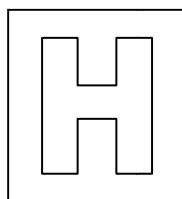


Candidate Name: _____

Class Adm No

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2015 Promotional Examination 2 Pre-University 2

H1 Biology

8875/02

Paper 2 Core Paper

18 September 2015

2 hours

Additional Materials: Writing paper

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

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

Section A

Answer **all** questions.

Section B

Answer any **one** question.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question. At the end of the examination, fasten all your work securely together.

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
Total	

This question paper consists of 18 printed pages including 1 blank page.

[Turn over

Section A

Answer **all** questions in this section.

1. The green algae are a large, informal grouping of algae consisting of the Chlorophyte and Charophyte algae, which are now placed in separate Divisions. The land plants are thought to have emerged from Charophyte algae.

Charophyte algae have both chloroplasts and mitochondria. Exchanges between a mitochondrion, a chloroplast and the cytoplasm surrounding them in a Charophyte alga cell are shown in the Fig 1.1.

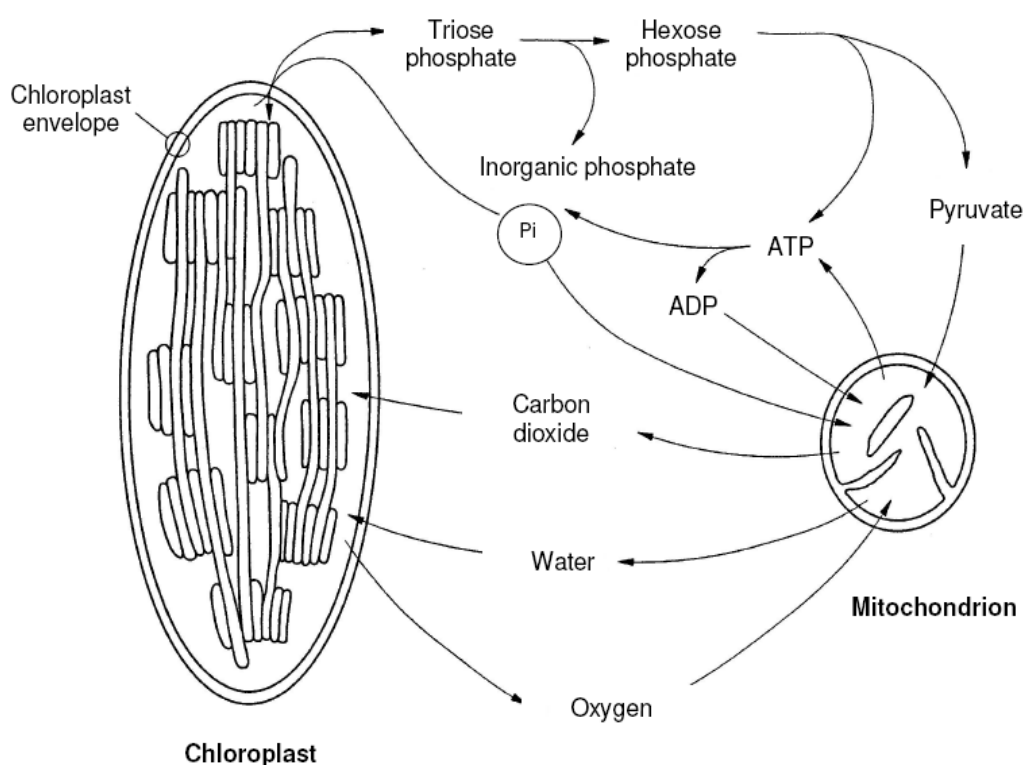


Fig. 1.1

- (a) Describe the role of oxygen in the mitochondrion and the chloroplast.

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Mitochondria were isolated from Charophyte algae cells for further investigations. A study was carried out to find out the effect of three inhibitors, **X**, **Y** and **Z**, on the electron transport chain in the mitochondria. In each of three experiments, a different inhibitor was added. Table 1.1 below shows the state of the electron carriers, **P–S**, after the addition of inhibitor.

Table. 1.1

Inhibitor added	Electron carrier			
	P	Q	R	S
X	oxidised	reduced	reduced	oxidised
Y	oxidised	oxidised	reduced	oxidised
Z	reduced	reduced	reduced	oxidised

- (b) With reference to Table 1.1, give the order of the electron carriers in this electron transport chain.

Order:

[1]

Inhibitors **X**, **Y** and **Z** were shown to also inhibit carbon dioxide production from mitochondria compared to control experiments. However the production of carbon dioxide can be detected when whole Charophyte algae cells is incubated with either one of these inhibitors.

- (c) Explain how inhibitors **X**, **Y** or **Z** is able to inhibit carbon dioxide production from mitochondria.

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 [2]

Porins are transmembrane proteins found on the outer membrane of the chloroplast in Charophyte algae and other eukaryotic cells. Their function is to transport ions across the membrane. Fig. 1.2 shows the side view and top view of the structure of a porin protein respectively.

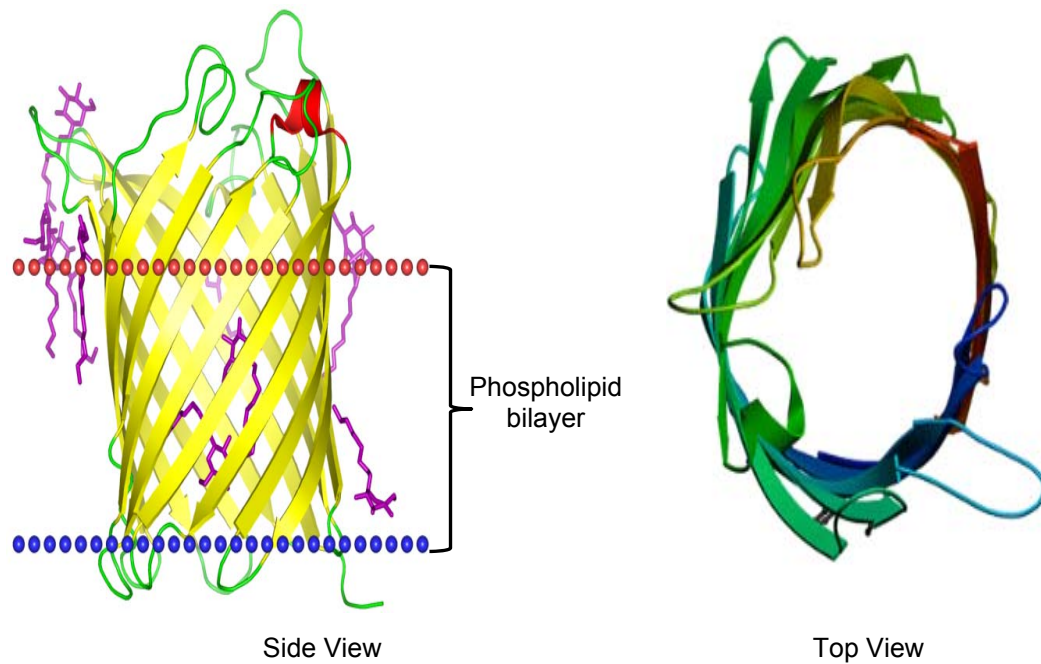


Fig 1.2

- (d) Explain why transmembrane proteins such as porins are needed to move ions across the outer chloroplast membrane.

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..... [2]

[Total: 9]

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2. An investigation was carried out to study the behaviour of chromosomes in early Cane toad (*Rhinella marina*) embryos. Using the radioactive-labelled DNA, a Cane toad embryonic stem cell with condensed chromosomes was carefully observed and the following measurements were taken:

1. Distance between the centromeres of the chromosomes and the poles of the spindle.
2. Distance between the centromeres of sister chromatids.
3. Distance between the poles of the spindle.

The results are enclosed in in Fig 2.1.

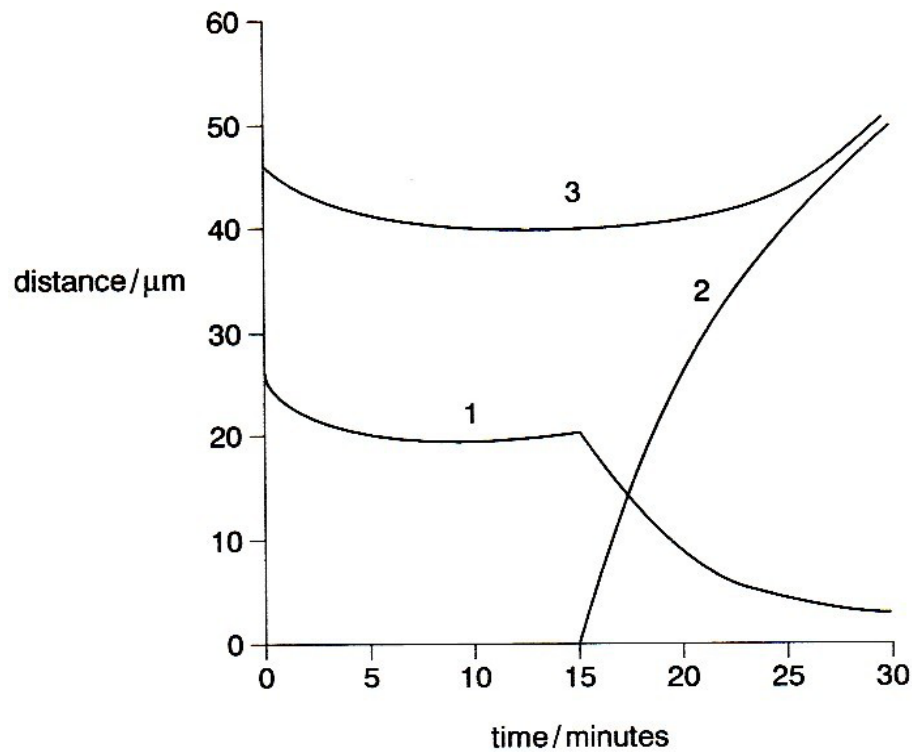


Fig 2.1

- (a) With reference to Fig 2.1, describe and account for the trend of curve 2.

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Docetaxel is a compound that is isolated from the bark of the Pacific Yew plant (*Taxus brevifolia*). Docetaxel has been shown to be cytotoxic based on its ability to inhibit microtubule disassembly.

A student repeated the previous investigation but introduced Docetaxel after 20 minutes to study the effect of this compound.

- (b) Sketch a graph on Fig. 2.2 to show the expected changes in distance between centromeres of the chromosomes and the poles of the spindle based on this experiment.

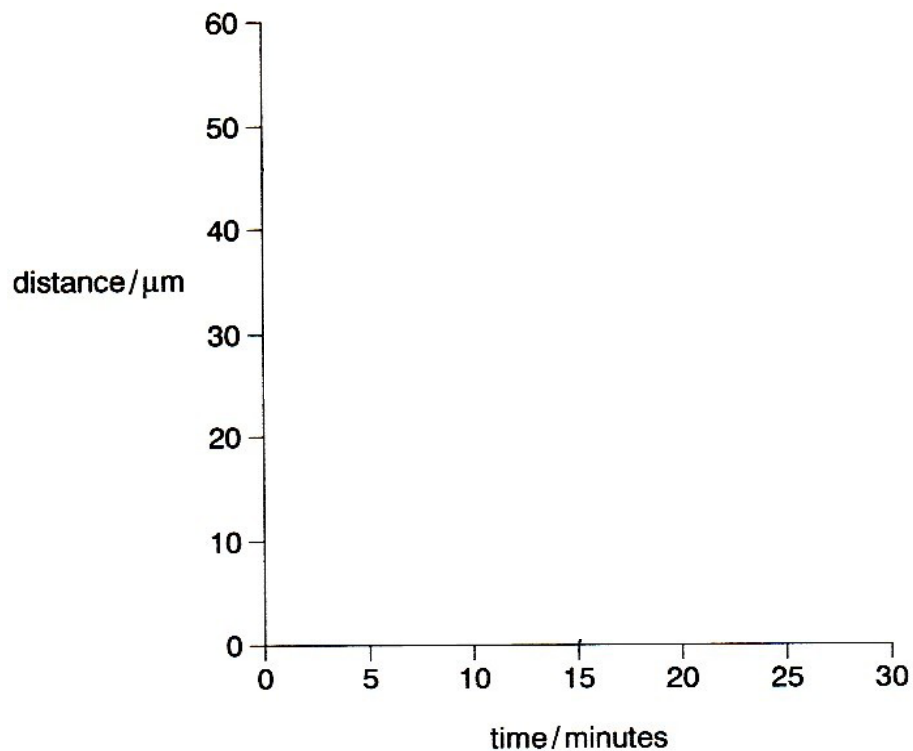


Fig 2.2

[1]

[Total: 4]

3. Tay–Sachs disease is an autosomal recessive disease which causes a progressive deterioration of nerve cells, mental and physical abilities in patients. This disease is caused by a mutation in the hexA gene found on chromosome 15, which codes for the alpha-subunit of hexosaminidase A, a lysosomal enzyme.

Anaemia is a condition that typically refers to a decrease in the amount of red blood cells in the blood. ABO haemolytic disease can result in anaemia. ABO haemolytic disease of the newborn (ABO HDN) refers to blood disorders that arise when the blood groups of the mother and newborn child do not match. It usually happens during a mother's second or subsequent pregnancy.

Antibodies from the mother can pass through the placenta and bind to the child's red blood cells. This leads to cell lysis, resulting in anaemia. While anaemia from ABO HDN is short lived, it can be fatal if severe. Table 3.1 shows the three different situations where blood group incompatibility can arise between a mother and her child

Table 3.1

	Blood group		
	Situation 1	Situation 2	Situation 3
Mother	O	A	B
Child	A or B	B	A

A man who is heterozygous at the locus for the blood type B antigen has a son with a woman with blood type O. Both parents are carriers for Tay-Sachs disease. The son was born with blood type B and does not suffer from Tay-Sachs disease. The couple decided to try for a second child and are worried about the risk of ABO HDN or Tay-Sachs disease.

- (a) Draw a genetic diagram to determine the possible phenotypes of a second child.

[4]

Sickle cell anaemia is another form of anaemia which is caused by defective haemoglobins resulting in fragile sickle shaped red blood cells.

In normal adults, the most common haemoglobin type is classified as haemoglobin A (HbA). HbA is a tetramer which consists of two α and β globin chains each. The genes for these chains are found on two different chromosomes. These genes pass on information via mRNA transcripts to synthesize the polypeptide chains which then assemble to form the haemoglobin quaternary complex.

Haemoglobin S (HbS) is a variant of adult haemoglobin (HbA) that arises by a mutation in the β -globin gene. Patients with with two copies of HbS are susceptible to forming sickle shaped red blood cells and consequently may suffer from sickle cell anaemia.

- (b)** Describe how the information carried on mRNA allows the synthesis of a complete polypeptide chain

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A clinic sequenced the β -globin gene locus of three different patients with anaemia. The results are tabulated in Table 3.2.

Table 3.2

Genetic profile of the 6 th codon of patients' β -globin gene		
Patient	DNA codon sequence*	Amino acid
1	GAG	Glutamic acid
2	GTG	Valine
3	GAC	Aspartic Acid

- (c) With reference to Table 3.2, explain why the change of amino acid would result in fragile sickle shaped red blood cells for patient 2.

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- (d) Suggest why anaemia experienced by patient 3 is unlikely due to the effect of fragile sickle shaped red blood cells.

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[Total: 11]

4. A mammoth can be any species belonging to the extinct genus *Mammuthus*, *proboscideans* commonly equipped with long, curved tusks. They were members of the family Elephantidae which contains, along with mammoths, the two genera of modern elephants and their ancestors.

About three million years ago, the ancestors of mammoths migrated from Africa into Europe and Asia. There, about 1.7 million years ago, the steppe mammoth (*Mammuthus armeniacus*) evolved and became adapted to the cooler conditions. Then, about 700 000 years ago, as the climate changed and the Arctic became much colder, the woolly mammoth (*Mammuthus primigenius*) evolved. Woolly mammoths showed a number of characteristics that include thick fur, small ears and small tails.

- (a) Explain how variation and natural selection may have brought about the evolution of the woolly mammoth from the steppe mammoth.

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A frozen, 43 000 year old woolly mammoth was found in Western Siberia. Its DNA was extracted and sequenced. The evolutionary relationship of the Woolly mammoth, Asian elephant (*Elephas maximus*) and African elephant (*Loxodonta africana*) was then investigated.

- (b) Explain how analysis of rRNA genes can be used to compare evolutionary relationships between the three members of the family Elephantidae.

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The Asian elephant is presently classified as an endangered species. Current populations are threatened by poaching, ecological challenges, urbanization as well as health problems. A scientist embarked on a study which involved the production of functional recombinant elephant growth hormone (eGH) protein in *Escherichia coli* bacteria to better understand dwarfism in Asian elephants.

The initial steps in the procedure to produce recombinant eGH proteins are summarized as follows.

- Step 1 Reverse transcriptase is used to make eGH from the elephant's mRNA from endocrine cells
- Step 2 eGH cDNA is amplified by PCR to increase the quantify of cDNA
- Step 3 eGH cDNA is cloned into an expression vector using BamH1 restriction enzyme

- (c) Explain why elephant cDNA prepared from mRNA was used for producing functional eGH proteins in *E.coli* instead of elephant genomic DNA

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During Polymerase chain reaction (PCR), the primers used to amplify eGH cDNA were extended sequences that included recognition sites for *Bam*H1 restriction enzyme. The recognition site for *Bam*H1 is enclosed in Table 4.1.

Table 4.1

Restriction enzyme	Specific recognition site
<i>Bam</i> HI	5'-G [^] A T C C-3' 3'-C C T A G [^] -5'

^ indicates where the restriction enzyme cuts

Fig 4.1 shows the plasmid pBR322 which was used as the expression vector to produce eGH proteins. *Bam*H1 restriction enzyme was used to clone amplified eGH cDNA into pBR322.

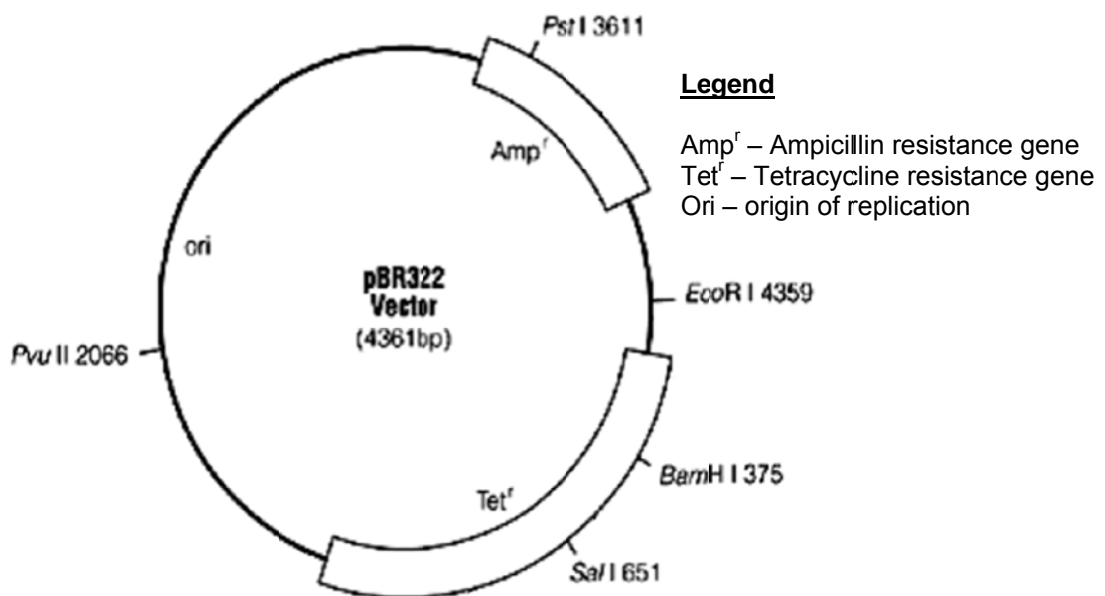


Fig 4.1

(d) Describe how amplified eGH cDNA was cloned into pBR322.

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After BamH1 restriction enzyme was used to clone eGH cDNA into pBR322, the mixture containing recombinant DNA was used to transform *E.coli* bacteria. Replica plating was used to identify the bacteria with the gene coding for eGH. Fig. 4.2 shows the bacterial colonies that grew on two replica plates.

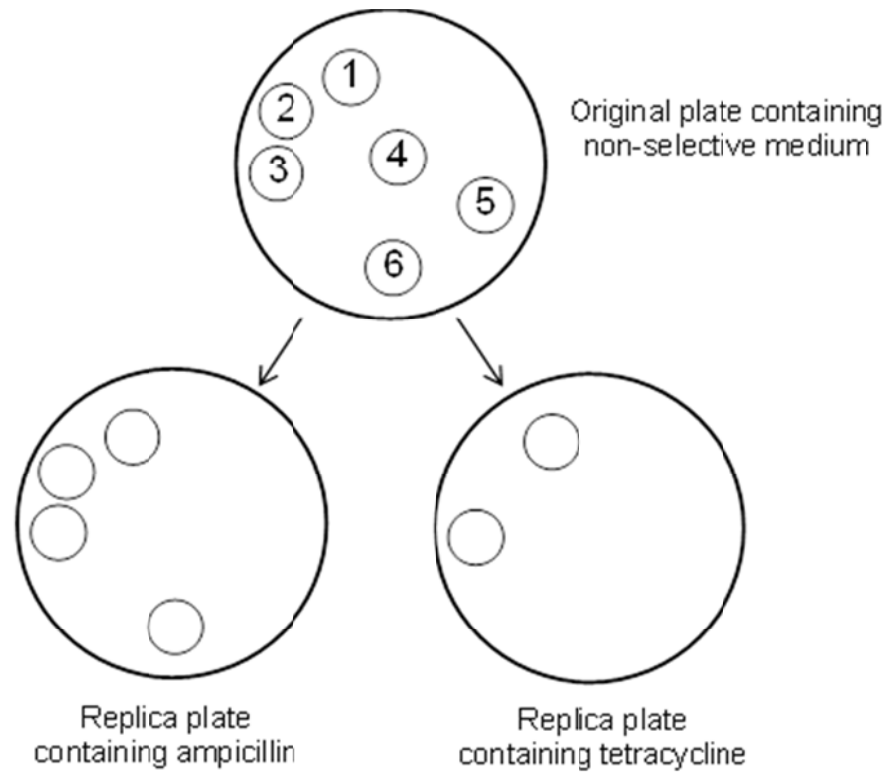


Fig 4.2

- (e) With reference to Fig 4.1 and Fig 4.2, explain which colonies the student may propagate to produce large quantities of eGH proteins.

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More than two thirds of an Asian elephant's day may be spent feeding. Bananas are a staple food for this elephant species. However this fruit is commonly infected by fungal pathogen *Fusarium oxysporum*. In recent times, a particularly infectious strain of this fungus, classified as the TR4 strain, is threatening to depress banana populations which may further affect the Asian elephant's survival.

A team of students conducted an experiment to study the TR4 resistance by genetically modified bananas

The following two groups of banana plants, growing next to each other, in identical conditions, were infected with TR4:

<u>Plant Group</u>	<u>Specimen</u>
Non-transgenic banana plants	Plant P And Plant Q
Banana plants genetically engineered to express TR4 resistance gene (<i>BRF</i> gene)	Plant R

The number of fungal colonies was tracked each day for 4 days after infection. The results are shown in Fig. 4.3.

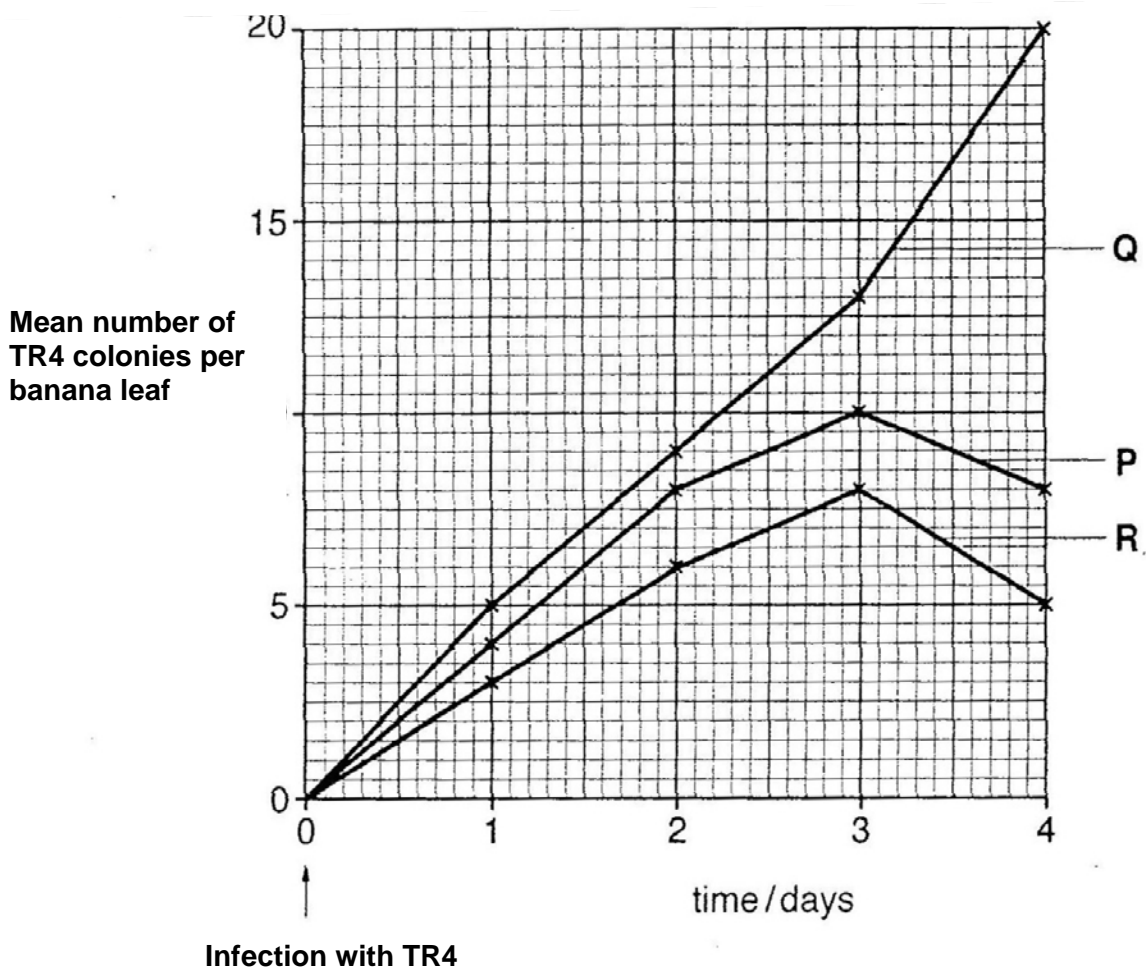


Fig. 4.3

- (f) With reference to Fig 4.3, explain if transgenic Plant **R** or non-transgenic Plant **Q** is more resilient to TR4.

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- (g) Suggest why Plant **P** has fewer TR4 colonies compared to Plant **Q**.

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[Total: 16]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

5.

- (a)** Explain how pH may affect the activity of mammalian catalase [8]
- (b)** Compare and contrast DNA replication with transcription [7]
- (c)** Using the example of honey bees, explain how the phenotype of organisms can be affected by the environment. [5]

[Total: 20]

6.

- (a)** Describe the structure and function of the endoplasmic reticulum. [7]
- (b)** Describe the role of membranes in photosynthesis. [7]
- (c)** Discuss the ethical and social concerns that arise from increasing reliance on genetically modified organisms [6]

[Total: 20]

End Of Paper