A-LEVEL BIOLOGY • EXERCISE SHEET

16.3 Gene control

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

KEY WORDS lac operon 乳糖操纵子 • regulatory gene 调节基因 • structural gene 结构基因 • transcription 转录 • transcription factor 转录因子

Objective

Build the skills to answer exam questions on **gene control** — **structural and regulatory genes** 结构/调节基因, **inducible and repressible enzymes** 可诱导/可抑制酶, the **lac operon** 乳糖操纵子, and **transcription factors** 转录因子.

You must be able to:

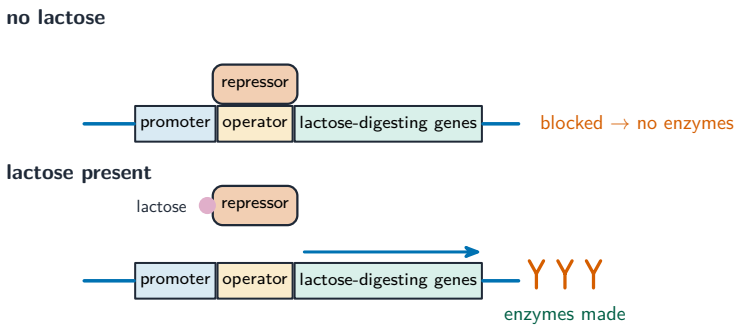
- distinguish structural and regulatory genes, and inducible and repressible enzymes
- explain the control of protein production by the lac operon
- state the role of transcription factors and explain gibberellin's action via DELLA proteins

1 Worked examples

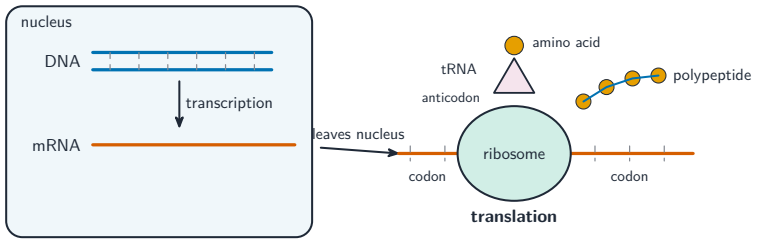
■ Genes and enzymes

A **structural gene** codes for a useful protein (e.g. an enzyme); a **regulatory gene** controls whether other genes are switched on. An **inducible enzyme** is made only when needed; a **repressible enzyme** is normally made but can be switched off.

■ The lac operon



A repressor blocks the genes until lactose pulls it off — so the enzymes are inducible



Gene control acts on transcription and translation

- **no lactose**: a **repressor** 阻遏物 protein binds the operator and blocks **transcription** 转录 — no enzymes made.
- **lactose present**: lactose binds the repressor and pulls it off; transcription occurs and the lactose-digesting enzymes are made (they are **inducible**).

■ Transcription factors and gibberellin

In eukaryotes, **transcription factors** are proteins that bind DNA and raise or lower the rate of transcription. **Gibberellin** 赤霉素 switches genes on by causing the breakdown of **DELLA** protein repressors, which normally block the factors that promote transcription.

2 Practice

2.1 State the difference between a structural gene and a regulatory gene. [2]

2.2 State what is meant by an inducible enzyme. [1]

3 Exam-style questions

3.1 In the lac operon, when **no** lactose is present, the repressor protein: [1]

- **A** is broken down
- **B** binds the operator and blocks transcription
- **C** is transcribed into mRNA
- **D** binds the lactose-digesting enzymes

3.2 What is the role of a transcription factor in a eukaryotic cell? [1]

- **A** to replicate DNA
- **B** to bind DNA and control the rate of transcription
- **C** to translate mRNA
- **D** to break down glucose

3.3 Explain how the lac operon allows a bacterium to make lactose-digesting enzymes only when lactose is present. [4]

3.4 Explain how gibberellin switches on genes by acting on DELLA proteins. [2]

3.5 In *Escherichia coli* the *lac* operon controls the enzymes that break down lactose.

(a) Distinguish between a structural gene and a regulatory gene, using the *lac* operon as your example. [3]

(b) Describe what happens at the operon when **no** lactose is present. [3]

(c) Describe what happens when lactose **is** present, and explain why the enzymes are described as inducible. [4]

(d) Explain the advantage to the bacterium of controlling these genes in this way. [2]

Solutions

2.1 a structural gene codes for a (useful) protein such as an enzyme; a regulatory gene controls whether other genes are switched on.

2.2 an enzyme that is made only when it is needed (e.g. when its substrate is present).

3.1 B. With no lactose, the repressor binds the operator and blocks transcription.

3.2 B. A transcription factor binds DNA and increases or decreases the rate of transcription.

3.3 when no lactose is present, the repressor binds the operator and blocks transcription, so no enzymes are made; when lactose is present, it binds the repressor and removes it from the operator; transcription can now occur, so the lactose-digesting enzymes are made.

3.4 gibberellin causes the breakdown of DELLA protein repressors; these normally block the transcription factors, so removing them lets the genes be transcribed/expressed.

3.5 (a) A structural gene codes for a protein used by the cell — here *lacZ*, coding for β-galactosidase; a regulatory gene codes for a protein that controls the transcription of other genes — here *lacI*, coding for the repressor.
(b) The regulatory gene is transcribed and the **repressor** protein is made; the repressor binds to the operator region; this blocks RNA polymerase from moving along the structural genes, so no mRNA and no enzyme are made.
(c) Lactose acts as the **inducer**: it binds to the repressor and changes its shape so that it can no longer bind to the operator; RNA polymerase is then free to transcribe the structural genes and the enzymes are made. They are *inducible* because they are produced only when their substrate is present to switch them on.
(d) Making enzymes costs amino acids and ATP, so producing them when there is no lactose to digest would be wasteful; the bacterium makes them only when they can be used, which gives it a selective advantage.