RIVER VALLEY HIGH SCHOOL
JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME										
CENTRE NUMBER	S					CLASS	22J	INDEX NUMBER		

BIOLOGY **9744/01**

Paper 1 Multiple Choice **22 September 2023**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

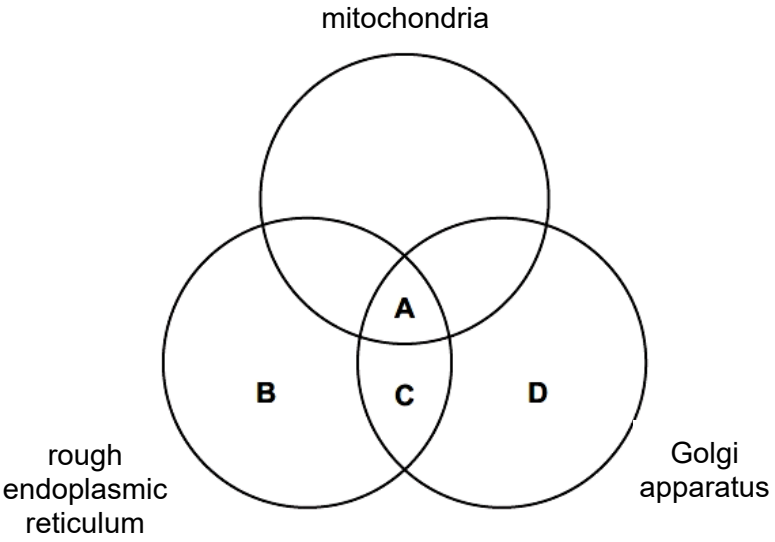
Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and index number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

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.

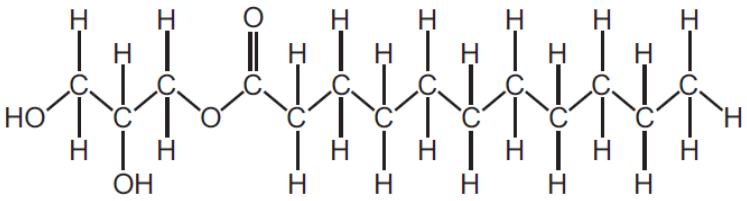
Read the instructions on the Answer Sheet very carefully.

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.

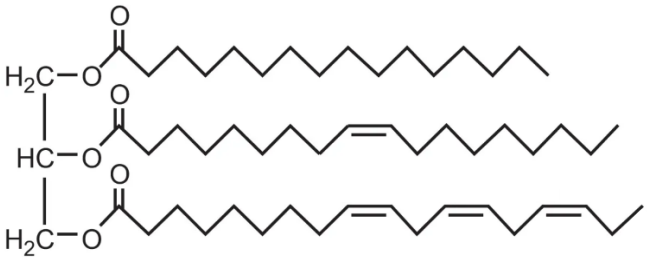
1 Which organelle(s) are required in the formation of glycoprotein 120 in the HIV viral envelope?



2 The diagram below shows a lipid molecule E, and a triglyceride.



molecule E



triglyceride

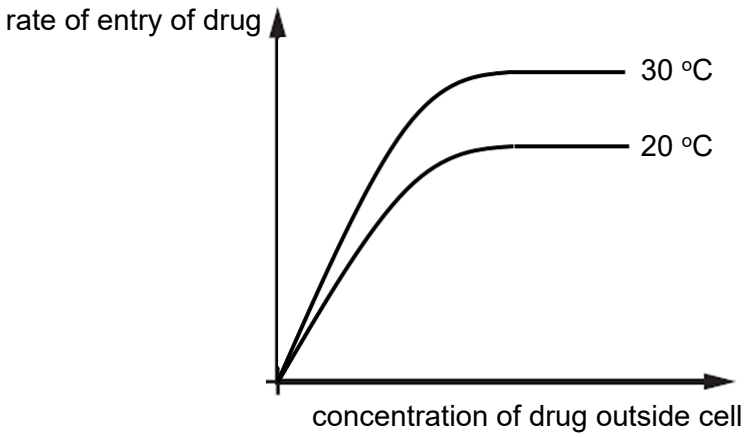
Which row correctly identifies a feature that is present in molecule E and a triglyceride?

	molecule E	triglyceride
A	one unsaturated fatty acid	one saturated fatty acid
B	no ester bonds	three ester bonds
C	one fatty acid	three fatty acids
D	zero double bonds	four double bonds

3 An experiment was conducted to determine the mode of entry of a water-soluble drug into animal cells. The animal cells were placed into separate containers with different concentrations of the drug. The initial rate of entry of the drug into the cells were measured.

The experiment was conducted at two different temperatures, 20 °C and 30 °C.

The results are shown in the graph below.



Which statement(s) are correct?

1 ATP is not required for the entry of the drug.

2 A change in pH will decrease the rate of drug entry.

3 An increase in membrane fluidity will increase the concentration of the drug inside the cell.

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

4 Bread contains a protein known as gluten.

Some features of the structure of gluten are listed below.

1 Short α-helical sections are present in both polypeptides because of their high proline content.

2 Intermolecular bonds form between different polypeptides.

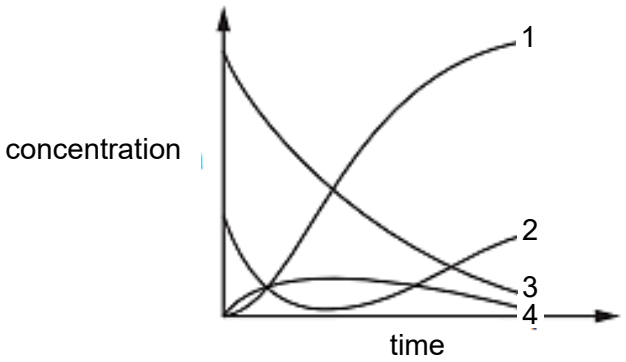
3 Up to 45% of the amino acids in both polypeptides are glutamine.

4 Hydrophobic amino acids such as glutamine and proline are not found on the surface of gluten proteins.

Which row correctly links each of the stated feature to its level of protein structure?

	primary structure	secondary structure	tertiary structure	quaternary structure
A	4	1	3	2
B	1	3	2	4
C	3	1	4	2
D	1	2	4	3

5 The graph shows how the concentration of components 1, 2, 3 and 4, of an enzyme-catalysed reaction changes with time.



Which row correctly identifies the components of this reaction?

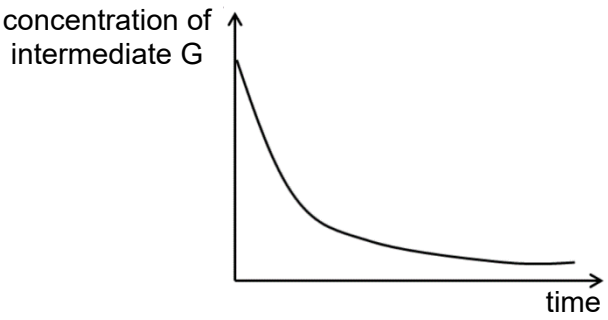
	component 1	component 2	component 3	component 4
A	enzyme–substrate complex	unbound enzyme	product	substrate
B	enzyme–substrate complex	product	substrate	unbound enzyme
C	product	enzyme–substrate complex	unbound enzyme	substrate
D	product	unbound enzyme	substrate	enzyme–substrate complex

6 In the production of isoleucine from threonine, the end product acts as an inhibitor of the first enzyme of the pathway. The pathway is shown below.

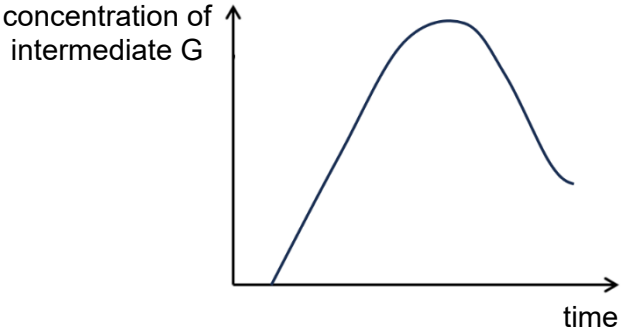
threonine $\xrightarrow[\text{enzyme 1}]{}$ intermediate F $\xrightarrow[\text{enzyme 2}]{}$ intermediate G $\xrightarrow[\text{enzyme 3}]{}$ isoleucine

Which of the following graphs shows the changes in concentration of intermediate G when threonine is supplied in excess?

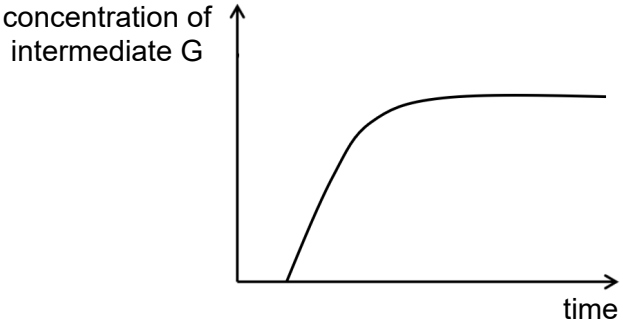
A



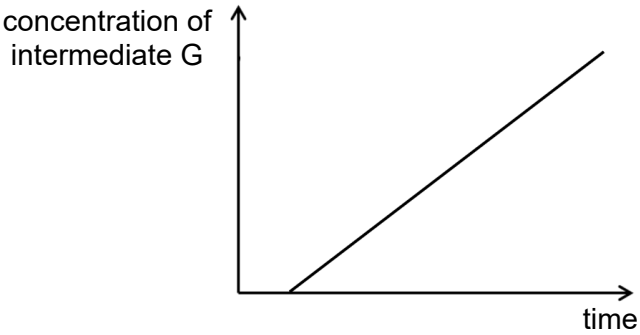
B



C

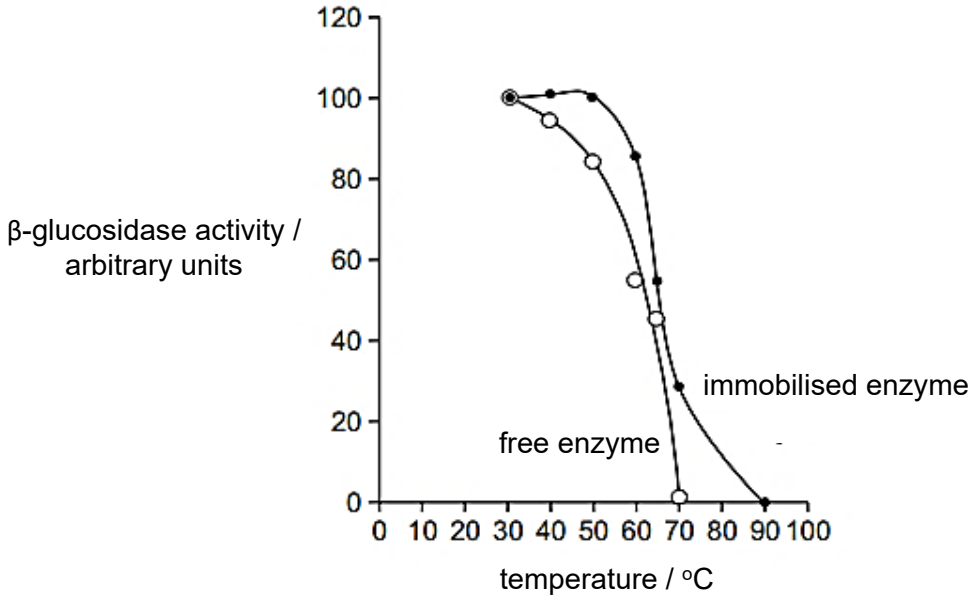


D



7 An experiment was conducted to investigate the effect of temperature on the activity of the enzyme β-glucosidase. The enzyme was tested when in solution (free) and when immobilised in alginate beads. The same amount of enzymes were used.

The results are shown in the graph below.



Which statements concerning the data in the graph are valid?

1 At all temperatures, immobilisation increased the stability of the enzyme structure.

2 Beyond 30 °C, temperature is now the limiting factor instead of enzyme concentration.

3 Activation energy of immobilised enzymes may be higher than that of free enzymes.

A 1, 2 and 3

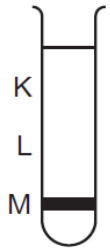
B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

8 A culture of bacteria was grown in a medium containing ^{15}N. After several generations, all of the DNA contained ^{15}N.

The diagram shows the position of the DNA molecules containing ^{15}N in the centrifuge tube.



The culture of bacteria was then allowed to reproduce using nucleotides containing the light isotope of nitrogen (^{14}N).

DNA samples were taken and separated by centrifugation after the bacteria had divided once and again after the bacteria had divided twice.

In which positions would the DNA be found after the bacteria had divided once and after the bacteria had divided twice?

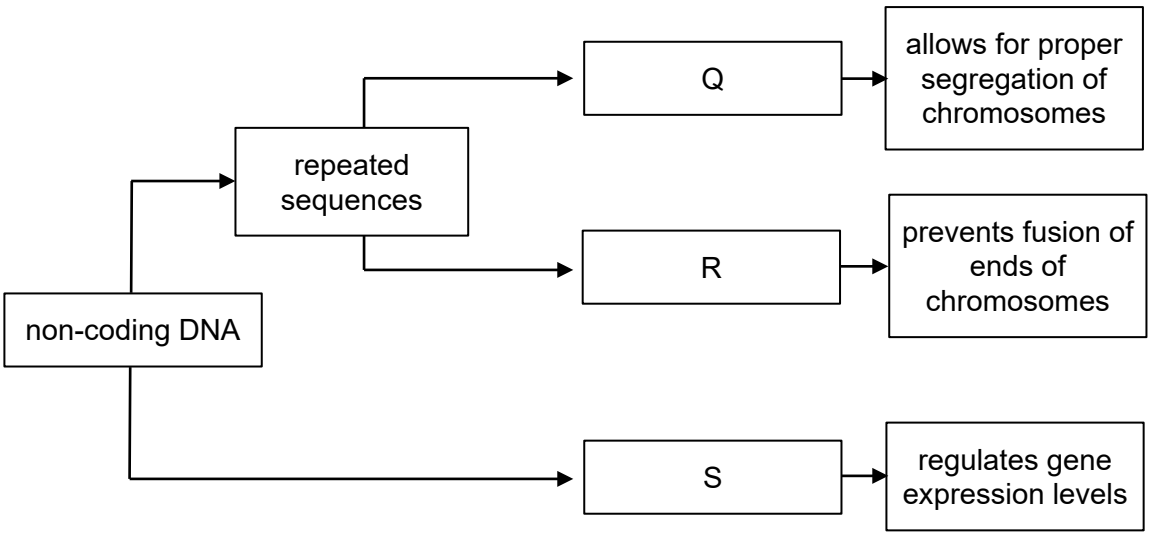
	after dividing once	after dividing twice
A	half at K and half at L quarter at K	quarter at M and half at L
B	half at K and half at M quarter at K	quarter at M and half at L
C	all at L	half at K and half at L
D	all at M	half at L and half at M

9 The structure of nucleic acids facilitates the accurate synthesis of proteins.

Which row describing the nucleic acid structure and its role is correct?

	structure	role
A	A mature mRNA has 997 nucleotides, including a 250-nucleotide poly-A-tail.	When translated, the polypeptide has a maximum number of 249 amino acids.
B	There are 61 different types of tRNA molecules, each with a different anti-codon, present in each cell.	During elongation, the activated tRNA brings the correct amino acid to the A-site of the ribosome.
C	rRNA are single-stranded but can fold to form double-stranded regions via A-T and C-G base-pairing.	rRNA has both structural and enzymatic functions in the ribosome.
D	The hexose sugar in the DNA and RNA nucleotides are deoxyribose and ribose respectively.	Both have free 3'-hydroxyl groups that form phosphoester bonds with incoming nucleotides during condensation.

10 The flowchart shows the classification of several types of non-coding eukaryotic DNA.



Which statements can be concluded?

1 Q is found at varied positions for all chromosomes in a cell.

2 Q and R are mostly associated with proteins, but S is only associated with proteins during gene expression.

3 S may involve DNA bending but R shortens during DNA replication in all cell types.

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

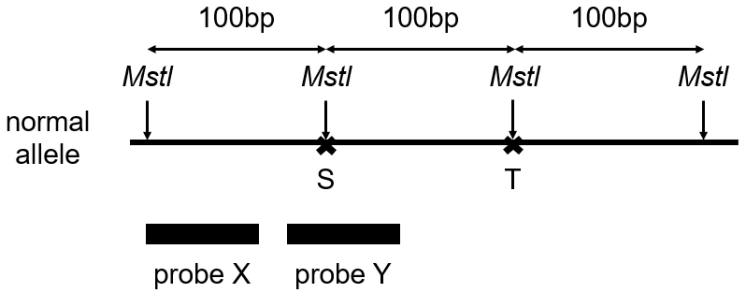
11 Which row correctly describes the effect of chromatin remodeling?

	process	positive charges on histone tails	state of chromatin	density on electronmicrograph
A	histone deacetylation	decrease	heterochromatin	more dense
B	DNA methylation	no change	heterochromatin	less dense
C	histone acetylation	decrease	euchromatin	less dense
D	DNA demethylation	no change	euchromatin	more dense

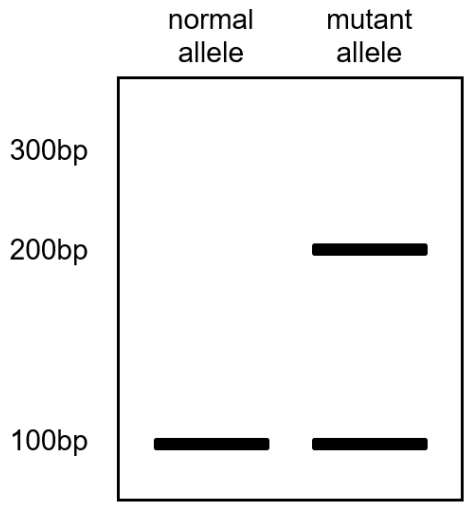
12 Scientists investigated the inheritance of a disease caused by a recessive mutant allele of a gene. The process consisted of the following:

- DNA was extracted and cut with the restriction enzyme *MstI* at *MstI* restriction sites
- The DNA fragments were separated by gel electrophoresis and transferred from the gel to a nylon membrane by Southern blotting
- The DNA on the membrane was hybridised to a probe (either X or Y) labelled with a fluorescent dye.

The diagram shows where the enzyme *MstI* cuts within the normal allele, the sizes of the fragments produced, the regions that bind to two probes, X and Y, and the possible sites of mutation of the mutant allele, S and T.



The unique blotting pattern after hybridisation for the normal and mutant alleles is shown below.



Which row correctly explains the blotting pattern in the Southern blot after treatment with *MstI* restriction enzyme?

	probe used	location of mutation for the mutant allele
A	Y	T
B	X	T
C	Y	S
D	X	S

13 Which processes occur in bone marrow cells that are undergoing the mitotic cell cycle?

1 disassembly of tubulin dimers in microtubules

2 centromeres replicate and then separate

3 tRNA anticodons hydrogen bond with codons on mRNA

4 formation of cleavage furrow

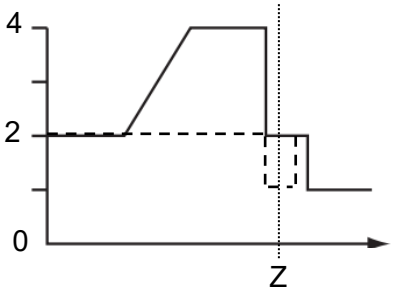
A 1, 2, 3 and 4

B 1, 2 and 4 only

C 1 and 3 only

D 2 and 4 only

14 The graph shows the change in the quantity of DNA (——) and the change in ploidy (- - ·) in a cell during reduction division.

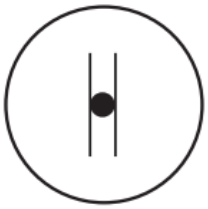


A cell with one pair of chromosomes (2n=2) undergoes meiosis.

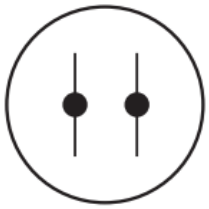
Which shows the correct chromosomes at time Z?

A

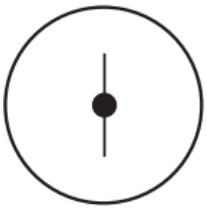
B



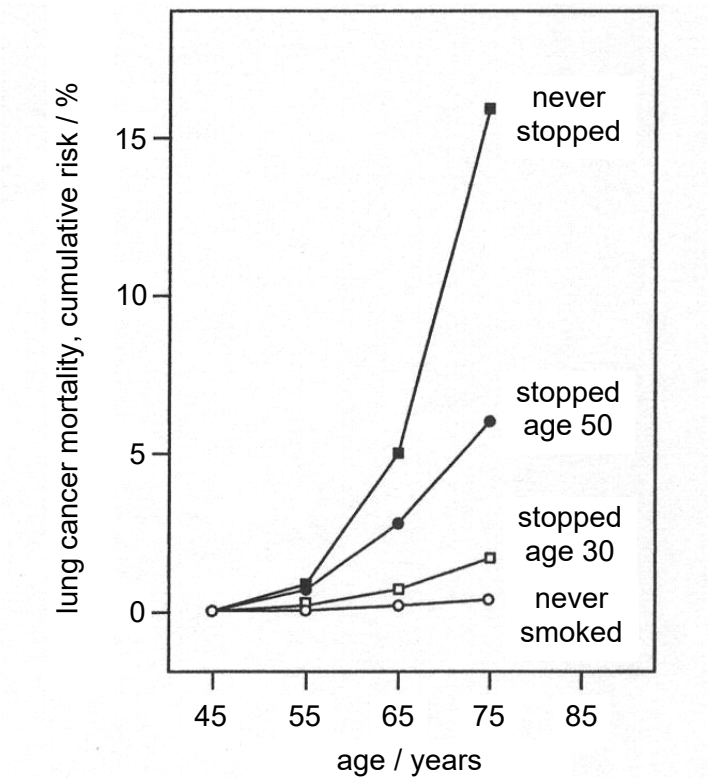
C



D



15 Mortality due to lung cancer was followed in four different groups of males in Singapore for 30 years. The cumulative risk of dying from lung cancer as a function of age and smoking habits for these four groups of males is shown below.



What may be concluded from the trends observed in the graph?

1 The rate of accumulation of mutations is higher after the individual stops smoking.

2 Compounds in smoke stimulate cells to enter mitotic cell cycle.

3 There is little risk of a non-smoker dying from cancer.

A 1, 2 and 3

B 1 and 3 only

C 2 and 3 only

D 2 only

16 What is the role of stem cells in relation to tissues and organs in adults?

A Stem cells that persist in the adult and can collectively give rise to almost all the cell types in the body.

B Stem cells are relatively unspecialised cells that reside in all tissues and take over the function of the tissue when the cells become damaged or worn out.

C Stem cells are pluripotent cells that divide asymmetrically, to replace damaged and worn-out cells in the adult tissue or organ.

D Stem cells have highly methylated genome but can express all their genes to differentiate into any tissue and organ.

17 Which statements apply to both influenza virus and HIV?

1 Glycoprotein-mediated fusion of membranes result in the release of viral genome into host cells.

2 Proteins within the capsid uses RNA as templates for synthesis.

3 Location-specific evagination of host cell surface membrane initiates virion release.

A 1, 2 and 3

B 1 and 2 only

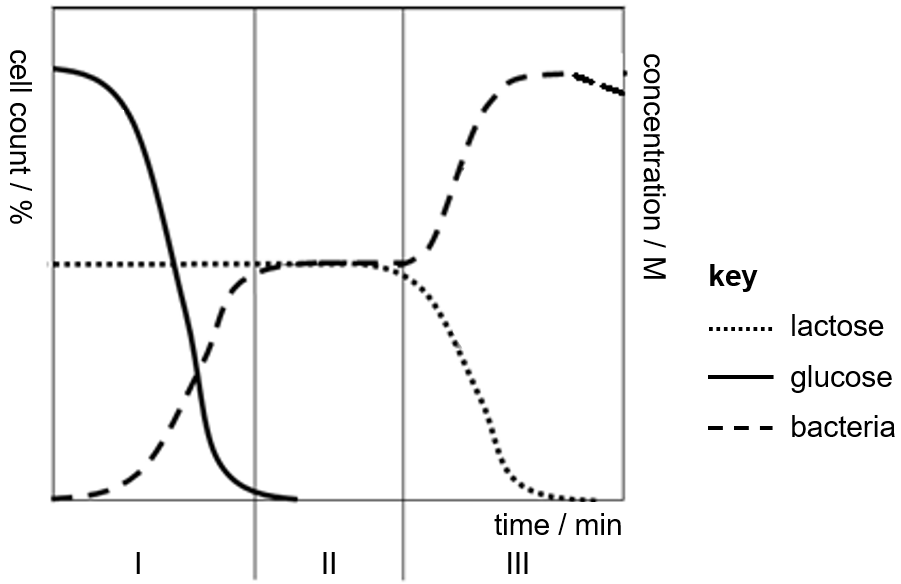
C 1 and 3 only

D 2 and 3 only

18 Which pair of statements is true for both transduction and conjugation?

	transduction	conjugation
A	transfer of bacterial DNA requires direct contact between bacteriophage and recipient cell	transfer of bacterial DNA requires direct contact between donor and recipient cell
B	only host DNA adjacent to prophage is transferred from donor cell to recipient cell in specialised transduction	both strands of the F plasmid are transferred from the donor cell to the recipient cell
C	lambda phage is involved in generalised transduction	T4 phage is involved
D	viral DNA is replicated via rolling-circle mechanism in the donor cell	DNA on F plasmid is replicated via rolling-circle mechanism in the donor cell

19 The graph below shows the number of bacterial cells growing in the presence of varying concentrations of glucose and lactose.



Which row correctly accounts for the bacterial growth at different sections of the graph?

	section	explanation
A	I	*lac* repressor is not bound to the operator and the catabolite activator protein (CAP) is not bound to the CAP-binding site on the promoter
B	II	cAMP levels are high and cAMP binds to its binding site on the promoter
C	II	*lac* repressor changes conformation to become inactive hence lac operon is switched on
D	III	allolactose levels are depleted hence *lac* repressor is inactive, causing bacterial growth to plateau

20 A test cross on *Drosophila* flies gave the following results:

red eye, normal wing	59
purple eye, vestigial wing	43
red eye, vestigial wing	37
purple eye, normal wing	62

The expected ratio of phenotypes for this test cross is 1:1:1:1.

A χ^2 test was performed to test the significance of the difference between the observed and the expected results.

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

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

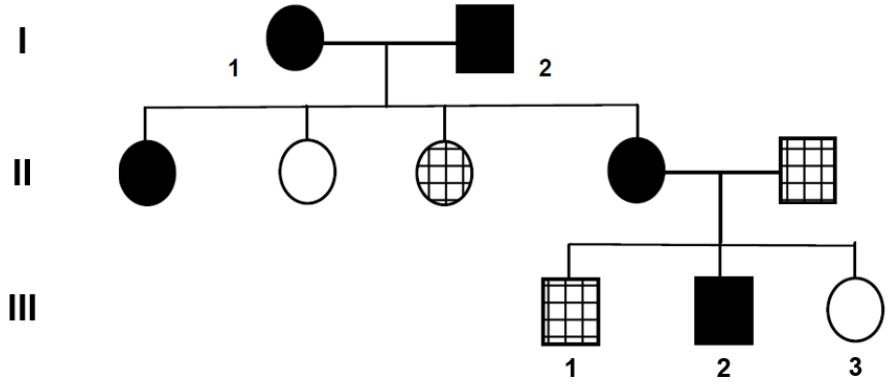
degrees of freedom	*probability, p*						
	0.50	*0.20*	*0.10*	*0.05*	*0.02*	*0.01*	*0.001*
1	0.46	1.64	2.71	3.84	5.41	6.64	10.38
2	1.39	3.22	4.61	5.99	7.82	9.21	13.82
3	2.37	4.64	6.25	7.82	9.84	11.35	16.27
4	3.36	5.59	7.78	9.49	11.67	13.28	18.47

Which combination correctly describes the result of the χ^2 test?

	probability	results fit expected ratio
A	< 0.05	yes
B	< 0.05	no
C	> 0.05	yes
D	> 0.05	no

21 The coat colours of Labrador Retriever dogs are determined by two pairs of unlinked genes, **E/e** and **G/g**. The allele **G** is dominant and must be present for the development of pigmentation in the coat. The allele **E** is dominant and produces a black pigment in the coat. The genotypes of golden-coated dogs are **E_gg** and **eegg** (where _ indicates the presence of either the dominant or recessive allele).

The pedigree chart below illustrates the inheritance of coat colour.



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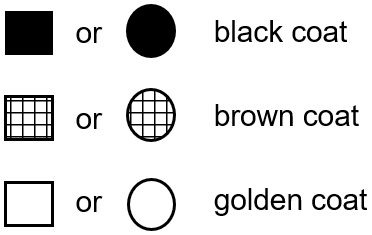


What are the possible genotypes of III-2 and III-3?

	III-2	III-3
A	EEGG or EeGg	Eegg or EEgg
B	EeGg or eeGg	EEgg or eegg
C	EEGg or EeGG	Eegg or EEgg
D	EeGg or EeGG	Eegg or eegg

22 Pure breeding plants of contrasting traits were cross fertilised and the seeds were planted in pots of soil containing equal proportion of fertiliser. The pots were then exposed to different light conditions for 60 days. Throughout the investigation, the plants were watered with equal amount of water twice daily.

At the end of the investigation, the plants' height, length of leaves and colour of leaves were measured and summarised in the table below.

	no light	dim light	bright light
height of plants / cm	10.3 ± 0.3	8.1± 0.5	6.6 ± 0.4
length of leaves / cm	1.7 ± 0.3	1.7± 0.2	1.6± 0.1
colour of leaves	yellow	pale green	dark green

Which statement may be concluded from the information given?

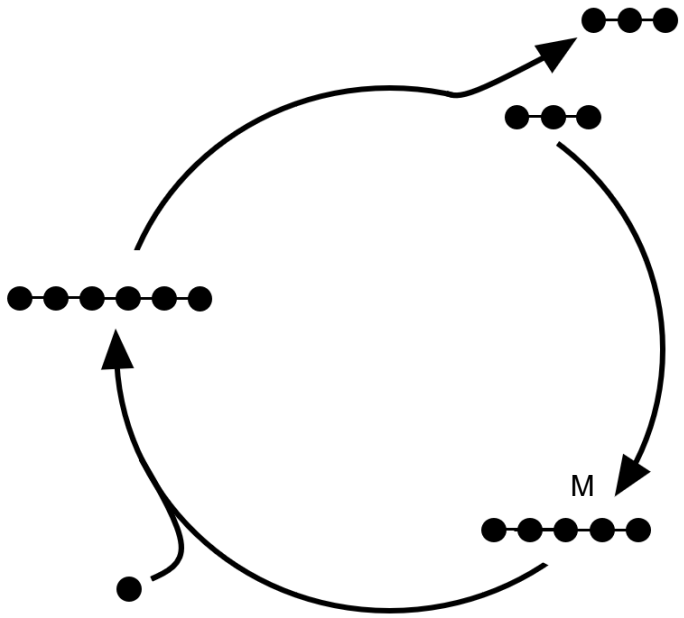
A The height of plants and colour of leaves exhibit continuous variation.

B The additive effect of genes is responsible for the variation observed in the height of plants and length of leaves.

C The genes involved in chlorophyll pigment synthesis are activated by light.

D The colour of leaves is controlled by a single gene with multiple alleles.

23 The simplified diagram shows a cyclic process that occurs in photosynthesis. Each ● represents a carbon atom in a molecule.



Which statements regarding this cycle are correct?

1 Light intensity and temperature are limiting factors of this cycle.

2 In the absence of water, molecules will all accumulate at M.

3 Six 1C molecules need to enter the cycle to form one glucose molecule.

A 1, 2 and 3

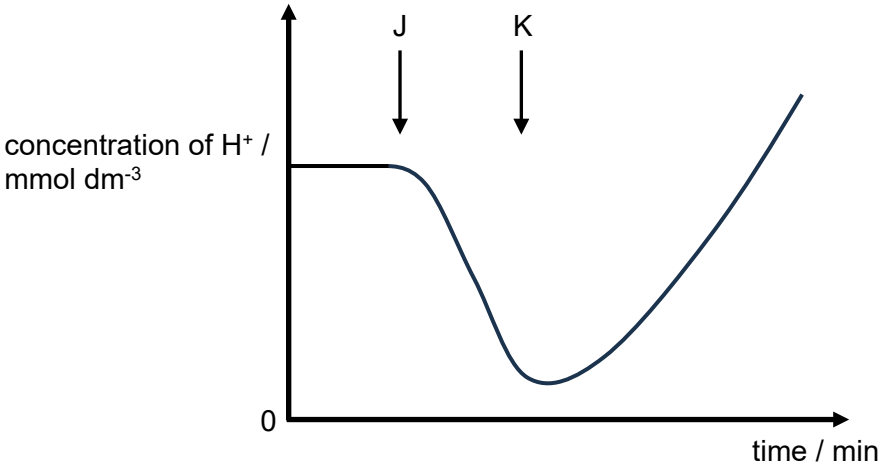
B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

24 A suspension of mitochondria was prepared in a buffer with excess of substrates.

An investigation was conducted to find out the effect of adding molecules J and K on the rate of respiration. The graph below shows the changes in H^+ concentration in one of the compartments of mitochondrion.



Which row is correct?

	compartment where H^+ concentration is measured	effect of molecule added
A	mitochondrial matrix	J converts cAMP to ADP
B	mitochondrial matrix	J competes with coenzyme NAD to bind irreversibly to electrons
C	intermembrane space	K forms pores in the mitochondrial inner membrane
D	intermembrane space	K is a source of oxygen

25 Insulin receptors are involved in cell signalling. 4 different mutant receptors, each with a single loss-of-function mutation affecting different domains of the receptor were produced.

Various functional abilities of the wild type and mutants were tested, and the results were summarised in the table below. The signs "+" and "-" indicate the presence and absence of the indicated functions respectively.

receptor subtype	binding of insulin	conformational change of receptor	auto-phosphorylation	protein kinase activity
wild type	+	+	+	+
mutant 1	+	+	+	-
mutant 2	+	+	-	-
mutant 3	+	-	-	-
mutant 4	-	-	-	-

Based on the information given above, which of the statements is **false**?

A Mutant 2 receptors may lack tyrosine kinase domain.

B Mutant 3 receptors are unable to dimerise to form activated receptors.

C Conformational changes in the receptor are necessary for autophosphorylation.

D Protein kinase activity requires the binding of insulin.

26 Researchers investigated the genus *Heliconius* which contains more than 40 species of butterflies and found the following.

- *H. cydno* and *H. melpomene* produce fertile hybrid offspring, which after some generations of mating amongst themselves, forms *H. heurippa*.
- *H. heurippa* has an intermediate phenotype between the parental species, and prefer to mate with each other, rather than individuals of either parent species.
- *Heliconius* butterflies taste unpleasant to predators and its wing coloration acts as warnings to predators. Each individual predator has to learn which patterns to avoid.
- In the wild, *Heliconius* hybrids occur in small numbers and have patterns that do not resemble the established warning pattern of either parent species.

What may be concluded from the findings?

1 *H. cydno* and *H. melpomene* contain the same number of chromosomes.

2 Biological species concept was used to determine *H. heurippa* is a new species.

3 Competition is necessary for natural selection to take place.

4 Micro-evolution resulted in a change in allele frequency of the population over time.

A 1 and 2

B 1 and 4

C 2 and 3

D 3 and 4

27 Which statements about sympatric speciation are correct?

1 Different selection pressures acting on different individuals in the same population in the absence of physical barriers.

2 Phenotypic variation in the immediate ancestral population is not necessary.

3 May result from physiological isolation mechanisms such as incompatibility of gametes or hybrid sterility.

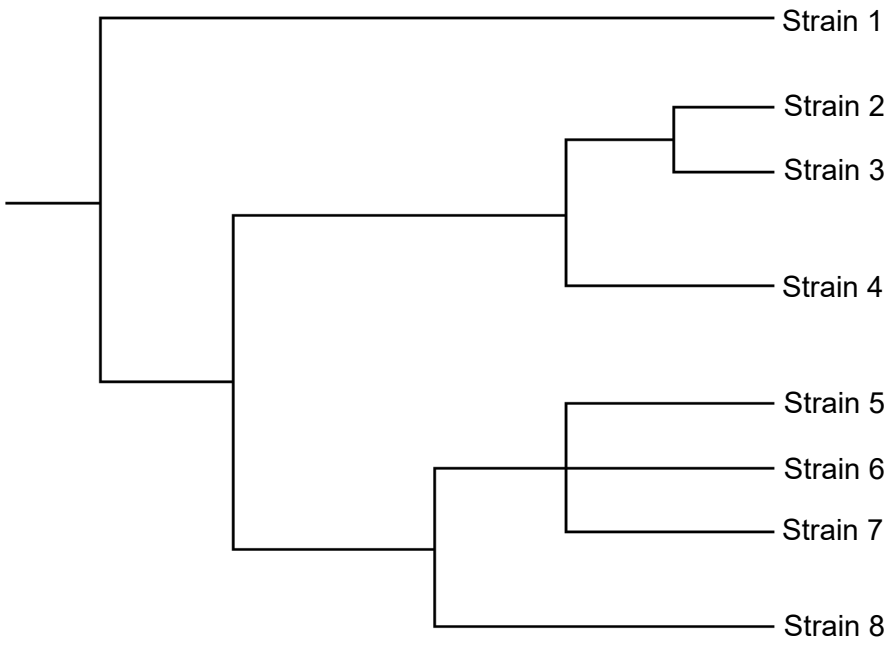
A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

28 Severe Acute Respiratory Syndrome (SARS) is caused by a coronavirus and results in a serious form of pneumonia. The RNA from different strains of coronavirus was obtained and the molecular information was used to construct the phylogenetic tree shown below. Strains 5 and 6 are from human, and Strain 7 is found in palm civets. All other strains are found in different species of horseshoe bats.



What can be concluded from this phylogenetic tree?

A Strains 1 and 8 are genetically more different than strains 4 and 8.

B Strains 2 and 3 are very closely related and share the same genus.

C Strains 5 and 7 can cross-infect palm civets and humans respectively.

D Strain 8 is more closely related to strain 3 than strain 2.

29 Measles vaccination was introduced to children during a measles epidemic. It was later discovered that vaccinated children were more likely to survive childhood than unvaccinated children, as the vaccine had given them protection against other pathogenic infections.

Which statement could account for this extra protection?

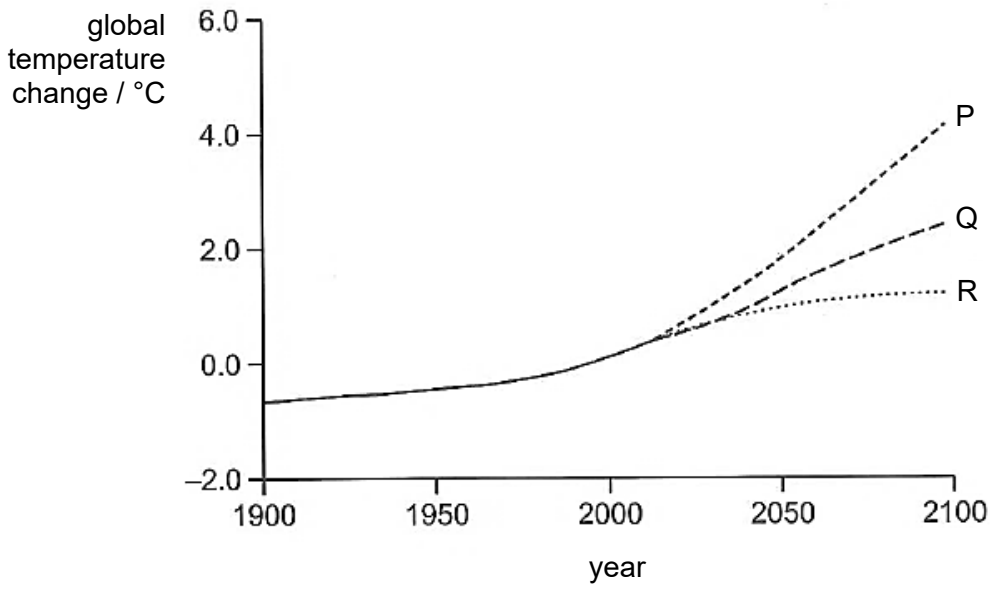
A Memory cells confer natural active immunity to these other pathogenic infections.

B Anti-measles antibodies secreted by plasma cells can bind to other antigens that resemble the measles antigens.

C Memory cells undergo somatic recombination to produce plasma cells that can produce antibodies that recognise other antigens.

D Memory cells differentiate into plasma cells that secrete more monoclonal antibodies.

30 The graph shows three possible models on the predicted change in global temperatures. Model Q assumes that no new factors act to influence the rate of climate change.



Which of the events supports the occurrence of model P and **not** model R?

1 mass deaths of pollinators
2 thawing of permafrost
3 rising sea temperatures

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

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