VICTORIA JUNIOR COLLEGE
BIOLOGY DEPARTMENT
JC2 PRELIMINARY EXAMINATIONS 2016
Higher 2

CANDIDATE NAME

CLASS	1	5	S		

EXAM NUMBER								

BIOLOGY 9648/02

Paper 2 Core Paper **14 September 2016**

Additional Materials: Answer Paper **2 hours**

READ THESE INSTRUCTIONS FIRST

Write your Class, exam number and name on all the work you hand in.
Write in dark blue or blue pen.
You may use a soft pencil for any diagrams or graphs.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided on the question paper.

Section B
Answer any **one** question on the writing paper provided.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use the appropriate units.

At the end of the examination,
1. hand in sections A and B separately;
2. fasten all your work securely;
3. enter the question number of section B that you have answered in the grid opposite.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
6	
7	
8	
Section B	
Total	

Section A: Structured questions
Answer **all** the questions. All answers must be written on the spaces provided and nowhere else.

1 (a) **Fig. 1.1** shows the electro-micrograph of a T-helper cell found in the bloodstream of a healthy individual. **Fig 1.2** shows the how a region of the T-helper cell looks like when magnified.

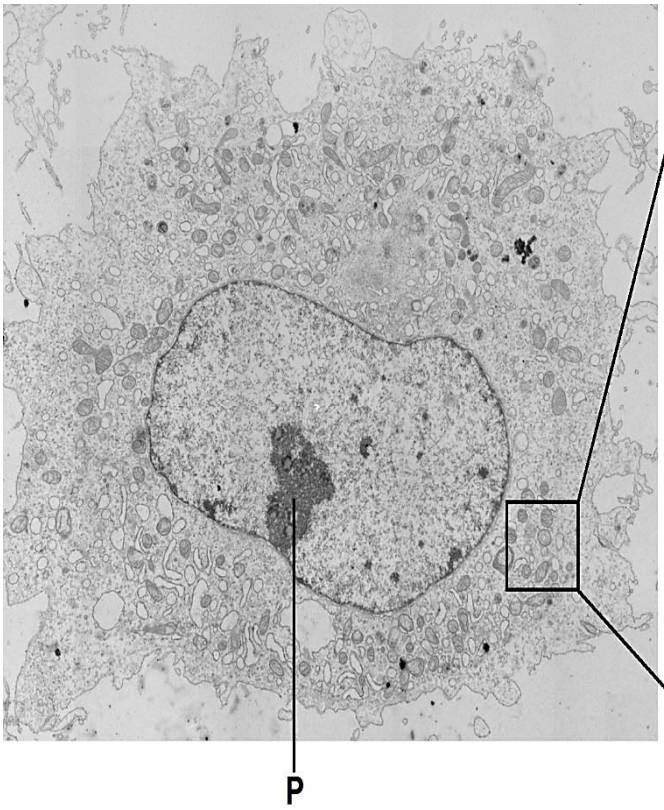


Fig. 1.1 EM of T helper cell

Fig. 1.2 Magnified region of a part of the T helper cell

(i) Identify structures **P** and **Q** and describe briefly their functions.

[3]

(ii) Contrast the structure of a lysosome with structure **P**.

[2]

(b) The cytoplasm of T-helper cells contains different proteins and enzymes, one of which is phosphofructokinase involved in the metabolism of glucose to produce energy necessary for cell survival and functions. In order to ensure a constant supply of energy, most organisms have evolved the use of storage molecules to store excess glucose.

(i) Name a carbohydrate that functions as a storage molecule for T-helper cells.

[1]

(ii) Describe **three** structural differences between the carbohydrate named in **(b) (i)**. and cellulose.

[3]

(iii) Explain how the presence of two types of bonds in amylopectin enables it to carry out its function.

[3]

(c) Phosphofructokinase is an allosteric enzyme. Explain how the presence of an allosteric inhibitor affects the enzymatic activity of an allosteric enzyme.

[2]

[Total: 14]

2 The Fig. 2.1 shows an enzyme involved in the activation of tRNA for translation in prokaryotes.

Fig 2.1

(a) (i) Explain the mode of action of this enzyme.

[3]

(ii) Explain the significance of having more than one type of the enzyme named in **(a) (i)** in the cell.

[2]

(b) How does the order of nucleotides in a gene encode the information that specifies the primary structure of a polypeptide? Include two features of the genetic code in your answer.

[3]

(c) Explain how different polypeptides can be synthesised simultaneously from a single mRNA is produced from an operon in prokaryotes.

[2]

[Total: 10]

3 Fig. 3.1 shows the *arg* operon found in *Escherichia coli*. In the absence of arginine, the operon is in the active state. In the presence of arginine, the expression of the structural genes decreases.

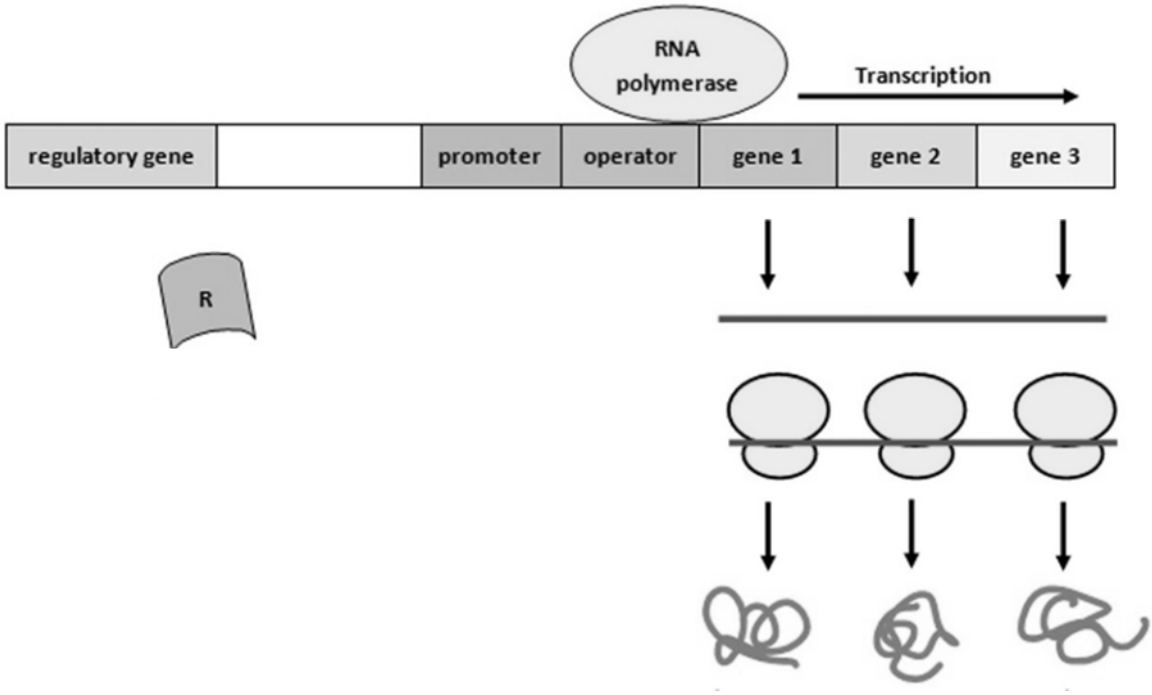


Fig 3.1

(a) Using **Fig 3.1** explain the mode of control of the Arg operon.

[2]

(b) Explain why it is useful for a bacterial cell to decrease expression of the structural genes when arginine is present.

[2]

Besides having operons, bacteria can have other means to enhance their adaptability to the changing environment through gene transfer. Fig. 3.2 shows one way in which bacteria can acquire new genetic material.

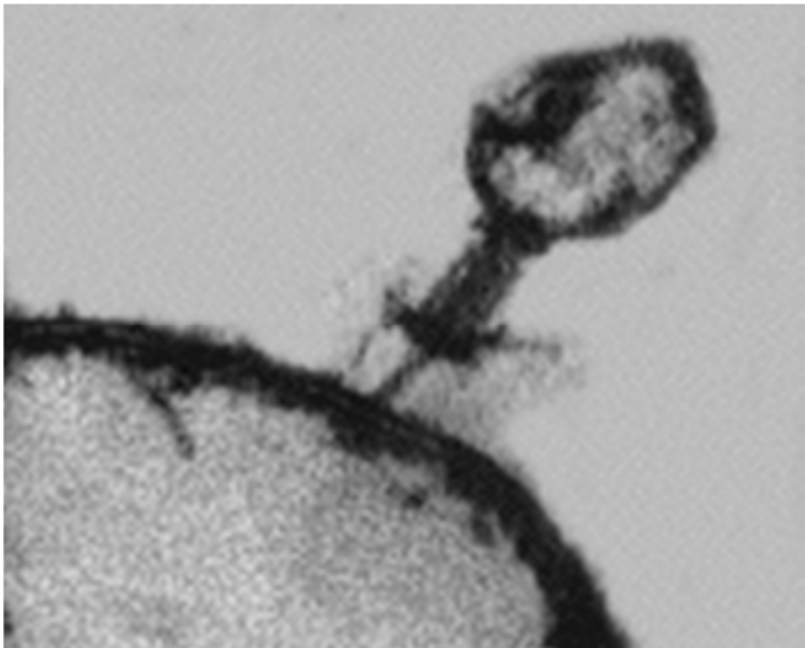


Fig. 3.2

(c) Name and describe the process which can result in this population of bacteria acquiring the same allele needed to increase their likelihood of survival.

[3]

Fig. 3.3 shows a classic experiment used to show that physical contact between bacterial cell is necessary in order for conjugation to happen

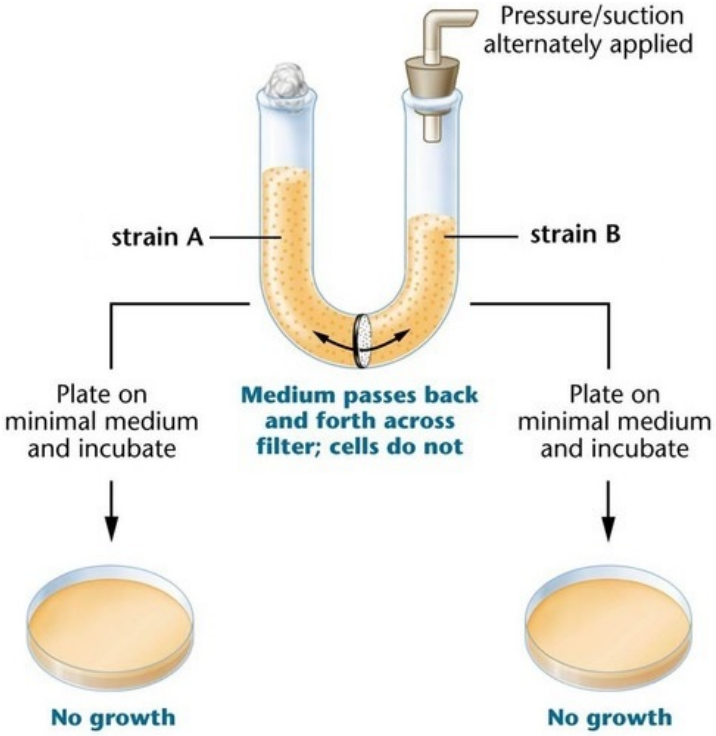


Fig. 3.3

(d) A student tried to replicate the experiment but did not get the result shown in Fig. 3.3. Instead, he observed a few bacterial colonies which are hybrids of strains A and B. He later realized that he had accidentally forgot to add in DNAase when carrying out the experiment.

(i) Briefly describe the role of DNAase in this experiment

[1]

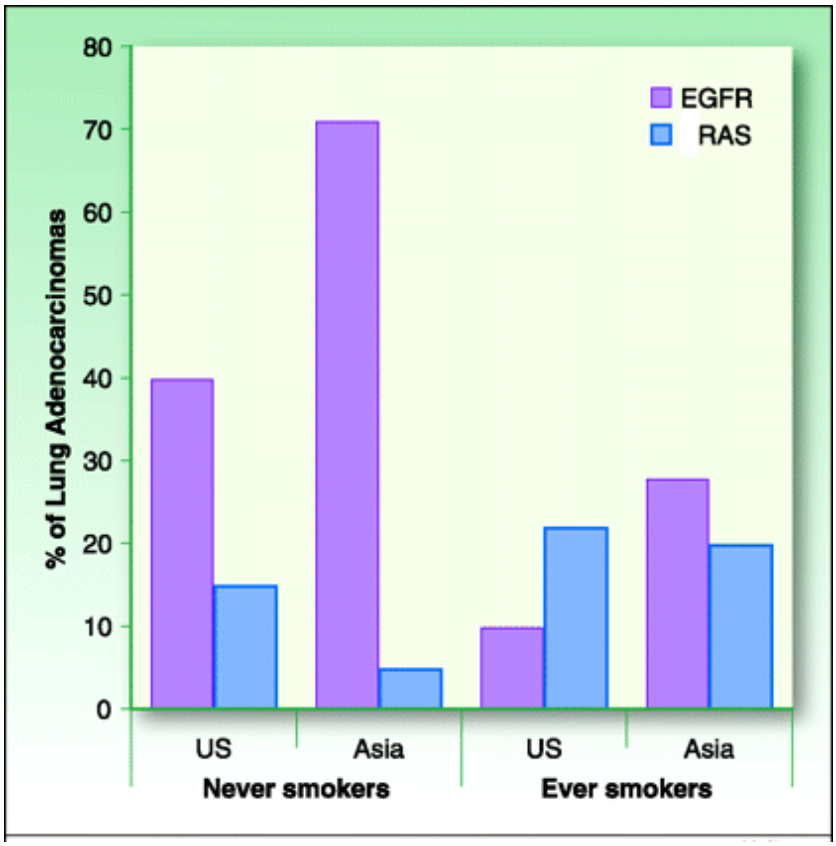
(ii) How does the lack of DNAase in the experiment result in the growth of the hybrid bacterial colonies?

[2]

[Total: 10]

4 The majority of lung cancers are caused by long term exposure to the several classes of carcinogens present in tobacco smoke. However there are instances of lung cancers arising in the absence of detectable tobacco exposure. Analysis of the different mutations in individuals who smoked (ever-smokers) and those who did not (never-smokers) suggest that lung cancers in never smokers may follow a very different cellular and molecular pathway of malignant transformation.

The Fig. 4.1 shows the differential frequencies of gene mutations of the epidermal growth factor receptor (EGFR) and Ras reported in lung adenocarcinomas in Asia versus United States, in never-smokers and ever-smokers.



http://clincancerres.aacrjournals.org/content/15/18/5646

Fig. 4.1

With reference to Fig. 4.1,

(a) (i) describe the effect of Ras and EGFR mutations on the development of lung cancer in never-smokers and ever –smokers in Asia.

[1]

(ii) Suggest the molecular basis behind why never-smokers in Asia develop lung cancer.

[2]

Data emerging over the past several years show that activating mutations in the epidermal growth factor receptor (EGFR) gene may underscore the development of a distinct class of lung cancers. EGFR signalling is triggered by the binding of growth factors resulting in the dimerization of EGFR.

(b) Suggest the role of the *EGFR* gene in relation to the development of cancer.

[3]

(c) Small molecule inhibitors of the tyrosine kinase enzymatic activity to inhibit cross-phosphorylation and signalling of the EGFR have been used in clinical treatment in the United States. Results found that the success of treatment of lung cancers is higher for never-smokers than ever-smokers. Based on Fig. 4.1 suggest why this is so.

[2]

(d) 50% of never-smokers with lung cancer also have mutations in the p53 gene. Explain how mutations in the *p53* gene may lead to the development of lung cancer.

[3]

[Total: 11]

5 In the Korean clover plant, the development of petals is determined by two genes on separate autosomes. Gene A has two alleles - the dominant allele **A** results in the development of normal petals, while the recessive allele, **a**, results in small petals. On another chromosome, the dominant allele **B** of another gene has no effect on petal development. However, allele **b** hinders petal development and so results in the formation of fused petals regardless of the nature of the allele at gene A.

A Korean clover plant was self-pollinated and obtained the following offspring:

Normal petals	46
Small petals	14
Fused petals	20

(a) (i) State the genotype and phenotype of the clover plant that was self-pollinated.

Genotype:

Phenotype: [1]

(a) (ii) Use a genetic diagram to illustrate the phenotypic ratio of the offspring from this cross.

[3]

(b) A scientist decided to study the inheritance of flower colour and plant height in another plant species. The alleles for these traits are shown below.

T: Allele for tall plants **t:** allele for dwarf plants

Y: allele for yellow flowers **y:** allele for white flowers

He carried out a cross between a heterozygous tall, yellow-flowered plant with a homozygous recessive dwarf, white-flowered plant and obtained a large number of offspring. Table 5.1 shows the results.

Phenotype	Number of offspring
Tall, yellow-flowered plant	78
Tall, white-flowered plant	22
Dwarf, yellow-flowered plant	20
Dwarf, white-flowered plant	80

Table 5.1

(i) State the expected phenotypic ratio of the offspring in Table 5.1.

[1]

(ii) Use the chi-squared (X^2) test and the table of probabilities shown in Table 5.2 to find the probability of the results of this cross departing significantly by chance from expectation. Show your working. [2]

$$X^2 = \sum \frac{(\text{Observed Value} - \text{Expected Value})^2}{(\text{Expected Value})}$$

Key to symbols

s = standard deviation	n = sample size (number of observations)	E = expected 'value'
Σ = 'sum of'	v = degrees of freedom	
x = observation	c = number of classes	
$\bar{x}$ = mean	O = observed 'value'	

Distribution of X^2

	probability, p				
degrees of freedom	**0.10**	**0.05**	**0.02**	**0.01**	**0.001**
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

Table 5.2

X^2 value = ...

number of degrees of freedom = ...

probability = ...

(iii) State what conclusions may be drawn from the probability found in (b) (ii).

.....

.....

.....

[2]

(iv) Explain the observed phenotypic ratio in Table 5.1.

.....

.....

.....

[2]

[Total: 11]

6 Myasthenia gravis is a disease of the neuromuscular junctions which causes muscular weakness. It develops because the muscle's response to repeated nerve signals declines with time, and the muscles become weak and tired.

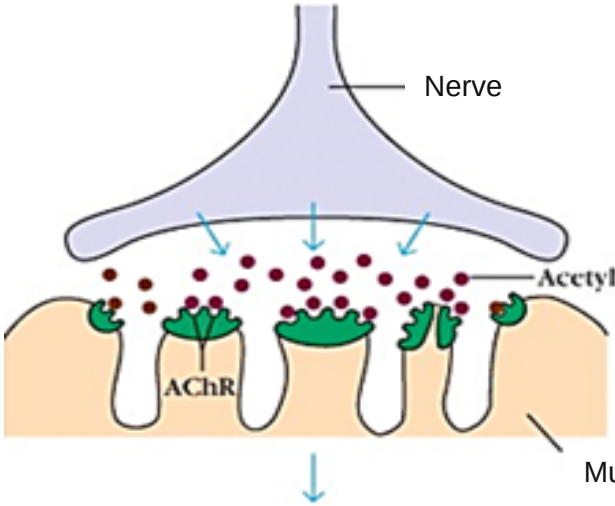


Fig. 6.1: Normal neuromuscular junction

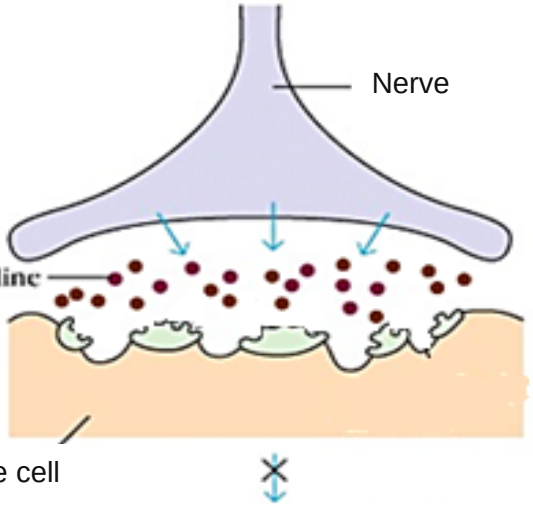


Fig. 6.2: Myasthenic neuromuscular junction

(a) (i) State one similarity in the structure of a normal and myasthenic neuromuscular junction as seen in Fig. 6.1 and 6.2 and explain how it aids in synaptic transmission.

[2]

(ii) State one difference in the structure as seen in Fig. 6.1 and 6.2 and explain how it affects synaptic transmission.

[2]

(b) Describe the mechanism that ensures unidirectional movement of nerve impulses along the axon of a neurone.

[2]

(c) Fig. 6.3 shows action potentials generated along an axon over a fixed time, X.

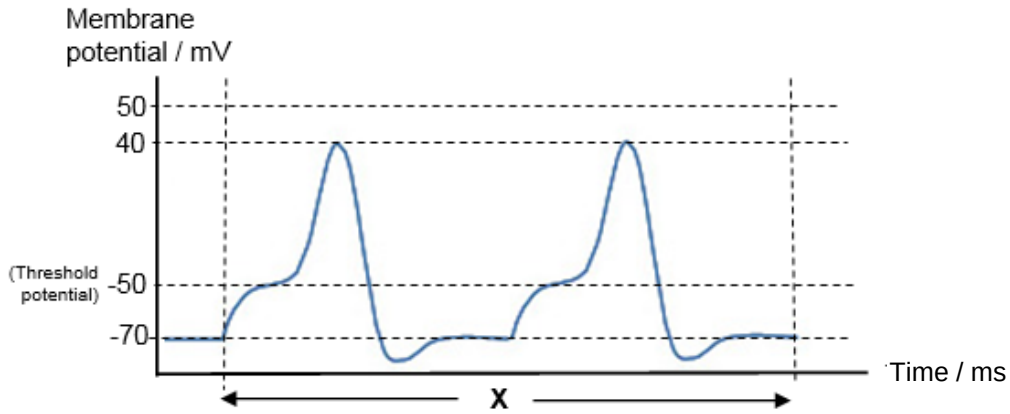
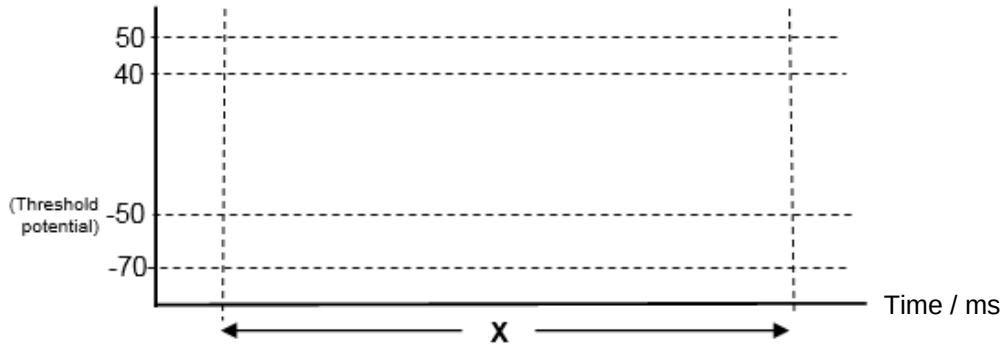


Fig 6.3

In the space provided, draw the action potentials generated over the same time period X if the stimulus is more intense. [2]



[Total: 8]

7 Glucagon plays a critical role in maintaining glucose homeostasis. The molecular mechanisms for glucagon-mediated glucose regulation are shown in Fig. 7.1.

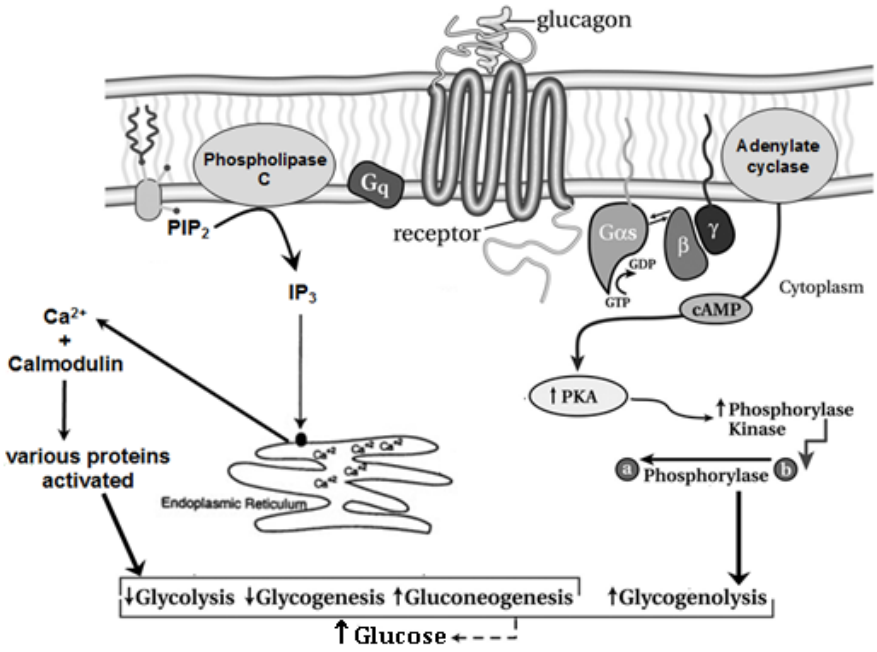


Fig. 7.1

(a) State the type of receptor that glucagon binds to and explain how this receptor is fully activated.

[2]

(b) With reference to Fig. 7.1, briefly explain how cAMP can lead to an increase in blood glucose concentration.

[3]

[Total: 5]

8 Members of the family Rhopalidae include the soapberry bugs which are brightly-coloured fruit-eaters, comprising of three genera and about 65 species. These bugs are specialists on plants in the soapberry family (Sapindaceae) in which they obtain the nutrients from the fruits by piercing the skin using their sharp beaks.

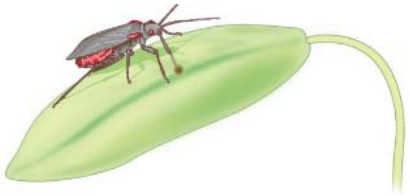


Fig. 8.1: A soapberry bug feeding on a fruit

Jadera haematoloma is a soapberry bug found in Florida following the introduction of a non-native soapberry plant in the 1920s which out-competed the native plant in some locations. At such locations, measurement of the beak length of individual bugs was also carried out (Fig. 8.2). Analysis of the fruit of the non-native plant also showed that it has thinner skin as compared to the fruit of the native plant.

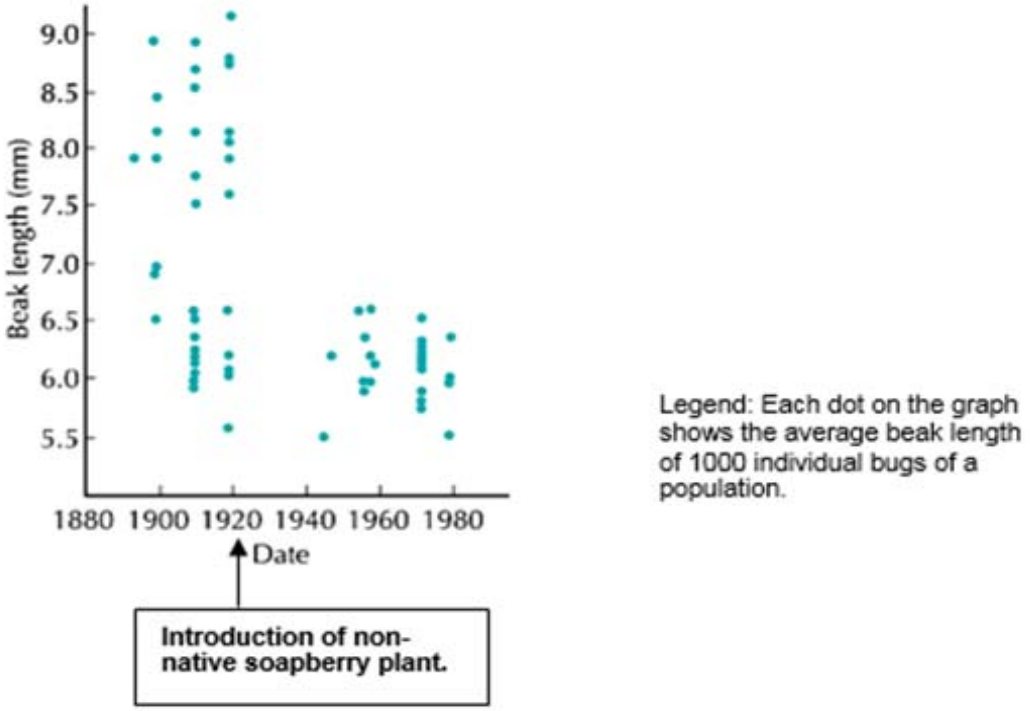


Fig. 8.2: Beak lengths of soapberry bugs (1880-1980)

(a) Explain why the evolution of *Jadera haematoloma* after the introduction of a non-native soapberry plant in the 1920s is not considered a form of divergent evolution.

[1]

(b) Account for the beak lengths over time.

[4]

(c) In 1980, 4000 soapberry bugs at one sampling site were caught and transported to island X with a variety of soapberry plants with thick and thin skinned fruits. The bugs were allowed to populate the island in the absence of predator. In 1990, the beak lengths of bugs were measured and showed a wide variety of beak lengths.
At the same time in 1980, 40 individuals were taken and released to an isolated island Y with the same conditions as island X. In 1990, the beak lengths of bugs in both islands were also measured but the beak lengths were all short (below 6mm) although both islands were similar to each other.

(i) Suggest a likely explanation for the result seen in island Y.

[2]

(ii) In 2000, both islands were invaded by a plant viral disease that destroyed the soapberry plants with thin-skinned fruits. The outcome of/effect on the bugs in both islands in terms of the beak length variety and total number of bugs over time are shown in Fig. 8.4.

Island	**X**	**Y**
Total number of bugs	Remains about the same	Nil (extinction)
Variety of beak length	Only long beaks	-

Fig.8.4

Explain the results in Fig. 8.4.

[2]

(c) Analysis of the DNA sequences of the soapberry bugs in both islands before the viral invasion revealed differences that could not be explained by the theory of natural selection. How may the neutral theory of molecular evolution account for the differences?

[2]

[Total: 11]

Section B

Answer **one** question.

Write your answers on separate writing paper.

Your answer should be illustrated by large, clearly labeled diagrams, where appropriate.

Your answer must in continuous prose, where appropriate.

Your answers must be set out in sections (a), (b) etc., as indicated in the question.

Begin your answers to each part (a), (b) and (c) on a new sheet of writing paper.

9 **(a)** Explain how molecular and anatomical homology supports Darwin's theory of natural selection [6]

(b) Describe the response of the muscle cell to insulin with respect to cell signaling [8]

(c) Define control elements and explain how they interact with other factors to influence transcription [6]

10 **(a)** Explain how recessive alleles may be preserved in a natural population [6]

(b) Explain the advantages and significance of having a cell signaling system [6]

(c) Describe binary fission and explain how it differs from bacterial conjugation. [8]

[20]