RAFFLES INSTITUTION

2024 Year 6 Preliminary Exam
Higher 2

BIOLOGY 9744/01

Paper 1 Multiple Choice **24 Sept 2024**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and shade your Index Number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions in 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.

Read the instructions on the Answer Sheet very carefully.

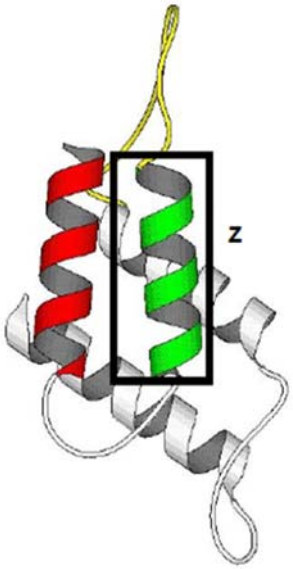
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

(Erase all mistakes completely. Do not bend or fold the OMR Answer Sheet).

This document consists of **20** printed pages.

Raffles Institution
Internal Examination

1. The figure below shows part of the structure of a proteinaceous enzyme.

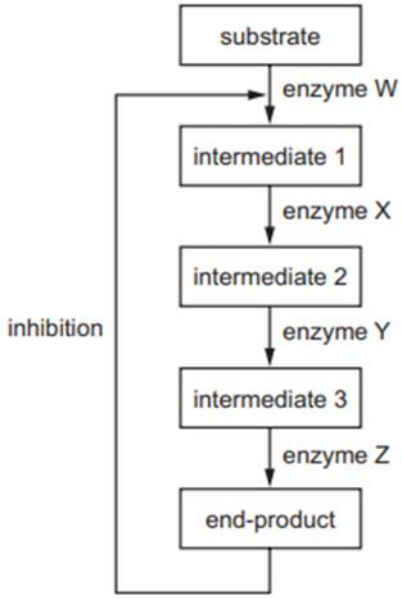


Which of the following correctly describe the structure in box **Z**?

	number of amino acids present	number of types of bond (s) present between amino acids
A	cannot be determined	only 2
B	approximately 11 amino acids	only 2
C	approximately 10 amino acids	only 3
D	approximately 7 amino acids	only 1

2. The end-product of a metabolic pathway can act as a competitive inhibitor. This is called end-product inhibition and allows a cell to control a metabolic pathway.

The diagram shows a metabolic pathway where the end-product could act as an inhibitor of enzyme W.



Which of the following statements would be true if enzyme Z was inhibited by the end-product instead of enzyme W?

1 The quantity of intermediate 1 would increase
2 The quantity of intermediate 1 would decrease
3 The quantity of end-product would remain unchanged
4 The quantity of intermediate 3 would decrease
5 There would be wastage of resources

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

3. Four students were asked to match the function of some cell structures in an animal cell with their appearance.

The functions were listed by number.

1 produces the mitotic spindle during cell division

2 synthesis of polypeptides

3 synthesis of lipids

The appearances were listed by letter.

V membranes which surround an enclosed inner cavity

W non-membrane-bound, spherical structures

X a double membrane interspersed with pores

Y non-membrane-bound, cylindrical structures

Z membrane-bound sacs, arranged as a flattened sac

Which student correctly matched the functions with the appearance of the cell structure?

student	1	2	3
A	W	X	Z
B	W	Z	V
C	Y	W	V
D	Y	Z	W

4. Batrachotoxin is a poison found in frogs in the Columbian jungle. The poison is used to produce poison darts.

The poison works by increasing the permeability of the cell surface membrane of nerve and muscle cells to sodium ions, which move out of the cells.

Four statements are made about how the poison affects the cells.

1 Water leaves the cells by osmosis, causing the cells to shrink.

2 Water enters the cells by osmosis, causing the cells to burst.

3 When the sodium ions move out of the cells the intracellular fluid has a more positive water potential than the extracellular fluid.

4 When the sodium ions move out of the cells the extracellular fluid has a more positive water potential than the intracellular fluid.

Which statements are correct for the cells affected by batrachotoxin?

A 1 and 3

B 1 and 4

C 2 and 3

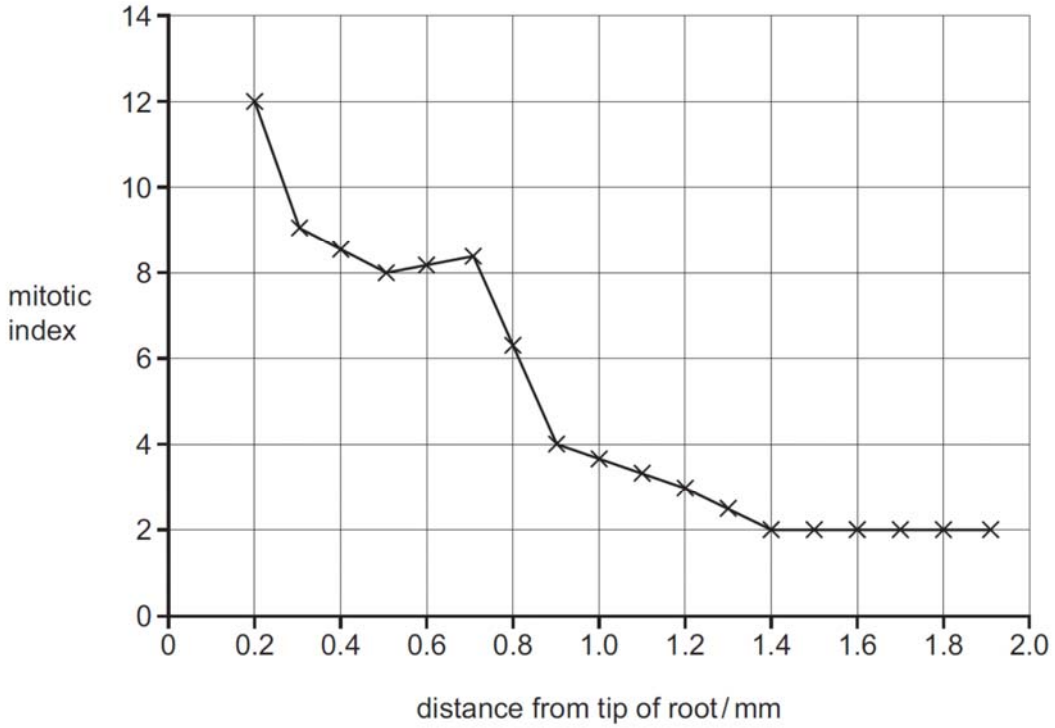
D 2 and 4

5. The mitotic index is a measure of the proportion of cells that are undergoing mitosis in an area of tissue. It is calculated using the formula shown.

mitotic index = (number of cells undergoing mitosis ÷ total number of cells) × 100

A scientist calculated the mitotic index of areas of onion root at different distances from the tip of the root.

The results are shown below.



Which statement is correct?

A No cell division occurs further than 1.4 mm from the tip of the root.

B The rate of cell division decreases as the distance from the root tip decreases.

C Most of the cells undergoing cell division are closer to the tip of the root.

D For a sample of 200 cells located 0.2 mm from the tip of the root, 6 would be undergoing mitosis.

6. The following experiment was carried out.

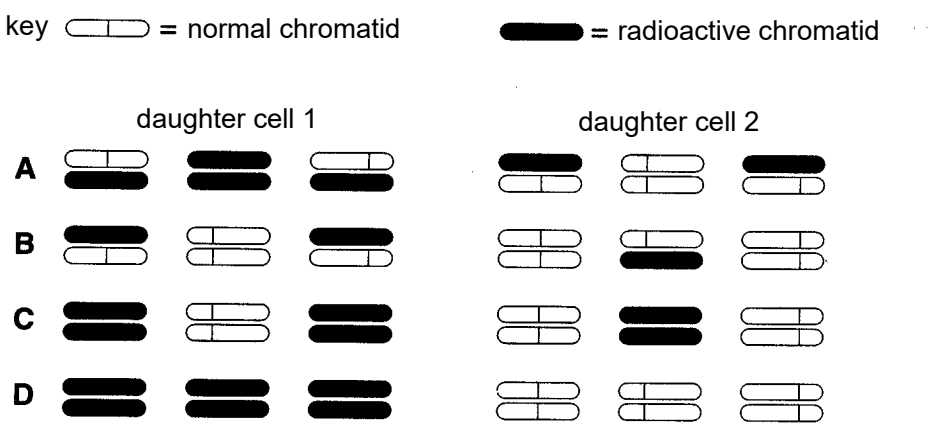
1 Haploid cells, containing three chromosomes each, were grown in a medium containing radioactive thymine, so that all the DNA was labelled.

2 Cells in early interphase were then transferred to a medium where the available thymine was not radioactive and allowed to divide once.

3 A single cell was immediately isolated and allowed to divide once more.

4 When the two daughter cells reached the next metaphase, they were fixed and their three chromosomes were inspected for radioactivity.

Which diagram represents a possible distribution of radioactivity at metaphase in the two daughter cells?



7. Part of the genetic code specifying amino acids is shown in the table below.

codon in mRNA	amino acid	codon in mRNA	amino acid
AAA	lysine	CCU/ CCA/ CCC/ CCG	proline
AUG	methionine	UAU	tyrosine
AGG / CGC/ CGG	arginine		
GGG	glycine		
UGG	tryptophan		

During translation initiation, the small ribosomal subunit attaches to the 5' untranslated region (UTR) and slides to the START codon.

A section of an mRNA sequence is shown below.

5' U A U A A A A U G C C U U G G 3'
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

From the above information, how many of the predictions stated below are **correct**?

I The insertion of an additional nucleotide before position 2 would be expected to result in greater change in the amino acid chain than an insertion after position 12.

II The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.

III The substitution of a different nucleotide at position 13 would result in the production of an amino acid chain with one alteration.

IV The deletion of a nucleotide at position 5 would result only in an alteration in the second amino acid in the chain.

A 4 **B** 3 **C** 2 **D** 1

8. The descriptions below are of nucleic acids in eukaryotes.

I a polynucleotide of variable length formed by base pairing

II a small polynucleotide with a specific 3-D shape

III a small polynucleotide with a specific shape, and is associated with proteins

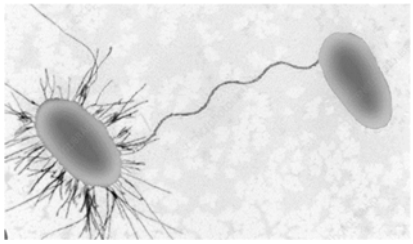
IV a large polynucleotide with super coiled sections, and is associated with proteins

Based on the above descriptions, which row correctly matches each description to its name and function?

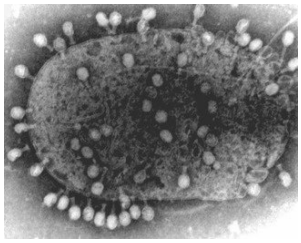
	name	function
A	I = mRNA	stores coded information
B	II = DNA	carries coded information
C	III = rRNA	catalyses peptide bond formation
D	IV = tRNA	carries specific amino acid

9. The following pictures show processes involving bacteria.

P



Q



R

Which of the following statements are true?

I All the processes, **P, Q** and **R** increase the genetic diversity in bacteria.

II The rolling circle mechanism of DNA replication occurs in processes **P** and **Q**.

III Process **R** may lead to the introduction of new bacterial DNA into the bacteria.

IV DNA replication occurs in processes **P** and **Q**.

A I, II and III only

B II and III only

C I and IV only

D III and IV only

10. Which of the following statements are incorrect?

1 When there is a mutation in the *lac I* gene of the *lac* operon which results in the production of a premature stop codon, the β-galactosidase, permease and transacetylase genes will not be transcribed in the presence of lactose.

2 When wild-type *E. coli* grown in glucose are transferred to a medium containing only lactose as sugar, all the operons are induced.

3 Mutation of the promoter of the *trp R* gene in the *trp* operon will result in the production of a polycistronic mRNA which will then be translated into a polyprotein which can then be cleaved into 5 different polypeptides.

4 When the corepressor allolactose binds to the allosteric site of the lac repressor, the repressor changes conformation and becomes an active repressor which binds to the operator of the *lac* operon.

A 1 and 3 only

B 2 and 4

C 1 and 4 only

D All of the above

11. Herpes simplex virus 1 (HSV-1) causes cold sores, while rhinoviruses cause the common cold. The common cold symptoms do not recur unless the person is infected by rhinovirus again. However, cold sores symptoms can show up again later in a person's life, even if there is no re-infection by HSV-1.

What is the most likely explanation for this difference?

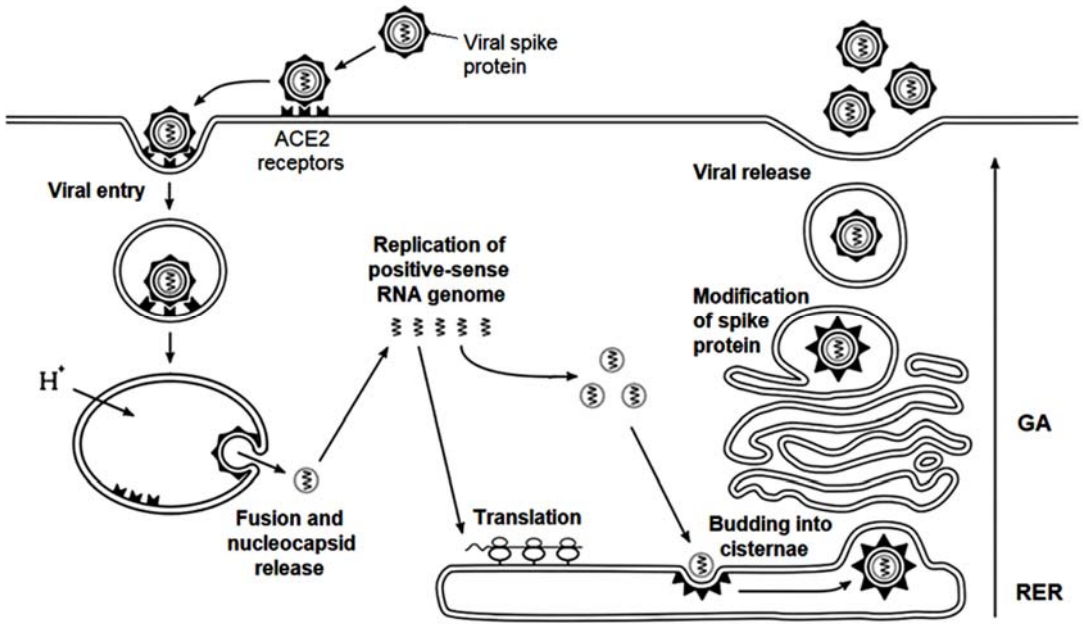
A HSV-1 replicates much faster than rhinoviruses within host cells.

B Rhinoviruses are less effectively eliminated by the immune system after infection.

C HSV-1 establishes a latent reservoir within host cells.

D The common cold has a shorter incubation period compared to herpes infections.

12. The diagram below shows the reproductive cycle of the SARS-CoV-2. It is a positive-sense single-stranded RNA enveloped virus.



Which of the following statements are correct?

1 The envelope of the virus is derived from the membrane of the Golgi Apparatus.
2 The viral genome can be used directly for translation.
3 Replication of the virus is via RNA dependent RNA polymerase.
4 The viral glycoprotein is synthesised only at the ribosomes of the RER.
5 The virus exits the host cell via budding.

A 2, 3 only

B 1, 4 only

C 1, 3, 4 only

D 2, 3, 5 only

13. Many fundamental concepts of telomere and telomerase function were first established in yeast, a unicellular organism, and then extended to other organisms.

The shortening of telomeres explains why many cells have a limited number of cell divisions and is associated with the ageing processes in organisms.

Parasitic infections often increase the rate of cell division.

A student made the following predictions:

1 Parasitic infections can lead to faster ageing.
2 Telomerase activity will be low in cancer cells.
3 There is a positive correlation between telomere length and age.
4 In yeast cultures with high reproductive rate, there is high telomerase activity.
5 Yeasts have linear chromosomes.

Using your knowledge of telomeres and telomerase and the information given, which of the above statements are correct?

A All of the above

B 1, 2 and 3 only

C 1, 4 and 5 only

D 3, 4 and 5 only

14. The following statements are about the regulation of eukaryotic gene expression.

1 It can be regulated at the level of initiation of transcription by altering chromatin structure.
2 The chromatin remodelling complex alters the accessibility of DNA to DNA polymerase.
3 Ubiquitination of proteins help to reduce their concentrations once they no longer needed.
4 The chromatin remodelling complex can alter nucleosomal architecture but cannot remove the histones.
5 The longer the poly A tail, the longer the half life of a pre-mRNA.
6 The binding of an active repressor to the operator can regulate the concentration of proteins synthesised.

Which of the above statements are incorrect?

A 5 and 6 only

B 2 and 6 only

C 2, 5 and 6 only

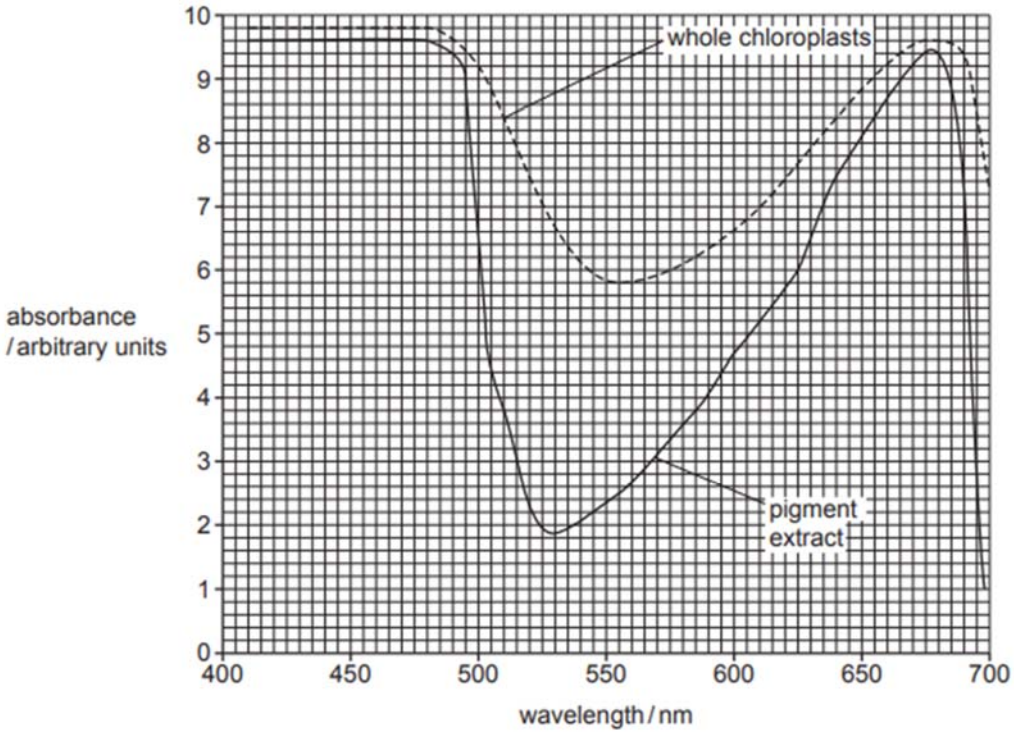
D 1, 3 and 4 only

15. Which of the following statements are correct?

1 Dysregulation of the checkpoints of cell cycle is common in cancer cells and leads to uncontrolled cell division.
2 Ionizing radiation causes DNA damage, and can be used to kill cancer cells.
3 The risk of cancer developing increases with age.
4 Exposure to ionizing radiation can increase the chance of the development of skin cancer.

A 1 and 2 only
B 2 and 4 only
C 1, 3 and 4 only
D All of the above

16. The figure shows the absorption spectrum of an extract of chloroplast pigments and an absorption spectrum of whole chloroplasts from the same plant.



Which of the following statements is the best possible explanation for the graph?

A The pigment extract is able to absorb more light because it is more concentrated.

B Whole chloroplasts contain compounds other than pigments that are able to absorb light.

C The pigments in the pigment extract were denatured during the extraction process.

D The whole chloroplasts are able to absorb more light because the pigments are arranged on the thylakoid membranes.

17. Which of the following statements are true of oxidative phosphorylation but not true of photophosphorylation?

1 ATP is produced
2 oxygen is the final electron acceptor
3 electrons flow down an electron transport chain
4 presence of proton reservoir in intermembrane space
5 NAD is converted to reduced NAD

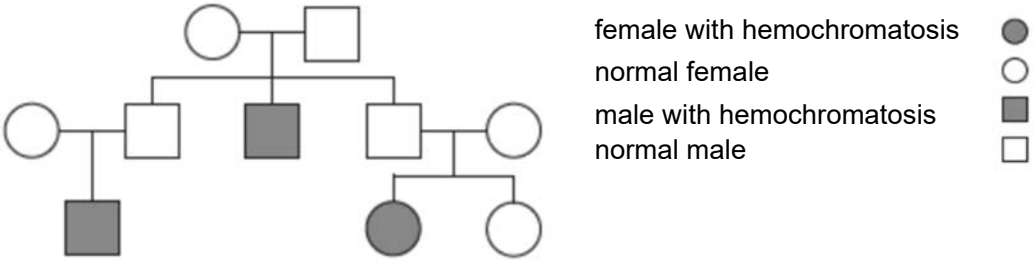
A 1 and 3 only

B 2 and 4 only

C 1, 2 and 3 only

D All of the above

18. The pedigree chart shows the inheritance of hemochromatosis, a genetic disease which causes an excessive accumulation of iron in the body.



What can be inferred about this genetic disease from the pedigree chart?

A It is sex-linked dominant.

B It is sex-linked recessive.

C It is autosomal dominant.

D It is autosomal recessive.

19. There are various varieties of tomatoes plant that exhibit different phenotypes. Their stems can be green or purple, and their fruits can be red or orange. The table below shows the numbers and phenotypes of offsprings produced in three separate crosses of different tomato plants. The genes for stem colour and fruit colour are on different chromosomes.

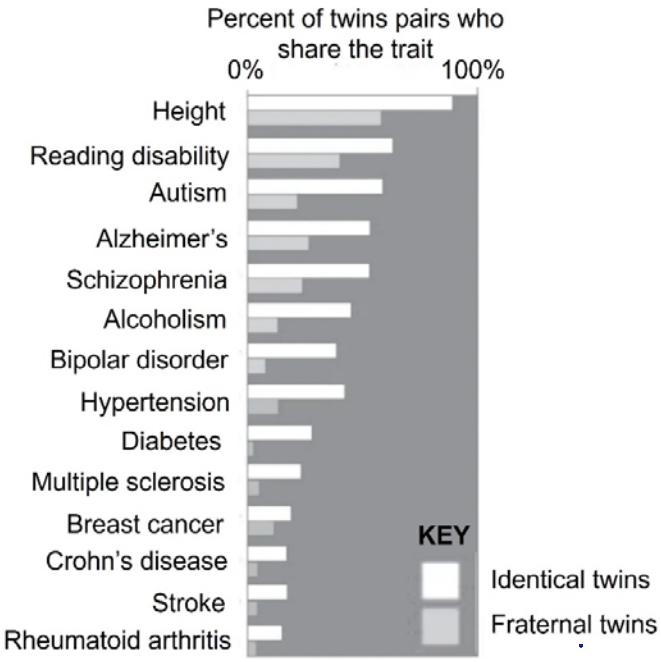
parental phenotypes	number and phenotypes of offsprings			
	green stem, red fruit	green stem, orange fruit	purple stem, red fruit	purple stem, orange fruit
cross 1: green stem, orange fruit x purple stem, red fruit	22	18	19	21
cross 2: green stem, red fruit x purple stem, orange fruit	0	0	41	39
cross 3: green stem, red fruit x green stem, orange fruit	0	80	0	0

Which of the following correctly defines the alleles for stem and fruit colour, and the genotype of the parents of cross 1?

	alleles for stem and fruit colour	genotype of parents of cross 1
A	P = purple, p' = green O = orange, o' = red	p'p'Oo' x Pp'o'o'
B	P = purple, p' = green R = red, r = orange	p'p'rr x Pp'Rr
C	G = green, g = purple O = orange, o' = red	GgOo' x ggo'o'
D	G = green, g = purple R = red, r = orange	Ggrr x ggRr

20. Studies involving twins are often employed to gain further insight into how nature and nurture work together to determine the phenotype of individuals. These studies involve both monozygotic (identical) twins and dizygotic (fraternal) twins who were raised in the same households.

Traits such as height or diseases (e.g. diabetes) were investigated in twin pairs and the results were illustrated in the figure below.



Which of the following statements explains the results above?

A Identical twins share the same genotype and environment and hence would be identical for all traits.

B Fraternal twins have different genotypes and hence show less similarity compared to identical twins for all traits.

C Height is influenced by genotype to a large extent since identical twins show the highest percentage of twins who share the same trait.

D Diabetes is not a genetic disease since there is a small percentage of fraternal twin pairs who share the same trait.

21. Stargardt's is an inherited disease caused by the mutation of a gene associated with vitamin A processing in the eye. A problem with vitamin A processing results in degeneration of receptor cells and loss of vision because receptor cells are not regenerated.

Haematopoietic stem cells have been harvested from the patient and induced to form induced pluripotent stem cells (iPSCs). The use of iPSCs has been proposed as a promising target for the treatment of Stargardt's disease.

Which statement explains why iPSCs are suitable for the treatment of Stargardt's disease?

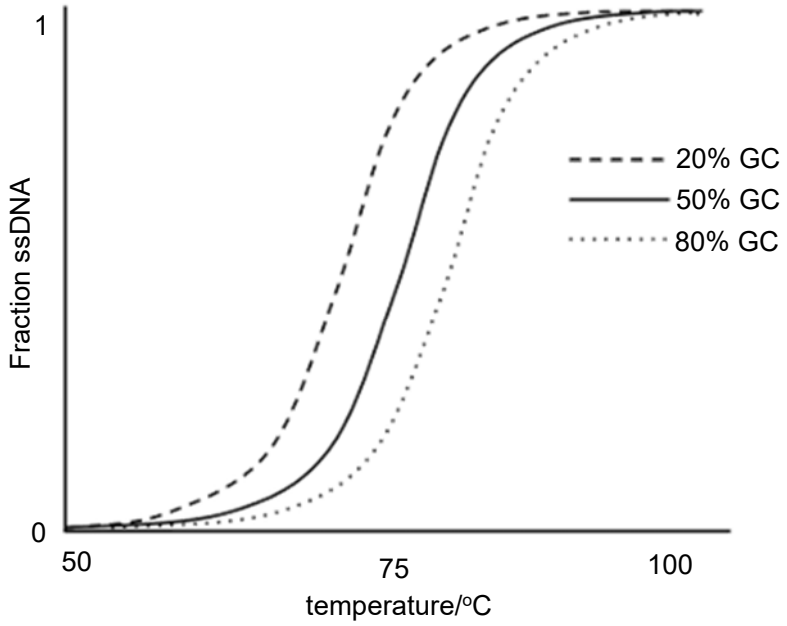
A iPSCs can be generated from an embryo and transplanted into the patient.

B iPSCs are able to process vitamin A to restore vision.

C iPSCs are able to differentiate into receptor cells to restore vision.

D iPSCs undergo symmetrical division to maintain a constant pool of stem cells.

22. The melting temperature of DNA refers to the temperature at which 50% of DNA in a sample has denatured from double-stranded DNA (dsDNA) to single-stranded DNA (ssDNA). The figure below shows the DNA melting curves for three strands of DNA with different levels of guanine-cytosine (GC) content. The y-axis indicates the fraction of DNA molecules that are single-stranded.



With reference to the information in figure, how would you modify a PCR procedure using primers that are lower in GC content?

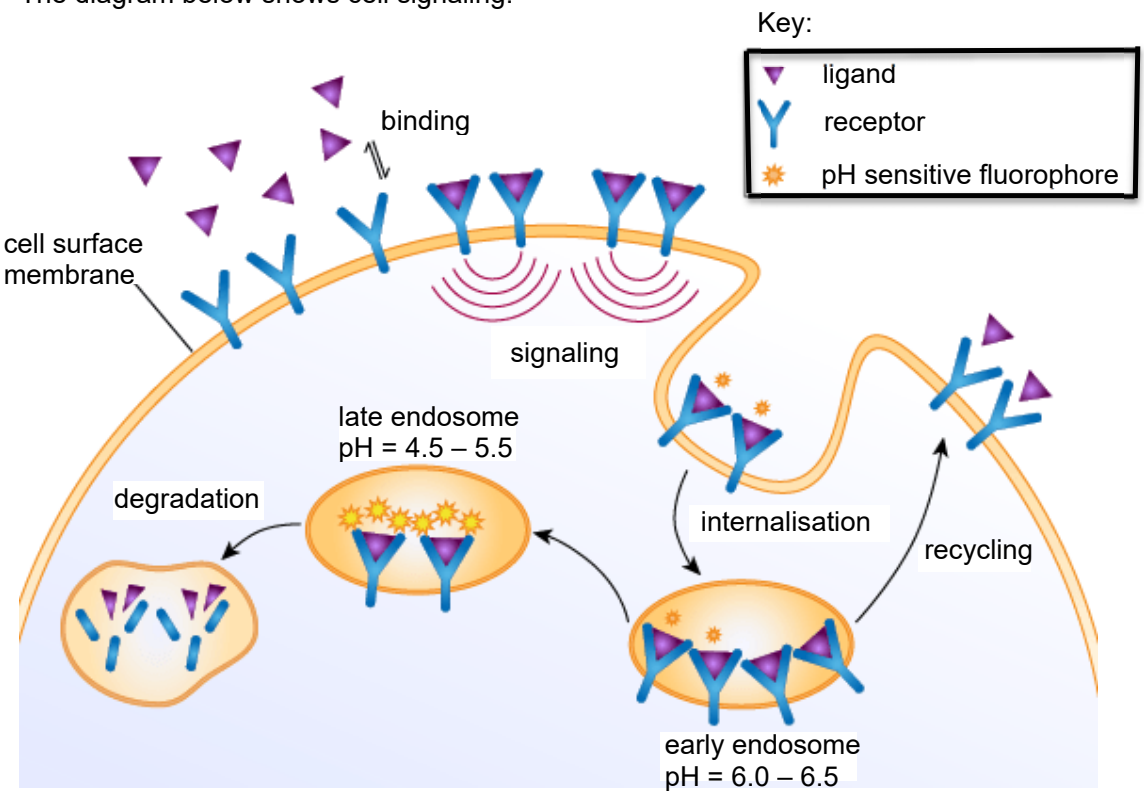
A decrease annealing temperature

B increase annealing temperature

C decrease denaturation temperature

D decrease annealing time

23. The diagram below shows cell signaling.



Which of the following statements explains the significance of the membrane receptor internalisation?

A Ligand transported into the cell is the first step in signal transduction.

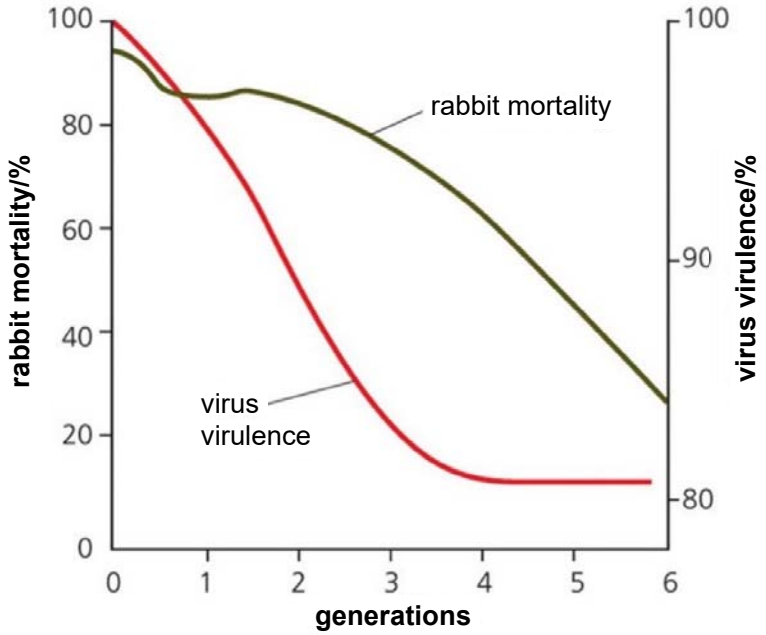
B Membrane receptor internalisation results in reducing the responsiveness to the ligand.

C Increase in the ligand-receptor complexes in the cell may lead to signal amplification.

D The signal transduction pathway for this cell is membrane cell receptor internalisation followed by recycling of the receptor to the cell surface.

24. The European wild rabbit was introduced to Australia in 1859. There were no natural predators in Australia to control their number and rabbits quickly overran large parts of the continent. Grassland, available to herds of herbivores, principally cows and sheep, was affected.

As a biological control measure, a myxoma virus that had been discovered in South American rabbits (a different species from the European rabbit) was introduced in 1950. Myxoma virus causes a parasitic disease of rabbits, myxomatosis. The changing effects of this virus on rabbit mortality (1950–56) are shown in the graph, as is the resulting change in virulence of the virus.



The following statements describe the scenario above.

1 A small number of rabbits that fell sick recover after a while.
2 The virus posed as a new disease to the rabbits.
3 Rabbits are highly prolific, reproducing by sexual reproduction.
4 Rabbit offspring retain traits similar to parents are also exposed to the virus.

Which is the correct order that explains the trend shown by the two curves over 6 years?

A 3 → 2 → 1 → 4
B 2 → 1 → 3 → 4
C 1 → 4 → 2 → 3
D 4 → 2 → 3 → 1

25. Studies over the last century have used mainly morphology and colour pattern to describe and group numerous snake species. Two such examples are the kingsnake (*Lampropeltis getula*) and the corn snake (*Pantherophis guttatus*).

Both the kingsnake and corn snake are found throughout North America, and both kill their prey by constriction.

Using scent disguise methods, scientists artificially induced mating between the kingsnake and the corn snake. The offspring produced were hybrids that had unique morphological skin patterns and were fertile.

Which of the following is not true?

A The kingsnake and the corn snake could share a common ancestor.

B The kingsnake and the corn snake were given different genus and species names due to their differing characteristics.

C The fertile hybrids are a new species, different from the two parental species.

D When classifying snakes, one should avoid using the morphological species concept.

26. Polyploidy has been a cause of rapid speciation in some plant genera, such as *Gossypium*.

Which observation is evidence that speciation has occurred?

A A polyploid plant reproduces asexually.

B A polyploid plant produces male and female gametes.

C Fertile offspring are produced when a tetraploid plant crosses with a diploid plant.

D Fertilisation between the polyploid individuals produces fertile and viable offspring, whereas fertilisation between polyploid and diploid individuals does not.

27. T-lymphocytes have a protein, PD-1, on their surface. Some cancer cells have a receptor molecule on their surface which binds with PD-1, inactivating the T-lymphocyte.

Lambrolizumab is an antibody that is specific to the epitope on this receptor.

Trials showed that in 54 of 135 people with advanced skin cancer who were given lambrolizumab, the tumours reduced by more than halved in volume. In six of the 57 people who were given the highest dose, the tumours disappeared.

What may be correctly concluded from this information?

1 Lambrolizumab binds with a receptor on the surface of skin cancer cells.

2 Cancer cells to which lambrolizumab is bound cannot inactivate T-lymphocytes.

3 Lambrolizumab targets and kills skin cancer cells.

4 Lambrolizumab allows a patient's own immune system to kill cancer cells.

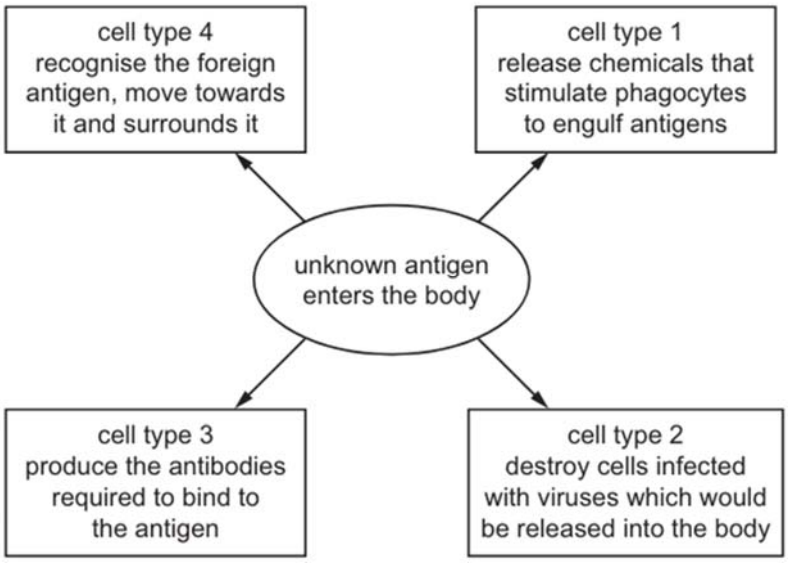
A 1, 2, 3 and 4

B 1, 2 and 4 only

C 1 and 3 only

D 2, 3 and 4 only

28. A student used a diagram to show four types of cells involved in the primary immune response.



Which row is correct?

	cell type 1	cell type 2	cell type 3	cell type 4
A	B-lymphocyte	macrophage	T-killer cell	T-helper cell
B	macrophage	B-lymphocyte	T-helper cell	T-killer cell
C	T-helper cell	T-killer cell	B-lymphocyte	macrophage
D	T-killer cell	T-helper cell	B-lymphocyte	macrophage

29. Three species of trout are found in different freshwater lakes found across different parts of North America. The preferred temperature range of each species is shown below.

lake trout
(*Salvelinus namaycush)*
6–13°C

rainbow trout
(*Oncorhynchus mykiss*)
12–18°C

brown trout
(*Salmo trutta*)
11–23°C

Climate change has resulted in higher mean temperature above 25°C in North America lakes, thus affecting the trouts' survival and consequently the fishery industry.

Which of the following is not true?

A Higher mean temperature allows the brown trout to adapt.
B Trout found in smaller freshwater lakes are impacted more than those found in larger freshwater lake.
C Fishermen who rely on catching lake trout to sell will suffer more in their livelihood compared to those who rely on catching brown trout to sell.
D When the trout migrate to another part of the lake, they are likely to face competition with existing fish population.

30. Snow geese fly north to the Arctic in the spring and form breeding colonies. Different colonies form at different latitudes. The closer to the poles, the higher the latitude where there is a greater likelihood of snow.

Snow geese are either white or blue in colour. There are also predators in the Arctic.

There is a positive correlation between the size of snow geese and how far north they breed. The table shows the percentage of white snow geese in colonies at different latitudes at different times over a 40-year period. The blank cells in the table are years for which no figures are available.

colony	latitudes in degrees north	percentage of white snow geese to entire geese population each year			
		1930	1950	1960	1970
M	72	100		100	100
N	71		> 99	> 99	> 99
O	66	95	85	76	
P	63	86	75	67	65
Q	55		62		28

Which of the following statements could be inferred from the information above?

1 The number of blue geese increased from 1930 to 1970.
2 The changes in the percentage of white snow geese could be due to climate change.
3 The mean size of white geese is larger than the mean size of blue geese at a specific latitude.
4 Melting of snow results in a greater selection pressure against the white geese more than the blue geese.

A 1 and 3

B 2 and 4

C 2 and 3

D 1, 2, 3 and 4

- End of Paper -