Civics Group	Index Number	Name (use BLOCK LETTERS)	**H2**

ST. ANDREW'S JUNIOR COLLEGE
2023 JC2 PRELIMINARY EXAMINATIONS

H2 BIOLOGY **9744/01**

Paper 1: Multiple Choice

Monday 18th September 2023 1 hour

Additional Materials: Multiple Choice Answer Sheet (OTAS)

READ THESE INSTRUCTIONS FIRST

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

Write your name, civics group and index number on the multiple choice answer sheet in the spaces provided.

There are **30** 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 multiple choice Optical answer sheet.

INFORMATION TO CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for wrong answer. Any rough working should be done in this booklet.

At the end of the examination, submit both question paper and multiple choice answer sheet.

This document consists of 22 printed pages

[Turn over]

*Answer **all** questions*

1 A new fossil unicellular organism was discovered in rocks 150 million years old. Scientists studied the cell structure of several samples under the electron microscope.

Which features suggest it was a eukaryote and not a prokaryote?

1 The nucleus was enclosed by a nuclear envelope with nuclear pores and contained two nucleoli.

2 The cisternae of rough endoplasmic reticulum were covered with ribosomes.

3 Oval organelles 1-2 μm long, in which the inner membrane was folded.

4 The cell wall was an extracellular structure, oval in shape.

A 1 and 2 only

B 1 and 4 only

C 1, 2 and 3 only

D 2 and 3 only

2 The following are a series of organic molecules and the chemical processes that occur to convert them into different molecules.

Which of the rows, A to D, is correct?

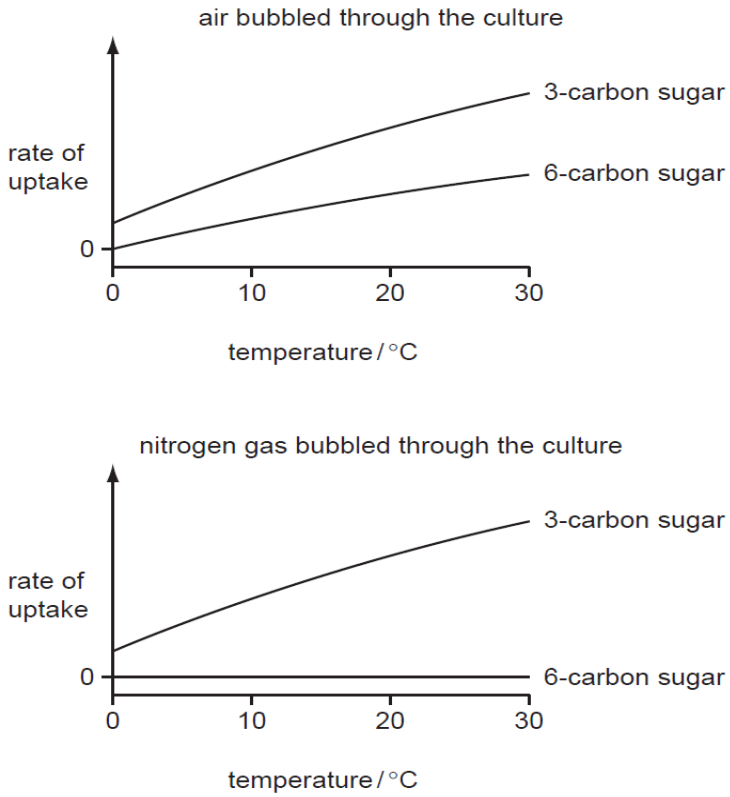
A nucleic acid $\xrightarrow{\text{hydrolysis}}$ nucleotide $\xrightarrow{\text{hydrolysis}}$ polynucleotide

B α-glucose $\xrightarrow{\text{condensation}}$ amylopectin $\xrightarrow{\text{hydrolysis}}$ α-glucose

C amino acid $\xrightarrow{\text{condensation}}$ dipeptide $\xrightarrow{\text{hydrolysis}}$ polypeptide

D β-glucose $\xrightarrow{\text{condensation}}$ cellulose $\xrightarrow{\text{condensation}}$ maltose

3 The graphs show the rate of uptake of sugars by a culture of animal cells, under different conditions.

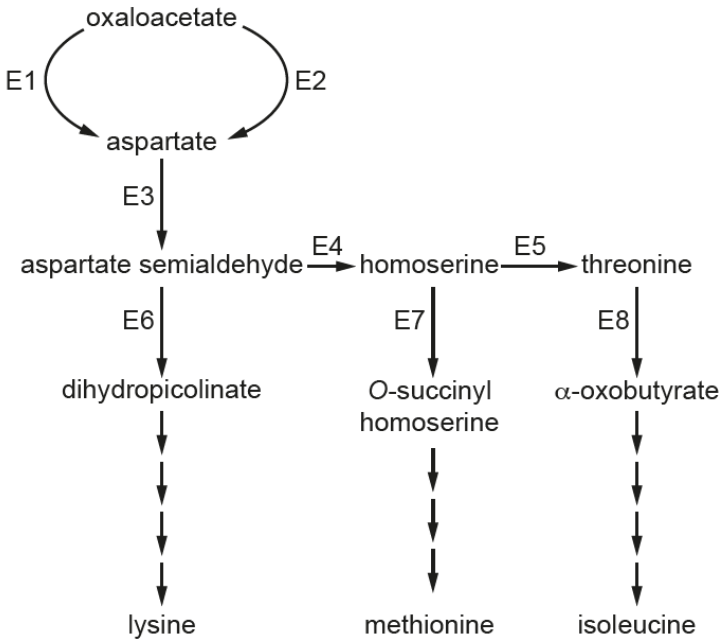


How are the sugars taken up by the cells when air is bubbled through the culture?

	3-carbon sugar	**6-carbon sugar**
A	active transport	active transport
B	active transport	diffusion
C	diffusion	active transport
D	diffusion	diffusion

4 The figure shows the metabolic pathways leading to synthesis of five amino acids: aspartate, lysine, methionine, threonine and isoleucine.

E1 to E8 represent different enzymes involved in these pathways.



Which of the options is an example of end-product inhibition?

A aspartate inhibits E3 and E4

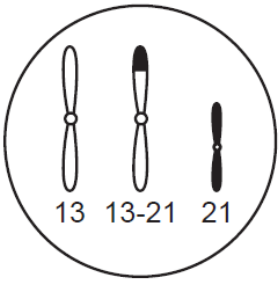
B lysine inhibits E1 and E6

C isoleucine inhibits E7

D methionine inhibits E8

5 Down's syndrome can be caused by a trisomy of chromosome 21, but can also result from translocation of chromosome 21 onto chromosome 13, forming a single chromosome 13-21.

The diagram shows chromosomes 13 and 21 in the nucleus of a diploid (2n) testis cell from a phenotypically normal male carrier of a 13-21 translocation. This cell has a chromosome number of 45.



Which is **not** a likely outcome of fertilisation of normal oocytes by sperm from this male?

	chromosomes in sperm	embryo
A	13 and 21	2n = 46 normal phenotype
B	13–21	2n = 45 normal phenotype
C	13–21 and 21	2n = 46 Down's syndrome
D	13–21 and 21	2n = 47 Down's syndrome

6 Which of the following statements is/are evidence that DNA replication is semi-conservative?

1 After one replication, the number of adenine nucleotides is equal to the number of guanine nucleotides.

2 After two replications, two DNA molecules have one original and one new strand, and two DNA molecules have two new strands.

3 After three replications, there are eight DNA molecules, only two of which have strands from the original DNA.

A 1, 2 and 3

B 1 and 2 only

C 2 and 3 only

D 1 only

7 The table shows the DNA triplet codes for some amino acids.

amino acid	DNA triplet code	amino acid	DNA triplet code
arginine	GCA	glycine	CCA
arginine	GCC	glycine	CCG
arginine	GCG	glycine	CCT
asparagine	TTA	lysine	TTC
asparagine	TTG	lysine	TTT
cysteine	ACA	proline	GGA
cysteine	ACG	proline	GGC
STOP	ATC	valine	CAC

The base sequence on the DNA template strand coding for part of a polypeptide is shown.

CCA TTC ACG GCG TTA GCA

Two mutations occur in this sequence during DNA replication.

Which mutated DNA would result in a polypeptide with one different amino acid?

A CCA ATC ACG GCG TTG GCA

B CCA TTC ACA GCA TTA GCA

C CCA TTC ACG CCG TTA GCC

D CCT TTC ACG GCG TTA GCC

8 A student wrote three statements about cell signalling.

1 A signal chemical always has the same shape as a protein receptor on a target cell.

2 An increase in temperature may decrease the effect of cell to cell signalling.

3 A mutation may decrease production of active protein receptors for the cell surface membrane.

Which statements are correct?

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

9 What are the conditions in a human cell just before the cell enters prophase?

	number of chromatids	number of molecules of DNA in nucleus	spindle present	nuclear envelope present
A	46	46	yes	no
B	92	46	no	yes
C	46	92	yes	yes
D	92	92	no	yes

10 What do the causative agents of HIV/ AIDS, malaria and TB have in common?

	cell surface membrane	genome	ribosomes	respiration
A	✓	✓	✓	✓
B	✓	×	×	✓
C	×	✓	×	✓
D	×	✓	×	×

11 Which of the following statement(s) on viruses is/are true?

1 The HIV polyprotein undergoes cleavage to form functional proteins during post-transcriptional processing.

2 Replication of both HIV and lambda phage have a latent phase.

3 The specific transfer of genes from one bacterial strain to another by a T4 phage occurs during specialized transduction.

4 Influenza virus undergoes genetic drift as there is an accumulation of mutations in the haemagglutinin gene with time.

A 2 only

B 1 and 3

C 1 and 4

D 2 and 4

12 What is present in all viruses?

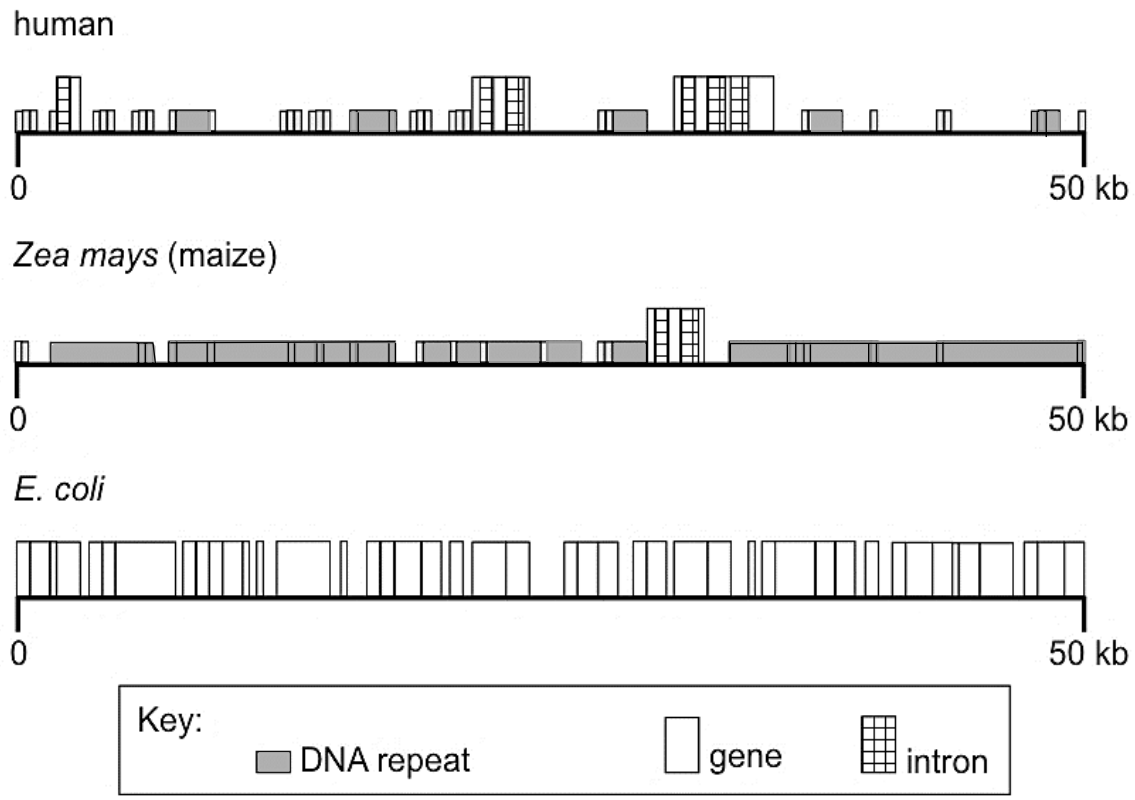
A ribose

B deoxyribose

C adenine

D thymine

13 The diagram shows 50 kb segments of the human, *E.coli* and *Zea mays* genomes.



Which one of the following statements can be concluded from the above results showing the genetic organisation of a 50 kb portion of the human, *E.coli* and *Zea mays* genomes?

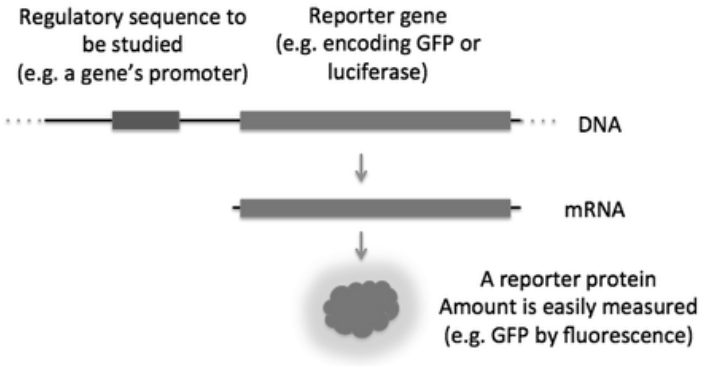
A More complex organisms have lower gene density.

B *Zea mays* has a higher density of DNA repeats as compared to humans and *E. coli*.

C Organisms with smaller chromosome number have higher gene density.

D The presence of introns in DNA of eukaryotes allows alternative splicing to occur to synthesise as many proteins as prokaryotes.

14 An experiment was conducted to determine the effects of a novel promoter on the transcription of a gene. The cloned promoter was ligated to luciferase, a reporter gene which when expressed allows the amount of proteins to be quantified by colorimetry.



Several regions of DNA in the promoter region were deleted and the construct transformed into cells and the luciferase activity measured. The data from the experiment is shown in the following table.

DNA region deleted	Relative luciferase expression
No deletion	100
A	320
B	100
C	15
D	<1

What conclusion can be drawn from the data?

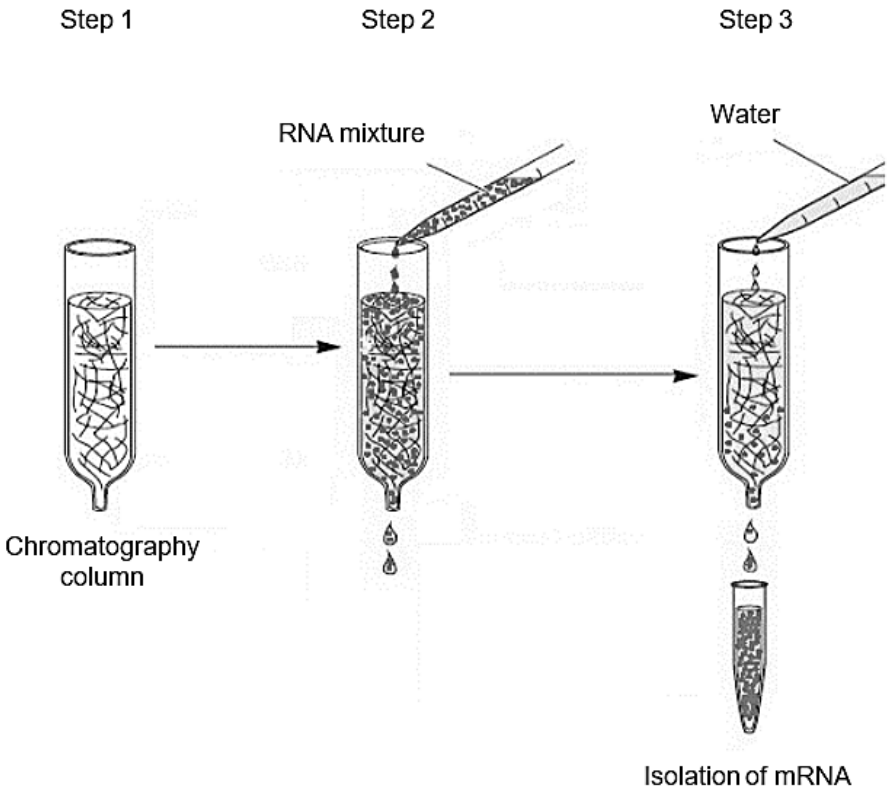
A Region D does not contain any control elements.

B Enhancers that increase transcription are located in region A.

C Expression of the gene is reduced when region C is deleted because silencers are deleted.

D Repressor binding sites are located in region A.

15 The isolation of mRNA can be done by passing an RNA mixture obtained from homogenised tissue through a chromatography column. The procedure of the mRNA isolation is as follows:



Step 1: Set up a chromatography column which contains short lengths of uracil nucleotides attached to a solid support medium.

Step 2: Add RNA mixture to the chromatography column. RNA that do not hybridise with the uracil nucleotides will pass through and leave the column.

Step 3: Add water to the chromatography column to remove and isolate the hybridised mRNA.

Which of the following statements is not true?

A rRNA and tRNA molecules could pass through and leave the column in Step 2.

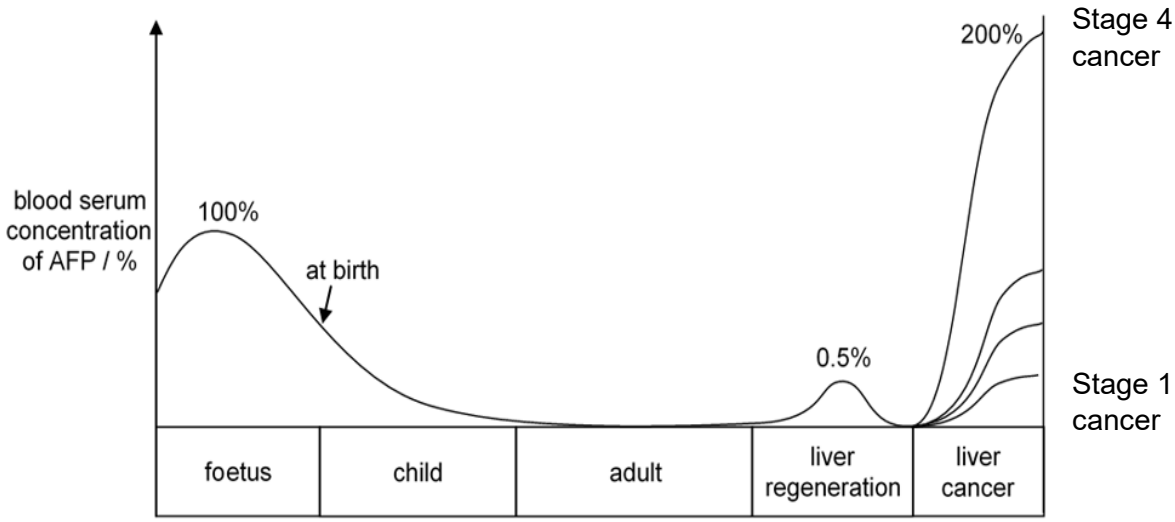
B Complementary base pairing is responsible for the attachment of RNA to the solid support medium.

C The isolated mRNA in Step 3 do not contain introns.

D The RNA that attached to the chromatography column lack poly-(A) tails.

16 α-fetoprotein (AFP) in blood serum is commonly used as a biomarker for the detection of liver cancer. The *AFP* gene is expressed only in the stages of human foetus, liver regeneration in healthy adults and liver cancer.

The graph (not drawn to scale) shows the blood serum levels of AFP at various stages of life.



Which statements are correct?

1 The *AFP* gene is found in euchromatin and not heterochromatin in the nucleus of a foetal cell.

2 Upon birth, deacetylation of lysine residues of histones could have occurred during chromatin remodelling.

3 It may be difficult to distinguish early-stage liver cancer from liver tissue regeneration.

A 1, 2 and 3

B 1 and 2

C 1 and 3

D 2 and 3

17 The enzyme telomerase prevents loss of telomeres after many mitotic cell cycles. Which cells need to transcribe telomerase enzyme?

1 cancer cells

2 stem cells

3 activated memory B-lymphocytes

A 1, 2 and 3

B 1 and 2

C 1 and 3

D 2 and 3

18 Six tubes containing preparations of animal tissues were set up as shown in the following table.

tube	contents
1	glucose + homogenised cells
2	glucose + mitochondria
3	glucose + cytoplasm lacking organelles
4	pyruvate + homogenised cells
5	pyruvate + mitochondria
6	pyruvate + cytoplasm lacking organelles

In which tubes would carbon dioxide be produced after incubation?

A 1, 2 and 3

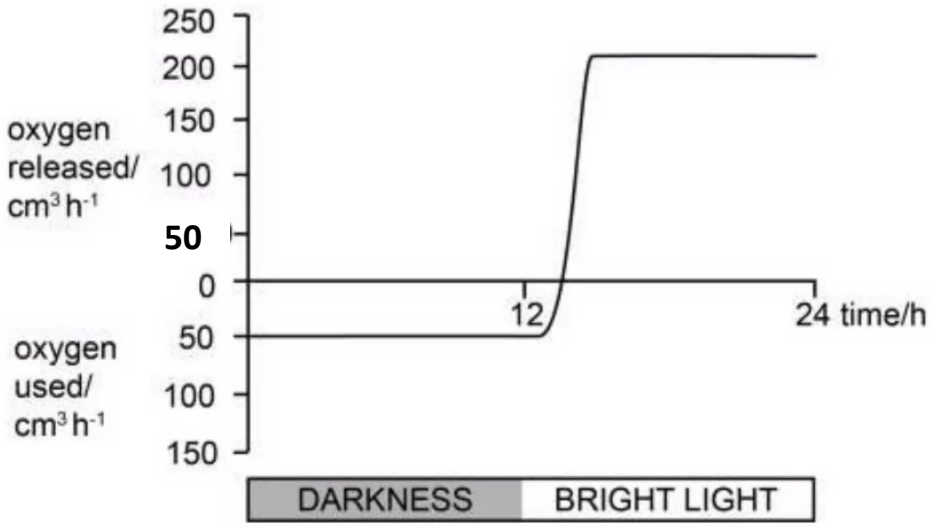
B 1, 4 and 5

C 2, 3 and 6

D 4, 5 and 6

19 Oxygen use and release by a plant was monitored for 12 hours of darkness and 12 hours of bright light. Temperature and all other variables were kept constant. The results are shown in the graph.

Calculate the volume of oxygen used by the plant in respiration over the duration of the experiment.



A 50 cm^3

B 600 cm^3

C 650 cm^3

D 1200 cm^3

20 Which of the following statements below apply to Polymerase Chain Reaction (PCR)?

1 Separates DNA by size and by charge.

2 Amplifies the number of copies of a target gene with the help of primers.

3 Detects a gene fragment.

4 Performed in cycles of three temperatures.

5 RNA primers recognising the regions flanking the target sequence are needed.

6 Primers are recycled after each round of PCR.

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

21 Which of the following statements describe the purpose of transferring DNA fragments from a gel to a nitrocellulose paper during Southern blotting?

1 To permanently attach the DNA fragments to a substrate with the subsequent help of using heat.

2 To separate the two complementary DNA strands.

3 To transfer only the DNA that is of interest.

4 To separate out the PCR products.

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

22 Which of the following statements are true about all stem cells?

1 Stem cells can be induced to differentiate by environmental signals.

2 Stem cells contain a different set of genome compared to differentiated cells.

3 Pluripotent stem cells are able to develop into whole organisms if implanted into the placenta of the womb.

4 Stem cells make more stem cells under appropriate conditions, during symmetric division.

A 1 and 4 only

B 2 and 3 only

C 1, 3 and 4 only

D 1, 2, 3 and 4

23 The flowers of the sweet pea plant are either purple or white. Flowers are purple if they contain anthocyanin pigment, and white if they do not.

Two independently assorting genes, **C** and **P**, are involved in anthocyanin synthesis. Each gene has a recessive allele that abolishes pigment production.

White flower Variety 1 has the genotype **CCpp** whilst white flower Variety 2 has the genotype **ccPP**. The two varieties are crossed to obtain F1 offspring. These F1 plants were then intercrossed to give a F2 generation.

The number of sweet pea plants with purple flowers and white flowers in the F2 generation was found to be 95 and 70 respectively. The chi-squared test was performed on these data and the chi-squared value is found to be 0.118.

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} \qquad v = c - 1$$

where

Σ = 'sum of…'
O = observed 'value'
v = degrees of freedom
E = expected 'value'
c = number of classes

A chi-squared table.

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

Which of the following statements is correct?

A It can be concluded that there is significant difference between expected and observed numbers. Any difference observed is not due to chance.

B The 2 gene loci C/c and P/p interact with one another.

C The Degree of Freedom for this test is 6.

D The probability of expected and observed numbers differing by chance is exactly at 0.10.

24 In guinea pigs, the allele R for rough coat is dominant over the allele r for smooth coat and the allele B for black fur is dominant over the allele b for white fur. The genes for fur coat and texture are not linked.

Two guinea pigs with genotype RrBb were mated together and one of the offspring had a rough, black coat.

What is the probability that a rough coat and black fur offspring is homozygous for both genes?

A 1 in 3

B 1 in 8

C 1 in 9

D 1 in 16

25 Which of the following is **not** necessary for evolution to occur by natural selection?

A inheritance of genes

B habitat variation

C genes affecting reproductive fitness

D genetic variation

26 Two types of palm trees, *Howea forsteriana* and *Howea belmoreana,* are endemic to Lord Howe Island, Australia. *Howea belmoreana* is restricted to the volcanic soils while *Howea forsteriana* is found on both alkaline calcareous and volcanic soils. The optimum pH of the soil that the two palm trees grow in are pH 8.0 and pH 6.0 respectively. No physical barriers exists between the two types of palm trees.

Scientists have studied how these two species of palm trees have evolved from a single ancestral palm species which colonised the island about 5 million years ago. This ancestral species grew on neutral and acidic soils on the island. At some point in the evolutionary history, some seeds germinated on the more calcareous soils. The high pH of these soils affected flowering time, making it occur earlier. As a result, these trees were unable to pollinate or be pollinated by the trees that grew on volcanic soils.

Which of the following statements can be concluded?

1 The ancestral species arrived at the island about 5 million years ago, demonstrating founder's effect.

2 There is temporal isolation between the subpopulations.

3 *Howea forsteriana* and *Howea belmoreana* diverged from their common ancestral species in a sympatric speciation event.

A 1, 2 and 3

B 1 and 3 only

C 1 only

D 2 only

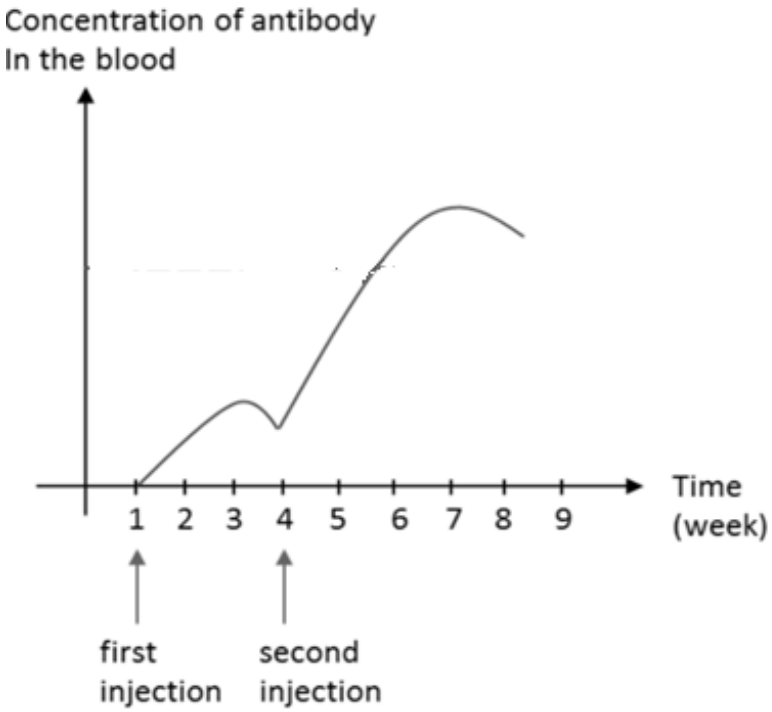
27 The table shows equivalent amino acid sequences of part of a protein from four species of animals.

animal	amino acid sequence							
1	trp	met	val	glu	cys	asp	arg	leu
2	trp	val	met	glu	cys	asp	asp	ala
3	trp	val	val	glu	cys	asp	arg	leu
4	phe	trp	val	gly	cys	arg	asp	leu

Using the technique of molecular homology, which pair of animals share the most recent common ancestor and which pair are least closely related?

	most closely related pair	least closely related pair
A	1 and 2	1 and 4
B	1 and 3	1 and 4
C	1 and 3	2 and 4
D	2 and 3	3 and 4

28 The graph below shows the concentration of antibody against a viral pathogen after two consecutive doses of vaccination consisting of a viral glycoprotein.



Which of the following statements is valid?

A During the first injection, only the innate immune system is involved.

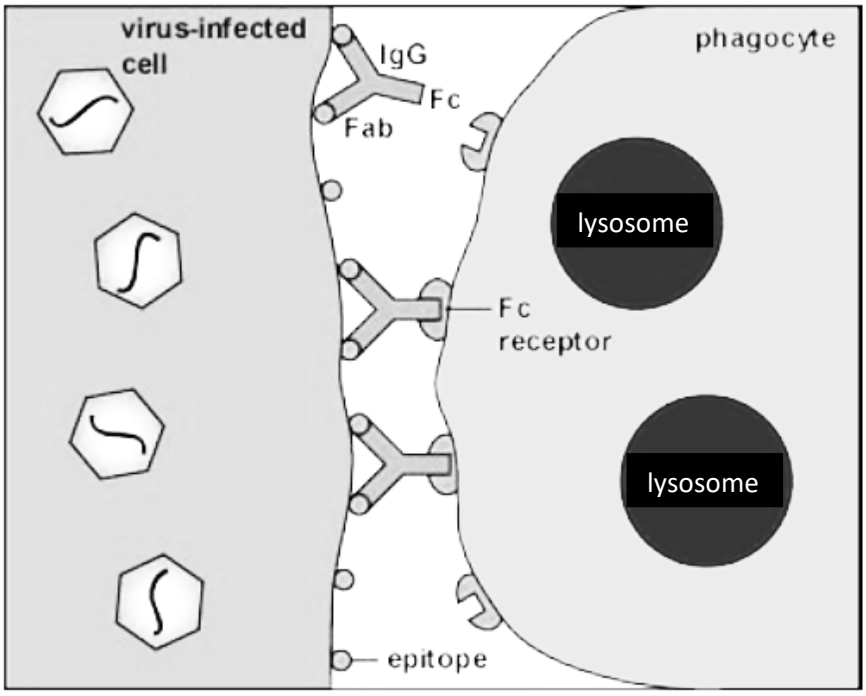
B The increase in concentration of antibodies is caused by a release of antibodies by CD4 T cells.

C The secondary immune response is initiated at week 4 and results in clonal selection and expansion of memory B cells, mounting a larger immune response.

D The vaccination is an example of artificial, passive immunity.

29 The diagram below shows the action of a white blood cell during a viral infection.

Which of the following statements are possible consequences?



A Phagocytosis occurs due to opsonization.

B Phagocyte releases granzymes and perforin to lyse the virus-infected cell.

C Phagocyte surrounds the virus-infected cell in a neutralization process.

D Phagocyte secretes cytokines and activates CD8 T lymphocytes.

30 Which of the following statements on climate change is/are false?

1 Human activities is a cause of increasing greenhouse gases emission.

2 Warmer temperatures led to migration of animals nearer the equator.

3 Warmer temperatures kill off all mosquitoes.

4 Coral reefs may undergo bleaching due to mutations of pigment producing genes due to heat stress.

A 1 only

B 1 and 2 only

C 2 and 3 only

D 2, 3 and 4 only

End of Paper