A-Level Biology

Regulation of Transcription and Translation

Question Paper

Time available: 62 minutes
Marks available: 47 marks

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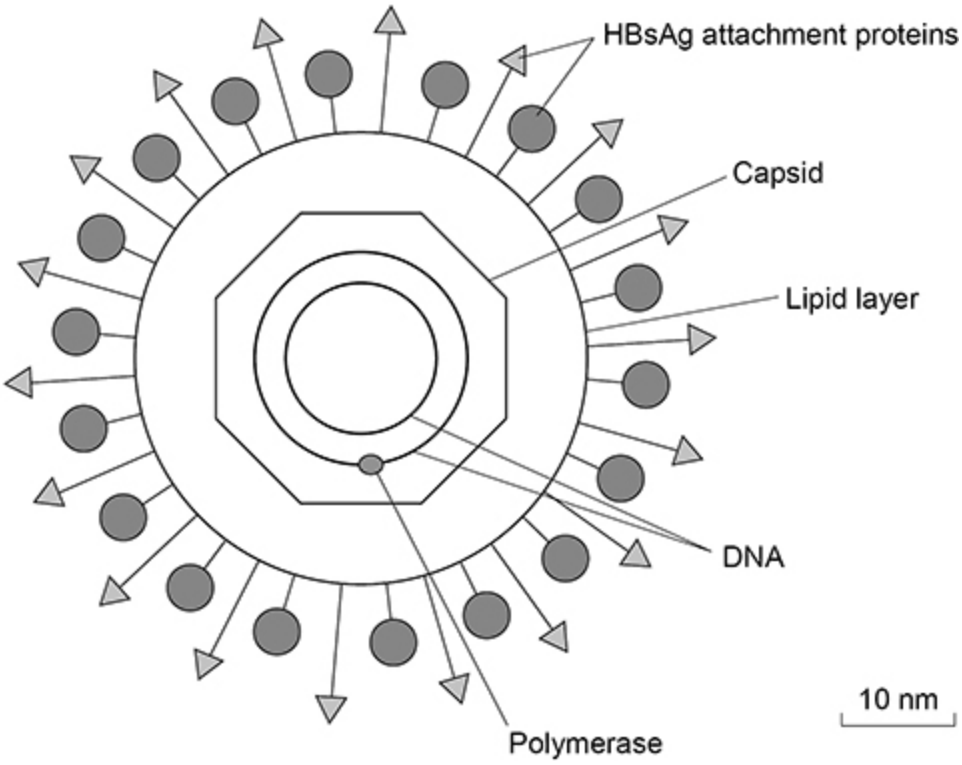
1. Hepatitis B is a life-threatening liver infection caused by the hepatitis B virus (HBV).

Figure 1 shows the structure of HBV.

Figure 1



(a) HBV infects a liver cell. The liver cell is 25 μm in diameter.

Use **Figure 1** to calculate how many times larger in diameter this cell is than HBV. You should use the lipid layer to measure the diameter of HBV.

Answer _____ times larger

(2)

Scientists investigated the effectiveness of two types of RNA interference (RNAi) molecules on reducing HBV replication. These molecules were:

- short hairpin RNA (shRNA)
- long hairpin RNA (lhRNA).

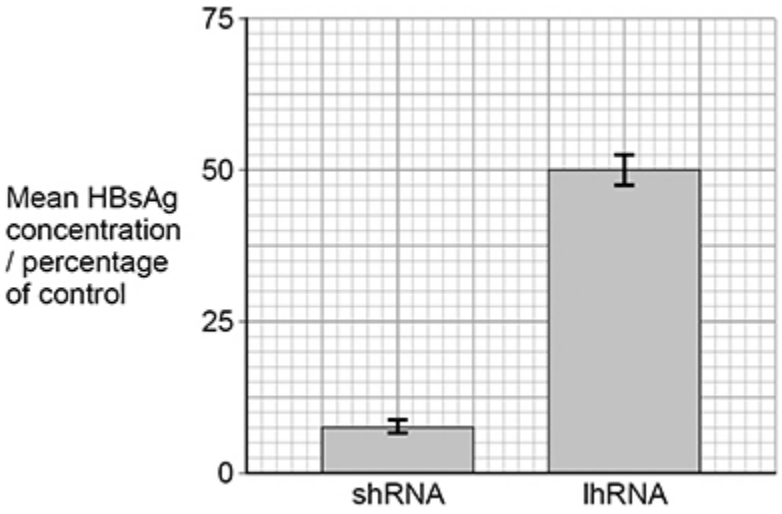
The scientists infected mouse liver cells with HBV and transferred either shRNA or lhRNA into these cells. Then they determined the concentration of the attachment proteins, HBsAg, in these cells.

The concentration of HBsAg is a measure of HBV replication.

Figure2 shows the scientists' results.

The error bars represent ±2 standard deviations from the mean, which includes over 95% of the data.

Figure 2



(b) One method of transferring RNAi molecules into cells involves combining these molecules with a lipid. Suggest why this increases uptake of RNAi molecules into cells.

(1)

(c) Using all the information provided, evaluate the use of the two types of RNAi in treating hepatitis B in humans.

Do **not** refer in your answer to how RNAi reduces HBV replication.

(5)

(Total 8 marks)

2. (a) Define what is meant by epigenetics.

(2)

(b) In eukaryotes, transcription of target genes can be stimulated or inhibited when specific transcriptional factors move from the cytoplasm into the nucleus.

Oestrogen, methyl groups and acetyl groups are control factors that can play a role in initiating transcription.

Complete the table to show features of these control factors.

Put a tick (✓) in the box if the control factor shows the feature.

	Feature	
Control factor	**Binds with DNA**	**Binds with protein**
Oestrogen		
Methyl groups		
Acetyl groups		

(2)

(c) Explain how increased methylation could lead to cancer.

(3)

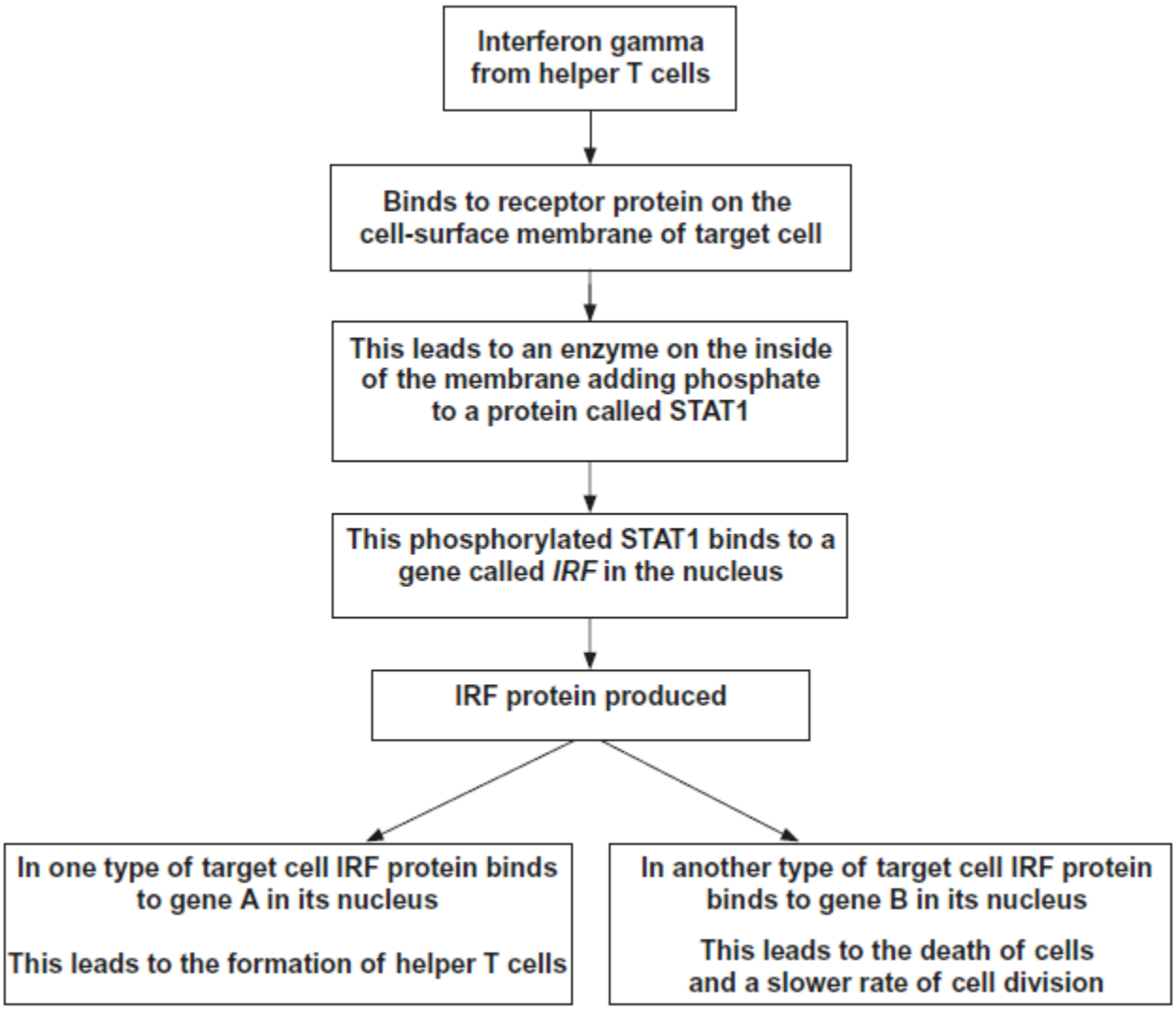
(d) Give **one** way in which benign tumours differ from malignant tumours.

(1)

(Total 8 marks)

3. Interferon gamma is a substance secreted by some types of white blood cells, including helper T cells. It regulates the production of a number of proteins by target cells. Which protein is produced depends on the type of target cell.

The diagram shows how interferon gamma regulates three genes.



(a) Use information in the diagram to suggest how the binding of interferon gamma to its receptor protein leads to the production of phosphorylated STAT1.

_____

_____

_____

_____

(2)

(b) Name the **two** transcription factors in the diagram.

1. _____

2. _____

(2)

(c) The regulation of the formation of helper T cells by interferon gamma is an example of positive feedback.

Explain why it is an example of positive feedback.

_____

_____

_____

_____

(2)

(d) The *IRF* gene can be a tumour suppressor gene.

Use the information in the diagram to explain how the *IRF* gene acts as a tumour suppressor gene.

_____

_____

_____

_____

_____

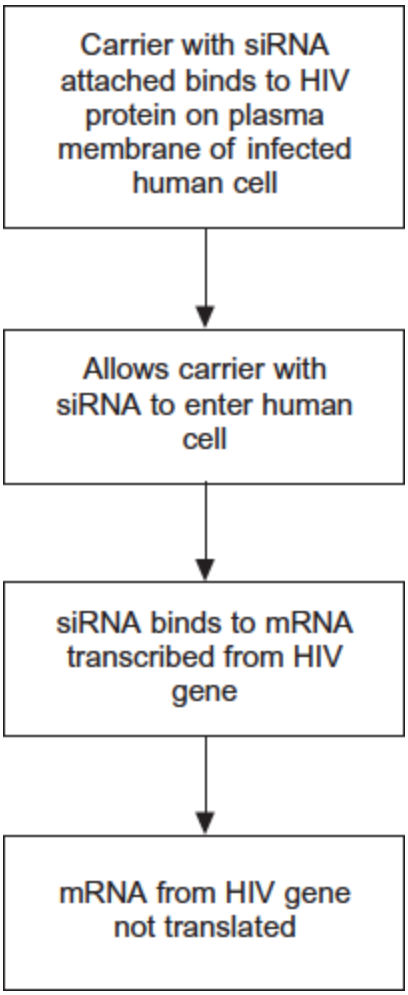
_____

(3)

(Total 9 marks)

4. Human immunodeficiency virus (HIV) particles have a specific protein on their surface.This protein binds to a receptor on the plasma membrane of a human cell and allows HIV to enter. This HIV protein is found on the surface of human cells after they have become infected with HIV.

Scientists made siRNA to inhibit expression of a specific HIV gene inside a human cell. They attached this siRNA to a carrier molecule. The flow chart shows what happens when this carrier molecule reaches a human cell infected with HIV.



(a) When siRNA binds to mRNA, name the complementary base pairs holding the siRNA and mRNA together. One of the bases is named for you.

_____with_____

_____**Adenine**_____with_____

(1)

(b) This siRNA would **only** affect gene expression in cells infected with HIV.

Suggest **two** reasons why.

1. _____

_____

_____

_____

2. _____

_____

_____

_____

(4)

(c) The carrier molecule on its own may be able to prevent the infection of cells by HIV.

Explain how.

_____

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_____

_____

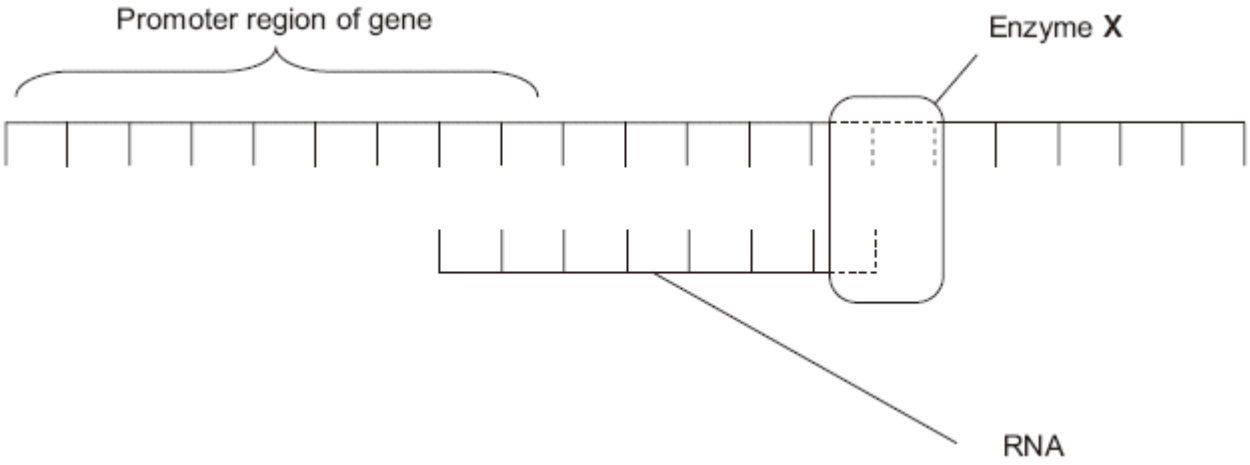
_____

(2)

(Total 7 marks)

5. **Figure 1** shows part of a gene that is being transcribed.

Figure 1



(a) Name enzyme **X**.

_____

(1)

(b) (i) Oestrogen is a hormone that affects transcription. It forms a complex with a receptor in the cytoplasm of target cells. Explain how an activated oestrogen receptor affects the target cell.

_____

_____

_____

_____

(2)

(ii) Oestrogen only affects target cells. Explain why oestrogen does not affect other cells in the body.

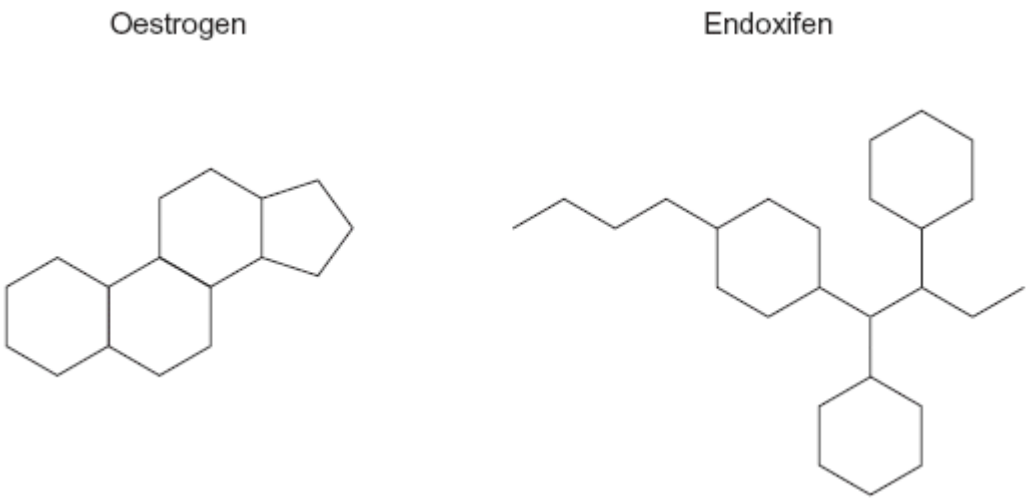
_____

_____

(1)

(c) Some breast tumours are stimulated to grow by oestrogen. Tamoxifen is used to treat these breast tumours. In the liver, tamoxifen is converted into an active substance called endoxifen. **Figure 2** shows a molecule of oestrogen and a molecule of endoxifen.

Figure 2



Use **Figure 2** to suggest how endoxifen reduces the growth rate of these breast tumours.

_____

_____

_____

_____

(2)

(Total 6 marks)

6. Testosterone is a steroid hormone that belongs to a group of male sex hormones called androgens.

(a) Steroid hormones are hydrophobic.

Explain why steroid hormones can rapidly enter a cell by passing through its cell-surface membrane.

_____

_____

_____

_____

_____

_____

_____

(2)

(b) In the cytoplasm, testosterone binds to a specific androgen receptor (AR).
An AR is a protein.

Suggest and explain why testosterone binds to a specific AR.

(2)

(c) The binding of testosterone to an AR changes the shape of the AR. This AR molecule now enters the nucleus and stimulates gene expression.

Suggest how the AR could stimulate gene expression.

(2)

The gene that codes for the AR has a variable number of CAG repeats.
Some studies have shown an association between the number of CAG repeats and the risk of developing prostate cancer.

The table below shows the results of a statistical test from one study.

Number of CAG repeats in the *AR* gene	**Probability (P) value**
⩽ 16	0.02
⩽ 17	0.30
⩽ 18	0.07
⩽ 19	0.09
⩾ 20	0.06

(d) What can you conclude from the data in the table above?

(3)

(Total 9 marks)