCH UP

Proteins and the sequences they bind

Cards: transcription factor, activator, repressor, RNA polymerase (proteins) and promoter, enhancer (DNA sequences). Pairs sort them into proteins and sequences, join each protein to the sequence it binds, and write what happens to transcription when it binds. Land on: the promoter and enhancer are DNA, the rest are proteins.

Needs: the cards, one set per pair.

SKETCH

Predict the protein

Under the mRNA graph in chapter 4, students sketch a second graph: the total amount of protein made from each mRNA over 24 hours. Then: a cell needs to stop making a protein within an hour of a signal. Which kind of mRNA should it use, and why?

Needs: chapter 4.

PLENARY

6 min

Exit

Explain why a nerve cell and a muscle cell from one person have the same genome but different proteomes.

WHAT STUDENTS GET WRONG

"Each cell only has the genes it needs." Nearly every cell has the whole genome; it expresses only some of it.

"A promoter is a protein that starts transcription." A promoter is a DNA sequence; transcription factors and RNA polymerase are the proteins that bind it.

"Once a gene is transcribed, the amount of protein is fixed." How long the mRNA lasts before nucleases break it down changes how much protein is made.

STRETCH AND SUPPORT

Support: the four-tile "Remember it" for the operon (chapter 9) and the key terms (tap the dotted words) as a glossary.

Support: the match-up cards with the proteins in one colour and the DNA sequences in another.

Stretch: one gene can give several proteins by alternative splicing (D1.2). How does that make the proteome bigger than the genome?

IN THE GUIDE

1 From gene to trait
2 Switches on the DNA
3 One genome, many cells
4 How long a message lasts
All The whole guide, with the figures that play
PPTX This lesson's slides, in the order of this plan

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on D2.2 each time, marked as students go and saved to their Exam practice when they are signed in.

biologybybradford.com/exam-maker/sit?topics=D2.2&level=HL&paper=quiz&marks=15&src=ep

PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- Tarsia puzzle, dominoes and picture reveal on D2.2, built from its key terms and ready to print
- A pub quiz with rounds on D2.2, to present or run with no projector
- An escape room built from the question bank on D2.2

ALREADY ON THE SITE FOR D2.2

- Quiz: Gene Expression (HL)
- Revision map: D2.2 Gene expression, to fill in
- Exam questions: D2.2 in the exam maker, a paper with its markscheme

CARD SETS ON SPLYCR

Open a set to host it as a class game, or make a copy to edit.

- D2.2 Gene Expression (HL)

How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.