HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		CT GROUP	23S7___

CENTRE NUMBER					INDEX NUMBER				

BIOLOGY

9744/01

Paper 1 Multiple Choice

17 September 2024

Additional Materials: Multiple Choice Answer Sheet

1 hour

INSTRUCTIONS TO CANDIDATES

1. Write your **name**, **CT group, Centre number** and **index number** in the spaces provided at the top of this cover page.
2. Fill in your particulars on the Multiple Choice Answer Sheet. Write your **NRIC number** and shade accordingly.
3. 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.
4. At the end of the paper, you are to submit **only** the Answer Sheet.

INFORMATION FOR CANDIDATES

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 used of an approved scientific calculator is expected, where appropriate.

This document consists of **22** printed pages.

1 The following experiments were conducted by early scientists.

Swan Neck Flask Experiment

- Louis Pasteur boiled nutrient broth in a flask with a swan neck that allowed air in but prevented dust and microbes from reaching the broth.
- The broth remained free of microbial growth until the neck was broken.

Observation of Cork Cells

- Robert Hooke used a microscope to examine thin slices of cork and observed tiny, box-like structures he called “cells”.

Matthias Schleiden and Theodor Schwann's Observations

- Schleiden and Schwann proposed that all living organisms are composed of cells, building on Hooke's earlier work.

Which of the following statements are consistent with the given information about these experiments?

1 Louis Pasteur demonstrated that cells come from pre-existing cells by showing that microorganisms do not spontaneously generate but come from other microorganisms in the air.

2 Robert Hooke proved that cells are the smallest unit of life, as he observed tiny, box-like structures in cork, which are the fundamental units of its structure.

3 Matthias Schleiden and Theodor Schwann's observations led to the understanding that living organisms are composed of cells, supporting the principle that cells are the basic structural and functional units of life.

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

2 A researcher is studying the properties of a toxin produced by a plant. When cellular contents are exposed to the toxin, the cell will die.

The table shows the relative percentages of various organelles in cells that are not actively producing the toxin and cells that are actively producing the toxin.

cell structure	description	relative % of cell	
		non-toxin producing cell	toxin producing cell
V	double membrane bound organelle with cristae	12	15
W	sheet-like, single membrane bound organelle with continuous lumen	15	20
X	single membrane bound organelle arranged in tubules	14	3
Y	large, dense, and contains rRNA	3	10
Z	single membrane bound organelle that does not contain phospholipids in the lumen.	35	46

Which conclusion is consistent with the data provided?

A Toxin production in structure V is energy-intensive, suggesting that the toxin is lipid-soluble.

B Protein synthesis is upregulated in structure W, implying that the toxin is protein-based and lipid-soluble.

C Increased ribosome production in structure Y suggests the toxin is RNA-based and water-soluble.

D Structure Z stores the water-soluble toxin.

3 In an experiment, fluorescent dyes were attached to proteins on the outer surface of cell surface membranes. Fluorescent dyes of one colour were attached to proteins of a living human cell and fluorescent dyes of a different colour were attached to proteins of a living mouse cell.

The human cell and the mouse cell were then fused to form a hybrid cell.

At first, the proteins attached to different fluorescent dyes remained separate, but after 40 minutes the proteins were distributed randomly across the hybrid cell surface membrane.

What does this experiment show?

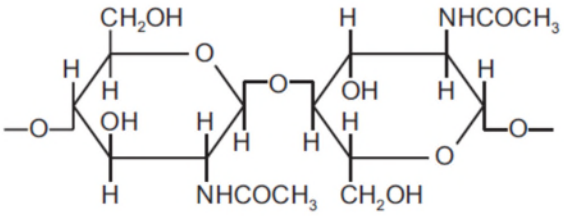
A Proteins are found only on the outer surface of cell surface membranes.

B Proteins in the outer layer of a bilayer do not penetrate into the inner layer.

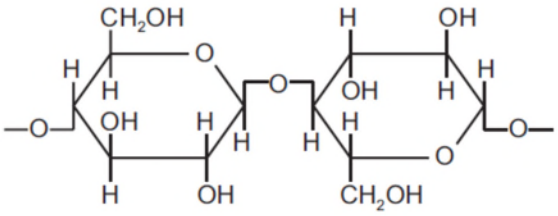
C Proteins move freely in the phospholipids of a bilayer.

D The cell surface membranes of the two cells are bilayers.

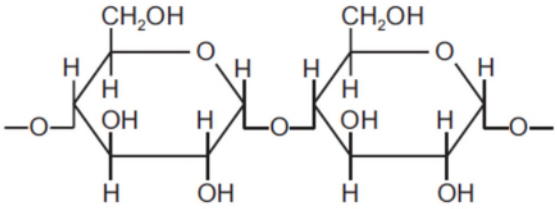
4 The diagrams show short sections of some common polysaccharides and modified polysaccharides.



1



2



3

The polysaccharides can be described as:

- F is composed of β-glucose monomers with 1,4 glycosidic bonds
- G is composed of α-glucose monomers with 1,4 glycosidic bonds
- H is composed of N-acetylglucosamine monomers with β-1,4 glycosidic bonds.

Which row correctly matches the numbered diagrams to the descriptions of the polysaccharides?

	polysaccharide F	polysaccharide G	polysaccharide H
A	2	1	3
B	2	3	1
C	3	1	2
D	3	2	1

5 Measurements of the speed of movement of oxygen (O_2) molecules through three types of membranes were made and compared with the speed of movement of O_2 molecules through water. The measurements were carried out at four different temperatures.

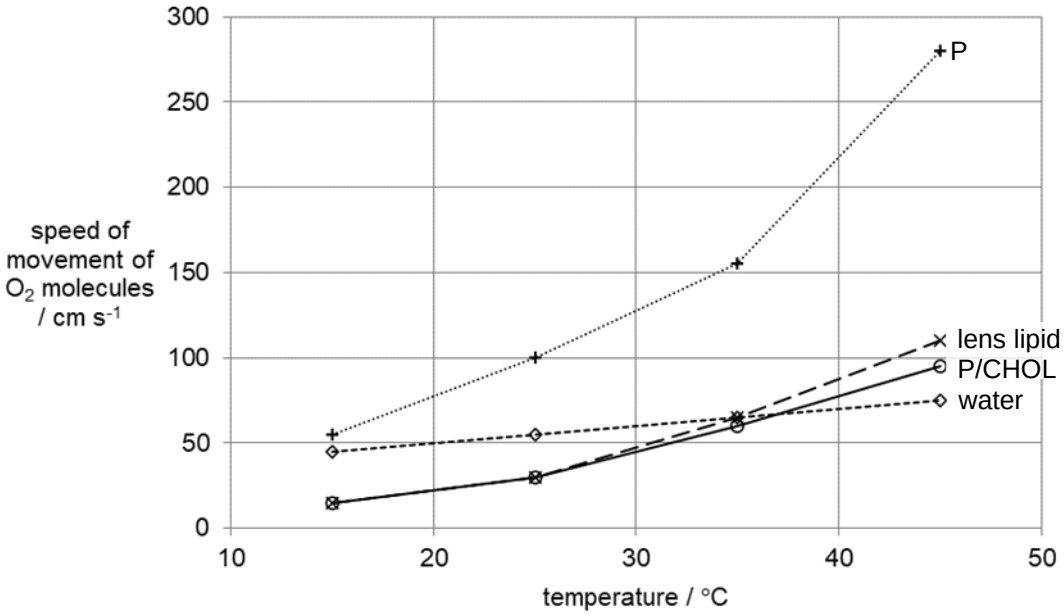
The three types of membranes were:

1 lens lipid, which is the membrane of cells in the eyeball of a calf

2 synthetic membrane composed of palmitic acid with cholesterol (P/CHOL)

3 synthetic membrane composed of palmitic acid without cholesterol (P)

The results of the experiment are shown in the graph.



Which statement can be deduced based on the results of the experiment?

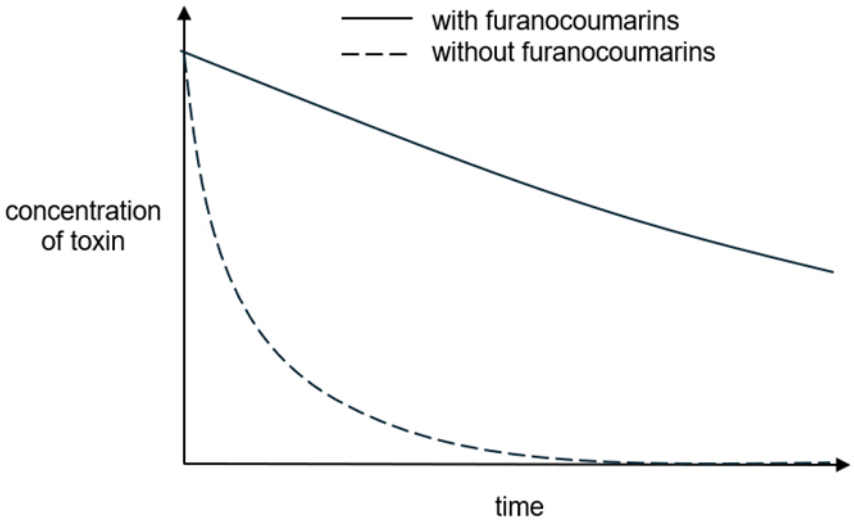
A Water does not impose a barrier to the movement of O_2 molecules that are polar and hydrophilic.

B Lens lipid is composed of palmitic acid without cholesterol (P), which ensures high oxygen permeability.

C Lens lipid contains high level of cholesterol, which is responsible for low oxygen permeability at low temperatures.

D Lens lipid contains high level of cholesterol, which is responsible for high oxygen permeability at high temperatures.

6 CYP3A4 is an important enzyme in the human digestive system where it is needed to break down a range of different toxins and drugs. Furanocoumarins found in some fruits have been shown to interfere with the activity of CYP3A4. The graph represents the effect of furanocoumarins on the breakdown of toxins in the digestive system by CYP3A4 over time.



Which of the following statements can be concluded from the information provided?

1 Furanocoumarins reduces the activity of CYP3A4.

2 Furanocoumarins binds reversibly to CYP3A4.

3 Furanocourmarins can result in the accumulation of toxin in the human digestive system.

4 Furanocoumarins decreases the affinity of toxin for CYP3A4's active site.

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

7 Which statement correctly describe a feature of stem cells that is essential for their role in cell replacement and tissue repair?

A A small population of stem cells is retained in the body of adults throughout their lifetime.

B After mitosis of stem cells, all daughter cells follow a developmental pathway that leads to the formation of specialised cells.

C Stem cells are different to all other body cells because they retain all of the genetic information in their DNA throughout the life of the organism.

D Stem cells have more telomeres than other body cells and this allows them to undergo an unlimited number of mitotic divisions.

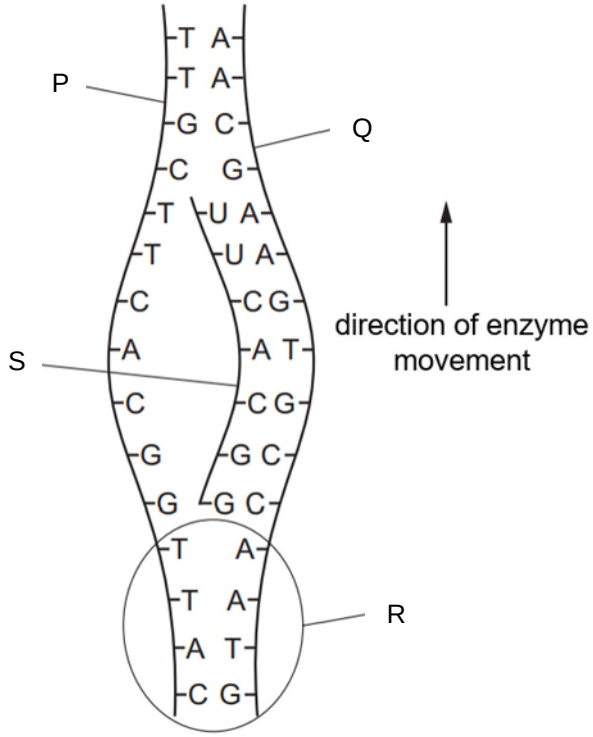
8 Different tissues in a plant were supplied with a radioactively labelled substance to identify which tissues were actively synthesising large amounts of mRNA.

How many of the following radioactively labelled substances would be suitable for this experiment?

- adenine
- uracil
- inorganic phosphate
- ribose
- cAMP

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

9 A student drew a poorly labelled diagram of a cellular process involving DNA.



Which of the following statements are correct?

1 Strand P contains the promoter which signals the initiation of the process.

2 The directionality of Strand Q can be labelled 5’ at the top and 3’ at the bottom.

3 Phosphodiester bonds are reforming at section R as the DNA double helix rewinds.

4 Strand S is the leading strand as it is synthesised continuously toward the replication fork.

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

10 A student compared HIV and lambda phage and made some statements based on his study.

Which statements are correct?

1 The capsid of both HIV and lambda phage enters the host cell.

2 HIV enters by fusion of viral envelope with host cell membrane, whereas lambda phage infects bacterial cells by injecting its DNA.

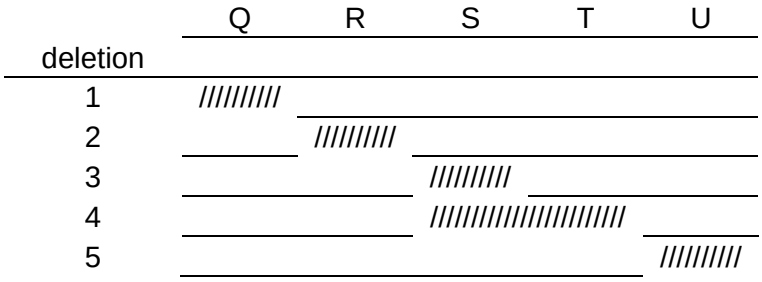
3 New HIV particles are released from the host cell via budding, while new lambda viruses are released via cell lysis.

4 The genome of lambda virus must undergo processing before integrating into the host chromosome, whereas the genome of HIV can directly integrate.

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

11 A hypothetical operon has a sequence of sites, Q R S T U, in the control region. The exact location of the operator and promoter consensus sequences have not been identified.

Various deletions of this control region are isolated and mapped. Locations with "/" represent a deleted region. Deletions 3 and 4 result in the operon being constantly switched on, while deletion 1 results in the operon being constantly switched off.

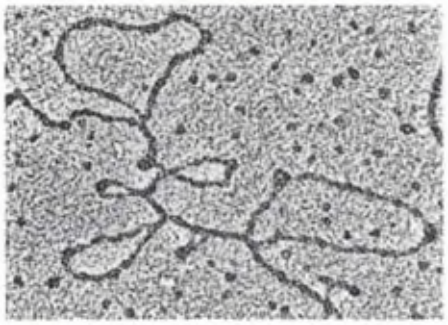


Which row is correct?

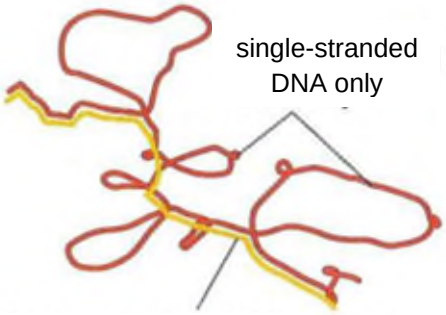
	location of operator	location of promoter
A	R, S	Q
B	S, T	Q
C	T, U	R
D	Q, U	R

12 In an experiment, scientists hybridised an mRNA to its DNA template and prepared the hybrid molecule for electron microscopy. The resulting hybrid was observed to have different sections of DNA-RNA hybrids as well as single stranded DNA loops as in the diagram.

micrograph of DNA-RNA hybrid



interpretation of micrograph



single-stranded DNA
base-paired with mRNA

Several statements attempting to explain the observations are presented:

1 Genes contains unique sequences within them that are not transcribed into mRNA.
2 DNA genes are not continuous and are interrupted by non-coding sequences.
3 Insertional mutations always disrupt genes and result in additional sequences.
4 mRNA undergoes processing to remove some of its sequences.

How many statements correctly explain the findings?

A 0 **B** 1 **C** 2 **D** 3

13 Circadian rhythm is the body's internal clock that regulates sleep and wake cycles over a 24-hour period.

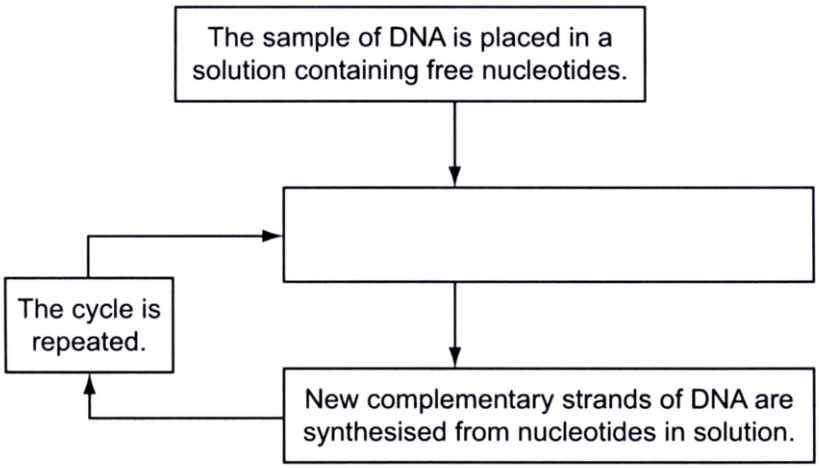
It is controlled by numerous proteins which regulate the cyclic nature of the rhythm. The roles of two such proteins are described here:

- Circadian Locomotor Output Cycles Kaput (CLOCK): This protein forms a complex with another protein called Brain and Muscle ARNT-Like 1 (BMAL1) to initiate the transcription of target genes involved in the circadian rhythm.
- Cryptochrome 1 (CRY1): Cryptochrome proteins play a role in the negative feedback regulation of the circadian rhythm. They interact with the CLOCK-BMAL1 complex to inhibit its action.

Which row correctly describes the level at which the proteins regulate expression of genes responsible for circadian rhythm?

	CLOCK	CRY1
A	transcriptional	translational
B	transcriptional	post-translational
C	translational	transcriptional
D	post-transcriptional	post-translational

14 The polymerase chain reaction is summarised in the flowchart below.



Which statement completes the flow chart?

A Complementary strands of DNA are separated and RNA primers bind to the 3' ends of DNA flanking the gene of interest.

B Complementary strands of DNA are separated and RNA primers bind to the 5' ends of DNA flanking the gene of interest.

C Complementary strands of DNA are separated and DNA primers bind to the 3' ends of DNA flanking the gene of interest.

D Complementary strands of DNA are separated and DNA primers bind to the 5' ends of DNA flanking the gene of interest.

15 The *myc* gene is often mutated in individuals with cancer. The mutant allele differs from the normal allele by only one base.

The codon sequences of both the normal and mutant allele are shown below.

Normal codon: 5' -CCAAGUCCA**GCU**GGCAGC- 3'
Mutant codon: 5' -CCAAGUCCA**GUU**GGCAGC- 3'

Which statement correctly explains how a mutation could lead to cancer?

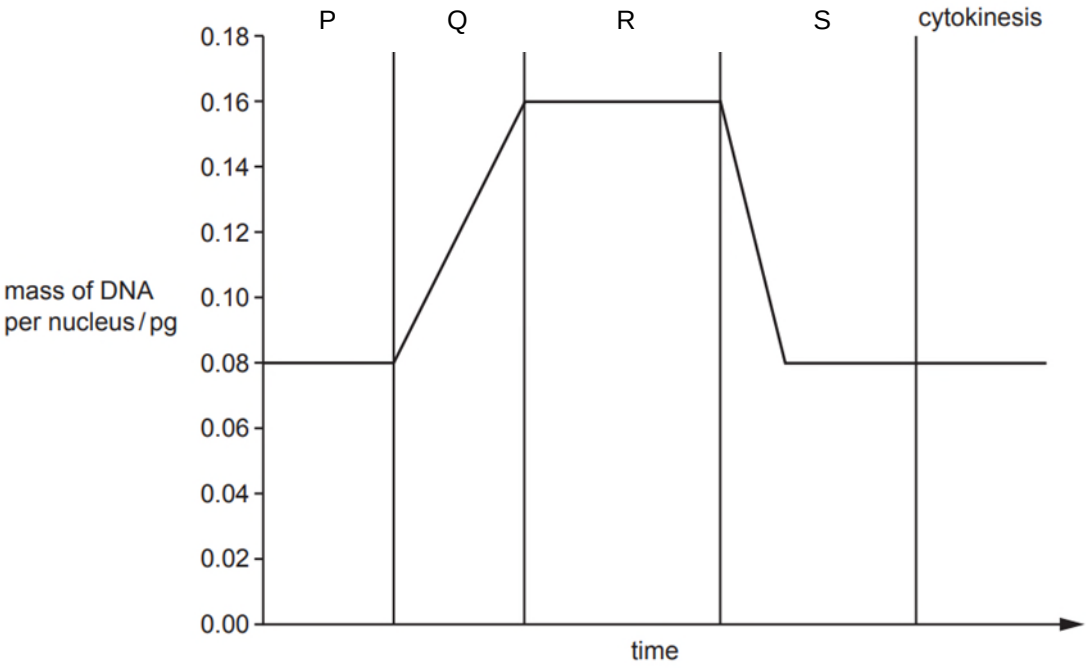
A A point mutation of 3'-CGA-5' to 3'-CAA-5' resulting in a missense mutation.

B A point mutation of 5'-GUU-3' to 5'-GCU-3' resulting in a frameshift mutation.

C A point mutation of 5'-CGA-3' to 5'-CAA-3' resulting in a frameshift mutation.

D A point mutation of 3'-GUU-5' to 3'-GCU-5' resulting in a missense mutation.

16 Stem cells of *Caenorhabditis elegans* have been studied. The diagram shows the change in mass of DNA per nucleus in a stem cell during one cell cycle.

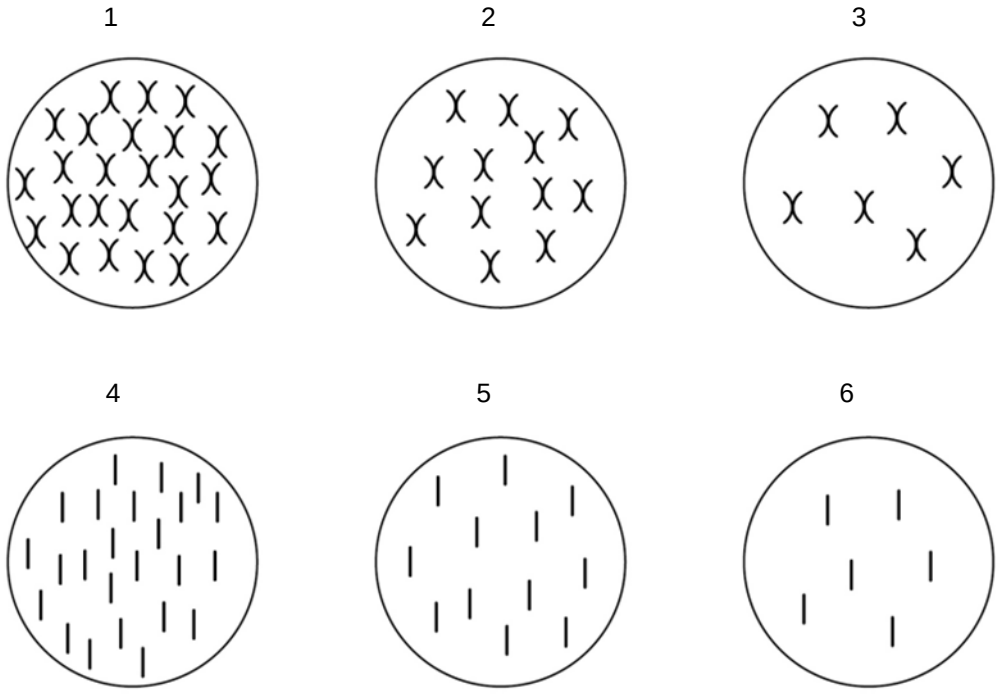


A stem cell of a *C. elegans* has 12 chromosomes.

Which rows shows the correct number of nuclei and the number of chromosomes in each nucleus during stages P, Q and S of the cell cycle?

	stage of cell cycle		
	P	Q	S
A	12 chromosomes in each nucleus	12 chromosomes in each nucleus	2 nuclei within the stem cell
B	1 nucleus within the stem cell	12 chromosomes in each nucleus	24 chromosomes in each nucleus
C	12 chromosomes in each nucleus	24 chromosomes in each nucleus	2 nuclei within the stem cell
D	1 nucleus within the stem cell	24 chromosomes in each nucleus	12 chromosomes in each nucleus

17 The diagrams show six possible arrangements of chromosomes in cells.



Before meiosis, a cell of a rice plant has 12 pairs of homologous chromosomes (24 chromosomes in total).

Which letter from the figure shows the chromosome content of rice cells after the first and second meiotic division?

	chromosome content of rice cells	
	after first meiotic division	after second meiotic division
A	3	5
B	2	5
C	2	6
D	1	4

18 Domestic rabbits vary in the length and colour of their fur.

The two genes that determine the length and colour of the fur of this rabbit occur at the A / a locus and the B / b^h / b locus. These two gene loci are on separate chromosomes.

- The allele A results in short fur.
- The allele a results in long fur.
- A is dominant to a.

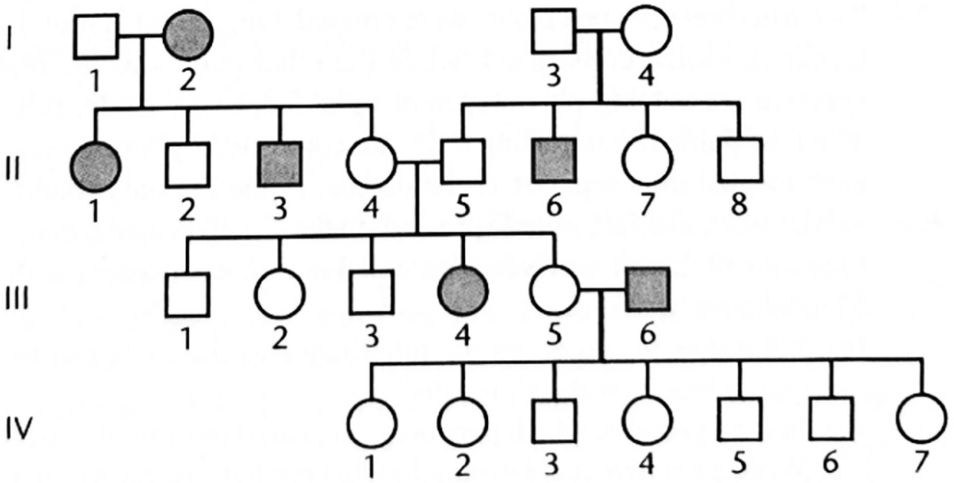
- The allele B results in black fur all over the body.
- The allele b^h results in black fur on the nose, ears, paws and tail of the rabbit, and white fur on the rest of the body (Himalayan pattern).
- The allele b results in white fur all over the body (albino).
- B is dominant to b^h and b^h is dominant to b.

A first cross between 2 rabbits of different genotypes with short, black fur all over the body produced offspring of four different phenotypes. A second cross between a rabbit with short, black fur all over the body and a Himalayan rabbit with short fur produced offspring of six different phenotypes.

Which of the following correctly shows the possible genotypes involved for each cross?

	first cross	second cross
A	AaBB x AABb	AaBb x Aab^hb^h
B	AaBb x $AaBb^h$	$AaBb^h$ x Aab^hb
C	AaBb x AaBb	$AaBb^h$ x Aab^hb
D	AaBb x $AaBb^h$	AaBb x Aab^hb

19 The following pedigree shows the inheritance of myopia (near-sightedness) in humans.



Which of the following statements are **correct**?

1 Myopia is an autosomal dominant trait as it does not skip the first 3 generations.

2 The probability for Individual II-8 having the same genotype as his father I-3 is 50%.

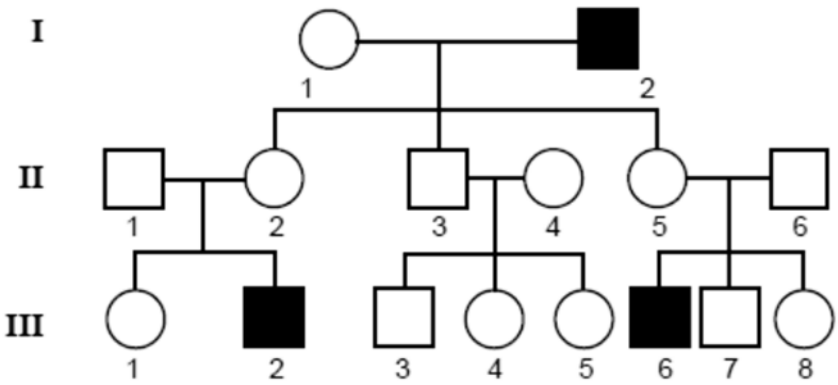
3 Individual III-5 must be homozygous dominant as all her 7 children in generation IV does not have myopia.

4 All the 7 individuals in generation IV are carriers as they would have received the affected allele for myopia from their father III-6.

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

20 The following pedigree shows the inheritance of Lesch-Nyhan Syndrome in humans.

Individuals marrying into the family, II-1, II-4 and II-6, have no history of the disease in their families.



Individual III-8 marries a normal male.

What is the probability that their first child will be a boy with Lesch-Nyhan Syndrome?

A 0 **B** 0.125 **C** 0.25 **D** 0.5

21 In rats, the following genotypes of two independently assorting autosomal genes determine coat colour.

genotype	coat colour
A_B_	grey
A_bb	yellow
aaB_	black
aabb	cream

A third gene pair on a separate autosome determines whether or not any colour will be produced. The CC and Cc genotypes allow colour according to the expression of the A/a and B/b alleles. However, the cc genotype results in albino rats regardless of the A/a and B/b alleles present.

The following two crosses are carried out.

cross 1: AaBbCC x AaBbCC

cross 2: AaBBCc x AaBBCc

Which of the following correctly shows the offspring phenotypic ratios of both crosses?

	cross 1	cross 2
A	all grey	3 grey : 1 black : 4 albino
B	9 grey : 3 black : 4 albino	3 grey : 1 yellow : 4 albino
C	9 grey : 3 yellow : 3 black : 1 cream	9 grey : 3 black : 4 albino
D	9 grey : 3 yellow : 3 black : 1 cream	9 grey : 3 yellow : 4 albino

22 To investigate the effect of wavelength of light on photosynthesis, blue DCPIP solution was added to a suspension of isolated chloroplasts. DCPIP turns from blue to colourless when it accepts hydrogen ions and electrons. The DCPIP/chloroplast mixture was kept in the dark until needed, when a sample was drawn into a capillary tube and illuminated by coloured light of a known wavelength.

Which statements about the expected results of the experiment are correct?

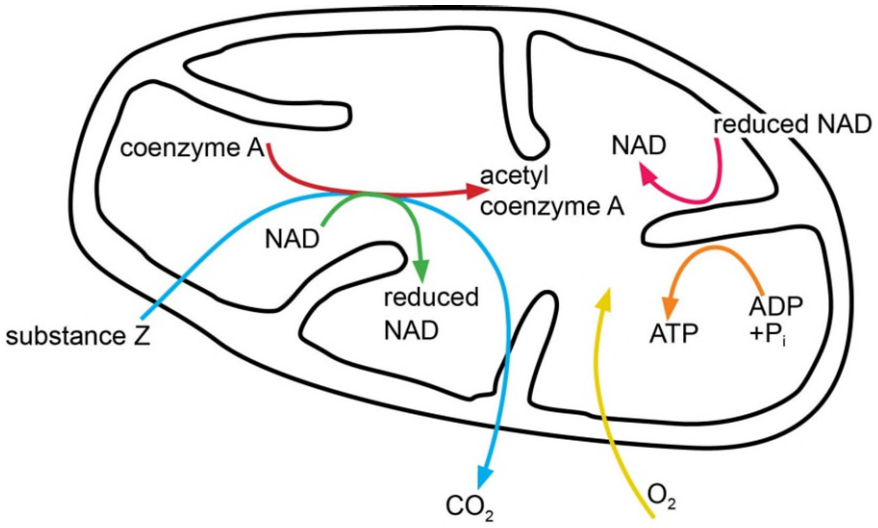
1 DCPIP decolourised at different rates in different wavelengths of light.

2 DCPIP decolourised faster in red than in green wavelengths of light.

3 The end point of the reaction was a colourless solution.

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

23 The diagram shows some of the reactions occurring in a mitochondrion.



Which description of the reactions are correct?

1 Acetyl group from acetyl coenzyme A will combine with a 4-carbon compound.

2 Reduction of NAD occurs at the cristae.

3 Substance Z had been formed by oxidation of a hexose.

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

24 Cyclic AMP (cAMP) is a second messenger that is used for signal transduction in different human cell types such as neurones and liver cells. Hence, the response to cAMP is different across cell types.

Which statement explains the different responses to cAMP in different human cell types?

A Different human cells express the same cell surface receptor, which binds to cAMP, but have a different response in each cell type.

B Different human cells express variants of a particular cell surface receptor through alternative splicing and binds to cAMP, resulting in different responses in each cell.

C Different human cells contain different genes, which express different cell surface receptors that bind to cAMP, activating different relay proteins and hence different responses in each cell.

D Human cells express different cell surface receptors that bind to the same ligand or the same receptor that binds to the same ligand, with different relay proteins, activating different responses in each cell.

25 Construction of a new road system splits a population of a rare snail species into three sub-populations, X, Y and Z. Each of these populations is reproductively isolated.

The table shows the sizes of the three populations immediately after the building of the road and again ten years later. DNA analysis was used to find:

p the relative frequency of the dominant allele of a gene

q the relative frequency of the recessive allele of this gene.

The three areas of habitat remained the same as each other over the ten years.

	immediately after road building			after 10 years		
	population size	*p*	*q*	population size	*p*	*q*
X	1000	0.50	0.50	1000	0.52	0.48
Y	100	0.49	0.51	100	0.63	0.37
Z	10	0.40	0.60	10	0.20	0.80

Which statements are supported by this data?

1 Natural selection is occurring in populations X, Y and Z.

2 The founder effect is strongest in population Z.

3 The observed allele frequency changes result from genetic drift.

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

26 There are 14 species of Darwin's finches inhabiting the Galápagos Islands. These finch species share a common ancestor, the dull-coloured grassquit, which is found on mainland South America. The finch species are similar in body size, shape and colour, with noticeable differences observed in their beak shape and size.

The *Howea* palms are native to Lord Howe Island, a small volcanic island approximately 600 km north-east of Sydney. Around five million years ago, the ancestral palms grew in both neutral and acidic soil. At one point, seeds from these ancestral palms spread to more alkaline soil. The resulting palms had different reproductive cycles, which led to the formation of new species.

In these examples, allopatric speciation gave rise to new species of Darwin's finches and sympatric speciation gave rise to new species of *Howea* palms. These speciation events are different, but also have some similarities.

Which one of the following is a similarity between the two types of speciation?

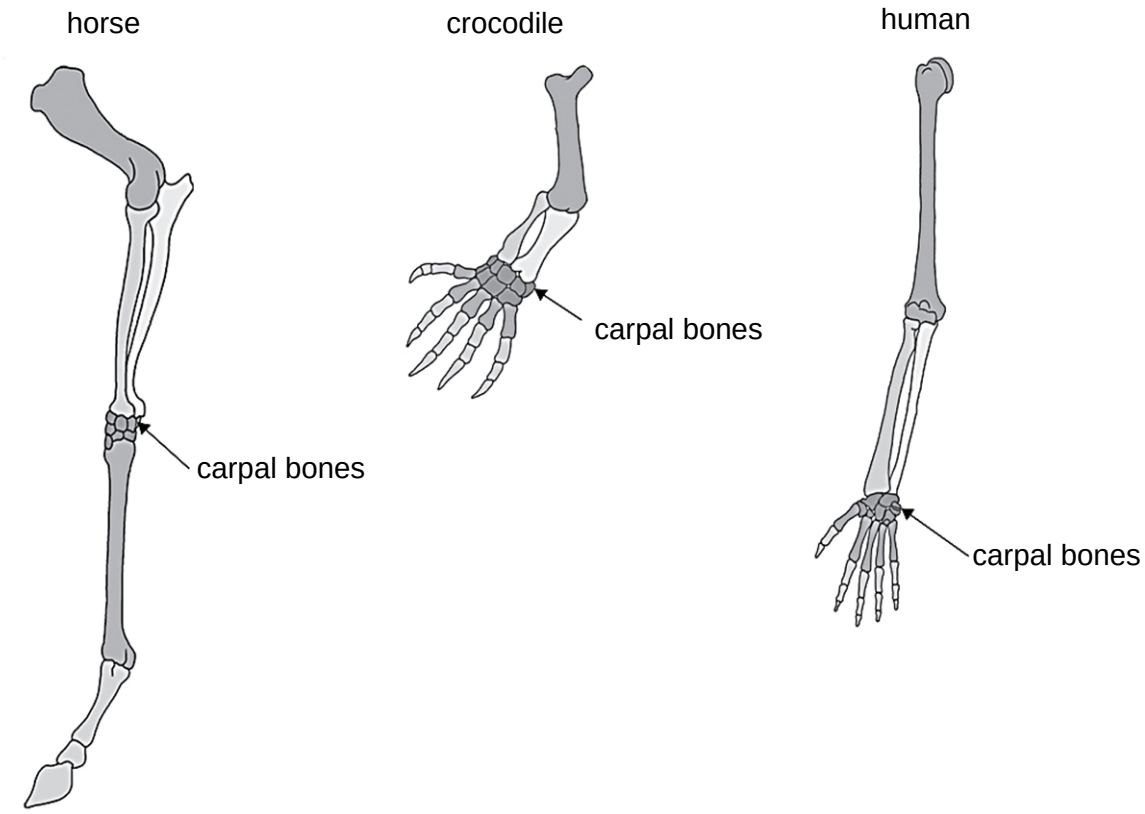
A The emergence of new species relies on the presence of a geographical barrier.

B The new species can produce viable and fertile offspring with the ancestral species.

C Both occur through the reproductive isolation of individuals in a population.

D The new species are identical to the ancestral species.

27 The images show the bones in the forelimbs of three vertebrates. The carpal bones of a human are located in the wrist. Note that the three images are not shown to the same scale.



Which row of statements can be concluded based on the images above?

	bones in the forelimbs of the three vertebrate species	relationship between the three vertebrate species
A	analogous structures	humans are more closely related to crocodiles than to horses
B	analogous structures	the earliest ancestors of horses had only one digit on their forelimbs
C	homologous structures	the crocodile is a transitional form between horses and humans
D	homologous structures	humans, crocodiles and horses share a common ancestor

28 Human papilloma virus (HPV) is transmitted through sexual contact. More than 95% of cervical cancers, which only affect females, are due to HPV infection. HPV infection of other tissues increases the risk of cancer but this is rare compared with cervical infection.

A vaccine is available that is over 80% effective at preventing HPV infection, if given before the person has been exposed to HPV. There is evidence of herd immunity when more than 50% of the population have been vaccinated.

Which statement can be deduced from the information provided?

A Men cannot contract HPV infection.

B The vaccine for HPV would induce natural, active immunity.

C Only females should be vaccinated to ensure more than 50% of the population to be vaccinated to achieve herd immunity.

D HPV vaccination given at age 12 would decrease the likelihood of contracting HPV infection compared to that given at age 40.

29 Which of the following statements are correct about generating antibody diversity?

1 Somatic recombination in B cells is responsible for creating diversity in both V_H and V_L domains.

2 There is no recombination of D segments in heavy chain synthesis.

3 Somatic recombination occurs during B cell development before antigen exposure.

4 Somatic hypermutation allows for affinity maturation after the plasma cell has encountered antigen.

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

30 Several factors can help to predict the risk of an outbreak of viral dengue disease in a human population. Four of these factors are listed.

	factor
W	frequency of rainfall
X	incidence of viral dengue disease in the human population
Y	size of the mosquito population
Z	temperature

Ways in which these factors could affect this risk are also listed.

	what the factor could affect
1	proportion of mosquitoes that are carriers of the dengue virus
2	generation time of vector
3	ability of vector to breed
4	rate of new infections in the human population

Which row links each factor to one way it could affect the risk of an outbreak of dengue disease?

	W	**X**	**Y**	**Z**
A	1	3	2	4
B	2	4	3	1
C	3	1	4	2
D	4	2	1	3

--- END OF PAPER ---