IB BIOLOGY D2.2 HL

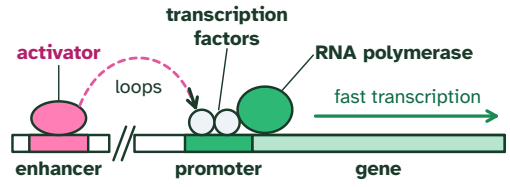
REVISION ON TWO PAGES

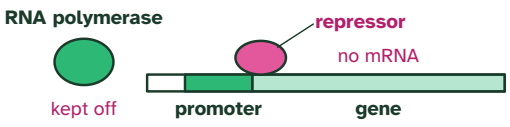
Same genes, different *cells*

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

THE ONE IDEA

Nearly every cell carries the same genes. What makes a cell what it is: which genes it expresses, and how much.





Sequences and proteins. Promoter and enhancer are DNA; the proteins that bind them switch the gene up or down.

D2.2.2 START HERE

Switches on the *DNA*

- Transcription is regulated by **proteins that bind specific base sequences** in the DNA; each recognises its own sequence.
- **Promoter:** the sequence just before a gene where **RNA polymerase binds**. In eukaryotes it needs **transcription factors** bound there first to help it attach.
- **Enhancer:** a sequence that can be thousands of bases away. **Activators** bound to it **raise the rate** of transcription; the DNA loops so they touch the promoter proteins.
- **Repressors** bind the DNA and **reduce or stop** transcription.

THE FOUR SWITCHES

P	**Promoter**	DNA: RNA polymerase binds
T	**Transcription factors**	proteins: help it attach
E	**Enhancer**	DNA: far away
R	**Repressor**	protein: blocks transcription

D2.2.1

From gene to *phenotype*

- Gene expression: how the information in a gene has an **effect on the phenotype**, through **what its protein does**, very often as an enzyme.
- **Example:** a non-functional tyrosinase makes little or no melanin: one form of **albinism**.

STAGE 1
Transcription
The gene is copied into mRNA.

STAGE 2
Translation
Ribosomes make the polypeptide.

STAGE 3
Function
Tyrosinase makes melanin.

D2.2.5

One genome, many *cells*

- **Genome:** all of a cell's DNA, the **same in nearly every cell** of one organism.
- **Transcriptome:** all the RNA transcribed at a given time.
  Proteome: all the proteins made.
- **No cell expresses all its genes**; the pattern decides **how it differentiates**.

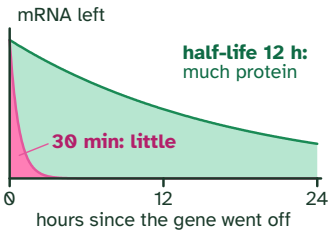
GENE	BETA CELL	RED CELL
Insulin	**on**	off
Haemoglobin	off	**on**
Rhodopsin	off	off
Respiration enzymes	**on**	**on**

Red cell: a red blood cell precursor.

D2.2.3

How long *mRNA* lasts

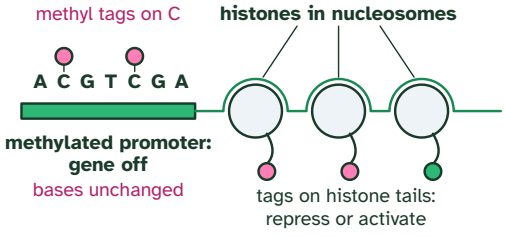
- Ribosomes translate an mRNA again and again until **nucleases** break it down.
- In human cells mRNA lasts from **minutes to days**. The longer it lasts, the **more protein** is made.
- Controlling breakdown **regulates translation**. Globin mRNA lasts a day or more; mRNA for some transcription factors, minutes.



D2.2.4, D2.2.6

Epigenetic *tags*, not new sequences

- **Epigenesis:** the development of **patterns of differentiation** as a zygote divides into the cells of an embryo.
- Epigenetic changes alter the **phenotype, not the genotype**: the DNA base sequence stays the same.
- **Promoter:** methyl groups on **cytosines in a promoter** repress transcription of the gene downstream.
- **Histones:** methyl groups on amino acids in histone tails can **repress or activate** transcription. How is beyond the course.



Tags that last, and signals from *outside*

D2.2.7, D2.2.9

Tags passed on, or *wiped clean*

- **Epigenetic inheritance:** a **phenotype passed on with no change in DNA sequence**: tags remain through mitosis or meiosis.
- **Mitosis:** enzymes methylate the new strand where the old one is tagged, so **a liver cell makes liver cells**.
- **Gametes:** most tags are **removed from egg and sperm**, so the zygote can make **every kind of cell**.
- **Not all:** some remain and **depend on the parent**, a gene off in one parent's copy and on in the other's. Many control growth.

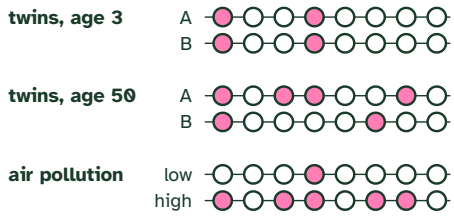
	LIGER	TIGON
Parents	Lion father, tigress mother	Tiger father, lioness mother
Size	**Larger than both parents**	No larger, often smaller
Tags	Strong growth genes, weak brakes	Weak growth genes, strong brakes

Same mix of genes: the tags differ. One explanation

D2.2.8, D2.2.10

The environment leaves *marks*

- Diet, stress, smoking and pollution can **add or remove tags**, changing gene expression.
- **Air pollution:** children who breathe more carry more methyl tags on an immune gene's promoter, and **express it less**.
- **Monozygotic twins** share their base sequence, so differences in their tags come from the **environment**.
- Twins' tags are alike when young and **differ more with age**, more so if they lived apart.

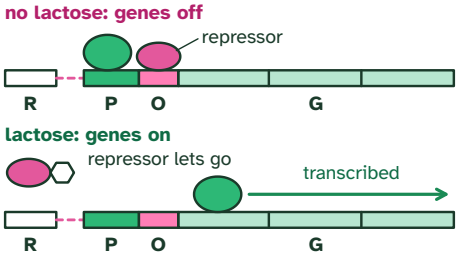


Pink: a methylated site. A cartoon of the pattern, not data.

D2.2.11

Signals from *outside*

- **Hormone:** oestrogen, a steroid, **passes through the membrane** and binds a receptor inside target cells (uterus lining).
- Together they act as a **transcription factor**, raising transcription of genes for growth and division.
- **Lactose in *E. coli*:** a repressor binds the **operator**, so RNA polymerase cannot transcribe the lac genes.
- A form of lactose **binds the repressor**, which lets go: enzymes are made **only when lactose is present**.



FOUR PARTS OF AN OPERON

R	**Regulatory gene**	makes the repressor
P	**Promoter**	RNA polymerase binds
O	**Operator**	the repressor binds
G	**Genes**	transcribed together

WATCH OUT

Six mistakes that *cost marks*

- ✕ **A promoter is DNA, not a protein.** Transcription factors, activators and repressors are the proteins that bind it.
- ✕ **A gene does not code for a trait.** It codes for a polypeptide; the trait comes from the protein.
- ✕ **Cells differ in the genes they express, not the genes they have.** A skin cell carries the insulin gene.
- ✕ **Methylation does not change the base.** A methylated C still pairs with G; the sequence reads as before.
- ✕ **Twins who differ have not changed genes.** Their tags, and so their expression, differ.
- ✕ **Ligers and tigons share their genes.** Only the parent each tag came from differs.

COVER THE SHEET

Can you *answer these?*

1. Outline how the tyrosinase gene affects skin colour.
2. Describe the roles of promoters, enhancers and transcription factors.
3. Explain how mRNA lifetime regulates translation.
4. Distinguish genome, transcriptome and proteome.
5. State the effects of promoter and of histone methylation.
6. Explain how tags keep a pattern of expression in mitosis.
7. Explain why ligers grow larger than tigons.
8. Outline what twin studies show about gene expression.
9. Describe how lactose switches on the lac operon.

IN THE EXAM

Name the DNA sequence and the protein that binds it, then whether transcription rises or falls. In epigenetics, add **"the base sequence is unchanged"**.

GO FURTHER

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