

CANDIDATE NAME: \_\_\_\_\_

INDEX NUMBER \_\_\_\_\_



SERANGOON JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION 2018

H2 BIOLOGY  
Paper 1 Multiple Choice

CG \_\_\_\_\_

9744/01

Friday  
21 September 2018

Additional Materials: Multiple Choice Answer Sheet

1 hour

### READ THESE INSTRUCTIONS FIRST

Write your name, index number and CG in the spaces at the top of this page.

On the Multiple Choice Answer Sheet, write your name, subject title, test name and CG. For your index number, write your full NRIC number. Shade the corresponding lozenges on the Answer Sheet according to the instructions given by the invigilators.

There are **thirty questions** on this paper. Answer **all** questions. For each question, there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

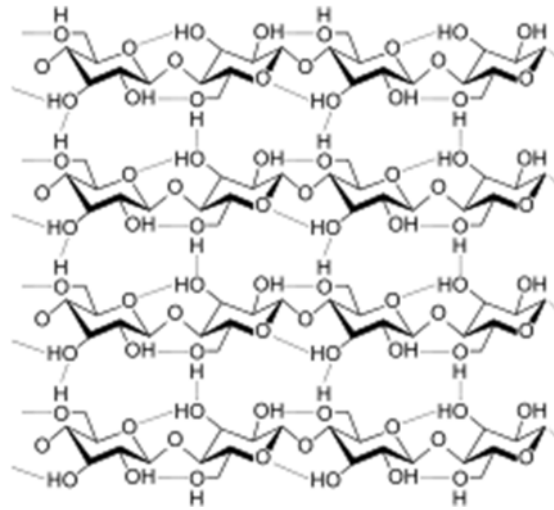
The use of an approved scientific calculator is expected, where appropriate.

**AT THE END OF THE EXAMINATION, SUBMIT BOTH THE MULTIPLE CHOICE ANSWER SHEET AND THE QUESTION PAPER.**

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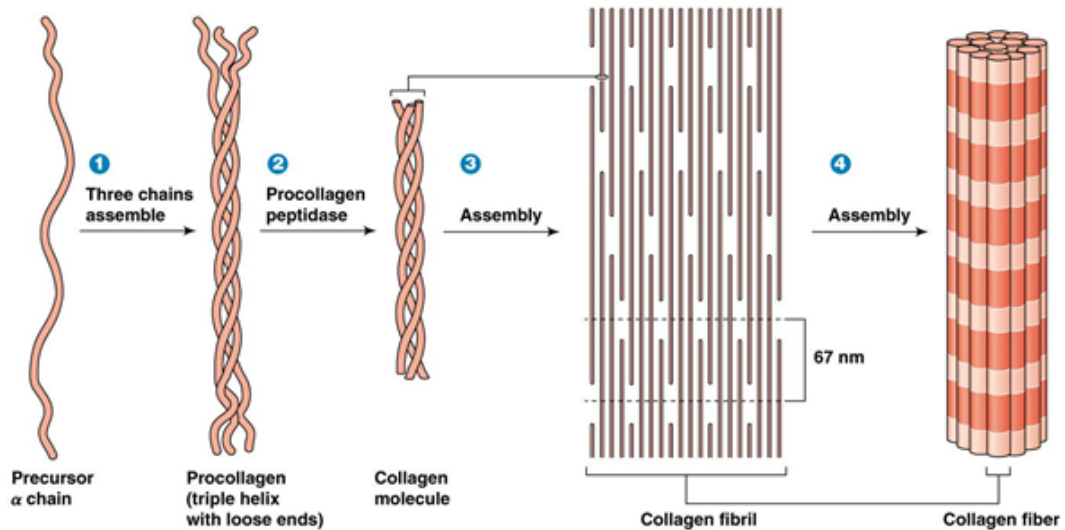
This question paper consists of **20** printed pages including this cover page.

1. The following biomolecule is



- A not a protein because of the presence of phenyl groups.
- B a protein because of the presence of peptide linkages.
- C not a carbohydrate because of the presence of regular repeated folding.
- D a carbohydrate because of the presence of glycosidic linkages.

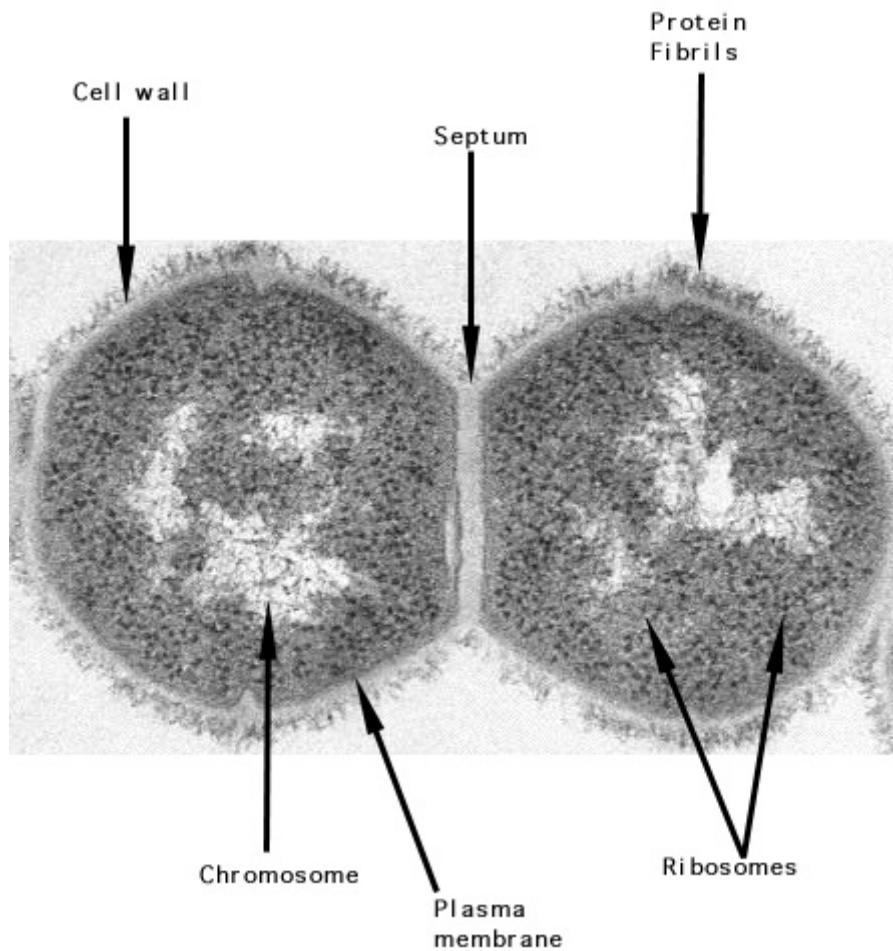
2. The following is a diagrammatic representation of the macromolecular assembly of a collagen fibre.



Which of the following descriptions is incorrect?

- A Every third amino acid is glycine as it has the smallest R group.
- B Collagen fibrils can be held together by covalent linkages.
- C Procollagen is a secondary protein due to regular coiling of three polypeptides.
- D Many procollagen molecules associate to create collagen.

3. The following is an electron micrograph of a living cell that is dividing.



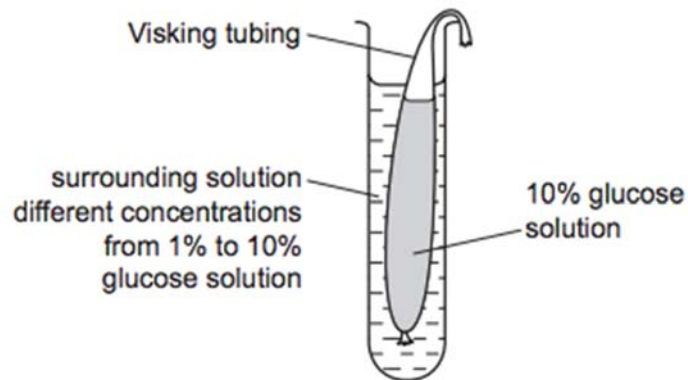
The following are some possible statements about the daughter cells:

- 1 These are a pair of plant cells as the septum represents the cell plate of the dividing cell.
- 2 These are a pair of bacterial cells as they have chromosomes and ribosomes.
- 3 These cannot be bacterial cells as they have a cell wall.
- 4 These are a pair of animal cells as they have proteins on their outer surface.
- 5 These cannot be animal cells as the ribosomes are located alongside the chromosomes.
- 6 These cannot be bacterial cells as circular DNA is not evident.

Which of the statements about these cells are correct?

- A** 1 and 3
- B** 1 and 6
- C** 3 and 4
- D** 2 and 5

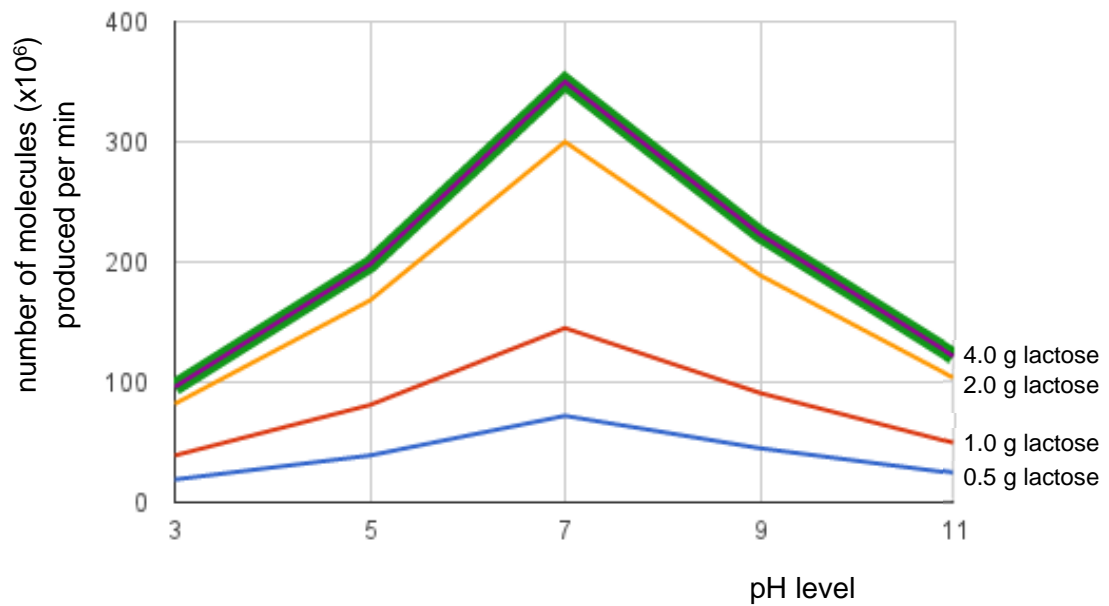
4. The diagram shows apparatus set up to investigate the effect of changing the concentration of glucose in the surrounding solution on the movement of molecules through a selectively permeable membrane (Visking tubing) in 15 minutes.



As the concentration of glucose solution in the surrounding solution increases, which statements are correct?

- 1 Net diffusion of water increases.
  - 2 Glucose molecules reach an equilibrium quicker.
  - 3 There is less change in the volume of surrounding solution.
  - 4 Net diffusion of glucose increases.
- A** 1 and 3 only  
**B** 2 and 3 only  
**C** 1, 2 and 4 only  
**D** 1, 2, 3 and 4

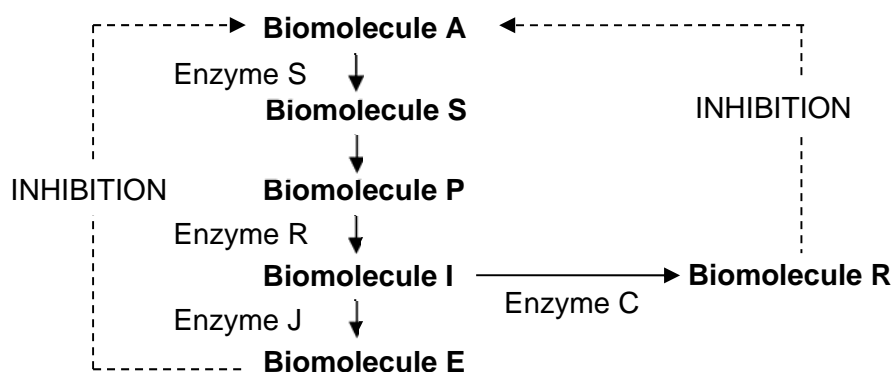
5. The following is a graph showing the number of molecules of product produced from the digestion of lactose at different pH levels.



Which of the following is **not** a valid conclusion from this graph?

- A Enzyme molecules are fully denatured at extreme pH levels.
- B The reaction rate is likely to level off past a certain substrate concentration.
- C pH level of 7 is the optimal pH for this enzyme.
- D Increasing substrate concentration increases the rate of enzyme reaction.

6. A hypothetical metabolic pathway is shown below.



Which changes in enzyme activity will result in the greatest increase in the yield of Biomolecule R?

	Enzyme	Change in activity	Enzyme	Change in activity
<b>A</b>	S	Decrease	J	Decrease
<b>B</b>	R	Increase	J	Decrease
<b>C</b>	J	Increase	C	Increase
<b>D</b>	C	Decrease	R	Decrease

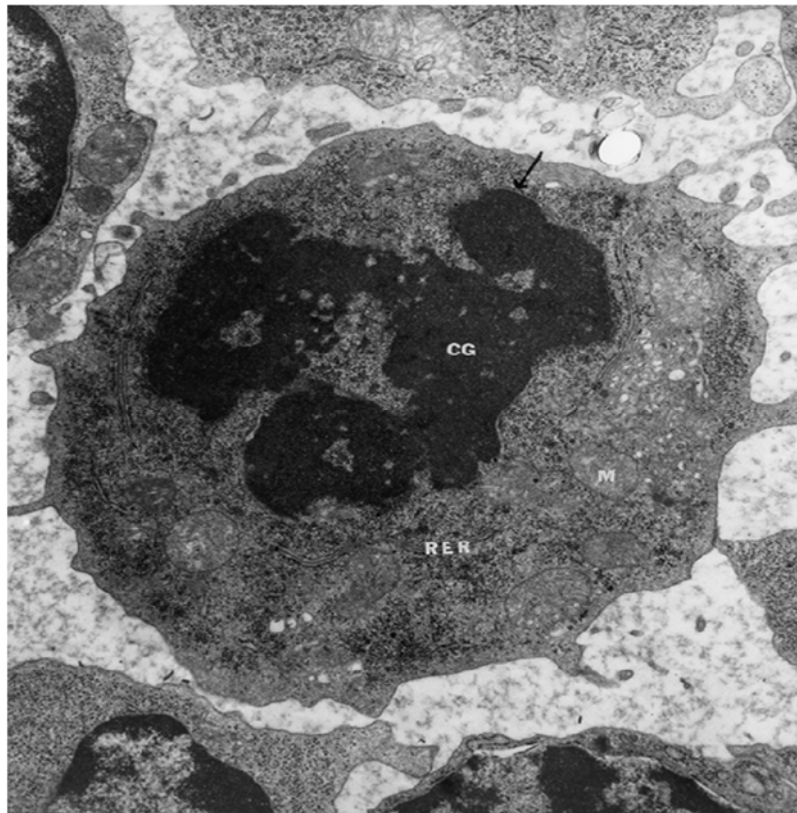
7. The following are some statements related to cell and nuclear division.

- 1 Both haploid and diploid cells have homologous chromosomes.
- 2 Fertilisation doubles the chromosome number while subsequent mitotic division temporarily doubles it further.
- 3 Meiotic division halves amount of DNA twice while mitotic division halves the amount of DNA only once.
- 4 The cell cycle of a specific cell includes either meiotic or mitotic division but never both at the same time.

Which of the above statements is/are **incorrect**?

- A** 1 only
- B** 1 and 2 only
- C** 2 and 3 only
- D** 2, 3 and 4 only

8. The following depicted cell is undergoing cell division.

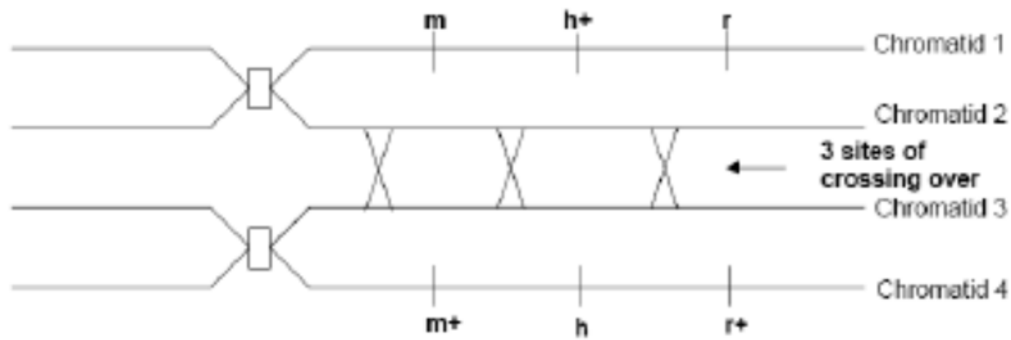


(CG = chromatin granules, RER = rough endoplasmic reticulum, M = mitochondrion)

Based on this electron micrograph, which of the following statements about this cell is accurate?

- A** The cell is undergoing meiosis 1 as the chromatin is separating into four components.
- B** The cell is undergoing prophase of meiosis as chromosomes are synapsing.
- C** The cell is undergoing interphase as the chromosomes are replicating.
- D** The cell is undergoing prophase as the nuclear envelope has broken down.

9. The diagram below shows a pair of homologous chromosomes during prophase of meiosis.



Determine the resulting segregation of the named alleles.

- |          |  |          |  |
|----------|--|----------|--|
| <b>A</b> | chromatid 1: m h+ r<br>chromatid 2: m h r<br>chromatid 3: m+ h+ r+<br>chromatid 4: m+ h r+ | <b>C</b> | chromatid 1: m h+ r<br>chromatid 2: m+ h+ r+<br>chromatid 3: m h r<br>chromatid 4: m+ h r+ |
| <b>B</b> | chromatid 1: m h+ r<br>chromatid 2: m+ h r+<br>chromatid 3: m h+ r<br>chromatid 4: m+ h r+ | <b>D</b> | chromatid 1: m h+ r<br>chromatid 2: m+ h+ r<br>chromatid 3: m h r+<br>chromatid 4: m+ h r+ |

10. Scientists have made a nucleic acid (HNA) that has a sugar with the same number of carbon atoms as glucose instead of deoxyribose. Although genetic information can be stored by HNA, naturally occurring DNA polymerase cannot replicate HNA.

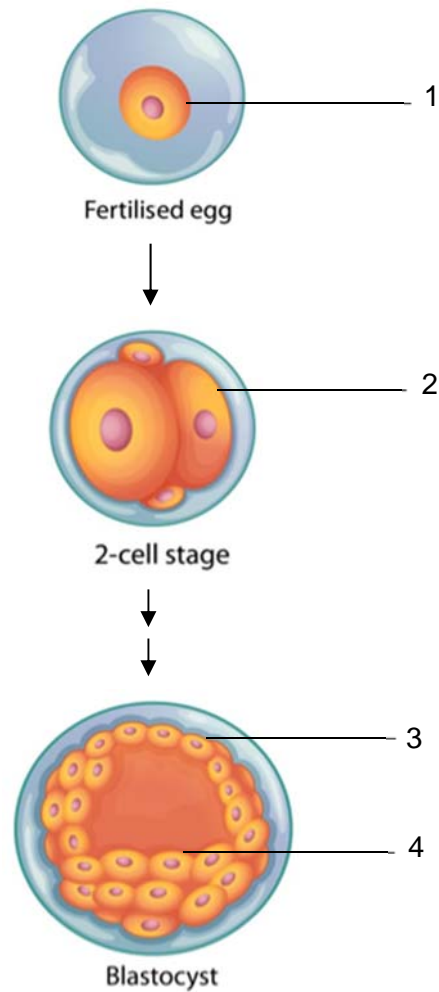
Which statements could explain why naturally occurring DNA polymerase cannot replicate HNA?

- 1 DNA polymerase cannot form bonds between the sugars of two HNA nucleotides.
- 2 DNA polymerase cannot form hydrogen bonds between two HNA nucleotides.
- 3 HNA nucleotides do not fit into the active site of DNA polymerase.
- 4 The shape of an HNA nucleotide is slightly larger than that of a DNA nucleotide.

- A** 1, 2, 3 and 4  
**B** 1 and 4 only  
**C** 2 and 3 only  
**D** 3 and 4 only



11. The figure below shows some stages of embryonic development. Four different cells are labelled 1, 2, 3 and 4 as shown.



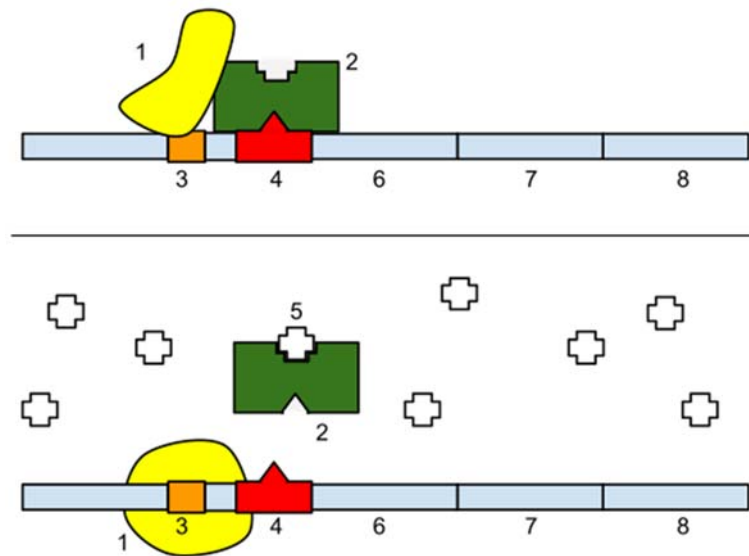
Which of the following statements is incorrect?

- A** Cells 1 and 2 are totipotent.
- B** Cells 3 and 4 are pluripotent.
- C** Cell 3 is a result of mitoses involving Cell 1.
- D** Cells 2 and 4 can give rise to adult stem cells.

12. Which of the following is an example of translational control of gene expression?

- A Activation of proteins by folding or enzymatic cleavage
- B Addition of chemical groups such as phosphate groups to free amino acids in the cytoplasm
- C Binding of protein factors to specific sequences in mRNA preventing ribosomes from attaching.
- D Formation of disulfide bridges in the protein being formed

13. A simplified figure of the lac operon is shown below. Several structures have been numbered 1 to 8.



Which of the following correctly identifies some of the structures above?

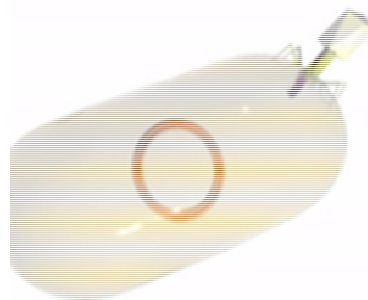
- A 1 is the lac repressor, 3 is the operator and 5 is allolactose.
- B 2 is an enzyme, 4 is the operator and 7 is a structural gene.
- C 2 is a catabolite activator protein, 5 is cyclic AMP and 8 is a structural gene.
- D 3 is the promoter, 5 is a carbohydrate and 6 is a structural gene.

14. Which of the following pairs of statements are correct of generalised and specialised transduction?

	<b>Generalised</b>	<b>Specialised</b>
1	Transfers any bacterial DNA	Transfers a specific set of bacterial genes
2	Contains a hybrid chromosome in its capsid	Contains only bacterial chromosome in its capsid
3	Host cell will die	Host cell may die
4	Viral genome is not transcribed	Viral genome is transcribed
5	Only involves lytic cycle	Only involves lysogenic cycle
6	Viral DNA is replicated by host cell machinery	Viral DNA is replicated by binary fission

- A 1, 3 and 6 only
- B 1, 4 and 5 only
- C 2, 3 and 6 only
- D 3, 4 and 5 only

15. The following shows a virus infecting a bacterial cell.



After the step shown above, the viral genome could possibly

- A be reverse transcribed.
- B replace the host genome.
- C be packaged into a new capsid coat.
- D be integrated into the host bacterial genome.

16. SR scientists carried out an investigation into the effects of increasing temperature from 37 °C to 55 °C on the rates of glycolysis and Krebs cycle in animal cells.

They found that the rate of glycolysis decreased by 10% upon the increase in temperature while the rate of Krebs cycle decreased by 6%.

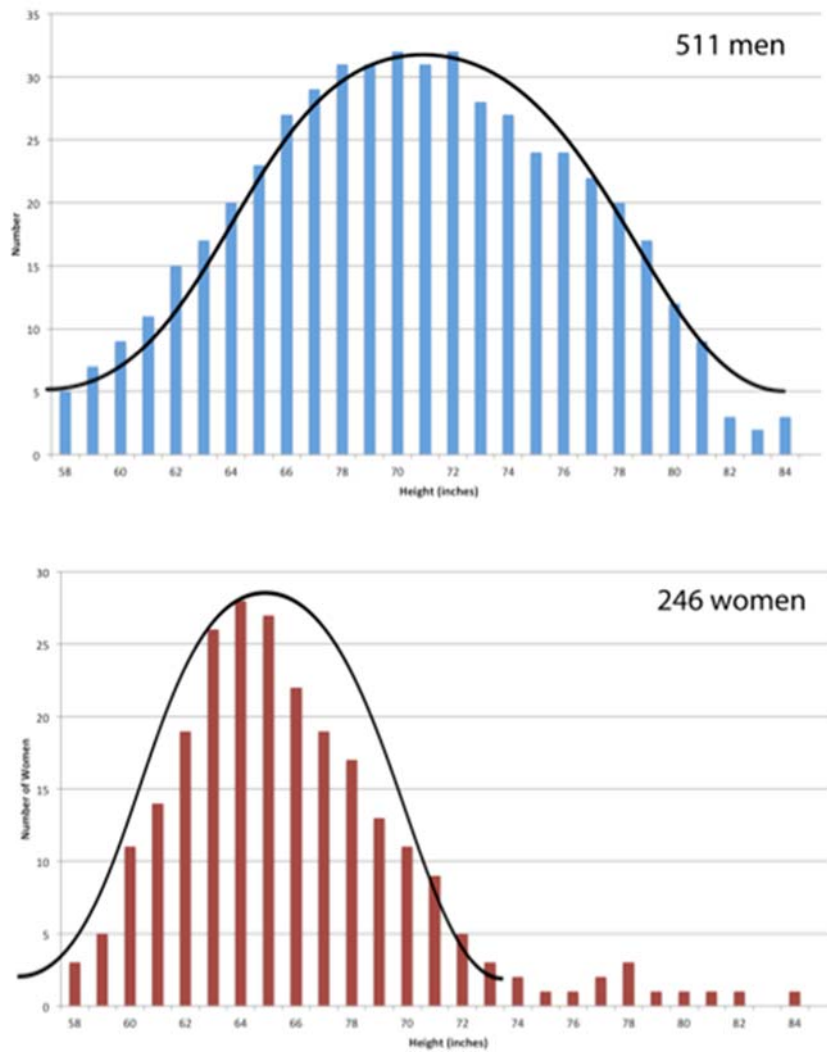
A Student's t-test was conducted, and the calculated t value at degree of freedom = 8 was 2.392.

v	$\alpha$													
	0.40	0.30	0.20	0.15	0.10	0.05	0.025	0.02	0.015	0.01	0.0075	0.005	0.0025	0.0005
1	0.325	0.727	1.376	1.963	3.078	6.314	12.706	15.895	21.205	31.821	42.434	63.657	127.322	636.590
2	0.289	0.617	1.061	1.386	1.886	2.920	4.303	4.849	5.643	6.965	8.073	9.925	14.089	31.598
3	0.277	0.584	0.978	1.250	1.638	2.353	3.182	3.482	3.896	4.541	5.047	5.841	7.453	12.924
4	0.271	0.569	0.941	1.190	1.533	2.132	2.776	2.999	3.298	3.747	4.088	4.604	5.598	8.610
5	0.267	0.559	0.920	1.156	1.476	2.015	2.571	2.757	3.003	3.365	3.634	4.032	4.773	6.869
6	0.265	0.553	0.906	1.134	1.440	1.943	2.447	2.612	2.829	3.143	3.372	3.707	4.317	5.959
7	0.263	0.549	0.896	1.119	1.415	1.895	2.365	2.517	2.715	2.998	3.203	3.499	4.029	5.408
8	0.262	0.546	0.889	1.108	1.397	1.860	2.306	2.449	2.634	2.896	3.085	3.355	3.833	5.041
9	0.261	0.543	0.883	1.100	1.383	1.833	2.262	2.398	2.574	2.821	2.998	3.250	3.690	4.781
10	0.260	0.542	0.879	1.093	1.372	1.812	2.228	2.359	2.527	2.764	2.932	3.169	3.581	4.587

Using the table above, which statement below gives an appropriate conclusion at the 5% significance level?

- A An increase in temperature to 55 °C has a greater effect on glycolysis.
- B An increase in temperature to 55 °C has a greater effect on the Krebs cycle.
- C Glycolysis and Krebs cycle are affected similarly by the increase in temperature to 55 °C.
- D Glycolysis and Krebs cycle are not significantly affected by the increase in temperature to 55 °C.

17. The following graph depicts the distribution of human heights in a sample of 20-year old males and females in the US.



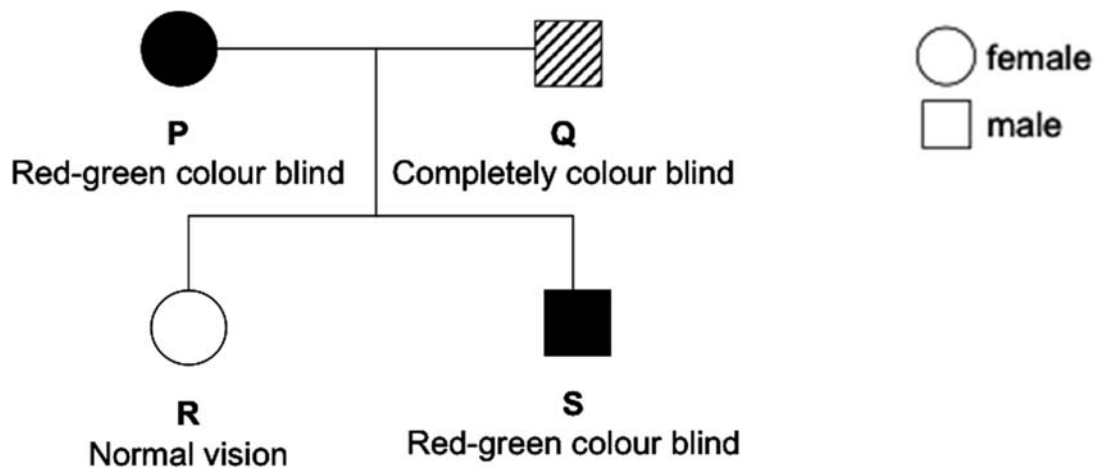
Based on the information above and your own knowledge, which of the following is **not** a valid inference?

- A Human height is controlled by more than one gene locus.
- B Human height involves multiple alleles or epistasis.
- C Both the environment and genes have an effect on human height.
- D Women have a lower mean height than men.

18. Red-green colour blindness is controlled by a gene on the X chromosome. The allele for colour blindness, **g**, is recessive to the allele for normal colour vision, **G**.

Complete colour blindness is controlled by a different gene which is not on the X chromosome. The allele for the development of normal cones (pigment cells in the retinal layer of the eye), **B**, is dominant to the allele for no cone development, **b**.

The figure below shows the phenotypes of members of a different family in which both types of colour blindness occur.



Which of the following are possible genotypes for individuals **P**, **Q** and **S**?

	<b>P</b>	<b>Q</b>	<b>S</b>
<b>A</b>	$BBX^GX^G$	$bbX^GY$	$BBX^gY$
<b>B</b>	$BbX^GX^g$	$BbX^GY$	$BbX^GY$
<b>C</b>	$BBX^gX^g$	$bbX^GY$	$BbX^gY$
<b>D</b>	$BbX^GX^g$	$BbX^GY$	$BBX^GY$

19. In the magpie moth *Abraxas sp.*, the female is the heterogametic sex and the gene for wing colour is sex-linked.

In a cross between a normal coloured male and a pale coloured female, the F1 offspring consisted of all normal coloured individuals with the two sexes in equal proportions.

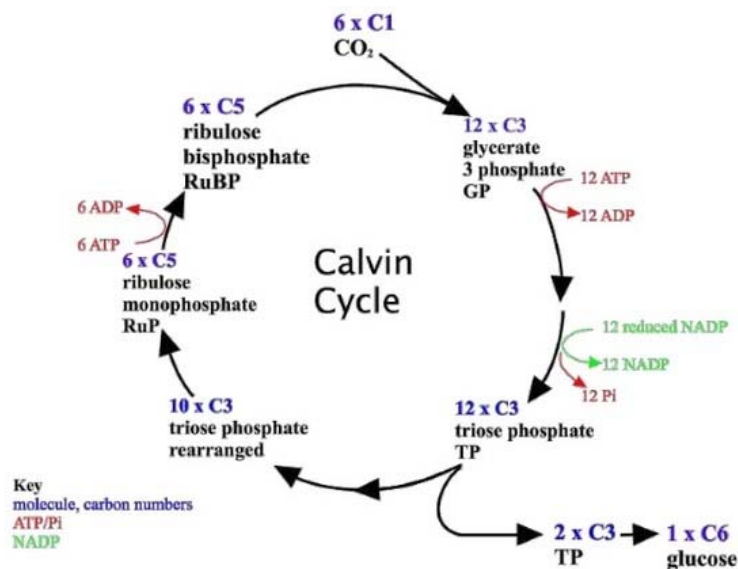
Which ratio would be obtained in the F2 generation produced from the F1 generation?

- A** Normal coloured males to normal females 1:1
- B** Normal coloured males and females to pale females 3:1
- C** Normal coloured males and females to pale males and females 1:1
- D** Normal coloured males to pale coloured females 1:1

20. Which of the following is the **most significant** reason for the effectiveness of nucleic acid hybridisation in highlighting a particular band of DNA on a gel electrophoresis slab?

- A The use of sponge and filter paper to draw buffer solution through the nitrocellulose paper containing the separated DNA
- B The use of radioactively labeled DNA primer sequences that specifically bind to the targeted sequences of DNA
- C The use of ethidium bromide that produces a strong reddish-yellow fluorescence when bands are exposed to UV radiation
- D The use of single stranded radioactively labelled probes complementary to the targeted bands

21. The following is a diagram of the Calvin cycle.



Assuming each turn starts with 1  $\text{CO}_2$  and 1 RuBP, how many turns of the Calvin cycle would be required to produce 40 molecules of glucose?

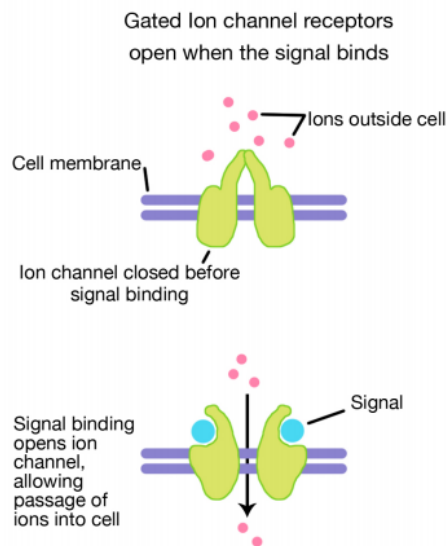
- A 40
- B 120
- C 240
- D 480

22. In living cells, 2,4 dinitrophenol acts as a proton ionophore, an agent that can shuttle protons across biological membranes.

Which of the following is **not** a possible consequence of the introduction of 2,4 dinitrophenol into an animal cell?

- A Less oxygen is taken up by the cell.
- B The proton gradient across the inner mitochondrial membrane is dissipated.
- C The rate of glycolysis in the cell will increase.
- D The rate of Krebs cycle in the cell will increase.

23. The following is a diagram of an ion channel receptor and how it works.



This is a type of cell signaling receptor found in nerve cells. When a signal molecule binds to these receptors, the receptor changes conformation and causes the influx of ions into nerve cells. This directly causes the formation of an electrical action potential, which is transmitted along the nerve cell.

Which of the following statements **incorrectly** compares ion channel receptors with a G protein linked receptor?

- A Both ion channel and G protein linked receptors involve the activation of genes.
- B Both ion channel and G protein linked receptors involve the change of conformation of a receptor protein.
- C Ion channel receptors do not involve a second messenger.
- D G protein linked receptors do not allow the passage of ions into the cell.



24. New research conducted by evolutionary biologists worldwide paints cities as evolutionary "change agents", says a trio of biologists from the University of Toronto Mississauga (UTM).

A compilation of 15 new research papers, published as a special issue of *Proceedings of the Royal Society B: Biological Sciences*, confirms that cities frequently alter evolution by natural selection.

The following statements are possible ways in which cities could alter evolution by natural selection.

- 1 Cities are generally warmer than natural areas and thus organisms adapted to higher temperatures would be selected for within cities.
- 2 Cities release large amounts of environmental pollutants and thus organisms with greater resistance to common pollutants would be selected for in areas within cities.
- 3 Cities provides additional food sources for many organisms and thus organisms that are adapted to feed on a wider range of food types would be selected for within cities.
- 4 Cities have a large human population so organisms that are better able to interact with humans will be selected for within the cities.

Which statements are potentially correct?

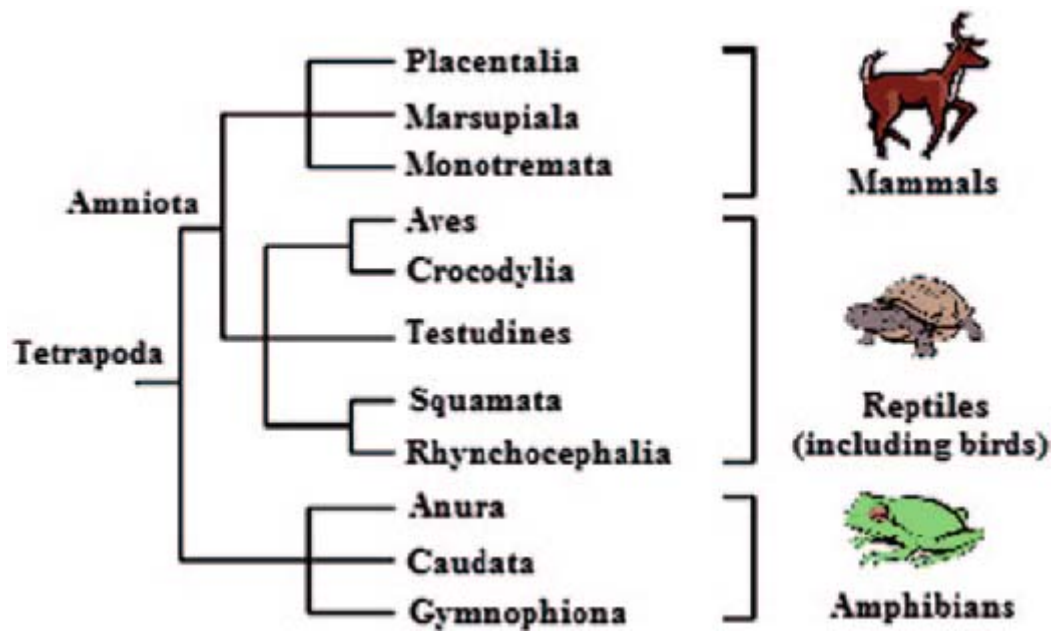
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- B 2 and 4 only
- C 1, 2 and 3 only
- D 1, 2, 3 and 4

25. Lizards in the secondary forests of Pulau Ubin have always been classified as the same species as the lizards on mainland Singapore. However, it is suspected that the lizards on Pulau Ubin have recently evolved into a new species.

Which of the following scientific investigations is **least likely** to confirm this suspicion?

- A A detailed comparison of lizard fossils obtained from both the Pulau Ubin secondary forests and the mainland.
- B Aligning and studying a homologous region of mitochondrial DNA obtained from both Pulau Ubin and mainland lizards.
- C A study of the habitats occupied by lizards in both locations and their interactions with both the biotic and abiotic components of their environment.
- D An in-depth comparative study of the primary morphological and physiological features of lizards from both locations.

26. The following figure shows the phylogenetic tree of some four-legged organisms.



Based only on the information in the phylogenetic tree, which of the following statements is **incorrect**?

- A Mammals are more closely related to reptiles than they are to amphibians.
- B There has been a greater amount of time for tetrapods to evolve compared with the group Amniota.
- C When comparing homologous DNA regions from an organism in the group Squamata and Rhynchocephalia, there will be fewer differences than when comparing Squamata with Crocodylia.
- D Placental mammals and Marsupials are very similar but they evolved slightly differently due to their separation by geography.

27. The following table depicts some ways in which drugs can be used to target immune system cells.

Target	Principal immune function	Source(s)	Principal pathway mechanism(s)	Select drug(s) in clinical investigation
B7-H3	Inhibitory	Transmembrane receptor protein found on APCs, tumor cells, host cells	Binds to unknown receptors on T cells causing inhibitor immune signals; however, primarily inhibitory	Enoblituzumab (MGA271)
ICOS	Inhibitory	Transmembrane receptor protein found on T cells (highly expressed on T-regulatory cells)	Exerts an immune inhibitory function by binding to ICOS-L on APCs stimulating T-regulatory cell function, thus mediating overall immune suppression	MEDI570
OX40	Stimulatory	Transmembrane receptor protein found on T cells	Binds to OX40-L on APCs to stimulate T-cell proliferation and activity	MEDI6469 MOXR0916
GITR	Stimulatory	Transmembrane receptor found on T cells	Produces stimulatory signal upon binding to GRITL on APCs stimulating T-cell proliferation and activity; also involved in T-regulatory cell function	TRX518

Which drug(s) could possibly be used in the clinical treatment of cancerous T cells?

- A MEDI570 only
- B MEDI6469 only
- C MGA271 and TRX518 only
- D MEDI570 and MOXR0916 only

28. Over the past month, a team from the Ethiopian Wolf Conservation Programme has suggested the implementation of the first oral vaccination campaign to pre-empt outbreaks of rabies among Ethiopian wolves, the world's most endangered canid, in their stronghold in the Bale Mountains of southern Ethiopia.

Which of the following is the most biologically accurate prediction of the effect of this oral vaccination attempt?

- A The vaccination will not work as vaccines only work for humans.
- B The vaccination will not work as the wolves are likely to develop resistance against the vaccine.
- C The vaccination will work as it contains antibodies that will target the rabies pathogen.
- D The vaccination will work as wolves will produce plasma cells to target the rabies pathogen.

29. It has been discovered that deep corals, which are found at ocean depths below the reach of sunlight, is also affected by climate change.

Which of the following statements is a valid explanation as to why this is so?

- A The rate of photosynthesis at the deeper waters inhabited by the deep coral species is inhibited by a lack of carbon dioxide.
- B Deep water coral species are adapted to lower temperatures and are unable to migrate to shallow waters which have a higher water temperature.
- C The warming of surface water temperatures due to global warming has led to even the deeper waters heating up beyond the natural range of deep water coral species.
- D The rising sea levels globally have led to deep corals being unable to receive sunlight for use by its symbiotic algae.

30. All of the following are possible impacts of global warming except

- A heavier strain on global food supplies such as livestock.
- B increased transmission of diseases such as tuberculosis and HIV.
- C larger populations of crop pests in the tropical and sub-tropical regions.
- D smaller reservoir for biomedicines due to reduced biodiversity of the tropics.

**END OF PAPER**

CANDIDATE NAME: \_\_\_\_\_

INDEX NUMBER \_\_\_\_\_



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Paper 1 Multiple Choice

9744/01

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1 hour

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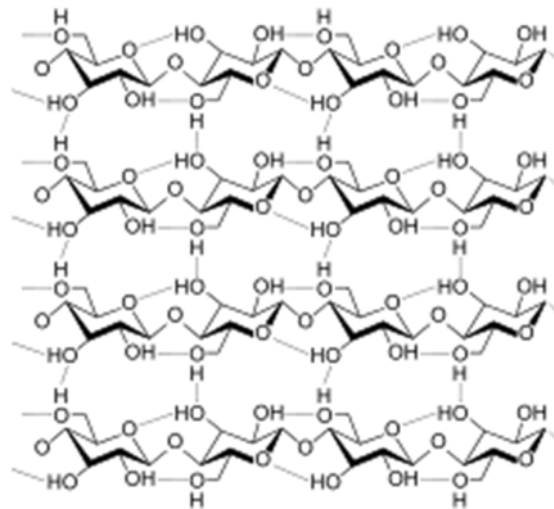
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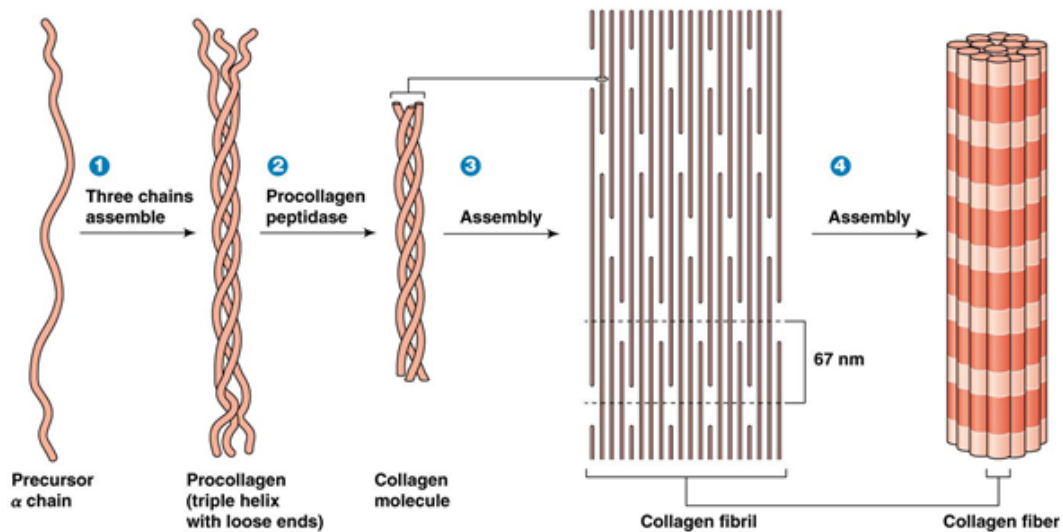
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1. The following biomolecule is



- A not a protein because of the presence of phenyl groups.
- B a protein because of the presence of peptide linkages.
- C not a carbohydrate because of the presence of regular repeated folding.
- D a carbohydrate because of the presence of glycosidic linkages.**

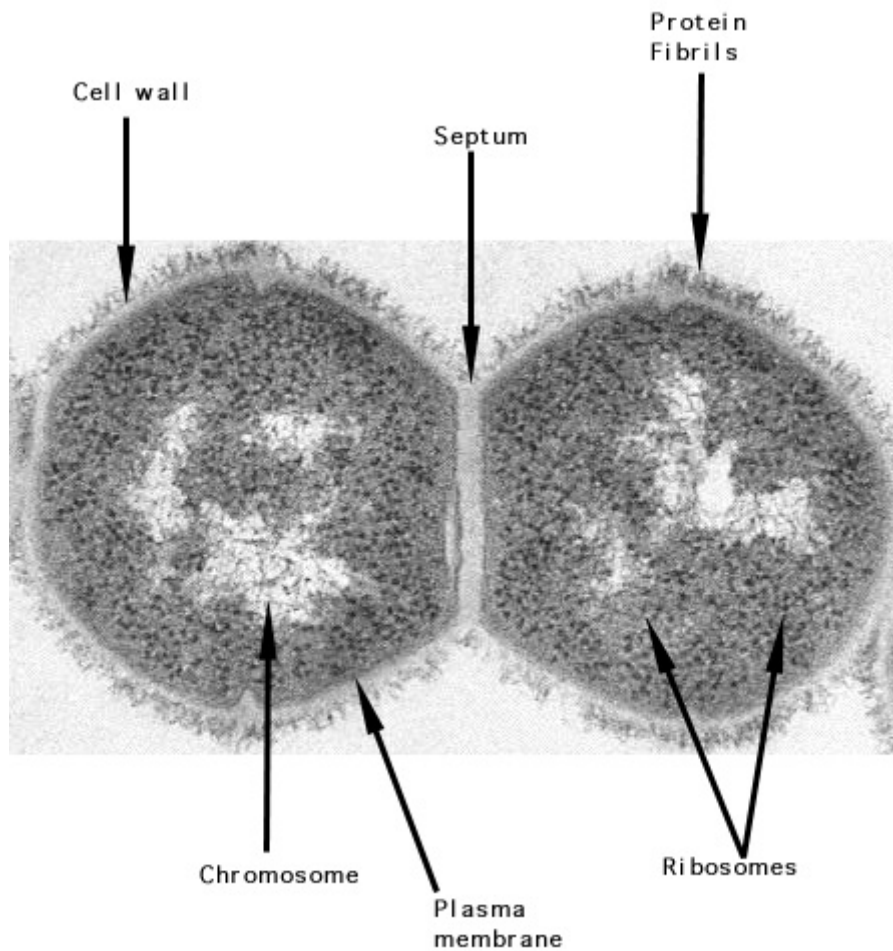
2. The following is a diagrammatic representation of the macromolecular assembly of a collagen fibre.



Which of the following descriptions is incorrect?

- A Every third amino acid is glycine as it has the smallest R group.
- B Collagen fibrils can be held together by covalent linkages.
- C Procollagen is a secondary protein due to regular coiling of three polypeptides.**
- D Many procollagen molecules associate to create collagen.

3. The following is an electron micrograph of a living cell that is dividing.



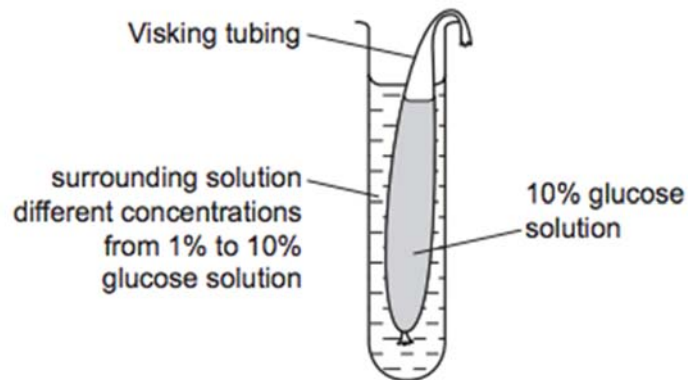
The following are some possible statements about the daughter cells:

- 1 These are a pair of plant cells as the septum represents the cell plate of the dividing cell.
- 2 These are a pair of bacterial cells as they have chromosomes and ribosomes.
- 3 These cannot be bacterial cells as they have a cell wall.
- 4 These are a pair of animal cells as they have proteins on their outer surface.
- 5 These cannot be animal cells as the ribosomes are located alongside the chromosomes.
- 6 These cannot be bacterial cells as circular DNA is not evident.

Which of the statements about these cells are correct?

- A 1 and 3
- B 1 and 6
- C 3 and 4
- D 2 and 5**

4. The diagram shows apparatus set up to investigate the effect of changing the concentration of glucose in the surrounding solution on the movement of molecules through a selectively permeable membrane (Visking tubing) in 15 minutes.



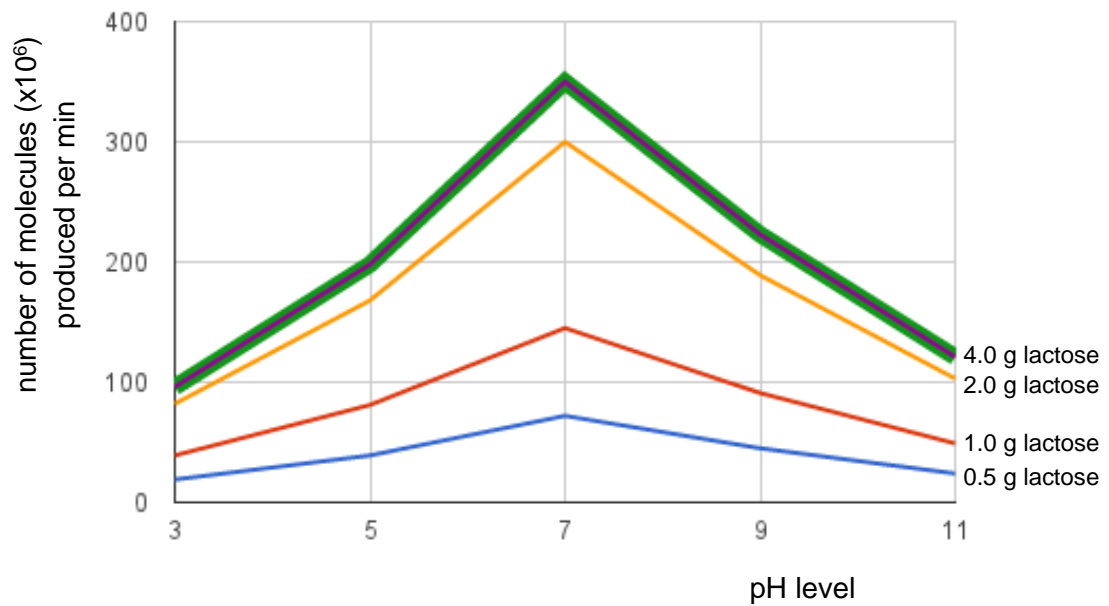
As the concentration of glucose solution in the surrounding solution increases, which statements are correct?

- 1 Net diffusion of water increases.
- 2 Glucose molecules reach an equilibrium quicker.
- 3 There is less change in the volume of surrounding solution.
- 4 Net diffusion of glucose increases.

- A 1 and 3 only  
B 2 and 3 only  
C 1, 2 and 4 only  
D 1, 2, 3 and 4



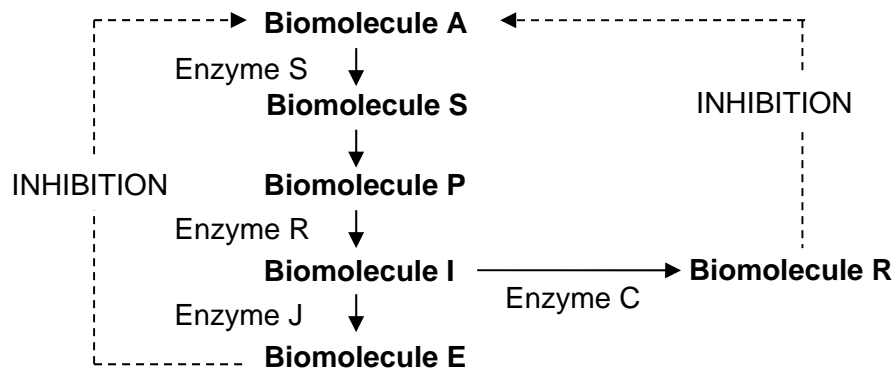
5. The following is a graph showing the number of molecules of product produced from the digestion of lactose at different pH levels.



Which of the following is **not** a valid conclusion from this graph?

- A** Enzyme molecules are fully denatured at extreme pH levels.
- B** The reaction rate is likely to level off past a certain substrate concentration.
- C** pH level of 7 is the optimal pH for this enzyme.
- D** Increasing substrate concentration increases the rate of enzyme reaction.

6. A hypothetical metabolic pathway is shown below.



Which changes in enzyme activity will result in the greatest increase in the yield of Biomolecule R?

	Enzyme	Change in activity	Enzyme	Change in activity
A	S	Decrease	J	Decrease
B	R	Increase	J	Decrease
C	J	Increase	C	Increase
D	C	Decrease	R	Decrease

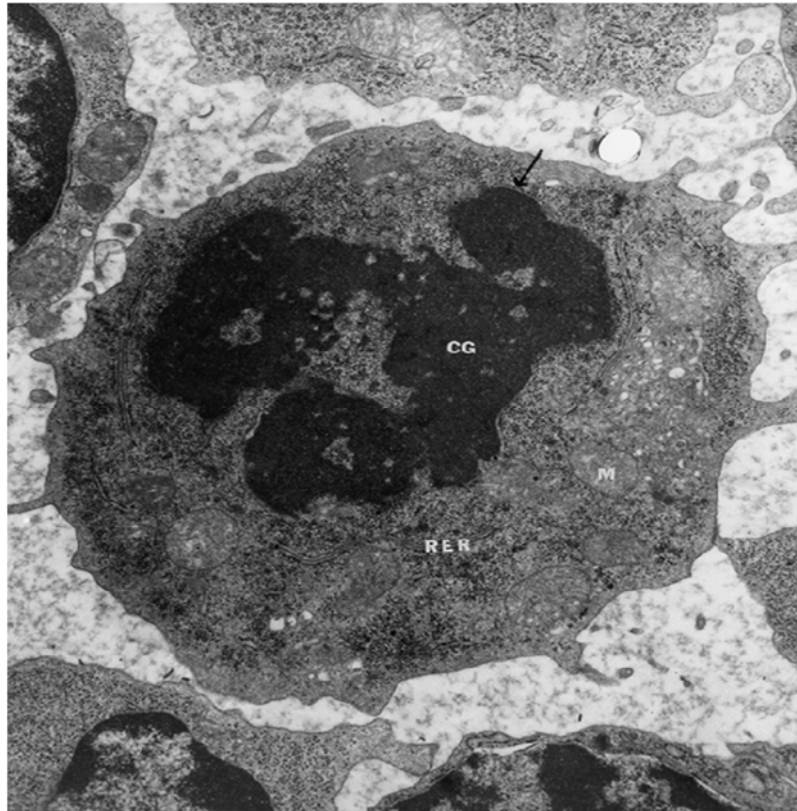
7. The following are some statements related to cell and nuclear division.

- Both haploid and diploid cells have homologous chromosomes.
- Fertilisation doubles the chromosome number while subsequent mitotic division temporarily doubles it further.
- Meiotic division halves amount of DNA twice while mitotic division halves the amount of DNA only once.
- The cell cycle of a specific cell includes either meiotic or mitotic division but never both at the same time.

Which of the above statements is/are **incorrect**?

- 1 only
- 1 and 2 only
- 2 and 3 only
- 2, 3 and 4 only

8. The following depicted cell is undergoing cell division.

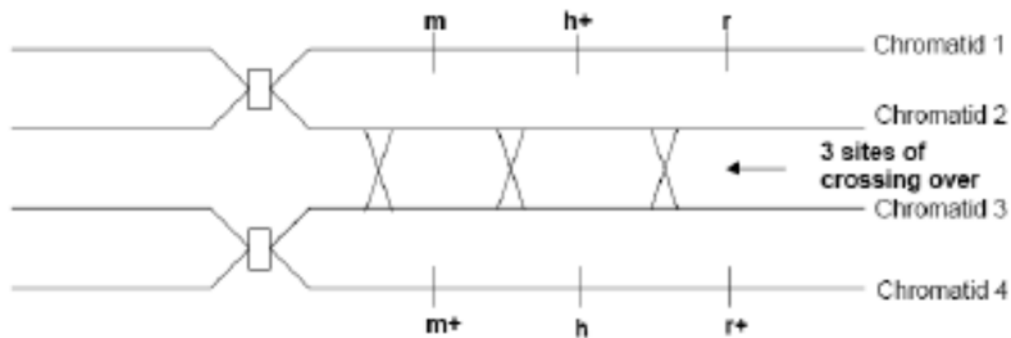


(CG = chromatin granules, RER = rough endoplasmic reticulum, M = mitochondrion)

Based on this electron micrograph, which of the following statements about this cell is accurate?

- A The cell is undergoing meiosis 1 as the chromatin is separating into four components.
- B The cell is undergoing prophase of meiosis as chromosomes are synapsing.
- C The cell is undergoing interphase as the chromosomes are replicating.
- D The cell is undergoing prophase as the nuclear envelope has broken down.**

9. The diagram below shows a pair of homologous chromosomes during prophase of meiosis.



Determine the resulting segregation of the named alleles.

- |          |  |          |  |
|----------|--|----------|--|
| <b>A</b> | chromatid 1: m h+ r<br>chromatid 2: m h r<br>chromatid 3: m+ h+ r+<br>chromatid 4: m+ h r+ | <b>C</b> | chromatid 1: m h+ r<br>chromatid 2: m+ h+ r+<br>chromatid 3: m h r<br>chromatid 4: m+ h r+ |
| <b>B</b> | chromatid 1: m h+ r<br>chromatid 2: m+ h r+<br>chromatid 3: m h+ r<br>chromatid 4: m+ h r+ | <b>D</b> | chromatid 1: m h+ r<br>chromatid 2: m+ h+ r<br>chromatid 3: m h r+<br>chromatid 4: m+ h r+ |

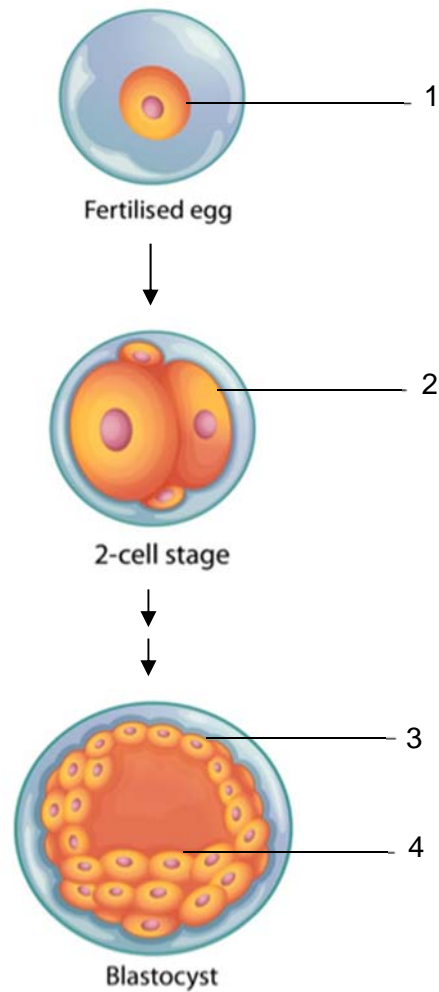
10. Scientists have made a nucleic acid (HNA) that has a sugar with the same number of carbon atoms as glucose instead of deoxyribose. Although genetic information can be stored by HNA, naturally occurring DNA polymerase cannot replicate HNA.

Which statements could explain why naturally occurring DNA polymerase cannot replicate HNA?

- 1 DNA polymerase cannot form bonds between the sugars of two HNA nucleotides.
- 2 DNA polymerase cannot form hydrogen bonds between two HNA nucleotides.
- 3 HNA nucleotides do not fit into the active site of DNA polymerase.
- 4 The shape of an HNA nucleotide is slightly larger than that of a DNA nucleotide.

- A** 1, 2, 3 and 4  
**B** 1 and 4 only  
**C** 2 and 3 only  
**D** 3 and 4 only

11. The figure below shows some stages of embryonic development. Four different cells are labelled 1, 2, 3 and 4 as shown.



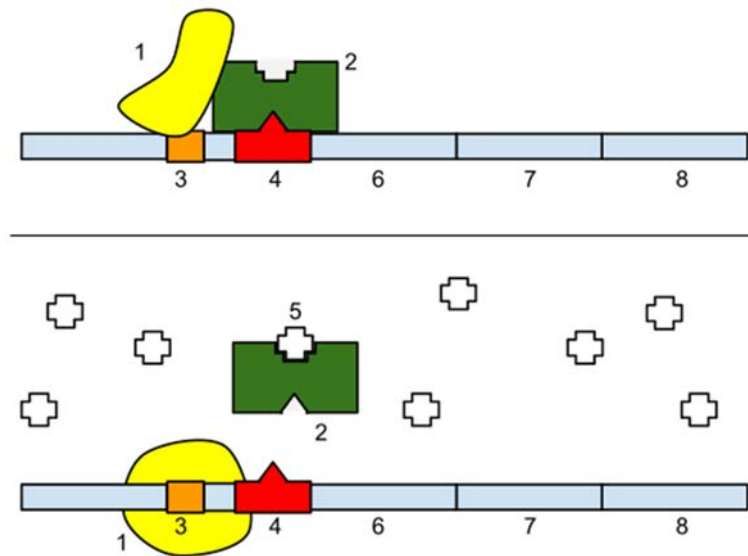
Which of the following statements is incorrect?

- A Cells 1 and 2 are totipotent.
- B Cells 3 and 4 are pluripotent.**
- C Cell 3 is a result of mitoses involving Cell 1.
- D Cells 2 and 4 can give rise to adult stem cells.

12. Which of the following is an example of translational control of gene expression?

- A Activation of proteins by folding or enzymatic cleavage
- B Addition of chemical groups such as phosphate groups to free amino acids in the cytoplasm
- C Binding of protein factors to specific sequences in mRNA preventing ribosomes from attaching.**
- D Formation of disulfide bridges in the protein being formed

13. A simplified figure of the lac operon is shown below. Several structures have been numbered 1 to 8.



Which of the following correctly identifies some of the structures above?

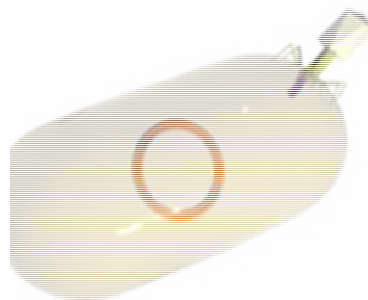
- A 1 is the lac repressor, 3 is the operator and 5 is allolactose.
- B 2 is an enzyme, 4 is the operator and 7 is a structural gene.
- C 2 is a catabolite activator protein, 5 is cyclic AMP and 8 is a structural gene.
- D 3 is the promoter, 5 is a carbohydrate and 6 is a structural gene.**

14. Which of the following pairs of statements are correct of generalised and specialised transduction?

	<b>Generalised</b>	<b>Specialised</b>
1	Transfers any bacterial DNA	Transfers a specific set of bacterial genes
2	Contains a hybrid chromosome in its capsid	Contains only bacterial chromosome in its capsid
3	Host cell will die	Host cell may die
4	Viral genome is not transcribed	Viral genome is transcribed
5	Only involves lytic cycle	Only involves lysogenic cycle
6	Viral DNA is replicated by host cell machinery	Viral DNA is replicated by binary fission

- A 1, 3 and 6 only
- B 1, 4 and 5 only
- C 2, 3 and 6 only
- D 3, 4 and 5 only

15. The following shows a virus infecting a bacterial cell.



After the step shown above, the viral genome could possibly

- A be reverse transcribed.
- B replace the host genome.
- C be packaged into a new capsid coat.
- D be integrated into the host bacterial genome.

16. SR scientists carried out an investigation into the effects of increasing temperature from 37 °C to 55 °C on the rates of glycolysis and Krebs cycle in animal cells.

They found that the rate of glycolysis decreased by 10% upon the increase in temperature while the rate of Krebs cycle decreased by 6%.

A Student's t-test was conducted, and the calculated t value at degree of freedom = 8 was 2.392.

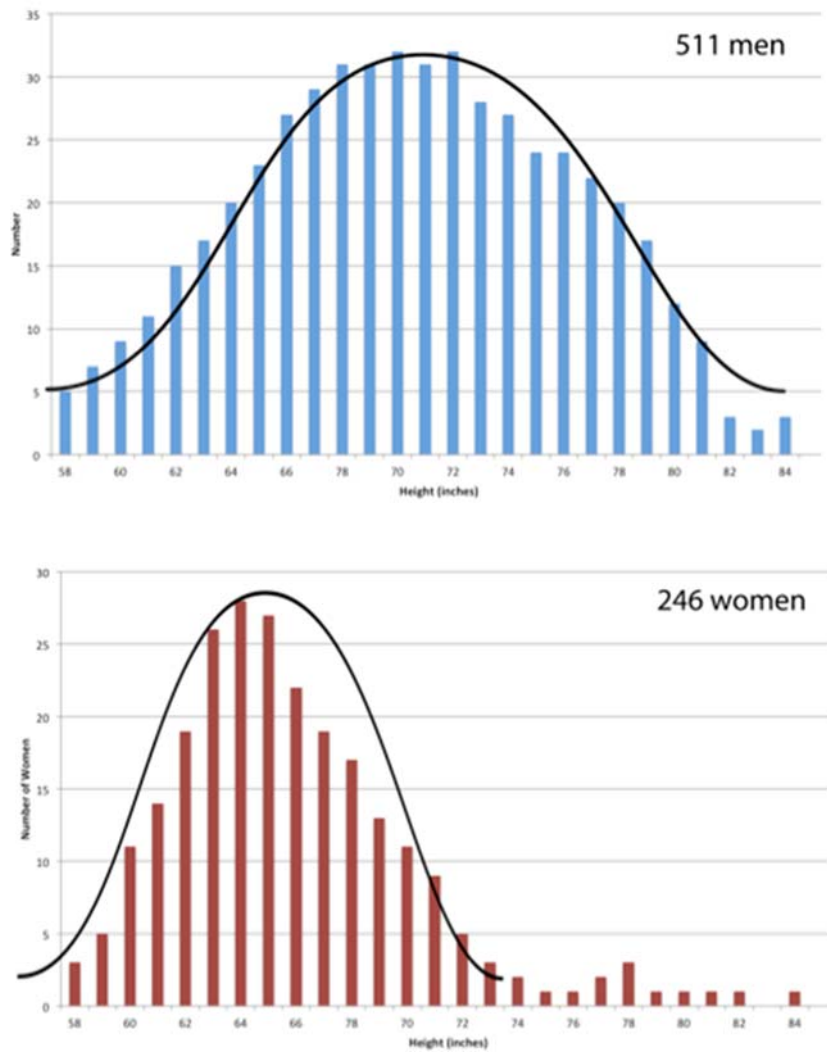
v	$\alpha$													
	0.40	0.30	0.20	0.15	0.10	0.05	0.025	0.02	0.015	0.01	0.0075	0.005	0.0025	0.0005
1	0.325	0.727	1.376	1.963	3.078	6.314	12.706	15.895	21.205	31.821	42.434	63.657	127.322	636.590
2	0.289	0.617	1.061	1.386	1.886	2.920	4.303	4.849	5.643	6.965	8.073	9.925	14.089	31.598
3	0.277	0.584	0.978	1.250	1.638	2.353	3.182	3.482	3.896	4.541	5.047	5.841	7.453	12.924
4	0.271	0.569	0.941	1.190	1.533	2.132	2.776	2.999	3.298	3.747	4.088	4.604	5.598	8.610
5	0.267	0.559	0.920	1.156	1.476	2.015	2.571	2.757	3.003	3.365	3.634	4.032	4.773	6.869
6	0.265	0.553	0.906	1.134	1.440	1.943	2.447	2.612	2.829	3.143	3.372	3.707	4.317	5.959
7	0.263	0.549	0.896	1.119	1.415	1.895	2.365	2.517	2.715	2.998	3.203	3.499	4.029	5.408
8	0.262	0.546	0.889	1.108	1.397	1.860	2.306	2.449	2.634	2.896	3.085	3.355	3.833	5.041
9	0.261	0.543	0.883	1.100	1.383	1.833	2.262	2.398	2.574	2.821	2.998	3.250	3.690	4.781
10	0.260	0.542	0.879	1.093	1.372	1.812	2.228	2.359	2.527	2.764	2.932	3.169	3.581	4.587

Using the table above, which statement below gives an appropriate conclusion at the 5% significance level?

- A** An increase in temperature to 55 °C has a greater effect on glycolysis.
- B** An increase in temperature to 55 °C has a greater effect on the Krebs cycle.
- C** Glycolysis and Krebs cycle are affected similarly by the increase in temperature to 55 °C.
- D** Glycolysis and Krebs cycle are not significantly affected by the increase in temperature to 55 °C.



17. The following graph depicts the distribution of human heights in a sample of 20-year old males and females in the US.



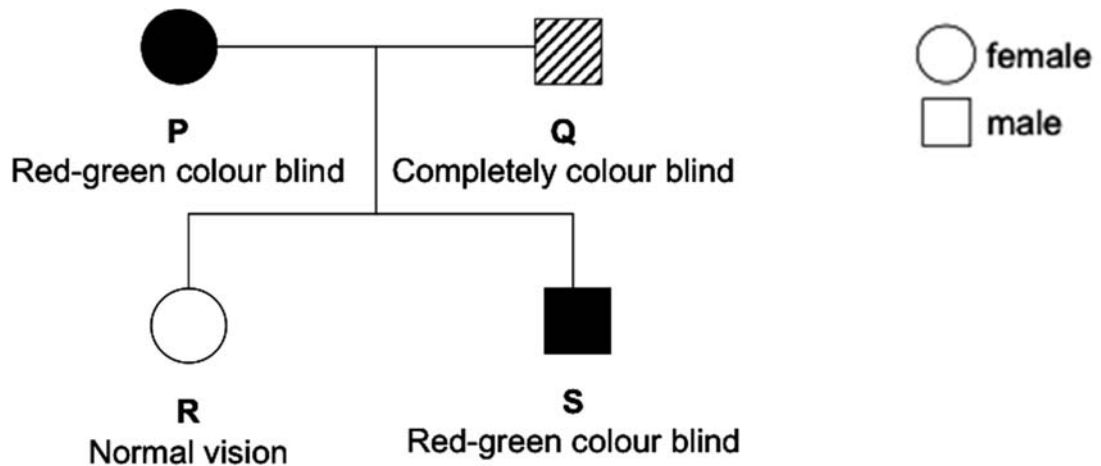
Based on the information above and your own knowledge, which of the following is **not** a valid inference?

- A Human height is controlled by more than one gene locus.
- B Human height involves multiple alleles or epistasis.**
- C Both the environment and genes have an effect on human height.
- D Women have a lower mean height than men.

18. Red-green colour blindness is controlled by a gene on the X chromosome. The allele for colour blindness, **g**, is recessive to the allele for normal colour vision, **G**.

Complete colour blindness is controlled by a different gene which is not on the X chromosome. The allele for the development of normal cones (pigment cells in the retinal layer of the eye), **B**, is dominant to the allele for no cone development, **b**.

The figure below shows the phenotypes of members of a different family in which both types of colour blindness occur.



Which of the following are possible genotypes for individuals **P**, **Q** and **S**?

	<b>P</b>	<b>Q</b>	<b>S</b>
<b>A</b>	$BBX^GX^G$	$bbX^GY$	$BBX^gY$
<b>B</b>	$BbX^GX^g$	$BbX^gY$	$BbX^GY$
<b>C</b>	$BBX^gX^g$	$bbX^GY$	$BbX^gY$
<b>D</b>	$BbX^GX^g$	$BbX^gY$	$BBX^GY$

19. In the magpie moth *Abraxas sp.*, the female is the heterogametic sex and the gene for wing colour is sex-linked.

In a cross between a normal coloured male and a pale coloured female, the F1 offspring consisted of all normal coloured individuals with the two sexes in equal proportions.

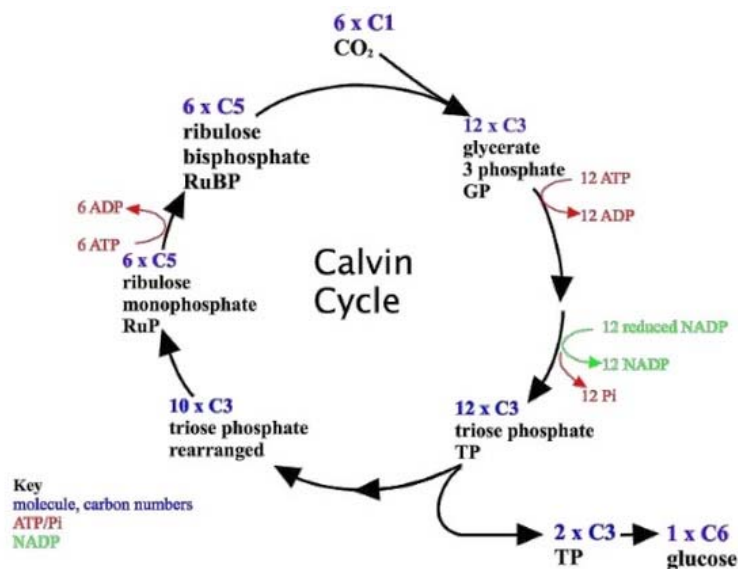
Which ratio would be obtained in the F2 generation produced from the F1 generation?

- A** Normal coloured males to normal females 1:1
- B** Normal coloured males and females to pale females 3:1
- C** Normal coloured males and females to pale males and females 1:1
- D** Normal coloured males to pale coloured females 1:1

20. Which of the following is the **most significant** reason for the effectiveness of nucleic acid hybridisation in highlighting a particular band of DNA on a gel electrophoresis slab?

- A The use of sponge and filter paper to draw buffer solution through the nitrocellulose paper containing the separated DNA
- B The use of radioactively labeled DNA primer sequences that specifically bind to the targeted sequences of DNA
- C The use of ethidium bromide that produces a strong reddish-yellow fluorescence when bands are exposed to UV radiation
- D The use of single stranded radioactively labelled probes complementary to the targeted bands**

21. The following is a diagram of the Calvin cycle.



Assuming each turn starts with 1  $\text{CO}_2$  and 1 RuBP, how many turns of the Calvin cycle would be required to produce 40 molecules of glucose?

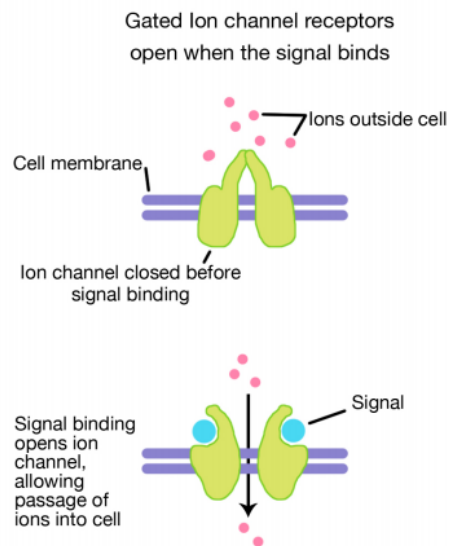
- A 40
- B 120
- C 240**
- D 480

22. In living cells, 2,4 dinitrophenol acts as a proton ionophore, an agent that can shuttle protons across biological membranes.

Which of the following is **not** a possible consequence of the introduction of 2,4 dinitrophenol into an animal cell?

- A Less oxygen is taken up by the cell.
- B The proton gradient across the inner mitochondrial membrane is dissipated.
- C The rate of glycolysis in the cell will increase.
- D The rate of Krebs cycle in the cell will increase.

23. The following is a diagram of an ion channel receptor and how it works.



This is a type of cell signaling receptor found in nerve cells. When a signal molecule binds to these receptors, the receptor changes conformation and causes the influx of ions into nerve cells. This directly causes the formation of an electrical action potential, which is transmitted along the nerve cell.

Which of the following statements **incorrectly** compares ion channel receptors with a G protein linked receptor?

- A Both ion channel and G protein linked receptors involve the activation of genes.
- B Both ion channel and G protein linked receptors involve the change of conformation of a receptor protein.
- C Ion channel receptors do not involve a second messenger.
- D G protein linked receptors do not allow the passage of ions into the cell.

24. New research conducted by evolutionary biologists worldwide paints cities as evolutionary "change agents", says a trio of biologists from the University of Toronto Mississauga (UTM).

A compilation of 15 new research papers, published as a special issue of *Proceedings of the Royal Society B: Biological Sciences*, confirms that cities frequently alter evolution by natural selection.

The following statements are possible ways in which cities could alter evolution by natural selection.

- 1 Cities are generally warmer than natural areas and thus organisms adapted to higher temperatures would be selected for within cities.
- 2 Cities release large amounts of environmental pollutants and thus organisms with greater resistance to common pollutants would be selected for in areas within cities.
- 3 Cities provides additional food sources for many organisms and thus organisms that are adapted to feed on a wider range of food types would be selected for within cities.
- 4 Cities have a large human population so organisms that are better able to interact with humans will be selected for within the cities.

Which statements are potentially correct?

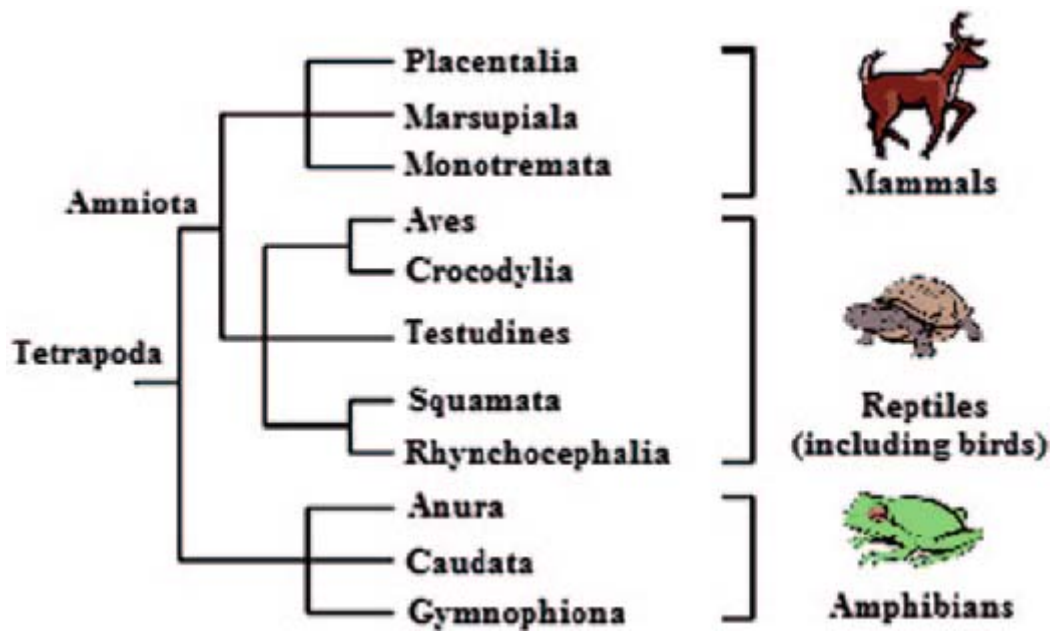
- A 1 and 2 only
- B 2 and 4 only
- C 1, 2 and 3 only
- D 1, 2, 3 and 4**

25. Lizards in the secondary forests of Pulau Ubin have always been classified as the same species as the lizards on mainland Singapore. However, it is suspected that the lizards on Pulau Ubin have recently evolved into a new species.

Which of the following scientific investigations is **least likely** to confirm this suspicion?

- A A detailed comparison of lizard fossils obtained from both the Pulau Ubin secondary forests and the mainland.**
- B Aligning and studying a homologous region of mitochondrial DNA obtained from both Pulau Ubin and mainland lizards.
- C A study of the habitats occupied by lizards in both locations and their interactions with both the biotic and abiotic components of their environment.
- D An in-depth comparative study of the primary morphological and physiological features of lizards from both locations.

26. The following figure shows the phylogenetic tree of some four-legged organisms.



Based only on the information in the phylogenetic tree, which of the following statements is **incorrect**?

- A Mammals are more closely related to reptiles than they are to amphibians.
- B There has been a greater amount of time for tetrapods to evolve compared with the group Amniota.
- C When comparing homologous DNA regions from an organism in the group Squamata and Rhynchocephalia, there will be fewer differences than when comparing Squamata with Crocodylia.
- D Placental mammals and Marsupials are very similar but they evolved slightly differently due to their separation by geography.**

27. The following table depicts some ways in which drugs can be used to target immune system cells.

Target	Principal immune function	Source(s)	Principal pathway mechanism(s)	Select drug(s) in clinical investigation
B7-H3	Inhibitory	Transmembrane receptor protein found on APCs, tumor cells, host cells	Binds to unknown receptors on T cells causing inhibitor immune signals; however, primarily inhibitory	Enoblituzumab (MGA271)
ICOS	Inhibitory	Transmembrane receptor protein found on T cells (highly expressed on T-regulatory cells)	Exerts an immune inhibitory function by binding to ICOS-L on APCs stimulating T-regulatory cell function, thus mediating overall immune suppression	MEDI570
OX40	Stimulatory	Transmembrane receptor protein found on T cells	Binds to OX40-L on APCs to stimulate T-cell proliferation and activity	MEDI6469 MOXR0916
GITR	Stimulatory	Transmembrane receptor found on T cells	Produces stimulatory signal upon binding to GRITL on APCs stimulating T-cell proliferation and activity; also involved in T-regulatory cell function	TRX518

Which drug(s) could possibly be used in the clinical treatment of cancerous T cells?

- A** MEDI570 only
- B** MEDI6469 only
- C** MGA271 and TRX518 only
- D** MEDI570 and MOXR0916 only

28. Over the past month, a team from the Ethiopian Wolf Conservation Programme has suggested the implementation of the first oral vaccination campaign to pre-empt outbreaks of rabies among Ethiopian wolves, the world's most endangered canid, in their stronghold in the Bale Mountains of southern Ethiopia.

Which of the following is the most biologically accurate prediction of the effect of this oral vaccination attempt?

- A The vaccination will not work as vaccines only work for humans.
- B The vaccination will not work as the wolves are likely to develop resistance against the vaccine.
- C The vaccination will work as it contains antibodies that will target the rabies pathogen.
- D The vaccination will work as wolves will produce plasma cells to target the rabies pathogen.

29. It has been discovered that deep corals, which are found at ocean depths below the reach of sunlight, is also affected by climate change.

Which of the following statements is a valid explanation as to why this is so?

- A The rate of photosynthesis at the deeper waters inhabited by the deep coral species is inhibited by a lack of carbon dioxide.
- B Deep water coral species are adapted to lower temperatures and are unable to migrate to shallow waters which have a higher water temperature.
- C The warming of surface water temperatures due to global warming has led to even the deeper waters heating up beyond the natural range of deep water coral species.
- D The rising sea levels globally have led to deep corals being unable to receive sunlight for use by its symbiotic algae.

30. All of the following are possible impacts of global warming except

- A heavier strain on global food supplies such as livestock.
- B increased transmission of diseases such as tuberculosis and HIV.
- C larger populations of crop pests in the tropical and sub-tropical regions.
- D smaller reservoir for biomedicines due to reduced biodiversity of the tropics.

**END OF PAPER**



CANDIDATE NAME: \_\_\_\_\_

INDEX NUMBER \_\_\_\_\_

CG \_\_\_\_\_



SERANGOON JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION 2018

H2 BIOLOGY  
Paper 2 Structured Questions

9744/02

Thursday  
13 September 2018

2 hours

**READ THESE INSTRUCTIONS FIRST**

Write your name, index number and CG in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

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 appropriate units.

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

FOR EXAMINER'S USE	
<b>Paper 1 (MCQ)</b>	<b>/30</b>
<b>Paper 2</b>	
<b>1</b>	<b>/18</b>
<b>2</b>	<b>/17</b>
<b>3</b>	<b>/11</b>
<b>4</b>	<b>/13</b>
<b>5</b>	<b>/12</b>
<b>6</b>	<b>/9</b>
<b>7</b>	<b>/8</b>
<b>8</b>	<b>/12</b>
<b>P2 Total</b>	<b>/100</b>
<b>Paper 3</b>	
<b>Paper 3</b>	<b>/75</b>
<b>Paper 4</b>	<b>/55</b>
<b>TOTAL (100%)</b>	

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This question paper consists of **28** printed pages including this cover page.

1. Fig. 1.1 is an electron micrograph of part of an animal cell obtained from a rodent.

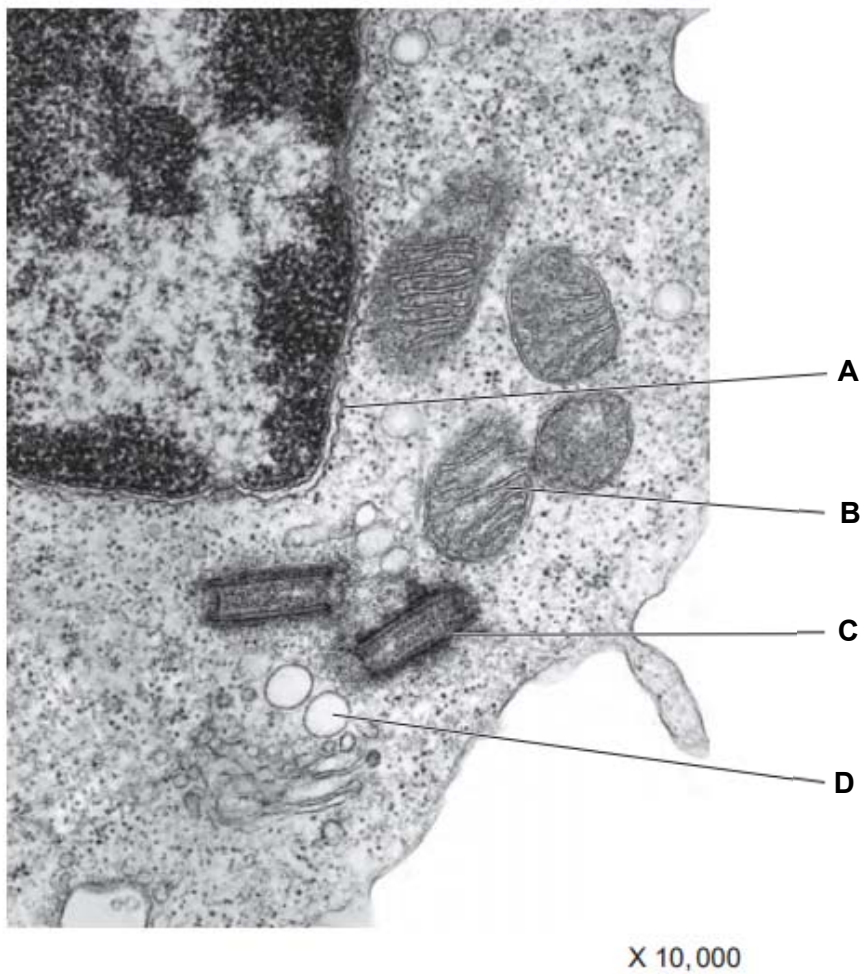


Fig. 1.1

(a) Name the structures labelled **A** to **C**.

**A:** .....

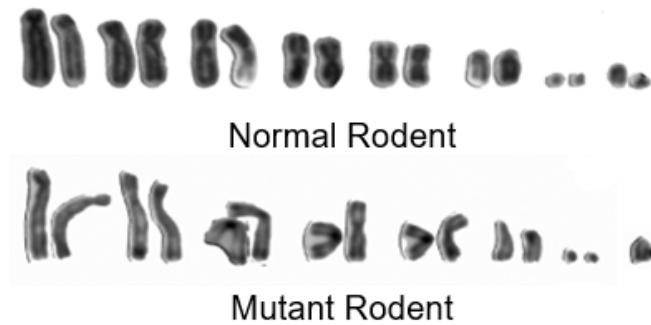
**B:** .....

**C:** ..... [3]

(b) Describe the role of structure **C** in animal cells.

.....  
.....  
.....  
..... [2]

(c) Complete karyotypes of two rodents of the same species were isolated as shown in Fig. 1.2. In this species of rodent, males are the heterogametic sex, where they have two different sex chromosomes.



**Fig. 1.2**

(i) State the diploid number of chromosomes in a normal rodent.

.....  
 ..... [1]

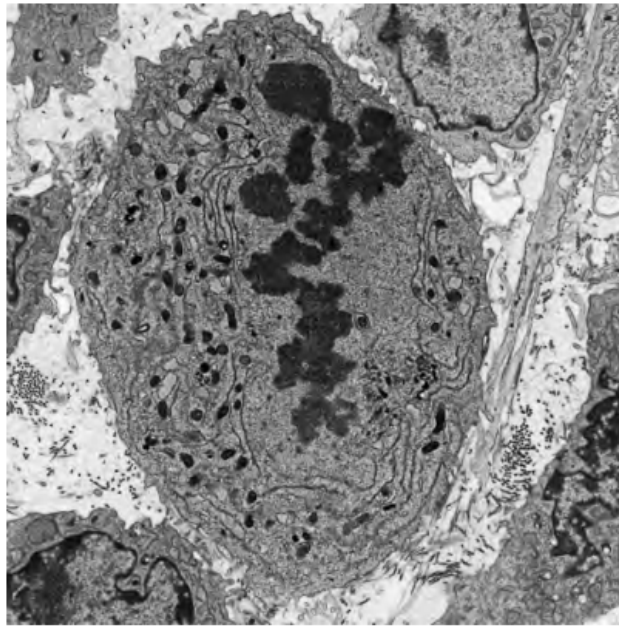
(ii) Explain how the mutant rodent karyotype was formed.

.....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

(iii) Suggest why the mutant rodent is still able to survive despite the mutation.

.....  
 ..... [1]

Fig. 1.3 is an electron micrograph of a cancer cell in the midst of mitosis.



**Fig. 1.3**

**(d)** Identify the stage of mitosis, giving a reason for your answer.

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.....  
..... [2]

People who have smoked cigarettes for many years are at risk of developing lung cancer.

**(e)** Explain why smoking increases the risk of cancer.

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..... [2]

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Fig. 1.4 shows the change in the percentage of smokers in the male population of the UK between 1950 and 2005. Fig. 1.5 shows the change in mortality rate in the UK in men aged 75 to 84 between 1950 and 2005.

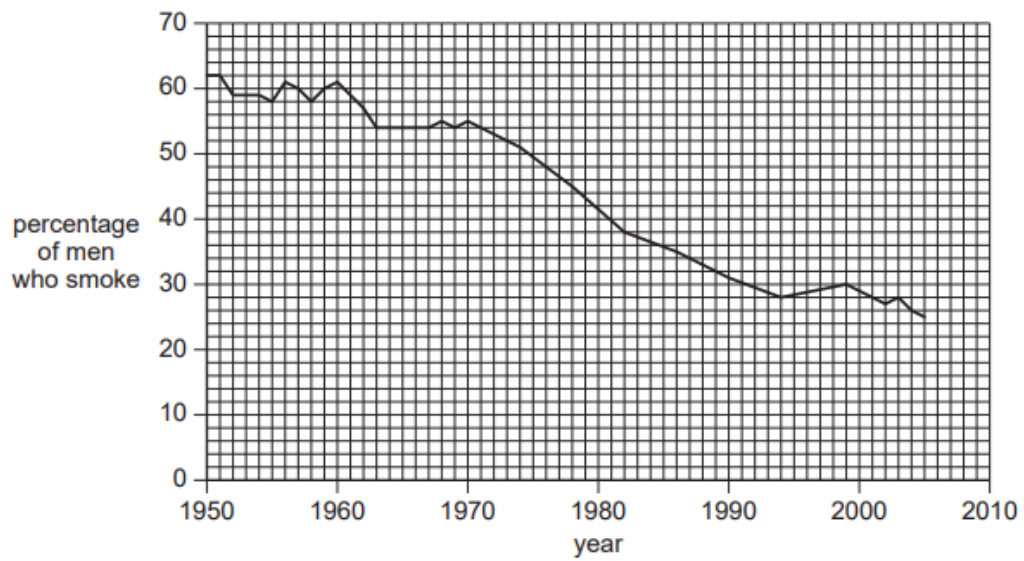


Fig. 1.4

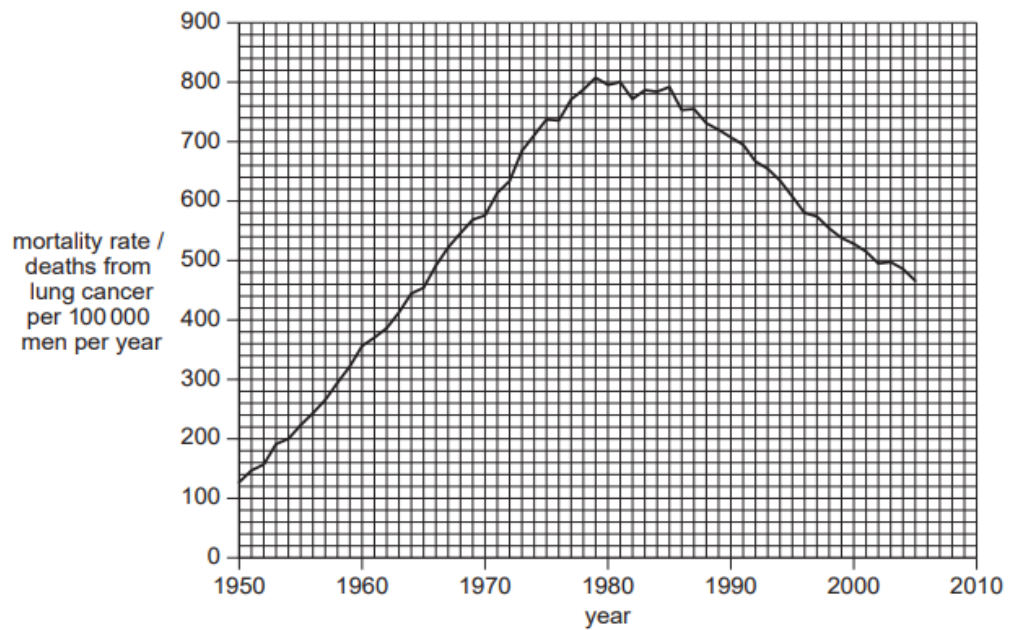


Fig. 1.5

(f) With reference to Figs. 1.4 and 1.5, discuss the observations made between 1950 and 2005.

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..... [4]

[Total: 18]

2. (a) Contrast between the structures of DNA and tRNA.

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.....  
.....  
.....  
..... [3]

(b) Table 2.1 shows two mRNA triplets. Fill in the complementary tRNA triplets in the spaces provided.

<b>mRNA triplets</b>	CGC	AAC
<b>tRNA triplets</b>		

**Table 2.1**

[1]

(c) Calculate the minimum number of DNA nucleotides required to code for a polypeptide with 238 amino acids. Show your working.

[2]

(d) Describe the role played by tRNA in polypeptide synthesis.

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.....  
.....  
.....  
.....  
..... [3]



Eukaryotic cells are able to regulate gene expression to ensure that resources within the cell are used effectively and efficiently.

**(e)** Regulation can be observed during the process of stem cell specialisation. Describe the most likely form of regulation taking place during stem cell specialisation, giving reasons for your answer.

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..... [4]

(f) Regulation can also occur following the synthesis of proteins. An example of such regulation is shown in Fig. 2.1 where inactive enzyme precursor pepsinogen is modified post-translationally to form active pepsin.

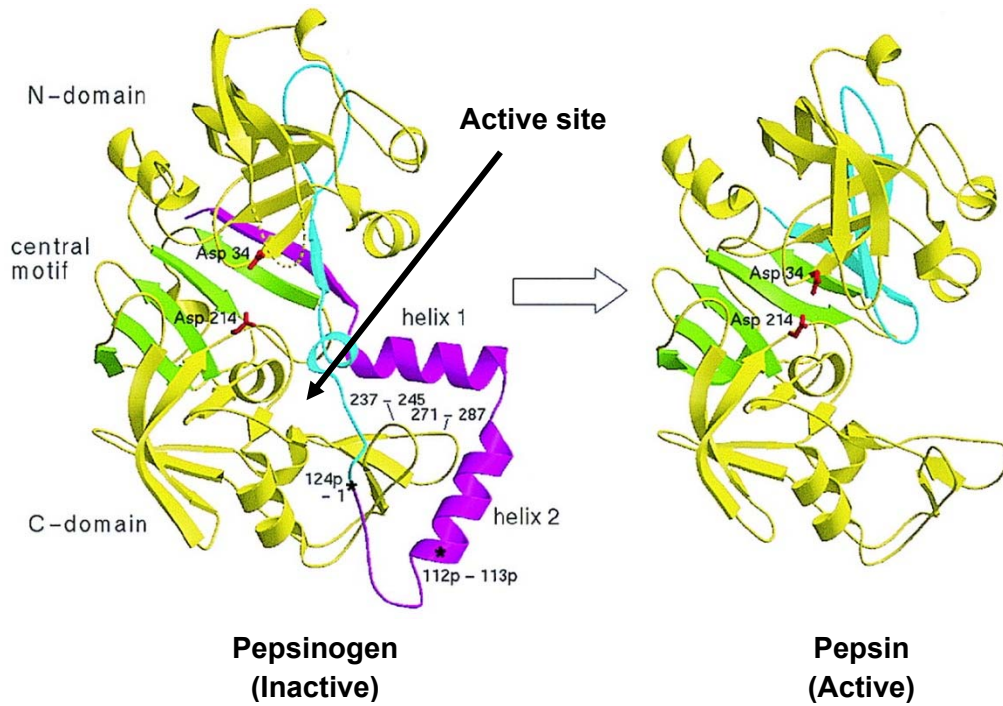


Fig. 2.1

(i) With reference to Fig. 2.1, identify the type of post-translational regulation observed in the enzyme and explain why it results in its activation.

.....

.....

.....

..... [2]

(ii) Suggest why pepsin is synthesised as an inactive precursor pepsinogen.

.....

.....

.....

..... [2]

[Total: 17]

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3. Bacterial cells can contain one or more plasmids which carry genes that are beneficial to its survival. One such plasmid contains *arg*, *his*, *leu* and *cys* genes that code for the biosynthesis of four essential amino acids; arginine, histidine, leucine and cysteine respectively.

A bacterial strain, strain **A**, with the following plasmid genes (*arg+*, *his+*, *leu+* and *cys-*) was grown in nutrient media for several generations.

- (a) State the amino acid(s), if any, that must be added to the nutrient media for strain **A** to grow.

.....  
 ..... [1]

Strain **A** was then mixed with another bacterial strain, strain **B**, with the following plasmid genes (*arg-*, *his-*, *leu-* and *cys+*) and allowed to grow together at various time intervals before strain **B** was isolated and grown on nutrient media containing a variety of amino acids.

Table 3.1 shows whether colonies of strain **B** were observed on the various media at different time intervals (+ indicates the presence of an amino acid in the medium while - indicates its absence).

Time of incubation/ minutes	Supplementation of amino acids in medium				Presence of colonies
	Arg	His	Leu	Cys	
10	-	+	+	-	No
	+	-	+	-	Yes
	-	-	+	-	No
20	+	-	-	-	Yes
	-	-	-	-	No
25	-	-	-	-	Yes

**Table 3.1**

- (b) Describe the process that has occurred between strains **A** and **B** when they were incubated together in the nutrient media.

.....  
 .....  
 .....  
 .....  
 .....  
 .....  
 .....  
 .....  
 ..... [4]

(c) Using information from Table 3.1, indicate the order of genes (*arg+*, *his+*, *leu+*) found on the plasmid in strain **A**. You should also indicate in your diagram the origin and direction of transfer.

[3]





(d) Using information from Table 3.1, explain your answer in (c).

.....  
.....  
.....  
.....  
.....  
..... [3]

[Total: 11]

4. The fruit fly, *Drosophila melanogaster*, has eyes, a striped abdomen and wings longer than its abdomen. This is called a 'wild-type' fly.

Mutation has resulted in many variations of these features. Table 4.1 shows diagrams of a wild-type fly and three other flies, each of which shows one recessive mutation.

				
<b>eyes</b>	present	present	absent	present
<b>abdomen</b>	striped	black	striped	striped
<b>wing description</b>	long	long	long	short

**Table 4.1**

- (a) Analysis of the mature mRNA formed from the mutant allele for black abdomen showed that one exon was missing although the length of both the mutant and normal alleles for abdomen colour were identical on the chromosome.

Suggest the genetic basis of this mutation and how it leads to a missing exon.

.....

.....

.....

.....

.....

.....

..... [3]

(b) Using appropriate symbols, illustrate a cross between a fly without eyes and long wings and one with eyes and short wings that would result in **four** different phenotypes being observed in the offspring.

[5]

- (c) A cross was carried out between a fly heterozygous for striped abdomen and long wings and a fly with a black abdomen and short wings. The results are shown below in Table 4.2.

offspring	number
striped abdomen long wing	86
black abdomen long wing	87
striped abdomen short wing	81
black abdomen short wing	78
total	332

**Table 4.2**

A chi-squared test ( $\chi^2$ ) was carried out on these data. Complete Table 4.3 and calculate the value of  $\chi^2$ .

Observed Number (O)	Expected Number (E)	(O - E)	(O - E) <sup>2</sup>	(O - E) <sup>2</sup> / E
86				
87				
81				
78				

**Table 4.3**

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

$\chi^2$ : ..... [3]



(d) Table 4.4 shows  $\chi^2$  values.

degrees of freedom	probability						
	0.50	0.20	0.10	0.05	0.02	0.01	0.001
3	2.37	4.64	6.25	7.82	9.84	11.34	16.27

**Table 4.4**

Using Table 4.4, explain what conclusions can be made about the results of the  $\chi^2$  test.

.....

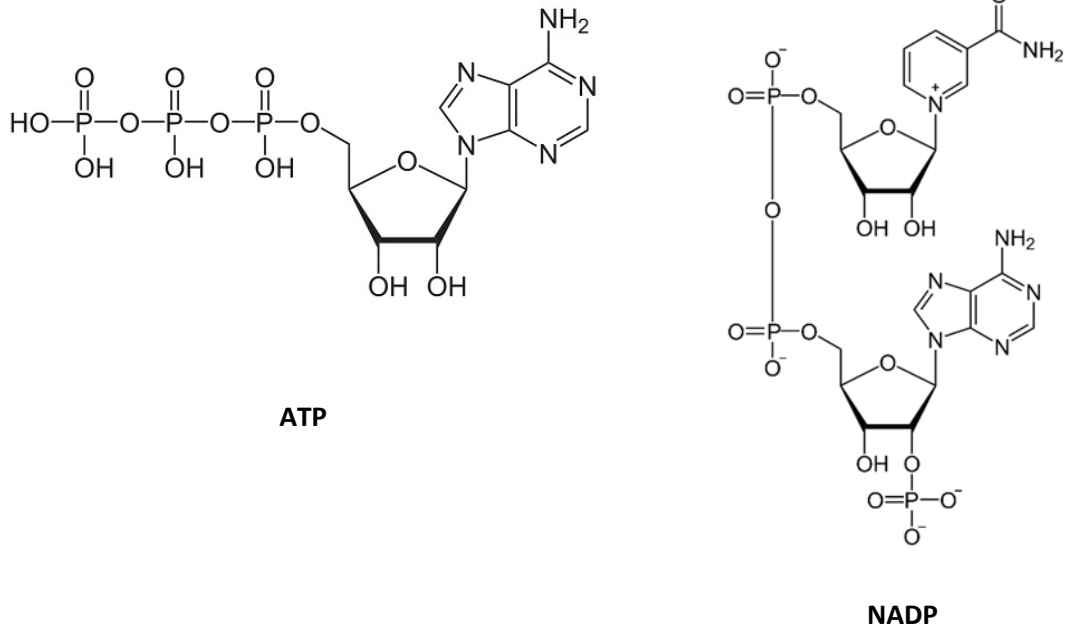
.....

.....

..... [2]

[Total: 13]

5. ATP and NADP both play important roles in photosynthesis. Fig. 5.1 represents the molecular structures of ATP and NADP.



**Fig. 5.1**

(a) Using Fig. 5.1, compare the structures of ATP and NADP.

.....

.....

.....

.....

.....

.....

.....

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.....

.....

[4]

(b) Outline the roles of NADP in a cell.

.....

.....

.....

.....

.....

[2]

(c) State the names of the processes in which ATP is synthesised during photosynthesis and respiration respectively.

.....  
.....  
.....  
..... [2]

(d) ATP serves as a source of energy for several metabolic processes in both photosynthesis and respiration. State two processes in **respiration** that requires ATP as an energy source.

.....  
.....  
.....  
..... [2]

(e) The first substrate used in respiration is glucose. In a situation of excess glucose, some of these glucose is stored as fats instead of carbohydrates. Explain why animals prefer to store lipid instead of carbohydrates.

.....  
.....  
.....  
..... [2]

[Total: 12]

6. Lactose intolerance is a condition in which individuals are unable to digest lactose as the cells in their small intestine are unable to synthesise sufficient quantities of the enzyme lactase. The undigested lactose will then interact with bacteria normally present in the large intestine and cause uncomfortable symptoms such as bloating, diarrhoea and gas production.

Lactose is commonly found in large quantities in dairy products. The distribution of adult population with lactose intolerance is shown in Fig. 6.1. A simplified world map illustrating major continents is shown in Fig. 6.2 for your reference.

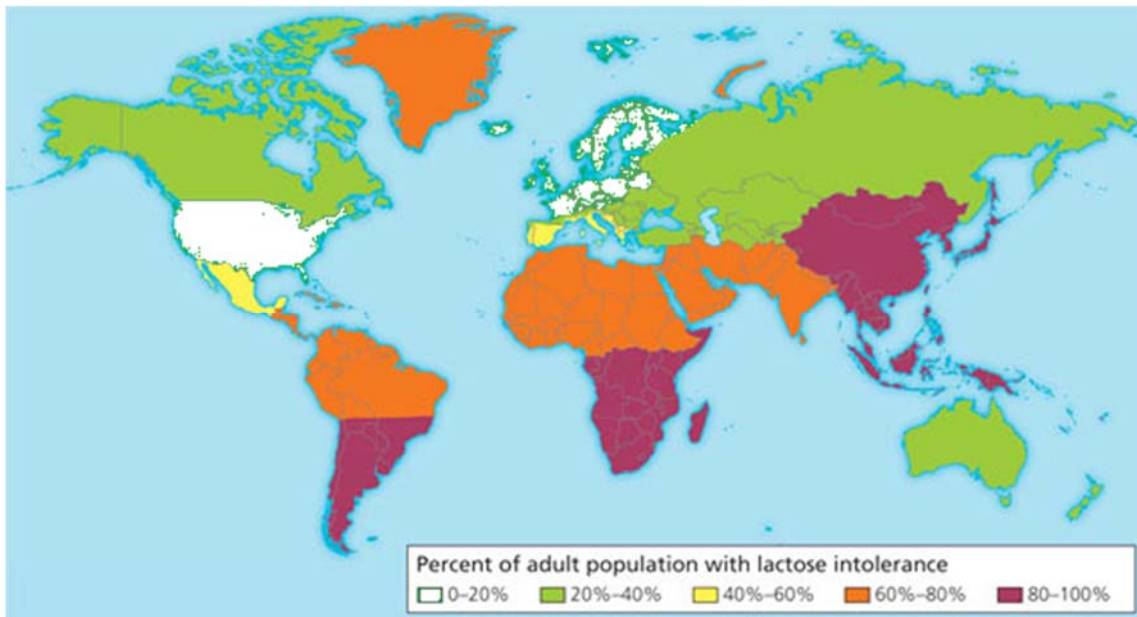


Fig. 6.1



Fig. 6.2

**(a)** With reference to Figs. 6.1 and 6.2, describe the distribution of lactose intolerance in adults.

.....  
.....  
.....  
..... [2]

**(b)** Research has shown that most individuals are able to produce large quantities of lactase from birth, although this value can decline as the individual grows older due to environmental factors. The most prominent decline in lactase production is often observed when babies are switched from a predominantly milk-based diet to a solid food diet.

**(i)** Suggest why there is a prominent decline in lactase production in babies following a switch to a solid food diet.

.....  
.....  
.....  
..... [2]

**(ii)** Using the information found in **(b)**, suggest a reason for your observations made in **(a)**.

.....  
..... [1]

Level of expression of lactase is regulated by a lactase activator which stimulates expression of lactase in the presence of lactose. Human populations that inhabited the earth millions of years ago were found to express a lactase activator which is only weakly active. At present, most human populations express a more active version of this activator protein.

**(c)** Using your knowledge of evolution, explain the basis of this observation.

.....

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.....

.....

..... [4]

[Total: 9]

7. Antigen presenting cells (APCs) such as macrophages are able to detect specific foreign antigens and present them to relevant adaptive immune cells. Recognition of these antigens require the use of specific receptors on the surface of these APCs.

(a) State the receptor found on macrophages that is used for antigen binding and recognition.

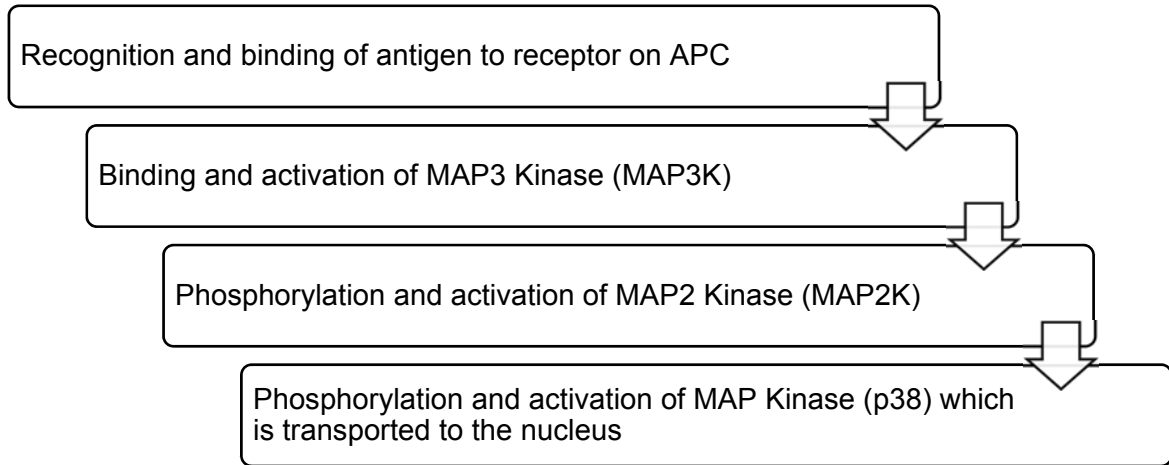
.....  
..... [1]

Following binding, these antigens are then taken into the cell and processed for presentation to T cells.

(b) Describe how an **extracellular** antigen is subsequently presented to a T cell following binding to the receptor mentioned in (a).

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..... [3]

Research has shown that a cell signalling pathway is triggered following binding of an antigen to its receptor. One of the more well understood signalling pathways involve a series of kinases, which are enzymes that catalyse the phosphorylation of its substrate. A common signalling pathway in APCs is shown in Fig. 7.1.



**Fig. 7.1**

Activation of the signalling pathway shown in Fig. 7.1 leads to a large cellular response consisting of both cytokine production and also antigen presentation.

**(c)** Using your knowledge of signalling pathways and the information from Fig. 7.1, explain this observation.

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..... [4]

[Total: 8]



8. Dengue and tuberculosis (TB) are two prominent infectious diseases of concern in many countries.

(a) Describe how TB is transmitted from an infected person to an uninfected person.

.....  
.....  
.....  
..... [2]

Fig. 8.1 shows the distribution of dengue.

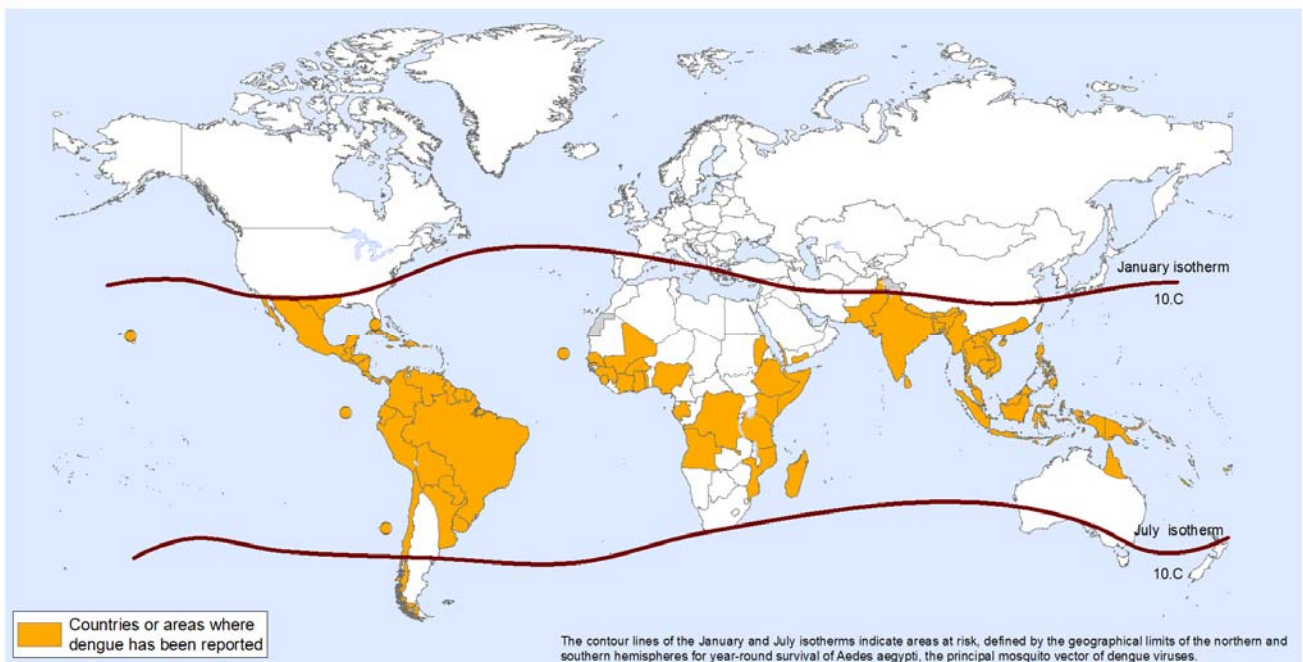


Fig. 8.1

(b) Unlike dengue, TB is found across the entire world. Explain why dengue shows the distribution shown in Fig. 8.1 whereas TB is found worldwide.

.....  
.....  
.....  
.....  
.....  
..... [3]

Vaccinations are used to control infectious diseases. They were used as part of the programme to eradicate smallpox and as part of the continuing programmes against diseases such as polio and measles.

Smallpox was eradicated from the world in the 1970s. Polio is likely to be the next infectious disease to be eradicated.

**(c)** Explain how vaccination provides immunity as an important part of programmes to control and eradicate infectious diseases.

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..... [5]

Despite being a disease that has persisted for hundreds of years, there is currently no vaccine approved for the treatment of TB.

**(d)** Using your knowledge of the pathogenicity of *M. tuberculosis*, suggest why it is difficult to develop an effective vaccine for TB.

.....  
..... [1]

Apart from the use of vaccination, other measures of controlling the spread of dengue involves the release of sterile male mosquitoes into areas with high dengue incidence. While this measure has successfully reduced mosquito populations dramatically, environmentalist are concerned about their potential detrimental ecological effects.

**(e)** Suggest one possible ecological concern that may arise from the use of sterile male mosquitoes.

.....  
..... [1]

[Total: 12]

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CANDIDATE NAME: \_\_\_\_\_

INDEX NUMBER \_\_\_\_\_

CG \_\_\_\_\_



SERANGOON JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION 2018

H2 BIOLOGY  
Paper 2 Structured Questions

9744/02

Thursday  
13 September 2018

2 hours

**READ THESE INSTRUCTIONS FIRST**

Write your name, index number and CG in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

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 appropriate units.

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

FOR EXAMINER'S USE	
<b>Paper 1 (MCQ)</b>	<b>/30</b>
<b>Paper 2</b>	
<b>1</b>	<b>/18</b>
<b>2</b>	<b>/17</b>
<b>3</b>	<b>/11</b>
<b>4</b>	<b>/13</b>
<b>5</b>	<b>/12</b>
<b>6</b>	<b>/9</b>
<b>7</b>	<b>/8</b>
<b>8</b>	<b>/12</b>
<b>P2 Total</b>	<b>/100</b>
<b>Paper 3</b>	
<b>Paper 3</b>	<b>/75</b>
<b>Paper 4</b>	<b>/55</b>
<b>TOTAL (100%)</b>	

This question paper consists of **18** printed pages including this cover page.

1. Fig. 1.1 is an electron micrograph of part of an animal cell obtained from a rodent.

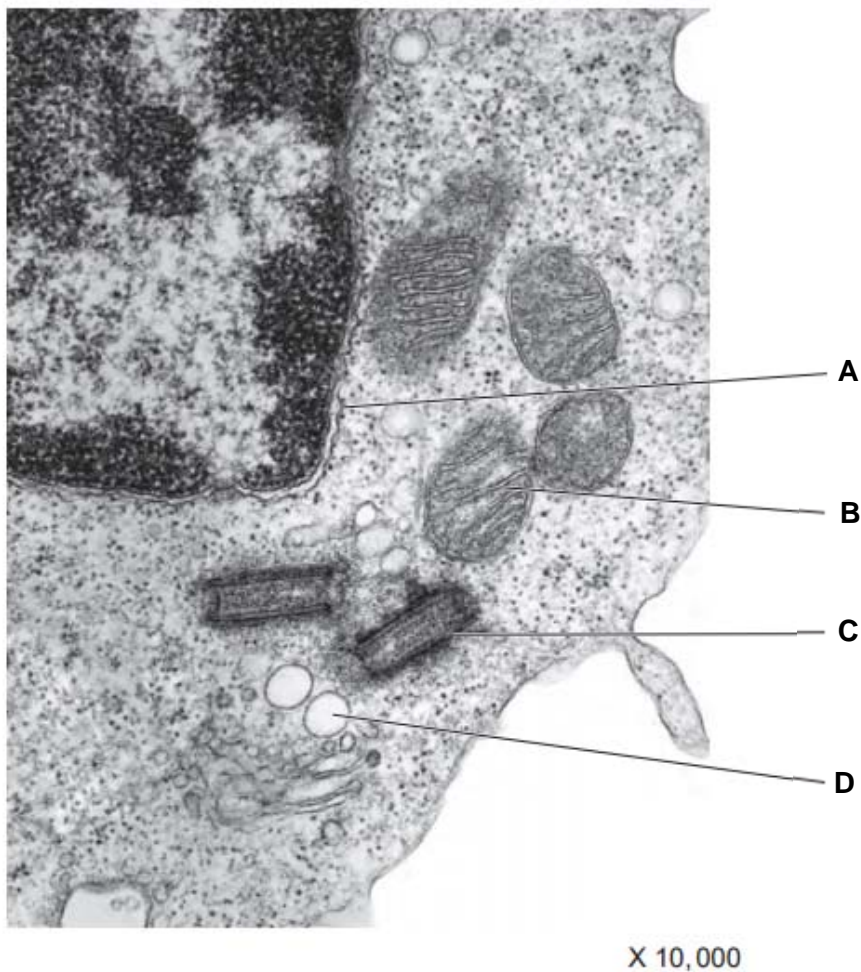


Fig. 1.1

(a) Name the structures labelled **A** to **C**. [3]

A: nuclear envelope/membrane / outer nuclear envelope/membrane / nucleus

B: crista/ mitochondrion/ inner mitochondrion membrane Rej: Matrix (image is clear enough)

C: centriole

(b) Describe the role of structure **C** in animal cells. [2]

1. Assembly/ organisation of spindle fibres/ microtubule

2. To separate chromosomes/ chromatids during mitosis and meiosis/ cell division

3. AVP: Modified centrioles can be found in flagella/ cilia for locomotion

- (c) Complete karyotypes of two rodents of the same species were isolated as shown in Fig. 1.2. In this species of rodent, males are the heterogametic sex, where they have two different sex chromosomes.

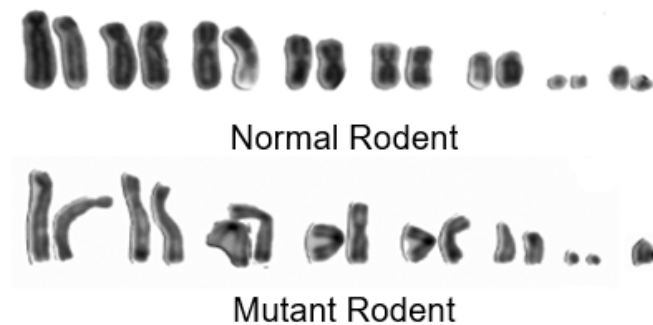
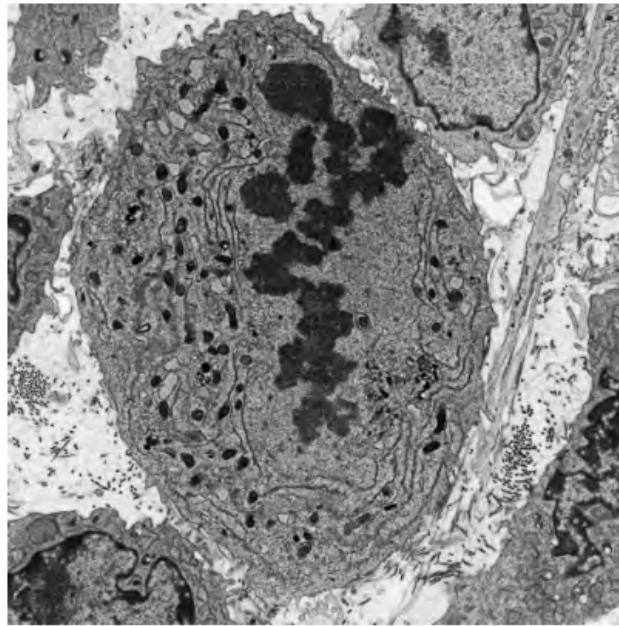


Fig. 1.2

- (i) State the diploid number of chromosomes in a normal rodent. [1]  
16
- (ii) Explain how the mutant rodent karyotype was formed. [3]
1. Mutant rodent is missing one sex chromosome (i.e. XO)
  2. Nondisjunction occurred during anaphase of meiosis I for the sex chromosome pair during formation of gametes in mutant rodent's father/ mother
  3. Both sex chromosomes were distributed to one daughter cell at the end of meiosis I, while none were distributed to the other, forming mutant gametes
  4. Fusion of mutant gamete (n-1) with a normal gamete during fertilisation led to formation of mutant rodent karyotype.
- Max 3
- (iii) Suggest why the mutant rodent is still able to survive despite the mutation. [1]
1. Only one copy of the X chromosome is required to express genes on the X chromosome sufficiently

Fig. 1.3 is an electron micrograph of a cancer cell in the midst of mitosis.



**Fig. 1.3**

**(d)** Identify the stage of mitosis, giving a reason for your answer. [2]

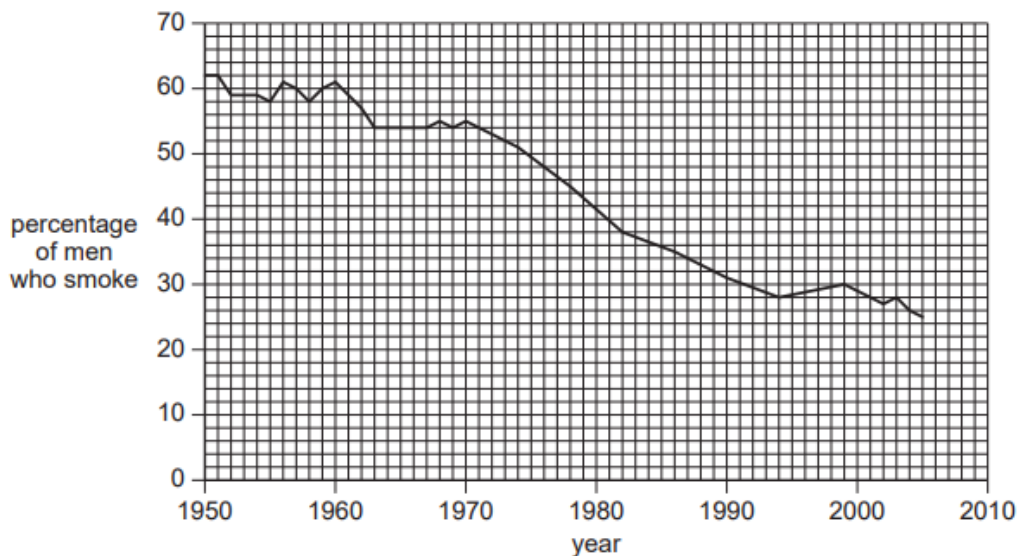
1. Stage: Metaphase
2. Reason: chromosomes align in a single/one row at the equator

People who have smoked cigarettes for many years are at risk of developing lung cancer.

**(e)** Explain why smoking increases the risk of cancer. [2]

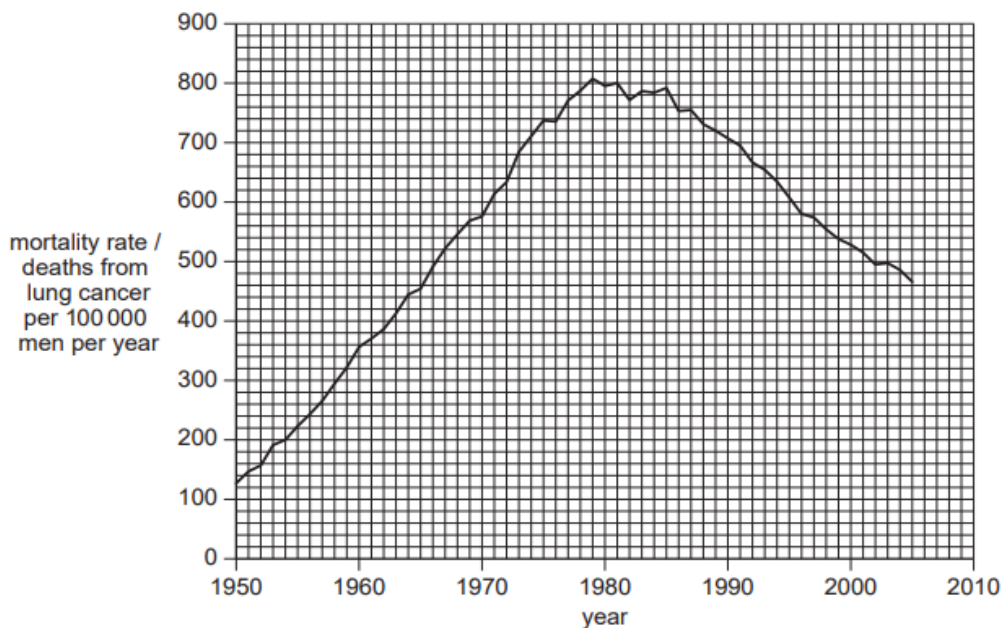
1. Cigarettes contain tar/ nitrosamines/ AVP which is a carcinogen
2. That increases rate of mutation in tumor suppressor genes/ proto-oncogenes

Fig. 1.4 shows the change in the percentage of smokers in the male population of the UK between 1950 and 2005. Fig. 1.5 shows the change in mortality rate in the UK in men aged 75 to 84 between 1950 and 2005.



**Fig. 1.4**





**Fig. 1.5**

(f) With reference to Figs. 1.4 and 1.5, discuss the observations made between 1950 and 2005. [4]

1. Percentage of men who smoke fell from 62 to 25% between 1950 and 2005
2. and mortality rate increased from 130 to 810 deaths from lung cancer per 100 000 men per year between 1950 and 1979 and then decreased to 470 in 2005
3. Increase in number of deaths despite fall in % smokers between 1950 and 1979 as cancer is multistep process/ requires multiple mutations to accumulate before it develops into cancer hence lag time/ death from cancer is often associated with metastasis which occurs typically in the later stages of cancer development
4. fall in cancer deaths due to improvements in health care that allow for earlier diagnosis/ treatment/AVP

[Total: 18]

2. (a) Contrast between the structures of DNA and tRNA. [3]

	DNA	tRNA
Number of strands	Double stranded/ two strands	Single stranded
structure	helix	Clover-leaf
monomer	deoxyribonucleotide	ribonucleotide
bases	Thymine present	Thymine absent, uracil is used instead
H bond frequency	H bond occurs between all bases	H bond only at selected regions to hold structure
A:T/U G:C ratio	A:T and G:C ratio is always 1	A:T/U and G:C ratio varies
length	longer	shorter

(b) Table 2.1 shows two mRNA triplets. Fill in the complementary tRNA triplets in the spaces provided. [1]

mRNA triplets	CGC	AAC
tRNA triplets	GCG	UUG

Table 2.1

(c) Calculate the minimum number of DNA nucleotides required to code for a polypeptide with 238 amino acids. Show your working. [2]

1.  $238 \times 3 = 714$
2. Stop codon: 3 bases, Total:  $714 + 3 = 717$

(d) Describe the role played by tRNA in polypeptide synthesis. [3]

1. Carries amino acid to tRNA binding sites on ribosome
2. Bring amino acids in close proximity for formation of peptide bond
3. Specific amino acid sequence ensured by complementary base pairing of anticodon on tRNA with codon on mRNA

Eukaryotic cells are able to regulate gene expression to ensure that resources within the cell are used effectively and efficiently.

(e) Regulation can be observed during the process of stem cell specialisation. Describe the most likely form of regulation taking place during stem cell specialisation, giving reasons for your answer. [4]

1. DNA methylation at cytosine residues in CpG island in promoter catalysed by DNA methyltransferases
2. Results in increased condensation of chromatin and is associated with long term and heritable inactivation of genes
3. During specialisation, stem cells differentiate to form specialised cells that perform specific functions
4. Differentiated cells no longer need to express a wide repertoire of genes involved in maintaining stem cell properties hence can be permanently inactivated
5. Modification must be heritable to allow differentiated cell to produce identical differentiated daughter cells by mitosis

Max 4

- (f) Regulation can also occur following the synthesis of proteins. An example of such regulation is shown in Fig. 2.1 where inactive enzyme precursor pepsinogen is modified post-translationally to form active pepsin.

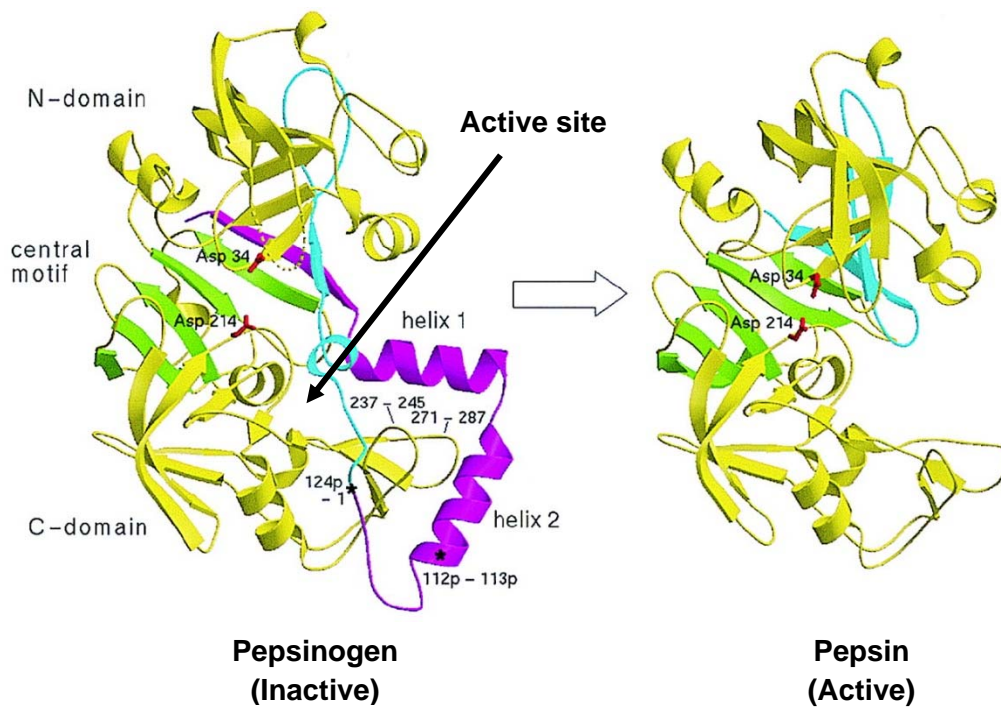


Fig. 2.1

- (i) With reference to Fig. 2.1, identify the type of post-translational regulation observed in the enzyme and explain why it results in its activation. [2]
1. Proteolytic cleavage and activation of pepsinogen which removes helix 1 and 2
  2. Exposes the active site to allow for substrate to bind and pepsin to catalyse breakdown of proteins
- (ii) Suggest why pepsin is synthesised as an inactive precursor pepsinogen. [2]
1. It is a hydrolytic enzyme that catalyses breakdown of protein
  2. Hence may degrade essential intracellular protein components (e.g. enzymes, membrane proteins etc.), thus is only activated when it needs to carry out its function

[Total: 17]

3. Bacterial cells can contain one or more plasmids which carry genes that are beneficial to its survival. One such plasmid contains *arg*, *his*, *leu* and *cys* genes that code for the biosynthesis of four essential amino acids; arginine, histidine, leucine and cysteine respectively.

A bacterial strain, strain **A**, with the following plasmid genes (*arg*+, *his*+, *leu*+ and *cys*-) was grown in nutrient media for several generations.

- (a) State the amino acid(s), if any, that must be added to the nutrient media for strain **A** to grow. [1]  
 Cysteine

Strain **A** was then mixed with another bacterial strain, strain **B**, with the following plasmid genes (*arg*-, *his*-, *leu*- and *cys*+) and allowed to grow together at various time intervals before strain **B** was isolated and grown on nutrient media containing a variety of amino acids.

Table 3.1 shows whether colonies of strain **B** were observed on the various media at different time intervals (+ indicates the presence of an amino acid in the medium while - indicates its absence).

Time of incubation/ minutes	Supplementation of amino acids in medium				Presence of colonies
	Arg	His	Leu	Cys	
10	-	+	+	-	No
	+	-	+	-	Yes
	-	-	+	-	No
20	+	-	-	-	Yes
	-	-	-	-	No
25	-	-	-	-	Yes

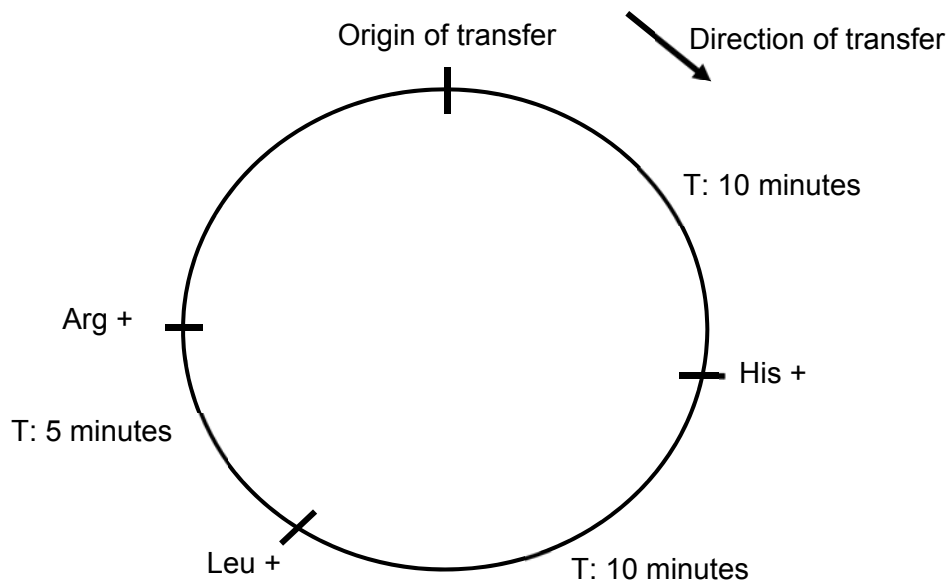
**Table 3.1**

- (b) Describe the process that has occurred between strains **A** and **B** when they were incubated together in the nutrient media. [4]

1. Conjugation
2. Sex pilus from strain A contacts surface of strain B and draws the two cells close
3. Allows formation of cytoplasmic bridge/ conjugation tube between the 2 cells
4. A single strand of the plasmid from strain A was transferred to strain B and used as a template for the synthesis of complementary strand.
5. Strain B now contains 2 double- stranded plasmids

Max 4

(c) Using information from Table 3.1, indicate the order of genes (*arg+*, *his+*, *leu+*) found on the plasmid in strain A. You should also indicate in your diagram the origin and direction of transfer. [3]



1. origin and direction of transfer
2. Order of genes
3. Relative distance between genes





(d) Using information from Table 3.1, explain your answer in (c). [3]

1. Genes that are located nearer to the origin of transfer will be transferred to recipient bacteria strain B first and thus would be expressed first
2. As strain B was able to grow in a media that was not supplied with histidine from 10 minutes, histidine and leucine at 20 minutes and none of the three amino acids at 25 minutes/ supplied with only leucine and arginine at 10 minutes, only arginine at 20 minutes and no amino acids at 25 minutes, this indicates that the order of transfer is *his+*, *leu+* and *arg+*
3. Length of time proportional to the distance between the genes

[Total: 11]

4. The fruit fly, *Drosophila melanogaster*, has eyes, a striped abdomen and wings longer than its abdomen. This is called a 'wild-type' fly.

Mutation has resulted in many variations of these features. Table 4.1 shows diagrams of a wild-type fly and three other flies, each of which shows one recessive mutation.

				
<b>eyes</b>	present	present	absent	present
<b>abdomen</b>	striped	black	striped	striped
<b>wing description</b>	long	long	long	short

**Table 4.1**

- (a) Analysis of the mature mRNA formed from the mutant allele for black abdomen showed that one exon was missing although the length of both the mutant and normal alleles for abdomen colour were identical on the chromosome.

Suggest the genetic basis of this mutation and how it leads to a missing exon. [3]

1. [Base pair substitution mutation in splice site/ snRNP gene](#)
2. [Spliceosome is unable to recognise the mutated splice site sequence and splice out introns properly](#)
3. [Leading to excision of the first exon found after mutated splice site](#)

- (b) Using appropriate symbols, illustrate a cross between a fly without eyes and long wings and one with eyes and short wings that would result in **four** different phenotypes being observed in the offspring. [5]

Legend [1]

Let E represent the dominant allele for presence of eyes and e the recessive allele for absence of eyes

Let L represent the dominant allele for long wing and l the recessive allele for short wings

Parental phenotype	Without eyes, long wings	X	With eyes, short wings
Parental genotype: [1]	eeLl	X	Eell
Gametes: [1] *to circle	eL      el	x	El      el
Punnet square: [1] *gametes must be circled		eL	el
	El	EeLl	Eell

	el	eeLl	Eell
Offspring genotype	EeLl: Eell: eeLl: eell		
Offspring phenotype: [1]	With eyes, long wings: with eyes, short wings: without eyes, long wings: without eyes short wings		
Phenotypic ratio	1:1:1:1		

(c) A cross was carried out between a fly heterozygous for striped abdomen and long wings and a fly with a black abdomen and short wings. The results are shown below in Table 4.2.

offspring	number
striped abdomen long wing	86
black abdomen long wing	87
striped abdomen short wing	81
black abdomen short wing	78
total	332

Table 4.2

A chi-squared test ( $\chi^2$ ) was carried out on these data. Complete Table 4.3 and calculate the value of  $\chi^2$ . [3]

Observed Number (O)	Expected Number (E)	(O - E) [1]	(O - E) <sup>2</sup>	(O - E) <sup>2</sup> / E [1]
86	83	3	9	0.11
87	83	4	16	0.19
81	83	-2	4	0.05
78	83	-5	25	0.30

Table 4.3

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

$\chi^2$ : 0.65 [1]

(d) Table 4.4 shows  $\chi^2$  values.

degrees of freedom	probability						
	0.50	0.20	0.10	0.05	0.02	0.01	0.001
3	2.37	4.64	6.25	7.82	9.84	11.34	16.27

**Table 4.4**

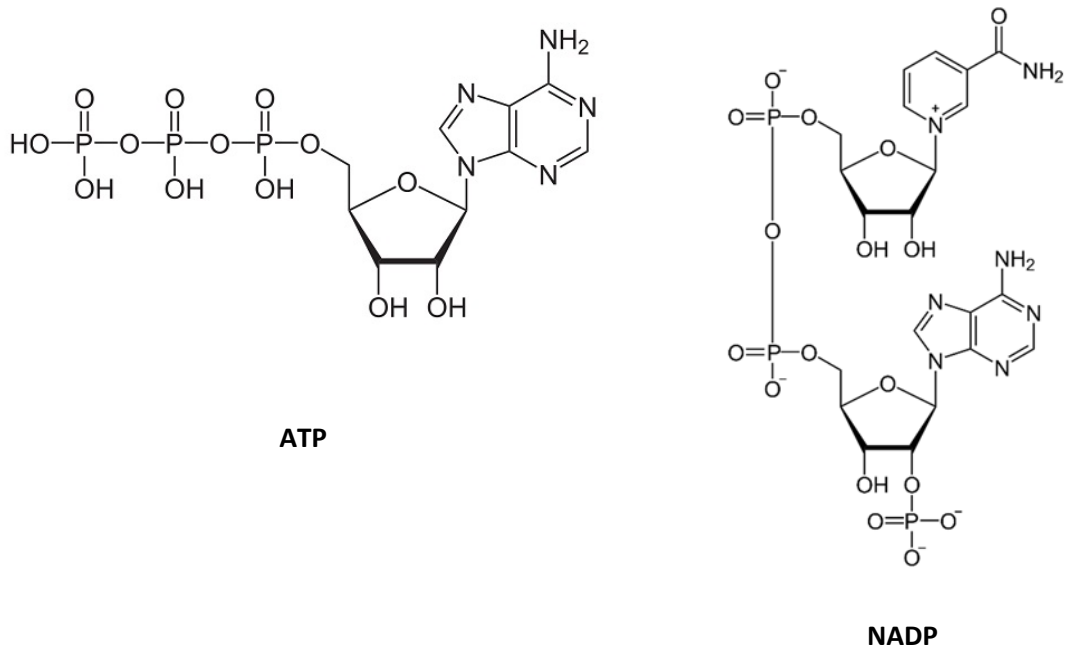
Using Table 4.4, explain what conclusions can be made about the results of the  $\chi^2$  test. [2]

1. Calculated  $\chi^2$  is less than critical  $\chi^2$  of 7.82 at probability 0.05.
2. Accept null hypothesis that there is no significant difference between observed and expected results, difference is due to chance.

[Total: 13]



5. ATP and NADP both play important roles in photosynthesis. Fig. 5.1 represents the molecular structures of ATP and NADP.



**Fig. 5.1**

- (a) Using Fig. 5.1, compare the structures of ATP and NADP. [4]

1. Both have three phosphate groups
  2. Both have an adenine/ purine
  3. Both have pentose sugar/ ribose
  4. Both have phosphoanhydride bonds
- Max 2

5. ATP has one pentose sugar while NADP has two
  6. NADP has nicotinamide base which is absent in ATP
  7. There are 2 phosphoanhydride bonds present in ATP, but only one present in NADP.
- Max 2

- (b) Outline the roles of NADP in a cell. [2]

1. Serves as final electron acceptor in non-cyclic photophosphorylation
2. To form reduced NADP/ NADPH which is used in light-independent reaction/ Calvin cycle

- (c) State the names of the processes in which ATP is synthesised during photosynthesis and respiration respectively. [2]

1. Photosynthesis: cyclic and noncyclic photophosphorylation
2. Respiration: substrate level phosphorylation and oxidative phosphorylation

(d) ATP serves as a source of energy for several metabolic processes in both photosynthesis and respiration. State two processes in **respiration** that requires ATP as an energy source. [2]

1. Active transport of pyruvate/ acetyl CoA into mitochondrion
2. Phosphorylation of intermediate compounds in glycolysis

(e) The first substrate used in respiration is glucose. In a situation of excess glucose, some of these glucose is stored as fats instead of carbohydrates. Explain why animals prefer to store lipid instead of carbohydrates. [2]

1. Twice the amount of energy produced per gram/ unit mass of lipid/ carbohydrate stored due to higher proportion of C-H to O present
2. Twice the amount of metabolic water per gram/ unit mass of lipid/ carbohydrate oxidised due to higher proportion of C-H to O present
3. Smaller volume stored for the same amount of energy hence aiding in locomotion
4. Ref. to lipids (triglycerides) being good thermal/ heat insulators
5. Ref. to lipids being stored around delicate organs hence acting as cushioning material/ protecting these organs
6. Ref. to lipids being less dense than water, thus providing buoyancy for aquatic animals

Max 1 for points 4 to 6

[Total: 12]

6. Lactose intolerance is a condition in which individuals are unable to digest lactose as the cells in their small intestine are unable to synthesise sufficient quantities of the enzyme lactase. The undigested lactose will then interact with bacteria normally present in the large intestine and cause uncomfortable symptoms such as bloating, diarrhoea and gas production.

Lactose is commonly found in large quantities in dairy products. The distribution of adult population with lactose intolerance is shown in Fig. 6.1. A simplified world map illustrating major continents is shown in Fig. 6.2 for your reference.

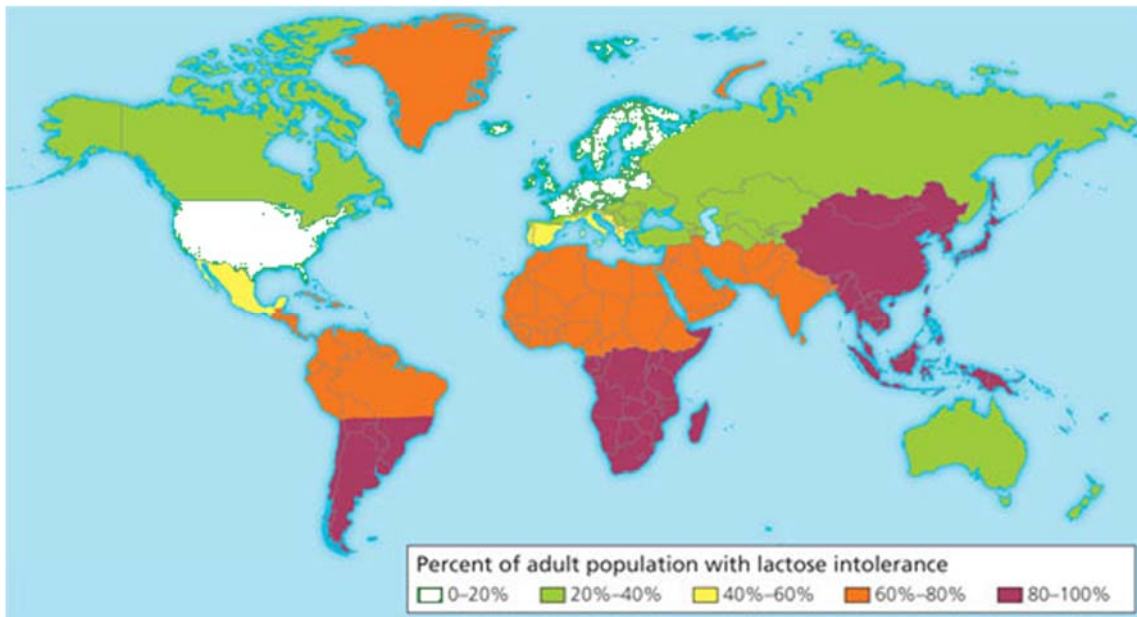


Fig. 6.1



Fig. 6.2

- (a) With reference to Figs. 6.1 and 6.2, describe the distribution of lactose intolerance in adults. [2]
1. High lactose intolerance in adult population of 80 to 100% is observed in East Asia, south Africa and southern regions of south America
  2. Low lactose intolerance of 0 to 20% is observed in Europe and North America (USA)
- (b) Research has shown that most individuals are able to produce large quantities of lactase from birth, although this value can decline as the individual grows older due to environmental factors. The most prominent decline in lactase production is often observed when babies are switched from a predominantly milk-based diet to a solid food diet.
- (i) Suggest why there is a prominent decline in lactase production in babies following a switch to a solid food diet. [2]
1. Babies are **originally fed a predominantly milk-based diet**, thus require large quantities of lactase at birth.
  2. Following a switch to solid food, amount of dairy consumed declines thus reducing the necessity for large quantities of lactase to be produced.
- (ii) Using the information found in (b), suggest a reason for your observations made in (a). [1]
1. Europe and USA has a diet which consist of much higher quantities of dairy products hence allowing for a smaller reduction in lactase production as the individual grows older.

Level of expression of lactase is regulated by a lactase activator which stimulates expression of lactase in the presence of lactose. Human populations that inhabited the earth millions of years ago were found to express a lactase activator which is only weakly active. At present, most human populations express a more active version of this activator protein.

- (c) Using your knowledge of evolution, explain the basis of this observation. [4]
1. Variation exist in the population in terms of the gene coding for the activator protein
  2. Selection pressure in the form of diet high in dairy products containing lactose
  3. Individuals that express the more active lactase activator protein are better able to produce higher quantities of lactase and hence digest lactose effectively to obtain nutrients are at a selective advantage, while those that cannot are at selective disadvantage in a diet high in dairy
  4. Favourable allele for more active lactase activator passed on to offsprings, changing frequency of allele in the population over time

[Total: 9]

7. Antigen presenting cells (APCs) such as macrophages are able to detect specific foreign antigens and present them to relevant adaptive immune cells. Recognition of these antigens require the use of specific receptors on the surface of these APCs.

(a) State the receptor found on macrophages that is used for antigen binding and recognition. [1]

Toll like receptors

Following binding, these antigens are then taken into the cell and processed for presentation to T cells.

(b) Describe how an **extracellular** antigen is subsequently presented to a T cell following binding to the receptor mentioned in (a). [3]

1. Antigen taken into the cell by receptor-mediated endocytosis and processed into short peptide fragments by phagocytosis
2. A peptide fragment binds to MHC Class II complex produced by rough endoplasmic reticulum of APC
3. Peptide: class II MHC complex transported to cell surface membrane for antigen presentation to CD4/ helper T cell.

Research has shown that a cell signalling pathway is triggered following binding of an antigen to its receptor. One of the more well understood signalling pathways involve a series of kinases, which are enzymes that catalyse the phosphorylation of its substrate. A common signalling pathway in APCs is shown in Fig. 7.1.

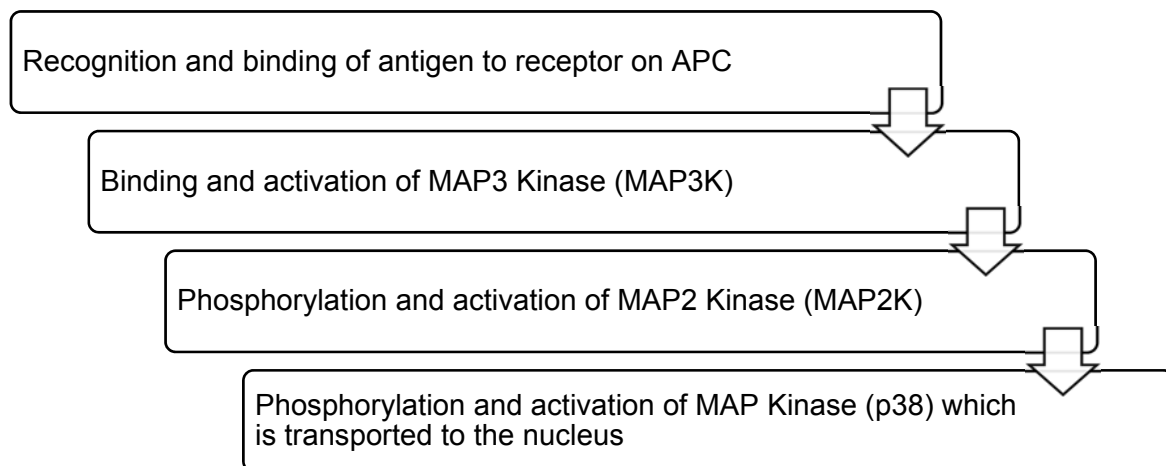


Fig. 7.1

Activation of the signalling pathway shown in Fig. 7.1 leads to a large cellular response consisting of both cytokine production and also antigen presentation.

(c) Using your knowledge of signalling pathways and the information from Fig. 7.1, explain this observation. [4]

1. Activation of protein kinases (MAP3K and MAP2K)
2. triggers a phosphorylation cascade
3. that amplifies the signal

4. More molecules are phosphorylated and activated in the subsequent step compared to the preceding step
5. p38 then triggers expression/ transcription of genes that code for cytokines and MHC molecules

\*Mark once for reference to MAP3K/2K

Max 4

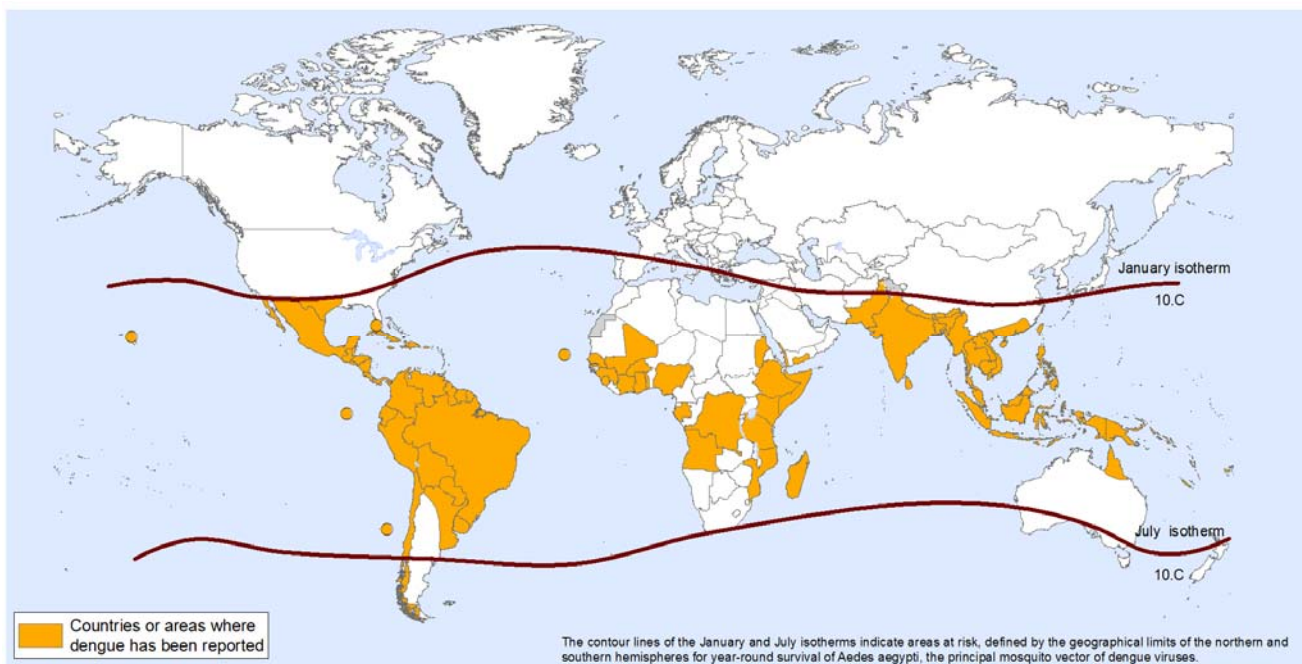
[Total: 8]

8. Dengue and tuberculosis (TB) are two prominent infectious diseases of concern in many countries.

(a) Describe how TB is transmitted from an infected person to an uninfected person. [2]

1. Airborne disease transmitted via aerosol/ droplets produced by infected person when they cough/ sneeze/ speak
2. Subsequent inhalation of respiratory secretions that contain TB bacterium by uninfected person

Fig. 8.1 shows the distribution of dengue.



**Fig. 8.1**

(b) Unlike dengue, TB is found across the entire world. Explain why dengue shows the distribution shown in Fig. 8.1 whereas TB is found worldwide. [3]

1. Dengue virus needs to reproduce within mosquito vector as part of its reproductive life cycle
2. *Aedes* mosquito vector lives predominantly in tropics/ hot areas with rainfall
3. TB only requires a human host where internal body temperature is constant

Vaccinations are used to control infectious diseases. They were used as part of the programme to eradicate smallpox and as part of the continuing programmes against diseases such as polio and measles.

Smallpox was eradicated from the world in the 1970s. Polio is likely to be the next infectious disease to be eradicated.

**(c)** Explain how vaccination provides immunity as an important part of programmes to control and eradicate infectious diseases. [5]

1. Vaccination involve introduction of antigens in a safe way to induce the adaptive immune response
2. A portion of these cells form memory cells, giving long term immunity/ immunological memory
3. Leads to a stronger and faster secondary adaptive immune response to the pathogens upon second exposure
4. Herd immunity is acquired
5. as immunised individual will not spread the disease to other unimmunised individual

Despite being a disease that has persisted for hundreds of years, there is currently no vaccine approved for the treatment of TB.

**(d)** Using your knowledge of the pathogenicity of *M. tuberculosis*, suggest why it is difficult to develop an effective vaccine for TB. [1]

1. *M. tuberculosis* bacteria spends most of its time hidden within macrophages as it replicates hence evading immune cells and antibodies.
2. Bacteria can remain dormant in tubercle for years and remain undetected by immune cells.
3. Mutation in *M. tuberculosis* changes epitopes recognised by antibodies thus requiring repeated/ new vaccination.
4. AVP

Apart from the use of vaccination, other measures of controlling the spread of dengue involves the release of sterile male mosquitoes into areas with high dengue incidence. While this measure has successfully reduced mosquito populations dramatically, environmentalist are concerned about their potential detrimental ecological effects.

**(e)** Suggest one possible ecological concern that may arise from the use of sterile male mosquitoes. [1]

1. Decline is populations that are directly dependent on *Aedes* mosquitoes for food
2. Loss of pollinators for plants that rely on mosquitos to pollinate them > loss in biodiversity
3. AVP

[Total: 12]

CANDIDATE NAME: \_\_\_\_\_

INDEX NUMBER \_\_\_\_\_

CG \_\_\_\_\_



SERANGOON JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION 2018

H2 BIOLOGY  
Paper 3 Long Structured and Free-response Questions

9744/03

Tuesday  
18 September 2018

Candidates answer on the Question Paper.  
No Additional Materials are required.

2 hours

**READ THESE INSTRUCTIONS FIRST**

Write your name, index number and CG in the spaces at the top of this page.  
Write in dark blue or black pen.  
You may use an HB pencil for any diagrams or graphs.  
Do not use staples, paper clips, glue or correction fluid.

**Section A**  
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**  
Answer any **one** question in the spaces provided on the Question Paper.

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 appropriate units.

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.

For Examiner's use	
1	/27
2	/23
Section B	/25
Total	/75



**Section A**

Answer **all** the questions in this section.

**Question 1**

**(a)** Outline the features found within a typical bacterium cell that distinguishes it from a typical plant cell.

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.....[3]

**(b)** One other way that bacteria differ from plants is in terms of how their genome is organised.

In bacteria, genes are generally organised into operons. Explain the advantage of this arrangement.

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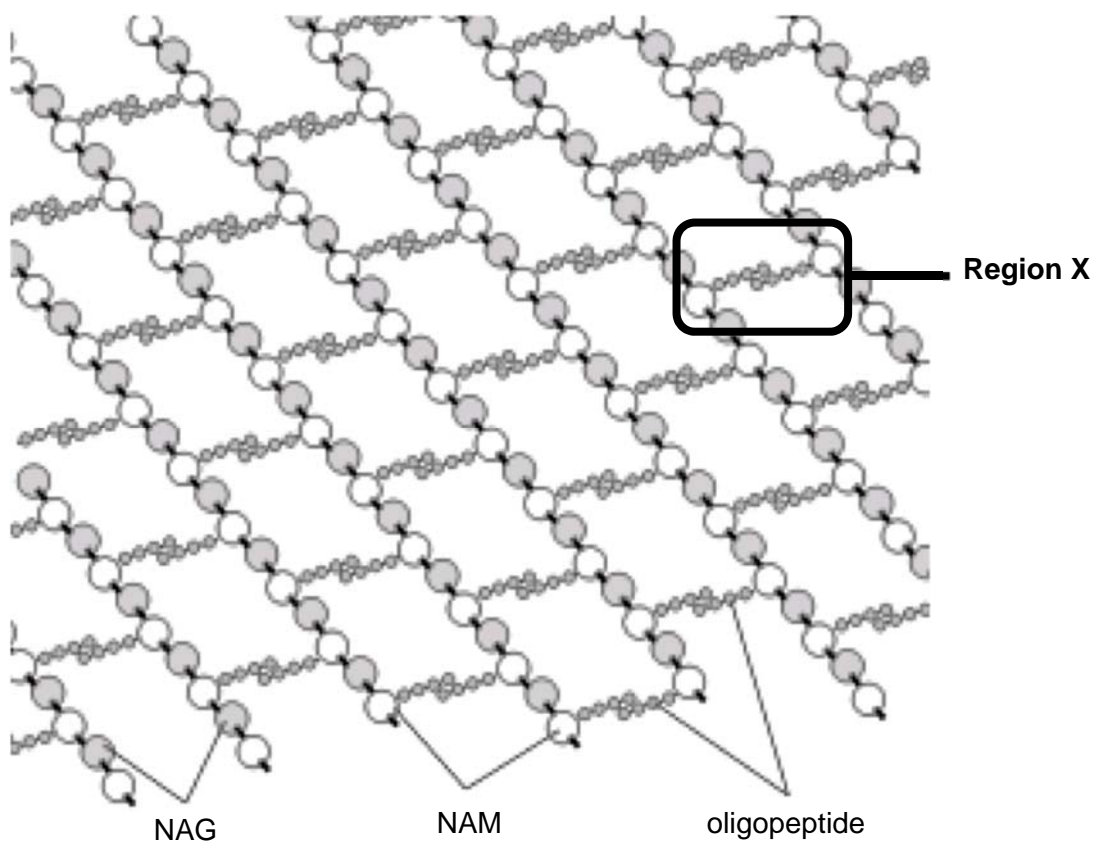
(c) Like plant cells, bacterial cells are also surrounded by a rigid cell wall. However, while cellulose is a major component in plant cell walls, the significant constituent of the bacterial cell wall is peptidoglycan.

The peptidoglycan in some bacterial cell walls has the following features:

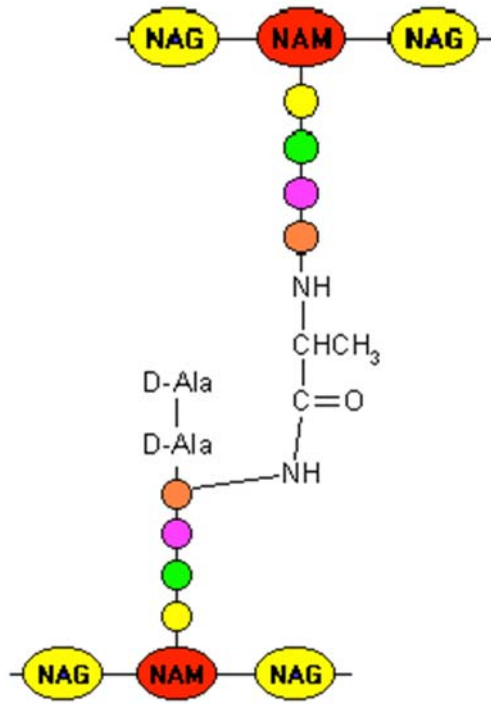
- It consists of linear chains of two alternating amino-sugars, N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM).
- In both NAG and NAM, the sugar component is covalently attached to a short oligopeptide sequence containing 4 to 5 amino acid residues.
- D-Alanine (D-Ala) and D-glutamine (D-Glu) are examples of amino acids that are commonly found in these sequences.

The structure of peptidoglycan in such bacterial cell walls is shown in Fig. 1.1 below.

A close-up of Region X is shown in Fig. 1.2 on page 4.



**Fig. 1.1**



**Close-up of Region X**

**Fig. 1.2**

(i) Describe how specific chemical groups of amino acids such as D-Ala and D-Glu allow them to be incorporated as part of an oligopeptide.

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.....[3]

(ii) Like cellulose, extensive cross-links are present in peptidoglycan.

With reference to the given information including Figs. 1.1 and 1.2, distinguish between the cross-links in cellulose and peptidoglycan.

.....

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.....

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.....[2]

**(iii)** Suggest how the plant cell wall and bacterial cell wall are similar in function.

.....  
.....[1]

(d) The formation of cross-links in peptidoglycan is catalysed by penicillin binding protein (PBP). A common antibiotic which targets this enzyme is penicillin. By inhibiting PBP, penicillin thus prevents the synthesis of the cell wall.

Fig. 1.3 below is a simplified sequence of events showing the action of PBP (1 – 3), and the action of penicillin on PBP (4 – 5).

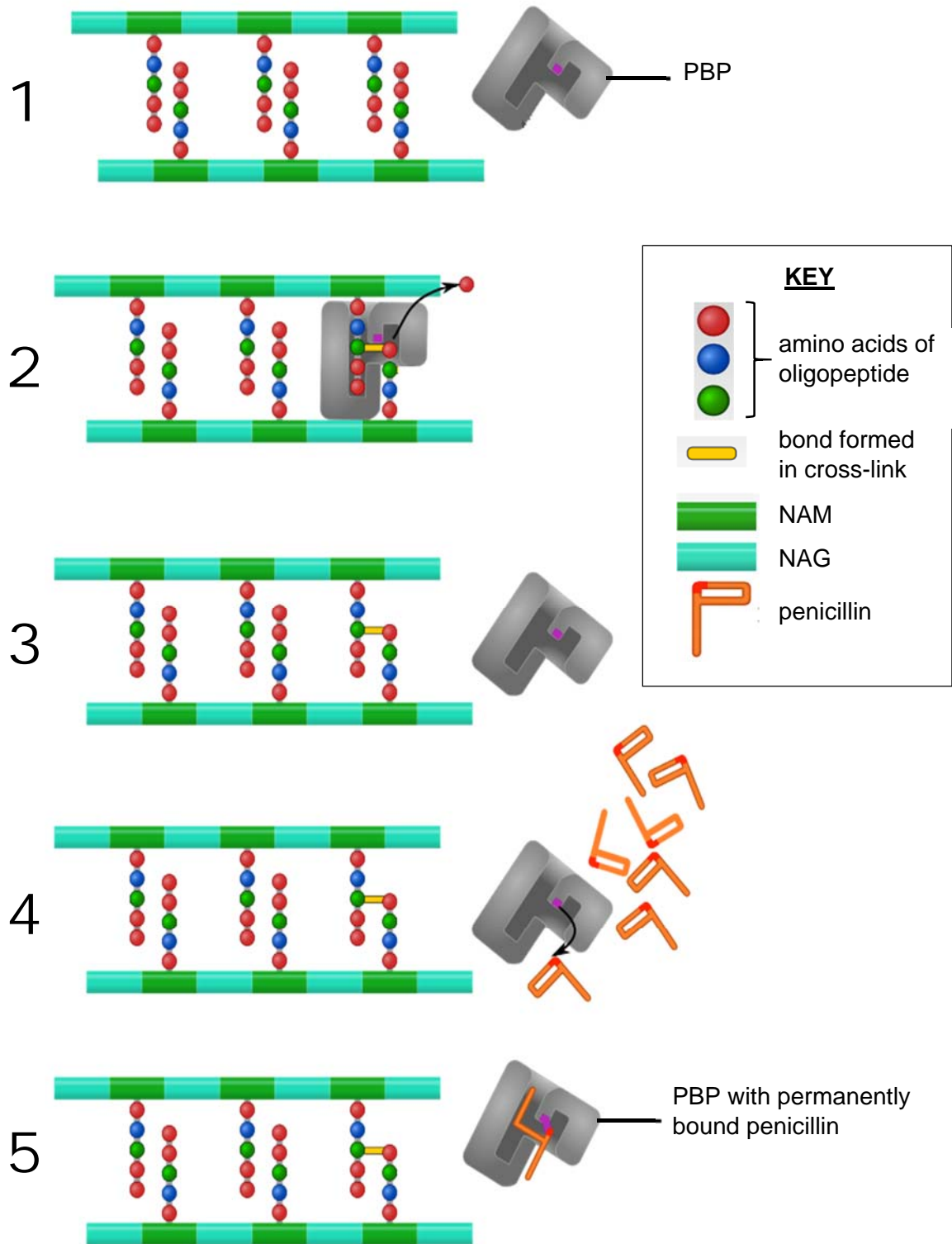


Fig. 1.3

(i) Although penicillin behaves like a typical competitive inhibitor, it is **not** a competitive inhibitor.

Compare the mode of action of penicillin with that of a typical competitive inhibitor.

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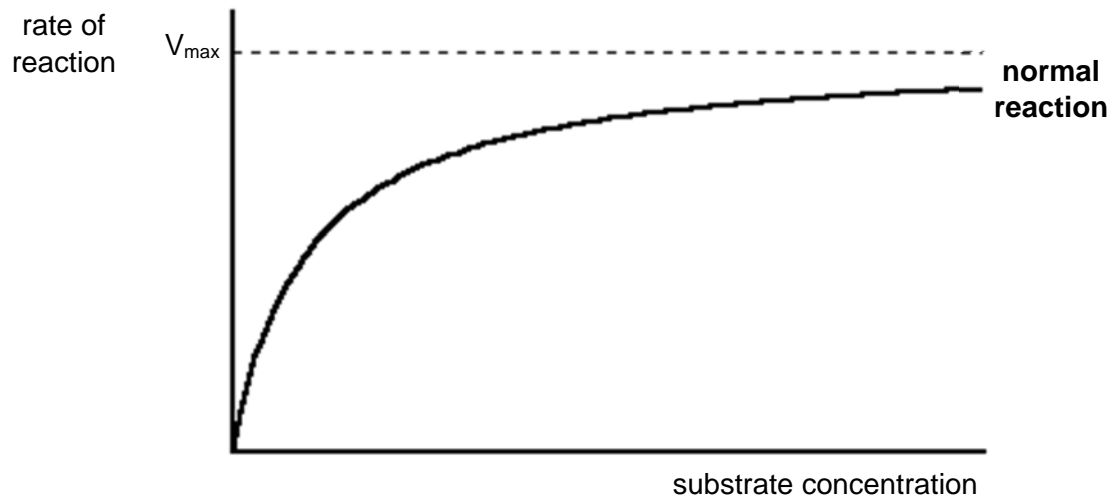
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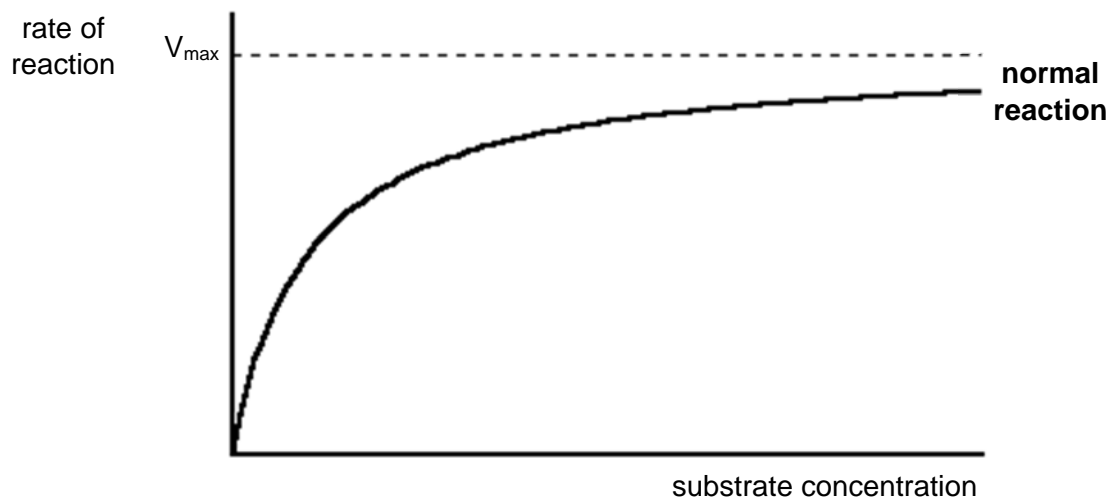
.....[2]

(ii) By drawing an appropriately labelled curve each, complete the graphs below to show the effect of

- a typical competitive inhibitor on its enzyme.



- penicillin on PBP.



[2]

(e) Another recently discovered antibiotic, SRJC30, inhibits bacterial growth by inhibiting protein synthesis.

SRJC30 functions by binding to the bacterial ribosome as shown in Fig. 1.4 below.

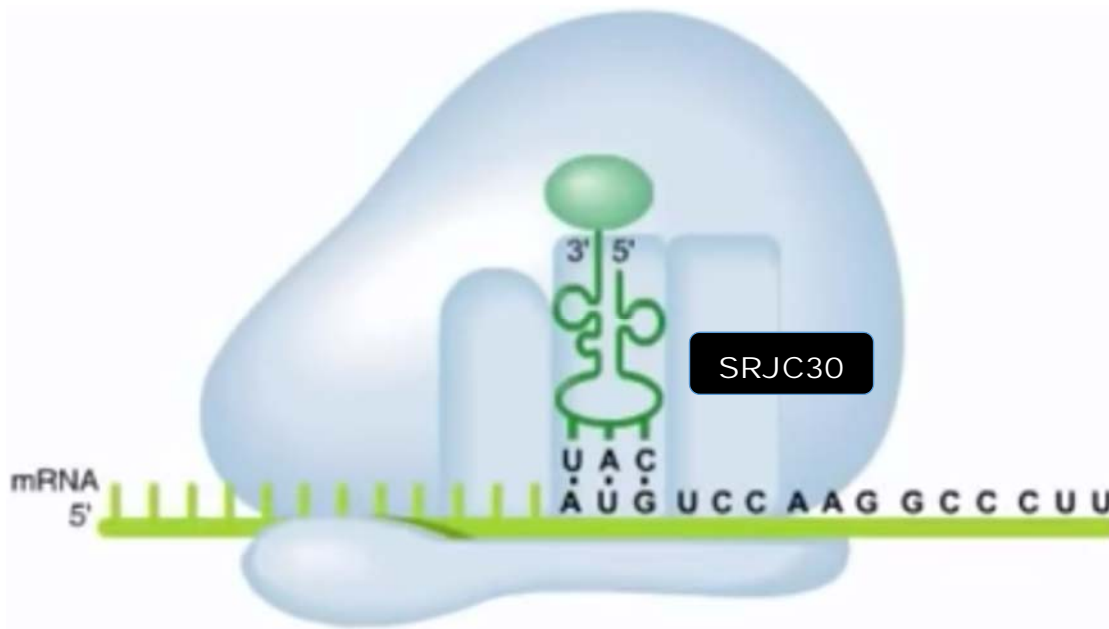


Fig. 1.4

Describe fully how SRJC30 inhibits protein synthesis.

In your answer, highlight **based on the context in Fig. 1.4**,

- the relevant specific locations on the ribosome and
- the specific molecules whose roles in protein synthesis have been prevented by SRJC30.

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[4]

- (f)** In a bacterial infection, the invading pathogen is recognised by the host's immune system as non-self. A co-ordinated and specific immune response is then mounted against it.

However, in treatment, the administered antibiotic is not recognised by the host's immune system, even when it is present in the bloodstream.

In modern medicine, antibiotics thus complement the host's immune system in fighting off a bacterial infection.

- (i)** Outline how a co-ordinated and specific immune response against a bacterial pathogen is possible.

In your answer, highlight the role of the specific immune cell that is directly involved in co-ordinating this response.

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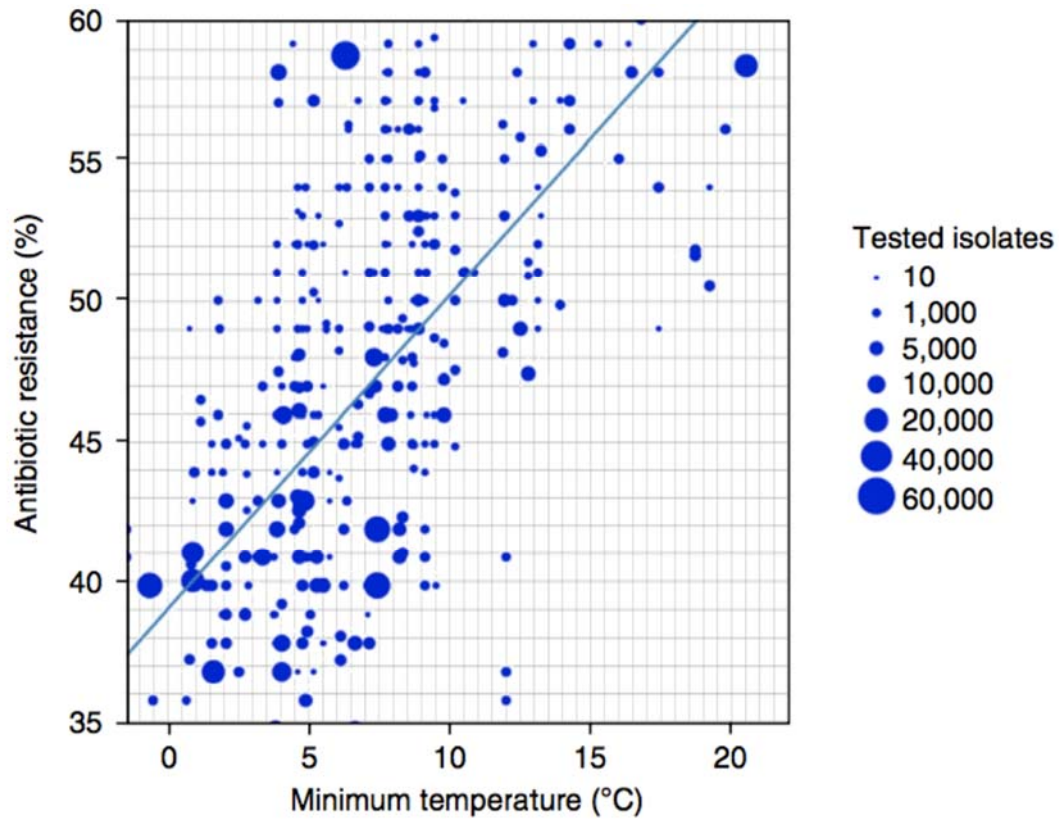
- (ii)** Suggest why the host's immune system does not recognise an administered antibiotic.

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.....[1]



(g) Antibiotic resistance among bacteria is a growing global problem. Recent evidence indicates a relationship between antibiotic resistance and climate change.

Fig. 1.5 presents a finding from a study conducted in the United States, and shows a scatter plot of resistance among *E.coli* against the antibiotic amoxicillin, against minimum temperature.



**Fig. 1.5**

Comment on how amoxicillin resistance among *E. coli* is affected with every 10 °C rise in minimum temperature, and suggest **two** reasons for this relationship.

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.....[3]

[Total: 27]

**Question 2**

Barley yellow dwarf virus (BYDV) is a positive sense single-stranded RNA virus; the virion is not enveloped in a lipid coating. The virus is transmitted by aphids, and the taxonomy of the virus is based on genome organisation, serotype differences and on the primary aphid vector of each isolate.

**(a)** Explain why viruses may be considered both living and non-living.

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**(b)** Using the information above and your knowledge, list two main classes of biomolecules present in a BYDV virion.

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.....[1]

**(c) (i)** Explain briefly how the virus is able to produce a complete new virion using the starting material of a positive sense single stranded RNA.

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.....  
.....[3]

**(ii)** Suggest one enzyme that is present in its host that the virus would need for the process explained in **(i)**, and one other enzyme that the host is unable to provide.

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.....[2]

The symptoms of a BYDV infection vary with the age of the plant at the time of infection, the strain of the virus and the environmental conditions. Symptoms appear approximately 14 days after infection. Affected plants may show a yellowing or reddening of leaves, stunting, an upright posture of thickened stiff leaves, reduced root growth, delayed (or no) heading, and a reduction in yield. Young plants are the most susceptible, and infected wheat leaves have a reduced ability to photosynthesise.

**(d)** Explain briefly how disrupting photosynthesis may lead to stunted growth.

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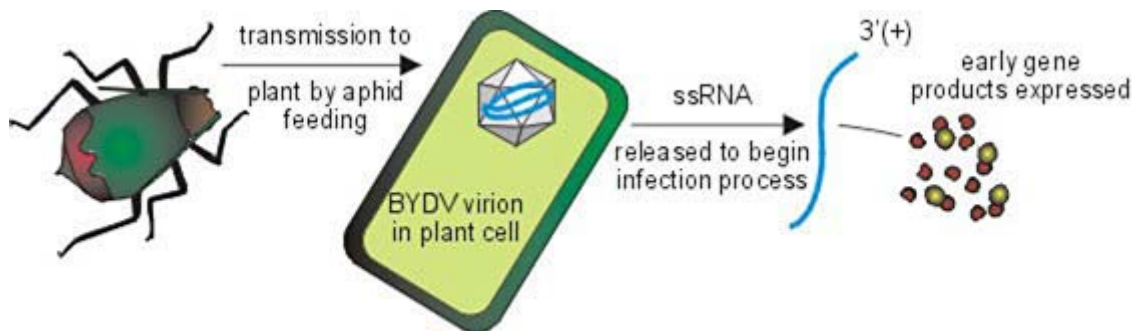
.....[2]

The host range of BYDVs consists of more than 150 grass species in the family *Poaceae*. A large number of grasses both annual and perennial are alternate hosts to the BYDV and can serve as reservoirs of the virus.

There are two main sources by which a cereal crop might be infected:

1. By non-migrant wingless aphids already present in the field and which colonise newly-emerging crops. This is known as "green-bridge transfer".
2. By winged aphids migrating into crops from elsewhere. These then reproduce and the offspring spread to neighbouring plants.

Transmission from an aphid is demonstrated in Fig. 2.1 below.



**Fig. 2.1**

**(e)** With reference to the grasses that serve as alternate hosts for the virus, explain what you understand about the concept of a species.

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.....[2]

**(f)** Climate change has affected the life cycle and distribution of animals and plants in the world.

Discuss how climate change may impact the rates of BYDV infection in a localised crop population.

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.....[5]

**(g)** Many farmers in rural farms in third world countries are struggling to cope with the impact of pests and pathogens such as the BYDV.

Suggest why many of these farmers are unable to overcome these issues.

.....  
.....[1]

The following is an excerpt from a research paper on BYDV infections of two types of grass.

*The wheat–Thinopyrum intermedium translocation line YW642 carries BYDV resistance gene BVDV-CP. To explore resistant wheat response in response to BYDV infection, we used GeneChip® Wheat Genome Arrays to analyze transcriptomes of YW642 and its susceptible parent Zhong8601 at 12 and 72 h postinoculation with BYDV.*

Fig. 2.2 below shows the result of this investigation.

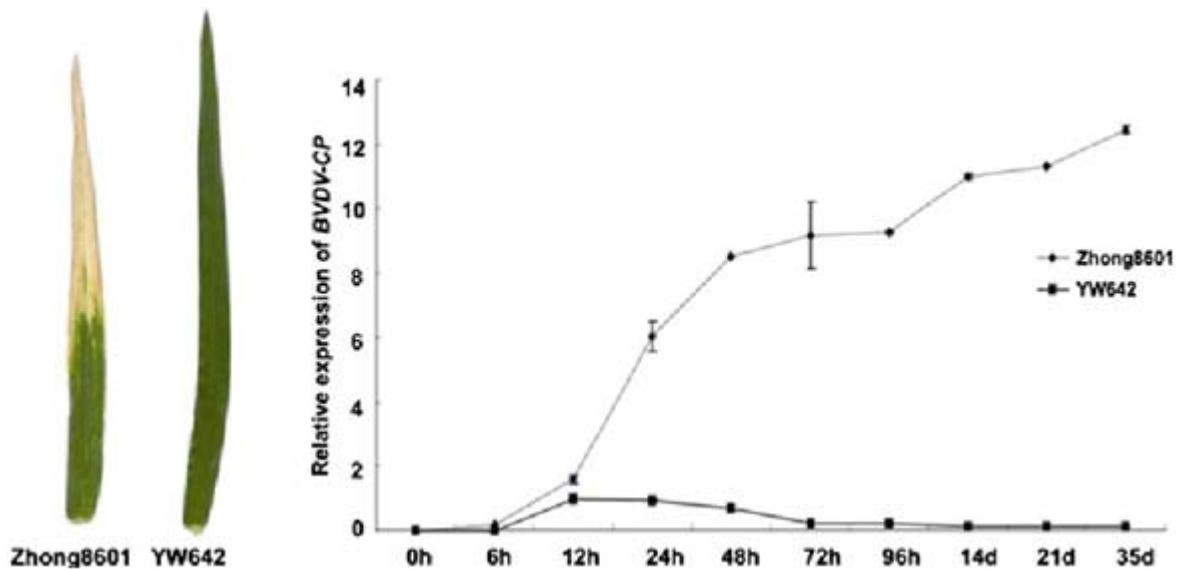


Fig. 2.2

(h) Using the information and data provided, describe the effects of inoculating the two grass strains with BYDV on the expression of the resistance gene *BVDV-CP*.

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 .....[2]

(i) Suggest why the relative expression of the resistance gene *BVDV-CP* was low for both strains at 6 hours.

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 .....[1]

(j) Suggest how the proteins coded for by *BVDV-CP* may lead to BYDV resistance.

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.....[2]

[Total: 23]

## Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

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 parts **(a)** and **(b)**, as indicated in the question.

### Question 3

**(a)** Describe the principles and processes of the Polymerase Chain Reaction (PCR). [10]

**(b)** Discuss how photosynthesis plays a critical role in sustaining life on earth.

You should consider both specific processes in photosynthesis that sustain life and its role in reducing the impact of climate change. [15]

### Question 4

**(a)** Describe the principles and processes of Southern Blotting. [10]

**(b)** It can be argued that humans have changed the levels of global respiration via economic activities and this has contributed to climate change.

Explain the processes in cellular respiration that release carbon dioxide and discuss how these and other human factors can contribute to climate change. [15]

[Total: 25]

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CANDIDATE NAME: \_\_\_\_\_

INDEX NUMBER \_\_\_\_\_

CG \_\_\_\_\_



SERANGOON JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION 2018

H2 BIOLOGY  
Paper 3 Long Structured and Free-response Questions

9744/03

Candidates answer on the Question Paper.  
No Additional Materials are required.

Tuesday  
18 September 2018

2 hours

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#### Section A

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

For Examiner's use	
1	/27
2	/23
Section B	/25
Total	/75

## Section A

Answer **all** the questions in this section.

### Question 1

(a) Outline the features found within a typical bacterium cell that distinguishes it from a typical plant cell. [3]

1. Ref to **lack of membrane-bound organelles** in bacteria vs. **presence** of such organelles in plant cells
2. Ref to bacterial cells containing **circular DNA** vs. plant cells containing **linear DNA**
3. Ref to DNA of bacterial cells found in **nucleoid** region vs. DNA in plant cells found in **nucleus**
4. Ref to bacterial cells containing **70S ribosomes** vs. plant cells containing **80S ribosomes** in the cytoplasm
5. Ref to bacterial cells containing **plasmids/ extra-chromosomal DNA**, which are **absent** in plant cells
6. Accept AVP

*Max 3*

*Reject: comparisons involving cell wall and flagella.*

*Ignore: comparisons involving chloroplasts, vacuoles, mitochondria etc.*

(b) One other way that bacteria differ from plants is in terms of how their genome is organised.

In bacteria, genes are generally organised into operons. Explain the advantage of this arrangement. [2]

1. The clustering of **several genes** that are **functionally related** (*or give idea of*) under a **single promoter**
2. Allows for **co-ordinated/ common regulation** or ref. to idea of **efficient gene expression**
3. Ref. to operons contributing to **compact chromosome size** in bacteria due to reduced need for multiple promoters etc.
4. Accept AVP

*Max 2*

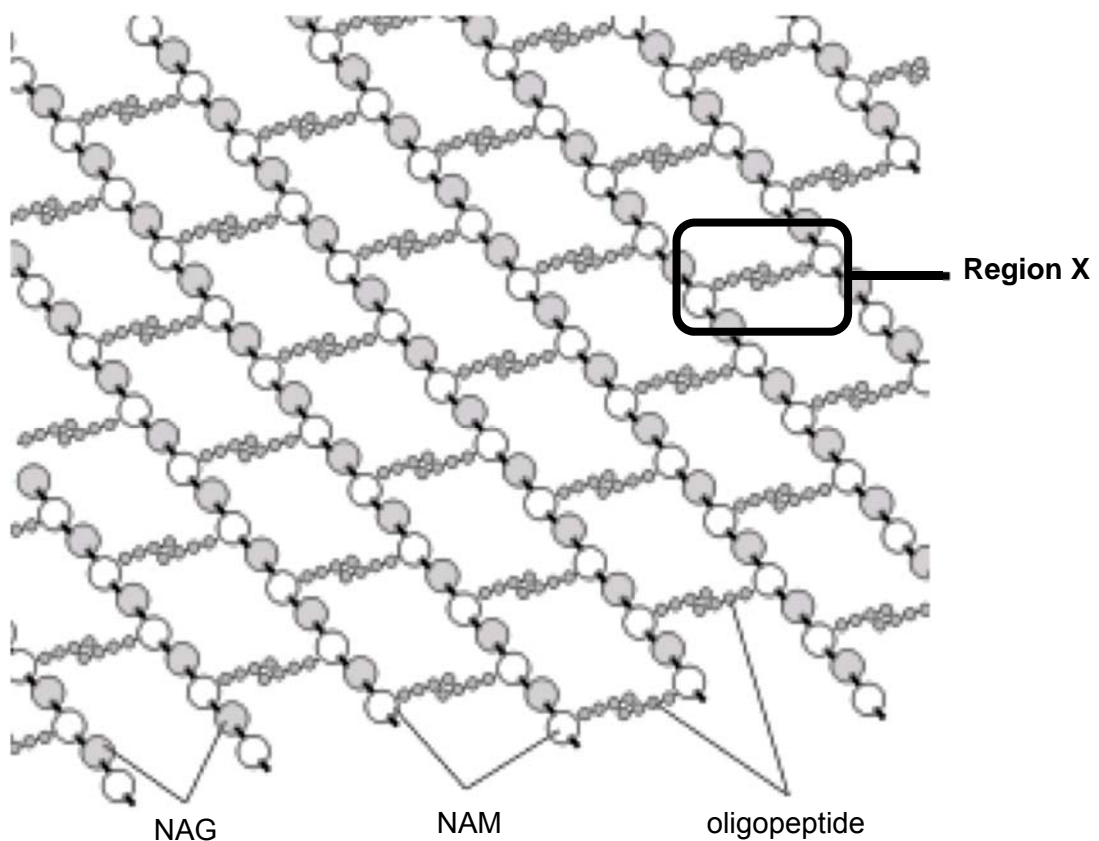
(c) Like plant cells, bacterial cells are also surrounded by a rigid cell wall. However, while cellulose is a major component in plant cell walls, the significant constituent of the bacterial cell wall is peptidoglycan.

The peptidoglycan in some bacterial cell walls has the following features:

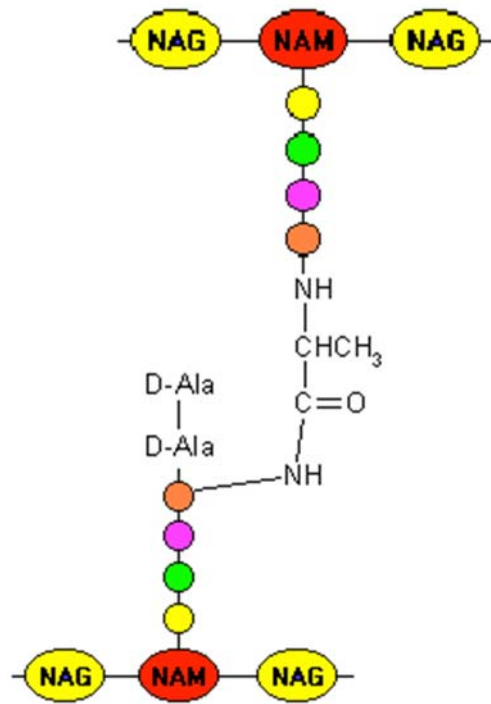
- It consists of linear chains of two alternating amino-sugars, N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM).
- In both NAG and NAM, the sugar component is covalently attached to a short oligopeptide sequence containing 4 to 5 amino acid residues.
- D-Alanine (D-Ala) and D-glutamine (D-Glu) are examples of amino acids that are commonly found in these sequences.

The structure of peptidoglycan in such bacterial cell walls is shown in Fig. 1.1 below.

A close-up of Region X is shown in Fig. 1.2 on page 4.



**Fig. 1.1**



Close-up of Region X

Fig. 1.2

(i) Describe how specific chemical groups of amino acids such as D-Ala and D-Glu allow them to be incorporated as part of an oligopeptide. [3]

1. Ref. to the presence of an **amino group** and a **carboxyl group** in these amino acids
2. Which form **peptide bonds** with other amino acids
3. In **condensation reactions** with a **water molecule lost** with each peptide bond formed

(ii) Like cellulose, extensive cross-links are present in peptidoglycan.

With reference to the given information including Figs. 1.1 and 1.2, distinguish between the cross-links in cellulose and peptidoglycan. [2]

1. In peptidoglycan, cross-links are formed **between oligopeptide chains** of NAM residues, while cross-links are formed **between -OH groups** of  $\beta$ -glucose residues in cellulose.
2. In peptidoglycan, cross-links are in the form of **peptide bonds**, while cross-links are in the form of **hydrogen bonds** in cellulose.

(iii) Suggest how the plant cell wall and bacterial cell wall are similar in function. [1]

1. **Maintains the shape** of the cell/ gives cell its **regular shape**/ provide **structural support**
2. Ref. to **protective** function
3. Ref. to preventing cells from bursting/ lysing due to influx of water

Max 1



(d) The formation of cross-links in peptidoglycan is catalysed by penicillin binding protein (PBP). A common antibiotic which targets this enzyme is penicillin. By inhibiting PBP, penicillin thus prevents the synthesis of the cell wall.

Fig. 1.3 below is a simplified sequence of events showing the action of PBP (1 – 3), and the action of penicillin on PBP (4 – 5).

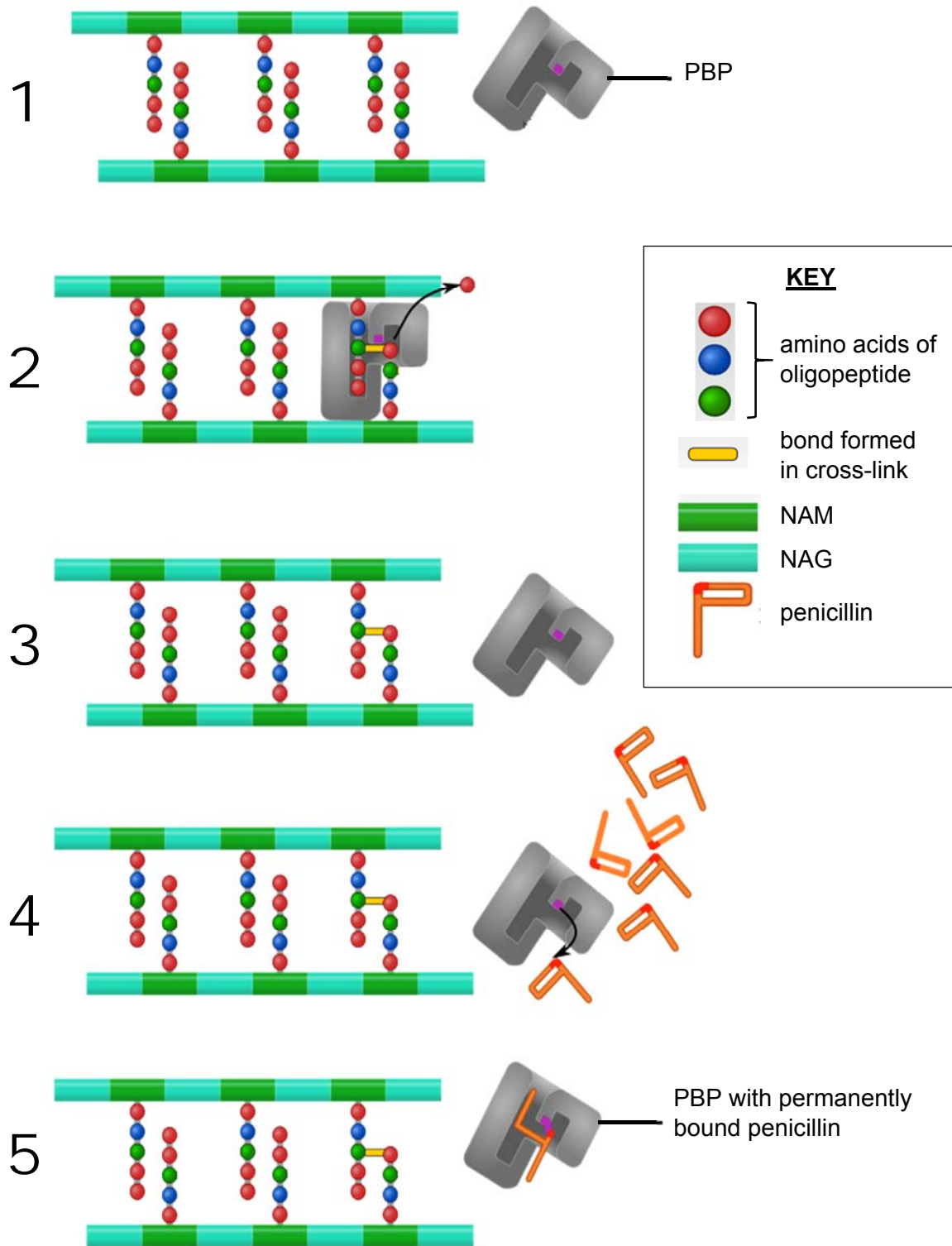


Fig. 1.3

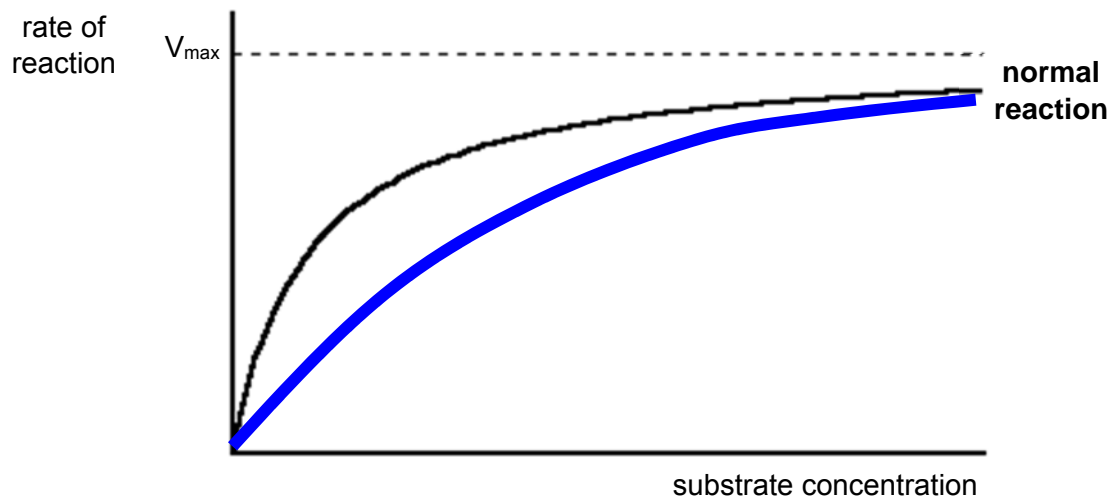
- (i) Although penicillin behaves like a typical competitive inhibitor, it is **not** a competitive inhibitor.

Compare the mode of action of penicillin with that of a typical competitive inhibitor. [2]

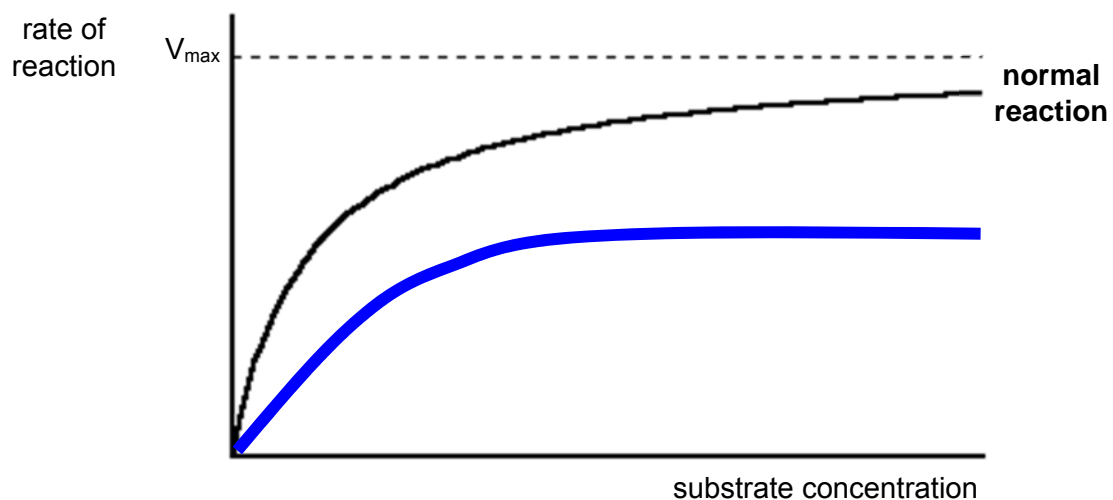
1. Similarity: Both penicillin and a typical competitive inhibitor **bind to the active site** of the enzymes that they inhibit. (*Reject: similarity in shape to substrate*)
2. Difference: Penicillin binds **irreversibly/ permanently** to penicillin-binding protein, while a typical competitive inhibitor **always binds reversibly** to its enzyme.

- (ii) By drawing an appropriately labelled curve each, complete the graphs below to show the effect of

- a typical competitive inhibitor on its enzyme. [1]



- penicillin on PBP. [1]



- (e) Another recently discovered antibiotic, SRJC30, inhibits bacterial growth by inhibiting protein synthesis.

SRJC30 functions by binding to the bacterial ribosome as shown in Fig. 1.4 below.

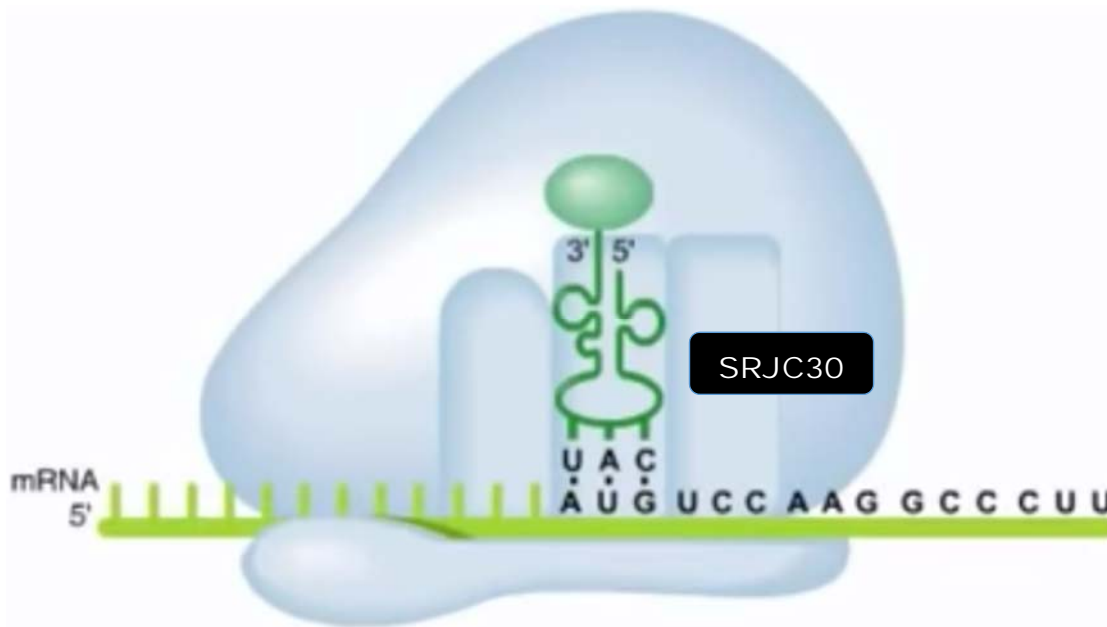


Fig. 1.4

Describe fully how SRJC30 inhibits protein synthesis.

In your answer, highlight **based on the context in Fig. 1.4**,

- the relevant specific locations on the ribosome and
- the specific molecules whose roles in protein synthesis have been prevented by SRJC30. [4]

1. SRJC30 binds to the **A site** on the **large/ 50S ribosomal subunit**
2. Thus **preventing** the **tRNA with the anti-codon AGG** and with the next amino acid from entering the A site
3. and undergoing **complementary base pairing** with the **UCC codon** on the mRNA at the A site
4. **Peptidyl transferase** on the large ribosomal subunit is thus **unable to catalyse the formation of a peptide bond**
5. Between **formyl-methionine** held by the initiator **tRNA at the P site** with this incoming amino acid.

Max 4

- (f) In a bacterial infection, the invading pathogen is recognised by the host's immune system as non-self. A co-ordinated and specific immune response is then mounted against it.

However, in treatment, the administered antibiotic is not recognised by the host's immune system, even when it is present in the bloodstream.

In modern medicine, antibiotics thus complement the host's immune system in fighting off a bacterial infection.

- (i) Outline how a co-ordinated and specific immune response against a bacterial pathogen is possible.

In your answer, highlight the role of the specific immune cell that is directly involved in co-ordinating this response. [4]

1. Activated **CD4 T helper cells** are the cells that co-ordinate a specific adaptive immune response to bacterial pathogen

*Max 3 from any of the following:*

2. Naïve CD4 T helper cells, after binding via their **T-cell receptors** to **peptide: class II MHC complexes** of **antigen presenting cells** are **activated by the cytokines** (*credit once only*) released
3. Before binding to **mature naïve B cells** and **releasing cytokines**, which causes these B cells to differentiate and proliferate into **plasma B cells** and **memory B cells** (humoral response).
4. plasma cells secrete **antibodies** that can cause **neutralisation/ opsonisation/ complement activation** (*any one*) against bacteria (*ignore: antibody dependent cell-mediated cytotoxicity*)
5. **Cytokine release** (*credit once only*) by these activated T helper cells also causes **naïve CD8 T cells** to proliferate and differentiate into **cytotoxic T cells** (cell-mediated response).
6. T cells secrete **cytotoxic proteins** (or give **named example** e.g. perforin, granulysin, granzymes) that **kill infected cells**.

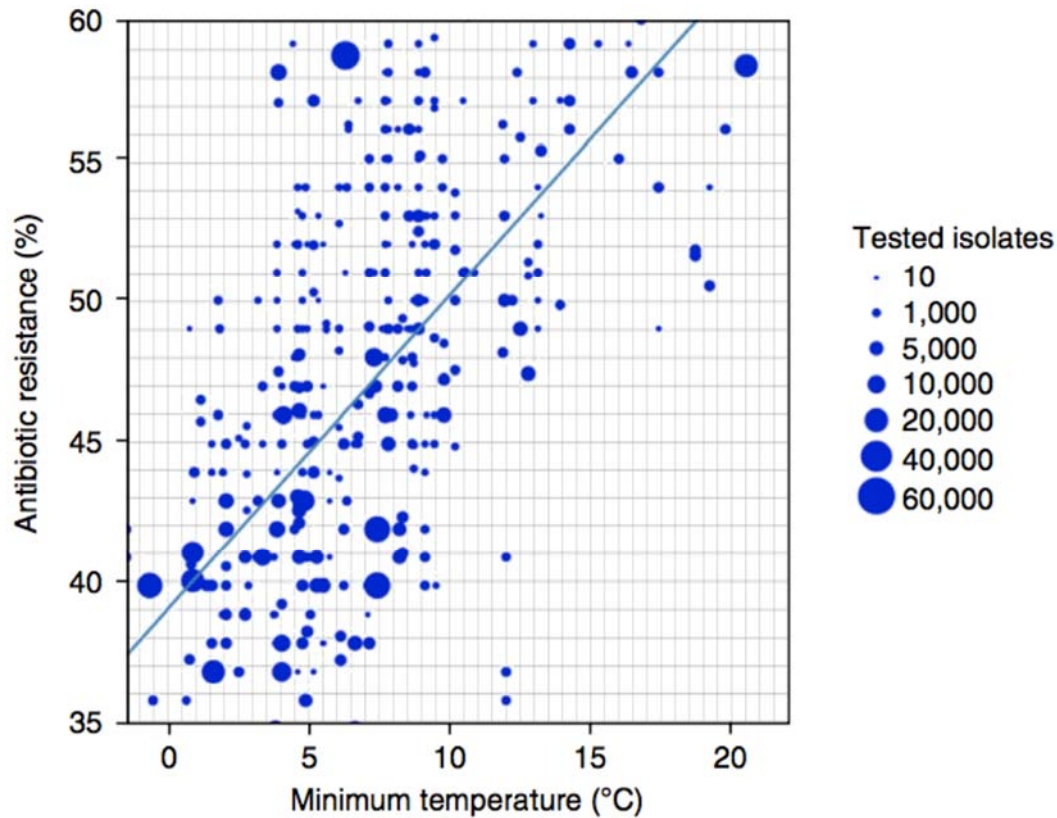
- (ii) Suggest why the host's immune system does not recognise an administered antibiotic. [1]

1. Unlike antigens, antibiotics are **not protein** (or polysaccharide) in nature
2. Ref. to **small size** of antibiotic molecules

*Max 1*

(g) Antibiotic resistance among bacteria is a growing global problem. Recent evidence indicates a relationship between antibiotic resistance and climate change.

Fig. 1.5 presents a finding from a study conducted in the United States, and shows a scatter plot of resistance among *E.coli* against the antibiotic amoxicillin, against minimum temperature.



**Fig. 1.5**

Comment on how amoxicillin resistance among *E. coli* is affected with every 10 °C rise in minimum temperature, and suggest **two** reasons for this relationship. [3]

1. Amoxicillin resistance **increases** by **12%** (A: 11 or 13%) with every 10 °C rise in minimum temperature
2. Ref. to increasing temperature **facilitating horizontal gene transfer/ conjugation/ transduction/ transformation/ uptake of free DNA**
3. Ref. to increasing temperature **increasing the rate of reproduction via binary fission**

[Total: 27]

## Question 2

Barley yellow dwarf virus (BYDV) is a positive sense single-stranded RNA virus; the virion is not enveloped in a lipid coating. The virus is transmitted by aphids, and the taxonomy of the virus is based on genome organisation, serotype differences and on the primary aphid vector of each isolate.

- (a) Explain why viruses may be considered both living and non-living. [2]
1. They have genome/ genetic material/ nucleic acid (Reject RNA/DNA)
  2. But no cytoplasm and organelles/ require host cell metabolic machinery for replication/ mention one or more enzymes for specific function
- (b) Using the information above and your knowledge, list two main classes of biomolecules present in a BYDV virion. [1]
1. Nucleic acid (Reject DNA/ RNA/ nucleotides)
  2. Proteins  
Reject carbohydrates
- (c) (i) Explain briefly how the virus is able to produce a complete new virion using the starting material of a positive sense single stranded RNA. [3]
1. Translation of positive sense single stranded RNA into viral proteins
  2. Assembly of proteins into a viral capsid
  3. Positive RNA used as template to make complementary negative RNA, which is in turn used as a template to make positive RNA genome / Positive RNA used as template to make complementary DNA via reverse transcription, which is in turn used to synthesize complementary strand to form double-stranded DNA that is transcribed to form + RNA genome
  4. Packaged into viral capsid (Reject: Nucleocapsid)

Max 3

- (c) (ii) Suggest one enzyme that is present in its host that the virus would need for the process explained in (i), and one other enzyme that the host is unable to provide. [2]
1. Peptidyl transferase
  2. RNA dependent RNA polymerase  
Mark for ECF from (c)(i)

The symptoms of a BYDV infection vary with the age of the plant at the time of infection, the strain of the virus and the environmental conditions. Symptoms appear approximately 14 days after infection. Affected plants may show a yellowing or reddening of leaves, stunting, an upright posture of thickened stiff leaves, reduced root growth, delayed (or no) heading, and a reduction in yield. Young plants are the most susceptible, and infected wheat leaves have a reduced ability to photosynthesise.

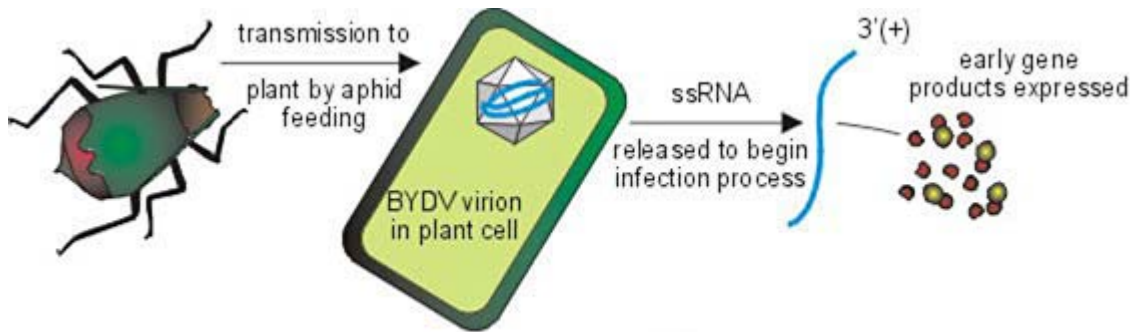
- (d) Explain briefly how disrupting photosynthesis may lead to stunted growth. [3]
1. No ATP/carbohydrates/starch/glucose made (effect of disrupting photosynthesis)  
Reject food/ chemical energy/ nutrients
  2. Unable to grow (link between effect and symptom)

The host range of BYDVs consists of more than 150 grass species in the family *Poaceae*. A large number of grasses both annual and perennial are alternate hosts to the BYDV and can serve as reservoirs of the virus.

There are two main sources by which a cereal crop might be infected:

1. By non-migrant wingless aphids already present in the field and which colonise newly-emerging crops. This is known as "green-bridge transfer".
2. By winged aphids migrating into crops from elsewhere. These then reproduce and the offspring spread to neighbouring plants.

Transmission from an aphid is demonstrated in Fig. 2.1 below.



- (e) With reference to the grasses that serve as alternate hosts for the virus, explain what you understand about the concept of a species. [2]
1. Ecological species concept where different species (of aphids) occupy different niche
  2. The different grasses help to define the different niches of the different (aphid) species.
- OR
1. Biological species concept where the grasses are classified at 150 different species
  2. Unable to produce fertile viable offspring
- (f) Climate change has affected the life cycle and distribution of animals and plants in the world. Discuss how climate change may impact the rates of BYDV infection in a **localised** crop population. [5]
1. Increase in global temperature leads to increase in reproduction rate/AVP of aphid vectors.
  2. Due to increased rate of enzyme reactions involved in metabolic processes.
  3. Therefore, increase in aphid population leading to increased infection rates
  4. Climate change may cause migration of aphid vectors northwards to cooler climates.
  5. Leads to a drop in aphid populations at the location of the crop leading to decreased infection rates.
  6. Migration of grasses that serve as alternate aphid hosts northwards to cooler climates
  7. Leads to a drop in aphid populations at the location of the crop leading to decreased infection rates.
  8. AVP (Links climate change to aphid/ viral infection rates and is well explained/ substantial logical explanation of plant life cycle being affected by climate change and its relation to vector or viral population)

Max 5

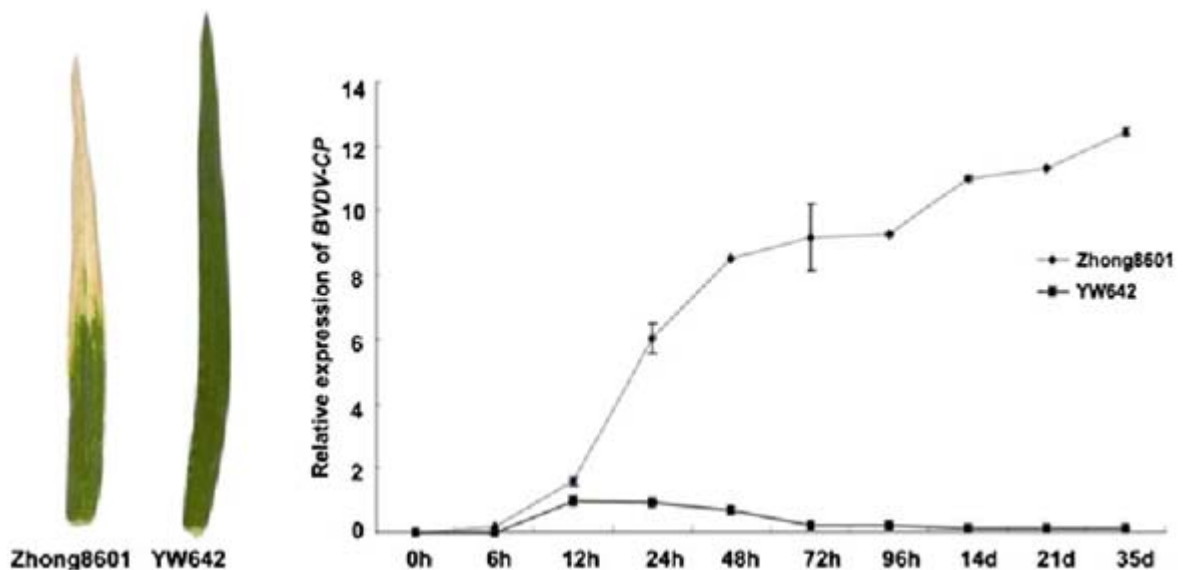
- (g) Many farmers in rural farms in third world countries are struggling to cope with the impact of pests and pathogens such as the BYDV. Suggest why many of these farmers are unable to overcome these issues. [1]
1. Lack of finance to buy new types of seeds (e.g. pest-resistant seeds) **Reject: afford solutions/ lack resources/ lack money without clear explanations**

2. Lack of skills to branch into alternative farming techniques (e.g. start growing new crops not affected by the pests)
3. AVP

The following is an excerpt from a research paper on BYDV infections of two types of grass.

*The wheat–Thinopyrum intermedium translocation line YW642 carries BYDV resistance gene BVDV-CP. To explore resistant wheat response in response to BYDV infection, we used GeneChip® Wheat Genome Arrays to analyze transcriptomes of YW642 and its susceptible parent Zhong8601 at 12 and 72 h postinoculation with BYDV.*

Fig. 2.2 below shows the result of this investigation.



**Fig. 2.2**

(h) Using the information and data provided, describe the effects of inoculating the two grass strains with BYDV on the expression of the resistance gene *BVDV-CP*. [2]

1. In YW642, relative expression of BVDV-CP remains 0 from 0 to 6h before increasing to 1 at 12h and decreasing to 0 at 14days
2. In Zhong8601, relative expression of BVDV-CP remains 0 from 0 to 6h before increasing to 12.5 (reject 14) at 35 days

(i) Suggest why the relative expression of the resistance gene *BVDV-CP* was low for both strains at 6 hours. [1]

1. Time needed for gene to be switched and the gene products expressed.

(j) Suggest how the proteins coded for by *BVDV-CP* may lead to BYDV resistance. [2]

1. They may compete with the BYDV virus for surface glycoproteins that allow entry into host cells/ bind to nucleocapsid and prevent entry
2. They may directly bind with viral capsid and break the virus down
3. AVP (showing how the specific proteins may interfere with a specific point in the viral life cycle but should not cause nonspecific harm to host)

[Total: 23]



## Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

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 parts **(a)** and **(b)**, as indicated in the question.

### Question 3

(a) Describe the principles and processes of the Polymerase Chain Reaction (PCR). [10]

#### Step 1: Denaturation

1. First, an excess of these primers are mixed with the DNA fragment to be amplified.
2. Primers are single stranded DNA sequences that are complementary to the sequence of DNA being amplified.
3. Primers are required for DNA replication as DNA polymerase needs an existing free 3' hydroxyl end for chain extension to take place.
4. This mixture of primer and fragment is heated to about 95°C for 30 sec.
5. At this temperature, the double-stranded DNA fragment dissociates into single strands. Due to the breakage of hydrogen bonds between complementary bases.

#### Step 2: Annealing of Primers

6. Next, the solution is allowed to cool to about 55- 68°C for 30 sec.
7. each strand of the fragment base-pairs with a complementary primer flanking the region to be amplified, (idea of annealing)
8. complementary base pairing

#### Step 3: Primer Extension

9. A thermo-stable type of DNA polymerase,
10. called Taq polymerase is required, along with a supply of all four nucleotides.
11. Polymerisation is usually carried out at 70-72°C for 1.5 minutes (optimum temperature for enzyme).
12. Polymerase copies the rest of the fragment as if it were replicating DNA, by adding nucleotides to the 3' OH of primer/growing strand
13. Because both DNA strands are replicated, there are now two copies of the original fragment.
14. Steps 1 to 3 are now repeated. For 25-30 cycles.

Max 10

(b) Discuss how photosynthesis plays a critical role in sustaining life on earth.

You should consider both specific processes in photosynthesis that sustain life and its role in reducing the impact of climate change. [15]

1. Specific Processes in photosynthesis

- State photolysis of water
- Water is split by light into hydrogen ions, electrons and oxygen
- Oxygen released used by other organisms in aerobic respiration to produce ATP for energy (Idea on how life is sustained)
  
- State calvin cycle
- Production of carbohydrates/starch
- Via reduction of phosphoglyceric acid (PGA/GP) to Triose Phosphate (TP)
- Carbohydrates used by other consumers in food chain to produce energy in the form of ATP
- Via cellular respiration

2. Role in reducing impact of climate change

- As carbon sinks that remove carbon dioxide from the atmosphere
- Idea of reducing greenhouse effect as carbon dioxide is a greenhouse gas
- Carbon dioxide fixation in calvin cycle
- Carbon dioxide from the atmosphere combines with RuBP to form GP.

3. Description of carbon sinks

- A carbon sink refers to a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period.
- The process by which carbon sinks remove carbon dioxide from the atmosphere is known as carbon sequestration.
- Involves forests
- Involves plankton in oceans
- Involves northern hemisphere regrowths

***QWC – Answer clearly focuses on role of photosynthesis BOTH in sustaining life and reducing the impact of climate change***

#### Question 4

(a) Describe the principles and processes of Southern Blotting. [10]

1. Southern Blotting involves Nucleic Acid Hybridisation
2. Objective is to highlight specific nucleic acid sequences by using radioactive or fluorescently labelled probes (Idea)
3. DNA from the sample is cleaved into restriction fragments with a restriction endonuclease, and
4. fragments are separated by gel electrophoresis.
5. The gel slab containing the DNA fragment is placed under a nitrocellulose membrane and a stack of paper towels.
6. These are placed on top of a sponge in a tray of alkaline solution.
7. The absorbent paper towels draw the solution towards themselves. This capillary action draws the alkali solution through the gel.
8. denaturing the double stranded DNA fragments.
9. The single stranded DNA on the gel is drawn upwards to the nitrocellulose membrane.
10. Next, a probe corresponding/complementary to a specific nucleotide sequence is poured over the nitrocellulose membrane.
11. Probe needs to be single-stranded DNA/RNA; Probe needs to be labelled
12. After hybridization, the membrane is washed to remove any unhybridized probes.
13. Any fragment that has a nucleotide sequence complementary to the probe's sequence will hybridize (base-pair) with the probe.
14. If the probe has been radioactively labeled, and the sheet will show a band of radioactivity where -the probe hybridized with the complementary fragment when autoradiography is performed.

Max 10

- (b) It can be argued that humans have changed the levels of global respiration via economic activities and this has contributed to climate change.

Explain the processes in cellular respiration that release carbon dioxide and discuss how these and other human factors can contribute to climate change. [15]

1: Processes in cellular respiration that release carbon dioxide

- Link Reaction & Krebs Cycle in aerobic respiration
- Occurs in the matrix of mitochondria
- 6 carbon dioxide molecules released per glucose
- Via Oxidative Decarboxylation
- Anaerobic respiration in yeast
- When pyruvate converted to ethanol
- 2 carbon dioxide released per glucose

Max 5

2. How these processes lead to climate change

- Increased aerobic respiration rates lead to increased release of carbon dioxide into atmosphere (idea) / accept reverse
- Increased respiration rates from livestock farming
- Increased respiration rates from crop farming
- Increased respiration rates in oceans due to increased growth of marine organisms due to increased pollution (or other relevant causes) / idea of eutrophication
- Further idea of eutrophication blocking sunlight and thus leading to death and decomposition of organic plant matter in water bodies – also releasing carbon dioxide into atmosphere.
- Increased respiration rates via decomposition of organic matter by microbes (due to deforestation/clearing land for agriculture)

Max 5

3. Brief description of how these lead to global warming

- Due to increased release of greenhouse gasses such as carbon dioxide
- Greenhouse effect – trapping of long wave radiation in the atmosphere

4. Other human factors leading to climate change

- Livestock farming – impacts other than increased respiration
- Brief description (linking to climate change)
- Deforestation
- Brief description (linking to climate change)
- Burning of fossil fuels
- Brief description (linking to climate change)

Max 4

***QWC – At least one point from each Section 3 and two points from each of the other sections.***