NAME _____ CLASS _____ DATE _____

IB BIOLOGY · D2.2

Gene expression

Notes to fill in alongside the guide. Each numbered block matches a chapter of the guide, and of the lesson slides. Write in the gaps, answer the cues, annotate the figures, and sum up each section in your own words.

BY THE END YOU CAN

- [ ] Outline gene expression as transcription, translation and the function of the protein made D2.2.1
- [ ] Explain how transcription is regulated by proteins binding promoters and enhancers D2.2.2
- [ ] Explain how the rate of mRNA breakdown regulates translation D2.2.3
- [ ] Outline epigenesis, and explain why it changes phenotype but not genotype D2.2.4
- [ ] Distinguish the genome, transcriptome and proteome of a cell D2.2.5
- [ ] Explain how methylation of promoters and of histones acts as an epigenetic tag D2.2.6
- [ ] Explain how epigenetic tags can be passed on to daughter cells or offspring D2.2.7
- [ ] Give examples of the environment changing gene expression, including air pollution D2.2.8
- [ ] Explain the differences between ligers and tigons by the tags left on egg and sperm D2.2.9
- [ ] Explain how monozygotic twin studies show the effect of the environment on gene expression D2.2.10
- [ ] Explain how a hormone and lactose change the pattern of gene expression D2.2.11

01 From gene to trait

D2.2.1 HL

CUES

Predict: 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?

What is meant by expressed?

NOTES

1 Its information has an effect on the organism only when the gene is _____, and in most cases that takes three steps.

2 The gene is _____ into mRNA, the mRNA is _____ into a polypeptide, and the protein that polypeptide folds into then does a job: very often as an enzyme.

3 Usually three stages: _____.

4 The _____: a length of DNA coding for the enzyme tyrosinase.

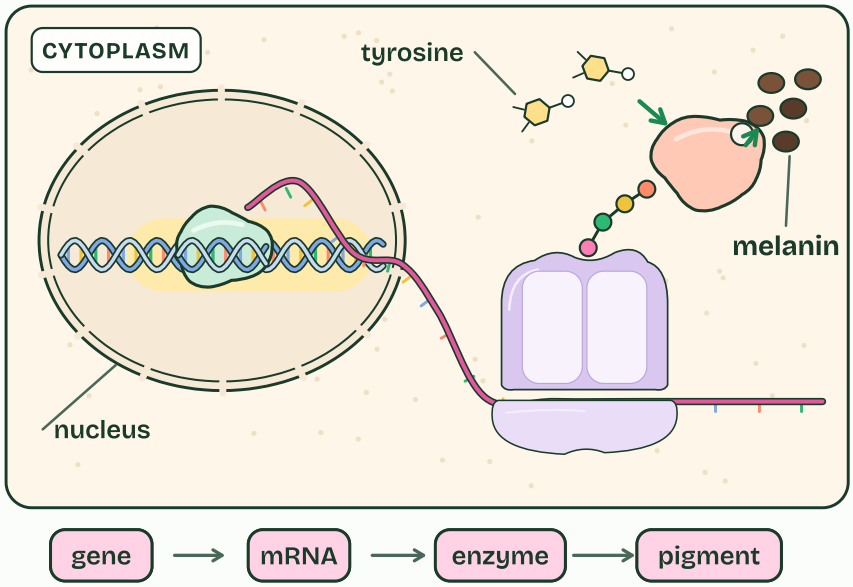
5 _____: RNA polymerase copies the gene into mRNA.

6 _____: ribosomes make a polypeptide, which folds into the enzyme.

Your own notes

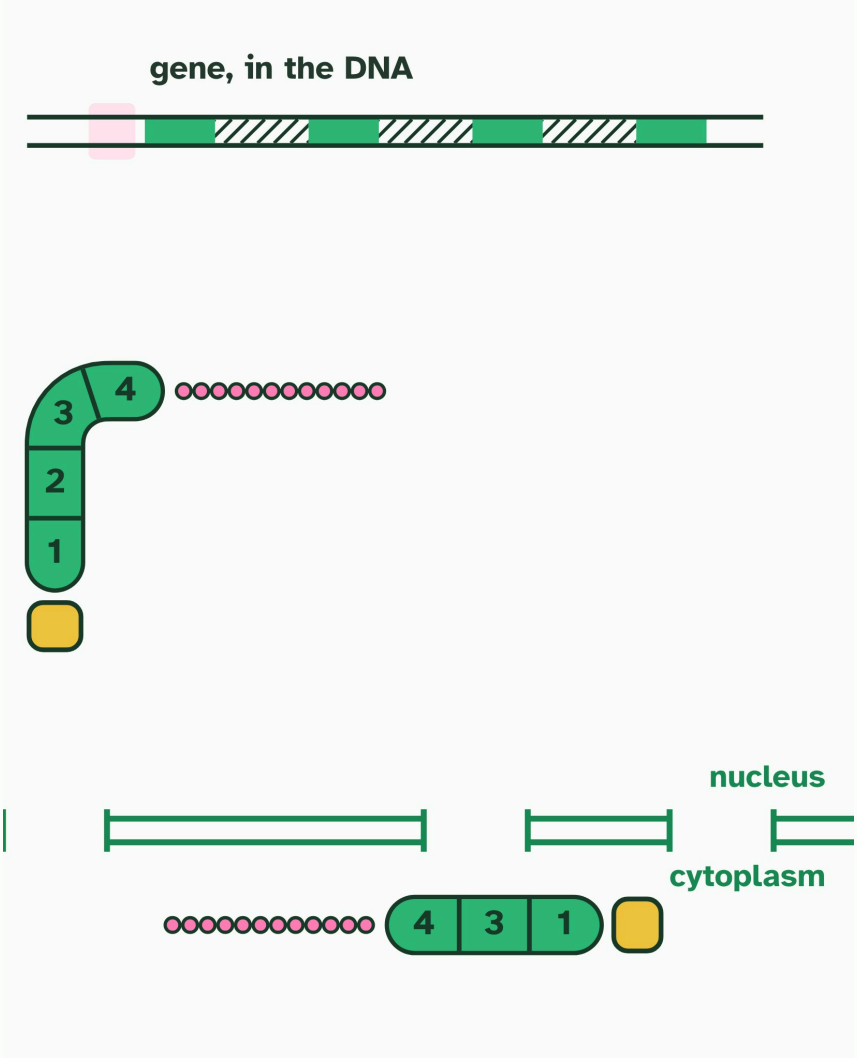
ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each: 1 gene; 2 Transcription; 3 Translation; 4 function.



ANNOTATE THE FIGURE

Annotate this still from the animation (From promoter to mature mRNA): what is happening, and why?



SPOT THE MISTAKE

What do students often get wrong about gene expression and the phenotype? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 01 in two or three sentences of your own.

02 Switches on the DNA

D2.2.2 HL

CUES

Predict: A cell stops making one activator protein. What happens to a gene whose enhancer that activator binds?

What is meant by promoter?

What is meant by transcription factors?

What is meant by enhancers?

NOTES

1 The _____ is a sequence just before the gene, where RNA polymerase binds to start transcription.

2 In eukaryotes RNA polymerase cannot bind on its own. It needs _____, proteins that bind at the promoter first and help RNA polymerase attach.

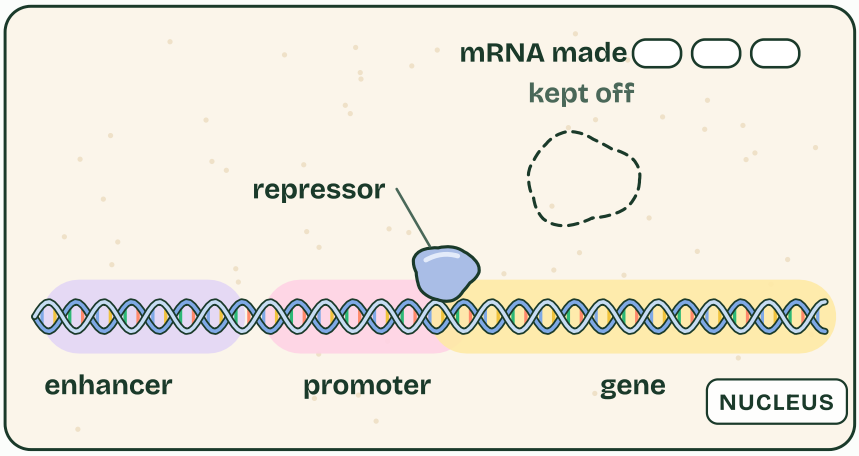
3 Further away, sometimes thousands of bases from the gene, are _____.

4 _____: where RNA polymerase binds, with the help of transcription factors.

Your own notes

ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each: 1 promoter, enhancer; 2 Transcription factors; 3 activator; 4 repressor.



SPOT THE MISTAKE

What do students often get wrong about regulation of transcription? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 02 in two or three sentences of your own.

03 One genome, many cells

D2.2.5 HL

CUES

Predict: Which of these is likely to be the most alike in a skin cell and a beta cell from the same person?

What is meant by genome?

What is meant by transcriptome?

What is meant by proteome?

NOTES

1 The _____ is all of a cell's DNA, every gene included.

2 The _____ is all the RNA a cell has transcribed at a given time, and the _____ is all the proteins it has made.

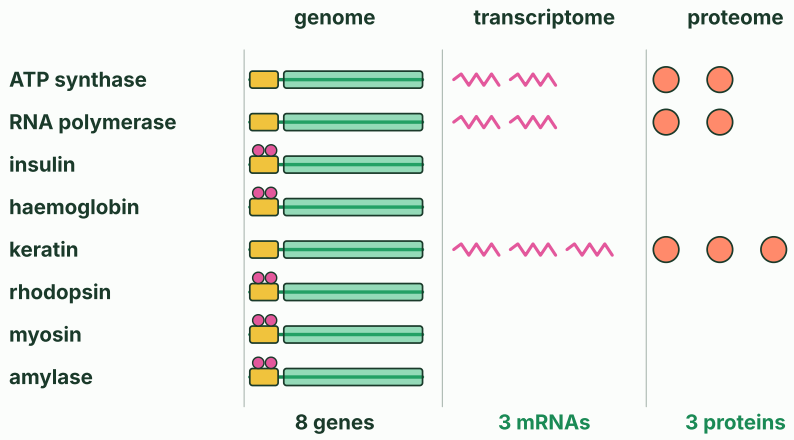
3 _____: all the DNA. The same in nearly every cell of one organism.

4 _____: all the RNA transcribed. Proteome: all the proteins made.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 beta cell; 2 red blood cell precursor; 3 skin cell.



SPOT THE MISTAKE

What do students often get wrong about genome, transcriptome and proteome? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 03 in two or three sentences of your own.

04 How long a message lasts

D2.2.3 HL

CUES

Predict: Two genes are transcribed at the same rate, but one gene's mRNA lasts ten times longer. What is the result?

What is meant by nucleases?

NOTES

1 Once an mRNA reaches the cytoplasm, ribosomes translate it again and again, until it is broken down by enzymes called _____.

2 mRNA is translated until _____ break it down.

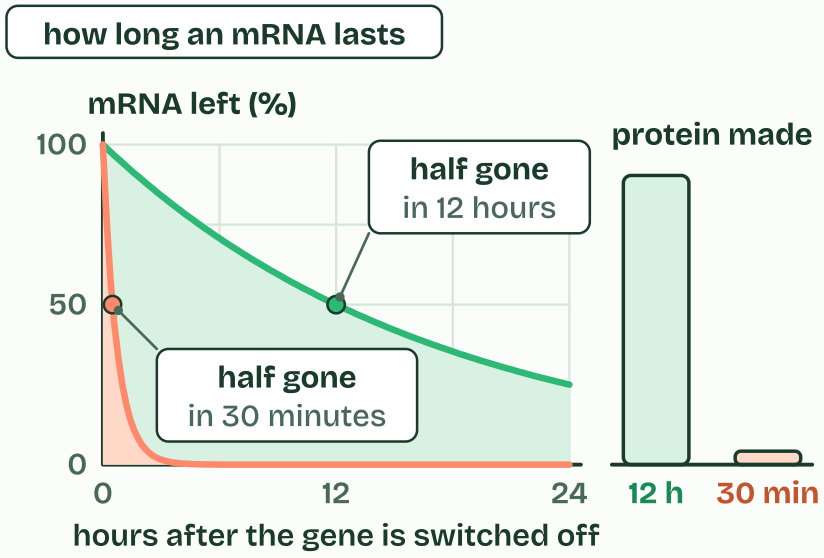
3 After the gene is switched off, one _____ is half gone in 30 minutes, the other only after 12 hours.

4 Protein is made the whole time an mRNA lasts: far more from the _____ one.

Your own notes

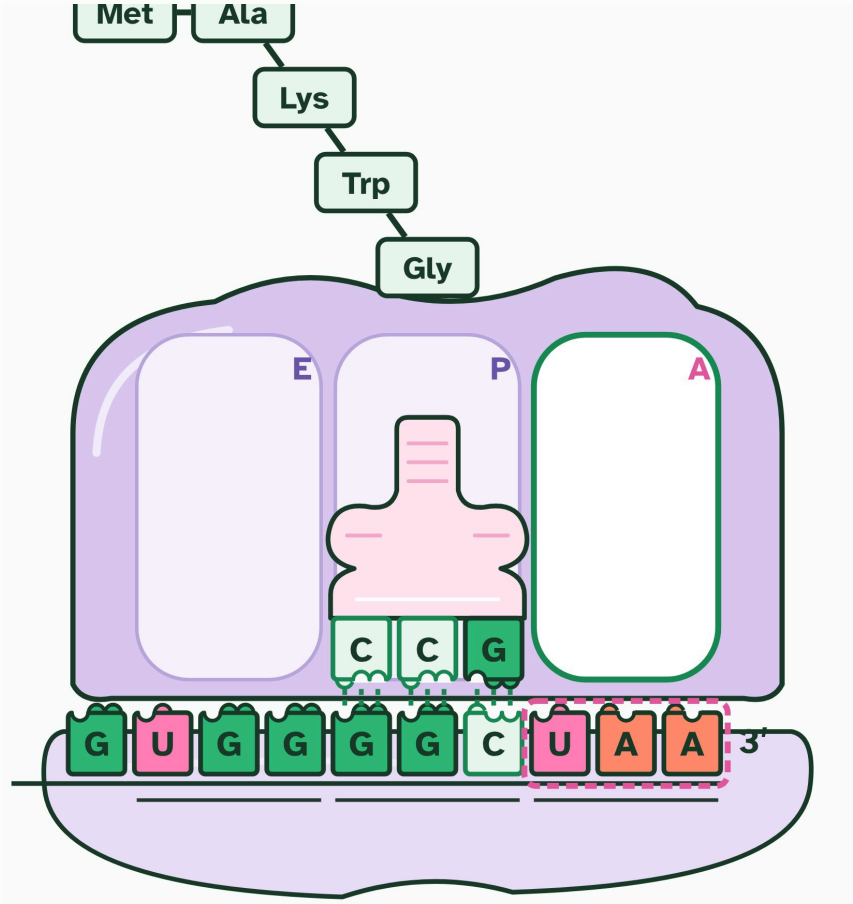
ANNOTATE THE FIGURE

Number the 2 steps on the figure and note what happens at each: 1 mRNA; 2 long-lived.



ANNOTATE THE FIGURE

Annotate this still from the animation (Start, then A, P and E): what is happening, and why?



SUMMARY

Sum up section 04 in two or three sentences of your own.

05 Tags, not changes

D2.2.4 HL D2.2.6 HL

CUES

Predict: A gene's promoter is heavily methylated, but the histones around the gene carry acetyl tags. Is the gene expressed?

What is meant by epigenesis?

What is meant by epigenetic tags?

NOTES

1 As it divides into an embryo, its descendants become different kinds of cell, each with its own pattern of gene expression. This development of patterns of differentiation is _____.

2 The patterns are held in place by chemical _____ added to the DNA and the proteins around it.

3 _____: the development of patterns of differentiation in a multicellular organism.

4 A gene with no tags: its promoter and three _____. It is transcribed a little.

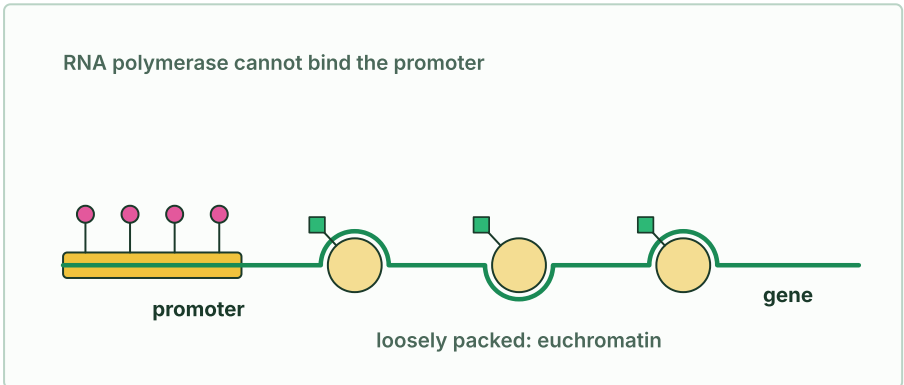
5 _____ and activating _____ tags on the histone tails loosen the nucleosomes: more mRNA.

6 Methyl tags on the promoter's cytosines: RNA polymerase cannot bind and the gene is _____. The base sequence has not changed.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 nucleosomes; 2 Acetyl, methyl; 3 off.



SPOT THE MISTAKE

What do students often get wrong about epigenesis; methylation of the promoter and histones? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 05 in two or three sentences of your own.

06 Tags that are passed on

D2.2.7 HL

CUES

Predict: A drug stops a cell copying methyl tags onto the new DNA strand when it replicates. What happens over several divisions?

What is meant by epigenetic inheritance?

NOTES

1 This is _____: a change in phenotype passed on to daughter cells, or sometimes to offspring, without any change in the nucleotide sequence.

2 _____: phenotype passed on with no change to the DNA sequence.

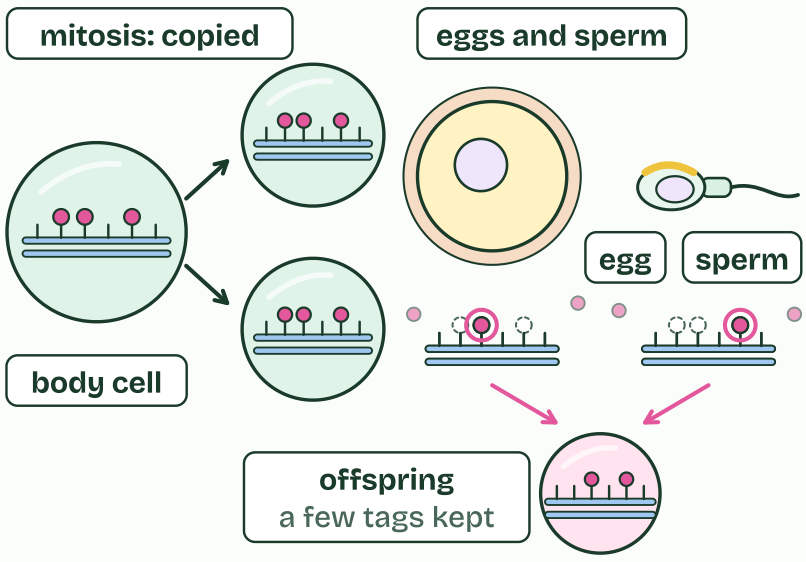
3 _____: the methyl tags are copied with the DNA, so both daughter cells keep the pattern.

4 Making _____: most tags are removed.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each.



SUMMARY

Sum up section 06 in two or three sentences of your own.

07 Wiped clean, nearly

D2.2.9 HL

CUES

Predict: Why does the zygote need most of the tags in the egg and sperm to be removed?

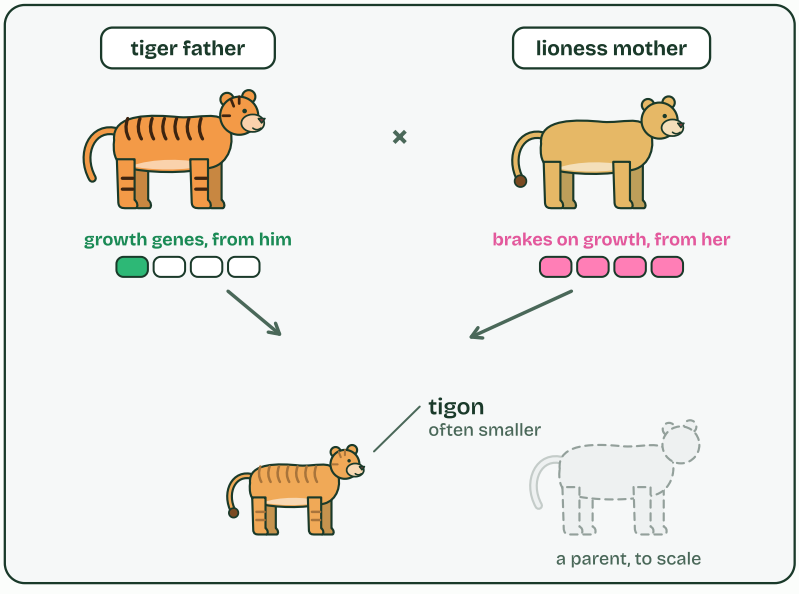
NOTES

1. A cross between a male lion and a female tiger, a _____, grows larger than either parent.
2. The reverse cross, a male tiger and a female lion, gives a _____, usually no larger than its parents and often smaller.
3. A _____: strongly active growth genes from the lion father, weak brakes from the tigress. It grows very large.
4. A _____: weaker growth genes from the tiger father, strong brakes from the lioness. It is often smaller.

Your own notes

ANNOTATE THE FIGURE

Number the 2 steps on the figure and note what happens at each: 1 liger; 2 tigon.



SPOT THE MISTAKE

What do students often get wrong about removal of most but not all tags from egg and sperm? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 07 in two or three sentences of your own.

08 The environment leaves marks

D2.2.8 HL D2.2.10 HL

CUES

Predict: Why are identical twins, rather than non-identical twins, used to study the effect of the environment on gene expression?

NOTES

1 _____ is one example.

2 _____ come from one zygote, so they have the same DNA base sequence.

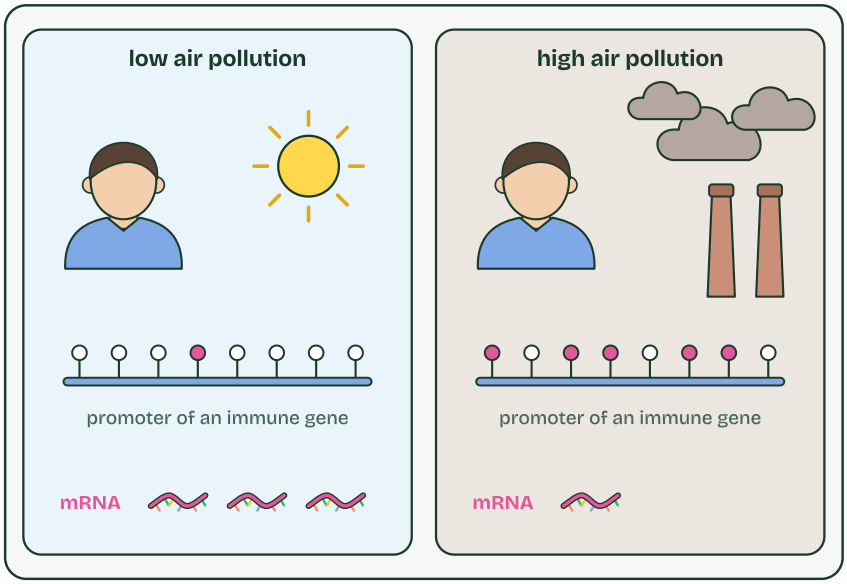
3 Identical twins aged 3: the same DNA and nearly the same _____.

4 _____: more methyl tags on an immune gene's promoter, and less of its mRNA.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each.



SPOT THE MISTAKE

What do students often get wrong about environmental effects; monozygotic twin studies? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 08 in two or three sentences of your own.

09 Signals from outside

D2.2.11 HL

CUES

Predict: A mutation changes the lac operator so that the repressor can no longer bind to it. What happens when there is no lactose?

What is meant by lac operon?

NOTES

1 **A biochemical: lactose in *E. coli*.** The genes for taking in and digesting lactose sit together in the _____, transcribed together from one promoter.

2 A regulatory gene makes a _____ protein that binds the _____, a sequence between the promoter and the genes, so RNA polymerase cannot transcribe them.

3 _____: a repressor binds the operator and blocks transcription.

4 _____, a steroid, passes through the cell membrane.

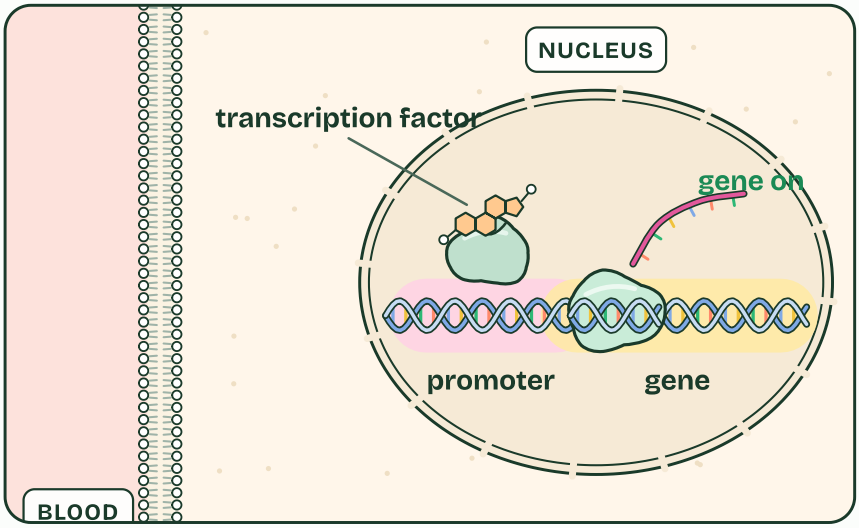
5 It binds a _____ protein inside the cell.

6 Together they act as a _____: they bind DNA and switch the gene on.

Your own notes

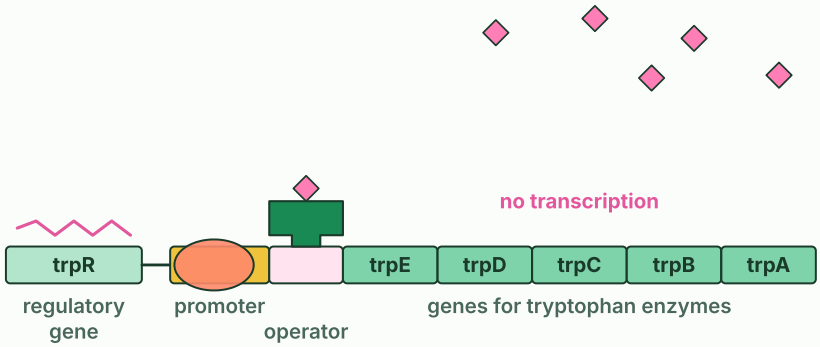
ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 Oestrogen; 2 receptor; 3 transcription factor.



ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each.



REMEMBER IT

Four parts of an operon

R	P	O	G
R	P	O	G

SUMMARY

Sum up section 09 in two or three sentences of your own.

Check yourself

The check for this guide is online: a fresh paper of past-paper style questions from the exam bank on D2.2 each time, marked as you go, and saved to your Exam practice progress when you are signed in. Scan the code, or type the link.

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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.