2018 Cell Signalling STQ

2018 / H2 / ACJC PRELIM / P2 Q2

1 Fig. 2.1 shows the activation of a G-protein linked receptor (GPLR) found in the cell surface membrane upon binding of a drug, salbutamol. Salbutamol is often used in the treatment of asthma – a long-term condition which narrows the airways in the lungs. The G protein consists of three subunits - α, β, and γ.

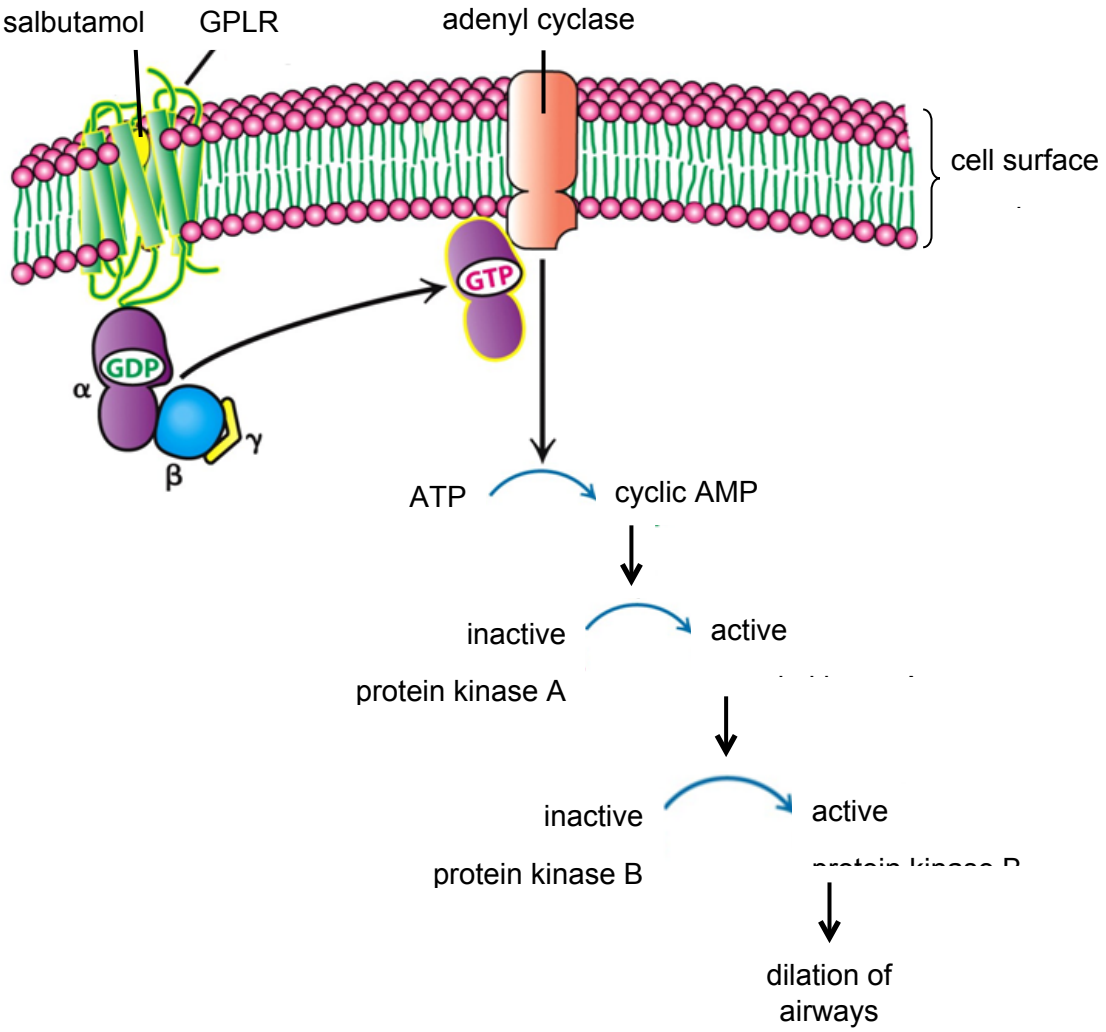

Fig. 2.1

(a) Describe how GPLR is held within the cell surface membrane.

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..... [2]

(b) With reference to Fig. 2.1, describe how the use of salbutamol can relieve symptoms of asthma.

[4]

(c) There are many different types of receptors used by a cell to transduce extracellular signals. Some are located on the cell surface membrane while others are located within the cell.

Explain why some receptors are found on the cell surface membrane while others are found within the cell.

[2]

[Total: 8]

Question 2

For Examiner's use

Many types of animal cells need to receive chemical signals to survive and grow. Fig. 3 shows how a cell receives Insulin-like Growth Factor 1 (IGF1) and prevents the cell from triggering apoptosis (cell death).

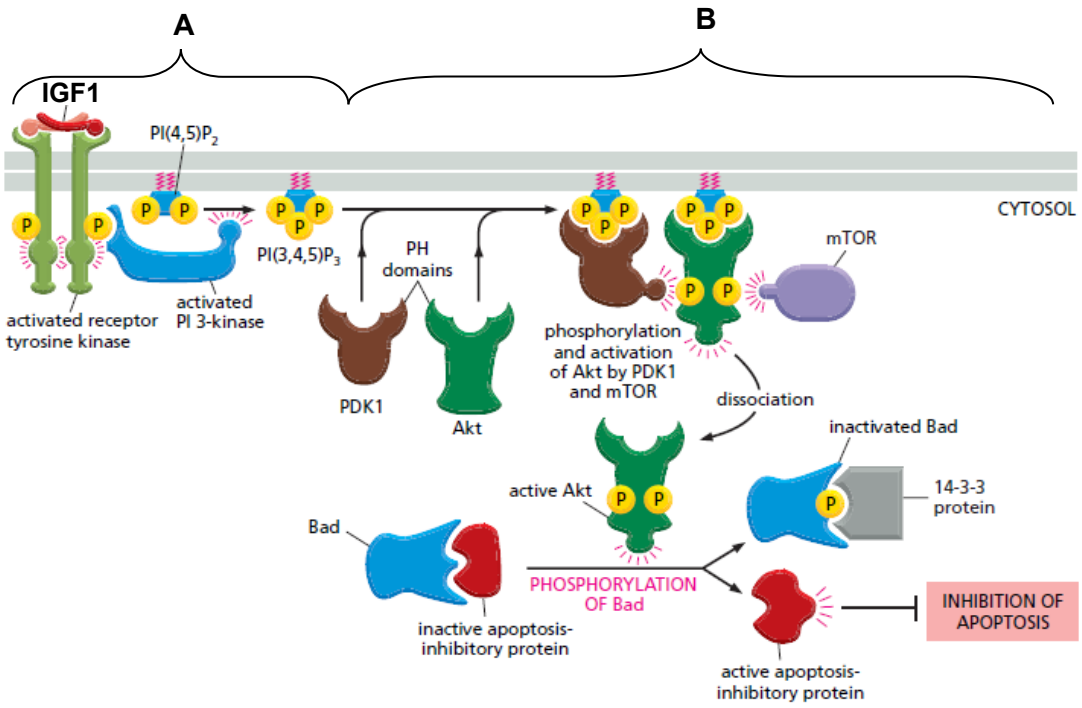

Fig. 3

(a) Describe stages A and B shown in Fig. 3. [6]

A:

For Examiner's use

B:

Scientists have found that the PI 3-kinase and Bad protein of the IGF1 signalling pathway has been mutated in tumour cells. Tumour cells are uncontrolled dividing cells which are resistant to apoptosis.

(b) Describe a possible mutation of the following proteins and the corresponding effect of the mutation of the protein's activity in tumour cells.

(i) PI 3-kinase [2]

(ii) Bad protein [2]

Total: [10]

3 Fig. 7.1 shows a CREB (cAMP response element binding) signalling pathway. This pathway is triggered when ligand X binds to a receptor at the cell membrane.

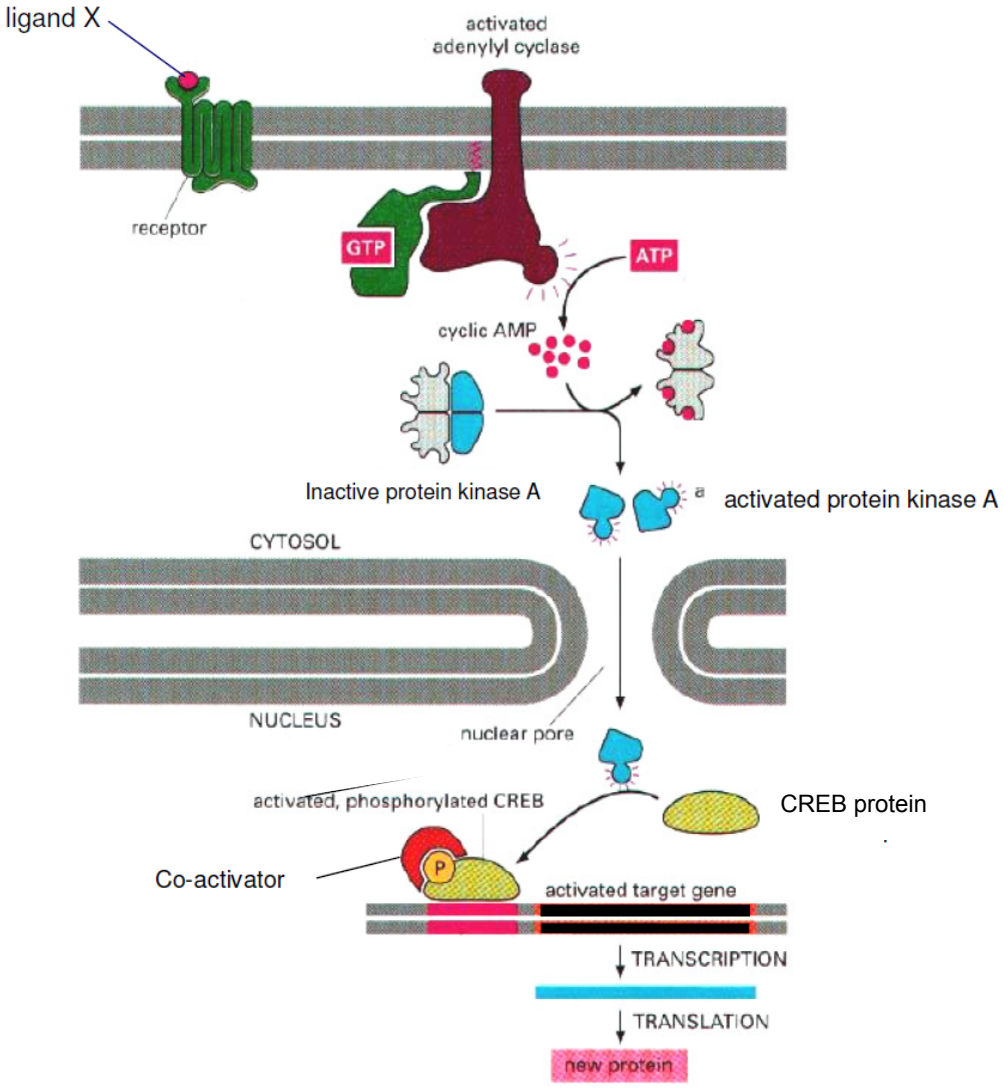

Fig. 7.1

(a) With reference to Fig. 7.1,

(i) Describe precisely the structure of the G protein coupled receptor and explain how the described structure enables it to perform its function.

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(ii) Describe how protein kinase A (PKA) is activated.

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(iii) State the role of PKA in this signaling pathway?

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(b) CREB is an activator protein that binds to its specific control element to upregulate the transcription of the target gene.

Explain how an activator protein like CREB can upregulate transcription of a gene.

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……[3]

(c) CREB is known to be involved in other signaling pathways. With reference to Fig. 7.1 or otherwise, suggest how it is possible for CREB to bind to other control elements so as to regulate the transcription of different genes.

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……[1]

[Total: 9]

2018 / H2 / MJC PRELIM / P2 Q6

QUESTION 4

STAT proteins are cytoplasmic transcription factors that play important roles in the development and differentiation of many cell types. Upon external stimulation, STAT protein is activated from its inactive form and binds to another activated STAT protein to form a dimer. This protein dimer then translocates to the nucleus and regulates the expression of other genes as shown in Fig. 6.1.

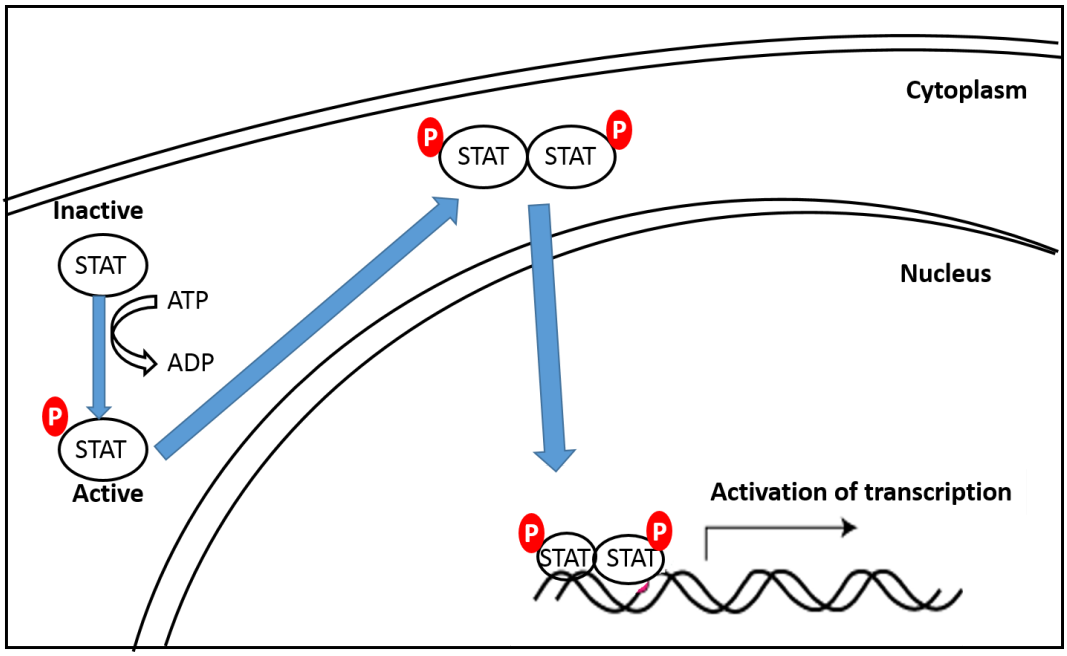

Fig. 6.1

(a) With reference to Fig. 6.1,

(i) explain how the inactive STAT protein is converted to its active form. [2]

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(ii) besides converting the inactive form of STAT protein to its active form, describe how the level of the inactive STAT protein may be controlled after its production. [2]

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STAT5 gene, a member of the *STAT* family, is widely expressed in hematopoietic stem cells (HSC) to regulate the self-renewal and differentiation of the stem cells.

Fig. 6.2 shows the differentiation of HSC leading to the formation of different cell types such as T cell and B cell.

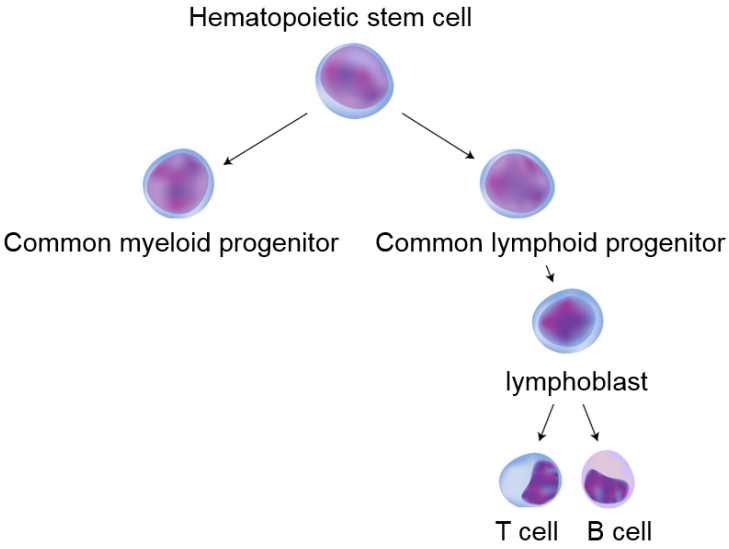

Fig. 6.2

(b) Explain how the different cell types such as T cell and B cell can arise from a single hematopoietic stem cell. [3]

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(c) In humans there are different forms of STAT5 protein, each plays a slightly different role in different cell types.

Explain how the same *STAT5* gene can produce different forms of STAT5 protein. [2]

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[Total: 9]

5 In an experiment to investigate the effect of insulin on glucose uptake by muscle cells, the concentration of free glucose inside muscle cells was measured with respect to the extracellular glucose concentration, in the presence of insulin (labelled as insulin) and in the absence of insulin (labelled as control).

Fig. 2.1 shows the results of the experiment.

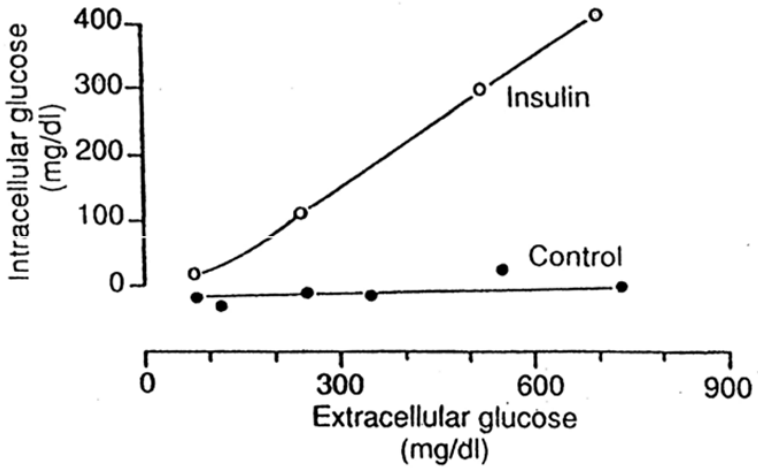

Fig. 2.1

(a) With reference to Fig. 2.1, describe the effect of insulin on glucose uptake by muscle cells.

[3]

(b) **(i)** Name the type of receptor that insulin binds to on the muscle cell.

[1]

(ii) Explain how the binding of insulin to its receptor could result in the effect shown in Fig. 2.1.

[4]

(c) Suggest how the effect of insulin on glucose uptake by muscle cells could be terminated.

[1]

[Total: 9]

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6 Fig. 9.1 shows the glucagon signalling pathway.

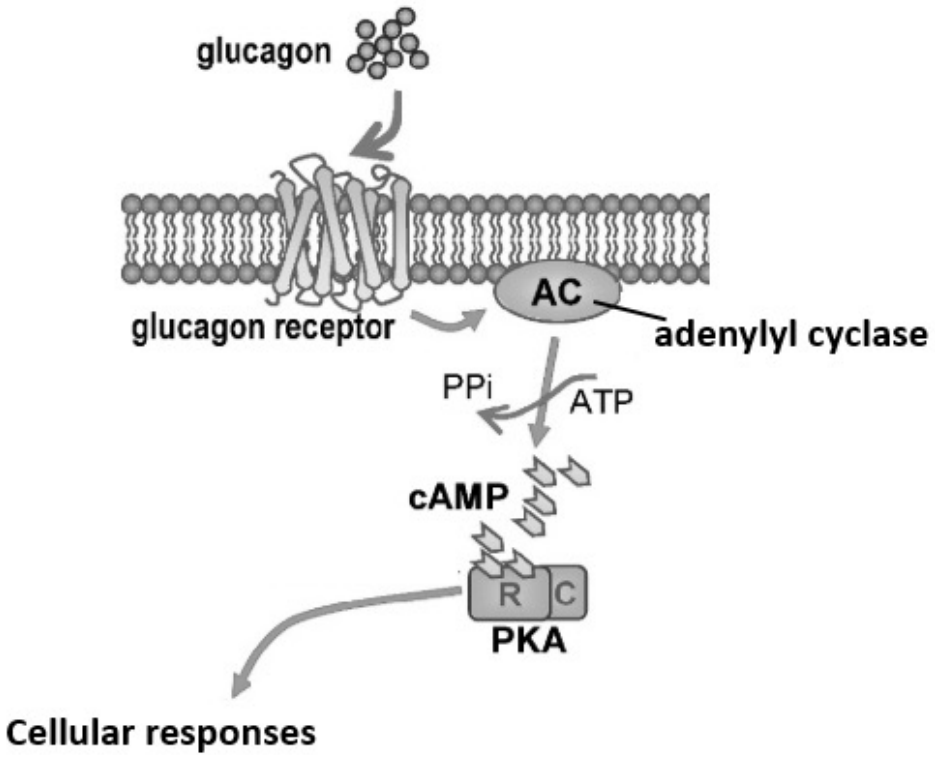

Fig. 9.1

(a) In humans, in which types of cells are glucagon receptors mainly found?

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(b) Describe how the glucagon receptor transmits information from the external environment to activate adenylyl cyclase inside of the cell.

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[Turn over

(c) Describe two cellular responses resulting from the cell signalling pathway shown in Fig. 9.1.

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(d) In signal transduction pathways, how can the response of the target cell to a hormone be amplified?

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[Total: 8]

QUESTION 7

Fig 1.1 shows the structure of a G-protein-linked receptor (GPLR) from a cross-section of the plasma membrane.

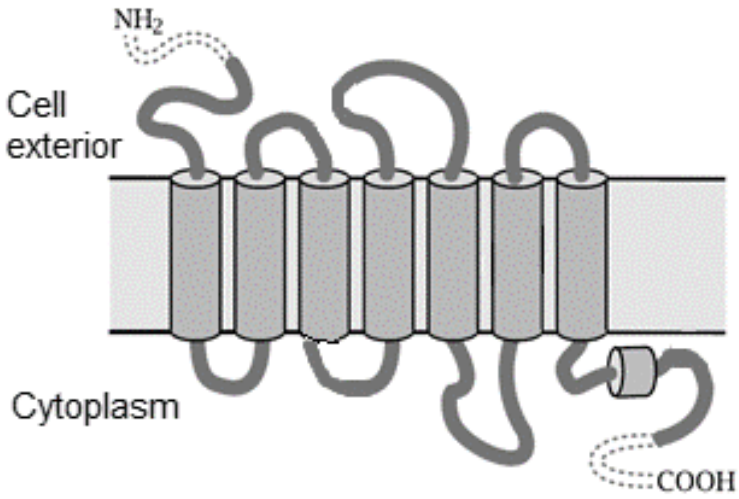

Fig 1.1

(a) With reference to **Fig 1.1**, describe the significance of R groups to the structure and function of a GPLR.

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(b) The GPLRs make up the largest family of cell surface receptors. Outline the route taken by the GPLR after its synthesis to its final location in the plasma membrane.

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GPLRs are found to be closely associated with a type of G protein called K-Ras in the cell signaling pathways.

Fig. 1.2 is a simplified diagram showing the normal roles of GPLR and K-Ras in the RAS/MARK signaling pathway.

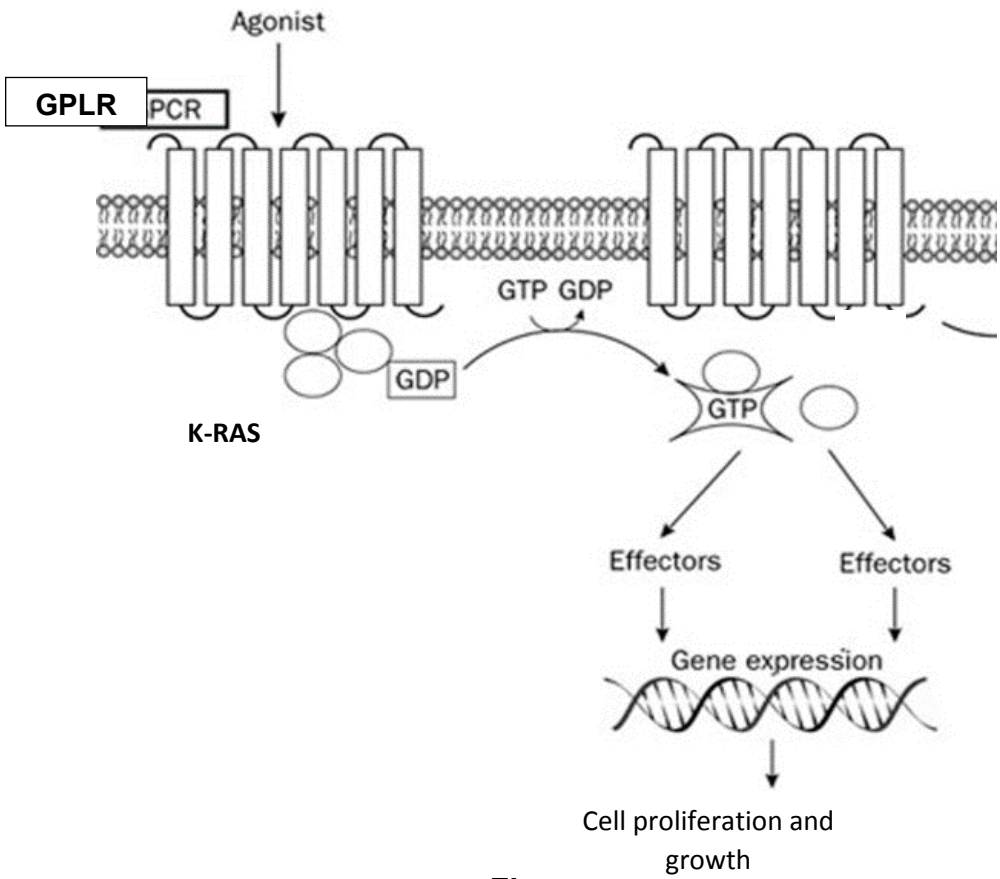

Fig.

(c) Assuming that the effectors (in **Fig. 1.2**) in the transduction pathways function normally, explain how a mutation can lead to the formation of tumours in cancer.

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2018 / H2 / VJC PRELIM / P2 Q6

8 Some hormones circulating in the blood are able to trigger transcription within a cell, even though they are unable to enter the cell. Phosphatases and kinases then take part in cell activities that eventually result in genes switching on and transcription beginning.

(a) Suggest why the hormones, referred to in the passage, are unable to enter the cell.

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(b) Use the information in the passage to outline the process of cell signalling.

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(c) Explain the role of the following in cell signalling.

(i) Phosphatases

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(ii) Kinases

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…… [2]

[Total: 9]