

5.6 Gene switching and transcription factors

Name: _____ Class: _____ Date: _____ **Total: 18 marks**

KEY WORDS transcription factor • epigenetics • methylation • imprinting

Objective

Practise statement 7.22: transcription factors switching genes on and off, steroid-hormone receptors acting as transcription factors, and epigenetic control by DNA methylation and histone modification.

1 Key knowledge and worked examples

■ The switch itself

A **transcription factor** is a protein that binds a gene’s promoter region and either enables or blocks RNA polymerase. In this activation model, the bound factor helps assemble the transcription machinery. Different cells use different combinations of transcription factors, contributing to differentiation.

■ Steroids walk in

Steroid hormones diffuse through the cell membrane and bind an internal receptor; the activated receptor binds regulatory DNA in the nucleus and acts as a transcription factor. Testosterone and oestrogen can regulate genes this way; the hormone molecule itself is not a DNA-binding protein.

■ Epigenetics

Control WITHOUT changing the base sequence: **methylation** of cytosine at a promoter silences the gene; histone acetylation loosens the DNA (active) while deacetylation packs it tight (silent). Epigenetic marks can be maintained through cell division. Heavy methylation at some tumour-suppressor promoters can reduce protective gene expression; imprinting errors can disrupt development, including some cases of Prader-Willi syndrome.

■ Worked example: cancer by silence

In this simplified model, a tumour-suppressor promoter becomes heavily methylated in a lung cell lineage. This reduces transcription-factor binding and gene expression, so less protective protein is made. Weakened cell-cycle control can contribute to uncontrolled division. The explanation changes gene activity without requiring a change in DNA sequence.

2 Practice

2.1 State what a transcription factor does. [1]

2.2 Name the two epigenetic mechanisms that silence genes without changing the base sequence. [2]

2.3 Explain how a steroid hormone can alter transcription through an intracellular receptor, whereas adrenaline first binds a cell-surface receptor. [2]

3 Exam-style questions

3.1 Explain how a gene can be switched on by a transcription factor, naming where the factor binds and what changes at the gene. [4]

3.2 The RASSF1 gene is a tumour suppressor. In some cancer cells its promoter is heavily methylated. Explain how this methylation leads to uncontrolled cell division. [5]

3.3 One gene can produce several different proteins in different tissues. Explain how, referring to post-transcriptional processing of the pre-mRNA. [4]
