H

NANYANG JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

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, highlighters, glue or correction fluid.

Write your name and CT on the Answer Sheet in the spaces provided unless this has been done for you.

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.

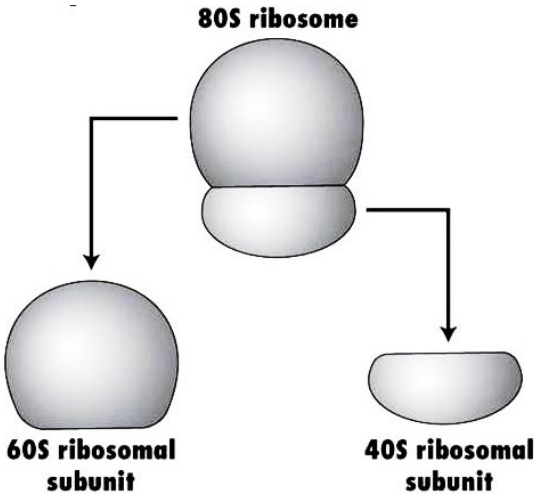
Read the instructions on the Answer Sheet very carefully.

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.

Calculators may be used.

1 A eukaryotic 80S ribosome consist of a 60S large and a 40S small subunit.



Which sequence of events concerning ribosomes is correct?

A rRNA and proteins are synthesized and subunits are formed within the nucleolus. They become membrane bound as they are exported through the nuclear envelope to the cytoplasm and rough endoplasmic reticulum (rER).

B rRNA and proteins assemble to form the 60S subunit in the nucleus while those of the 40S subunit are assembled independently in the cytoplasm.

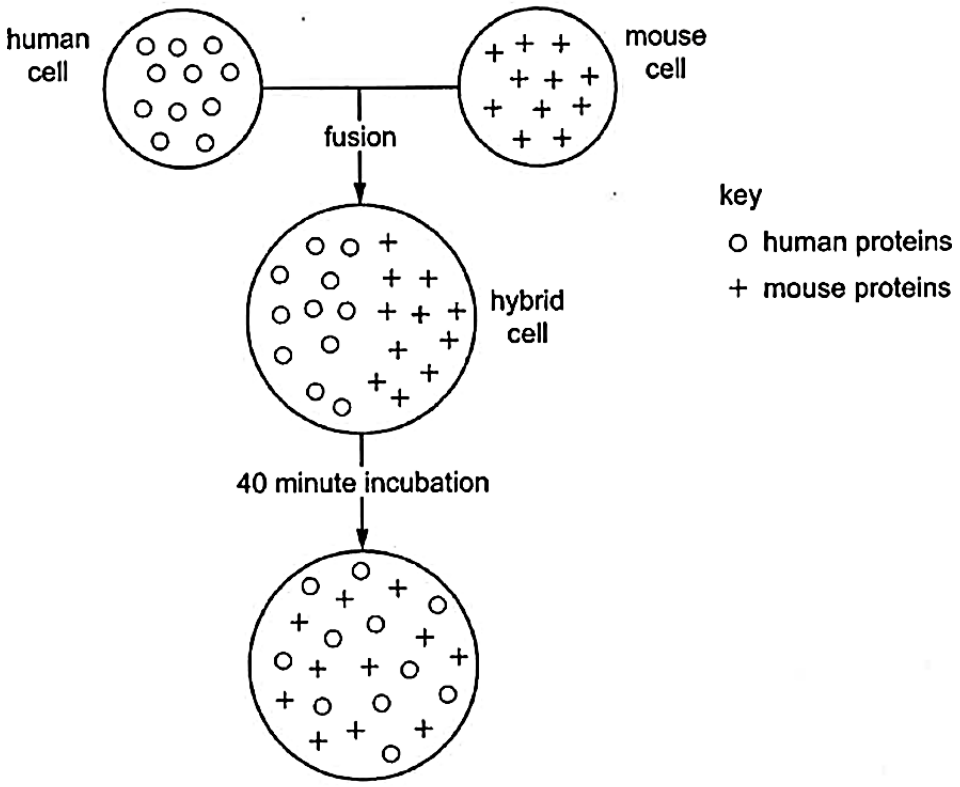
C rRNA is synthesized in the nucleolus and proteins are synthesized by the rough endoplasmic reticulum (rER). Subunit formation occurs within the cytoplasm for free ribosomes and on the surface of the rER for attached ribosomes.

D rRNA synthesised within the nucleolus is complexed with proteins that have been imported from the cytoplasm. The subunits formed are exported separately to the cytoplasm via the nuclear pores.

2 Human and mouse cells were fused to make hybrid cells. Anti-human and anti-mouse antibodies, carrying different coloured fluorescent dyes, were added. The antibodies bind to the protein of the cell surface membrane.

The fused cells were incubated for 40 minutes. The locations of the human and mouse membrane proteins were identified at intervals using the fluorescent dyes.

The diagram represents the results of the experiment by showing the positions of the human and mouse proteins on the surface of the cells.



What does this experiment show?

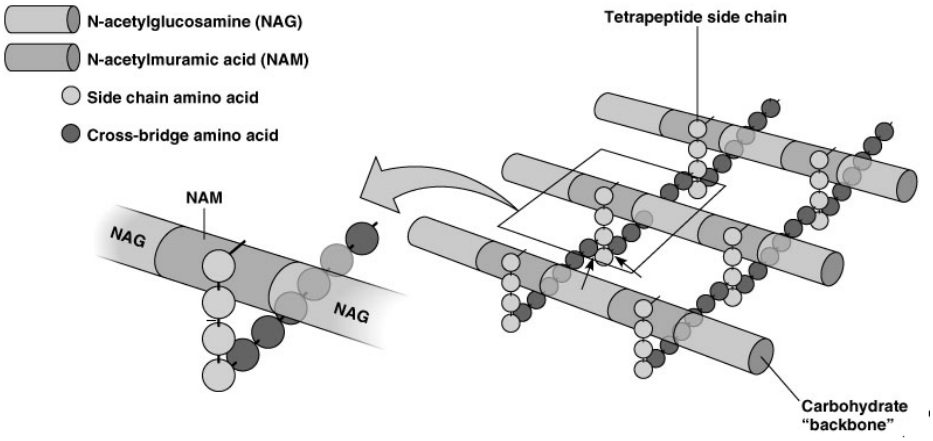
A Movement of the phospholipids pushes the membrane proteins apart.

B Some membrane proteins move through the phospholipids to different places.

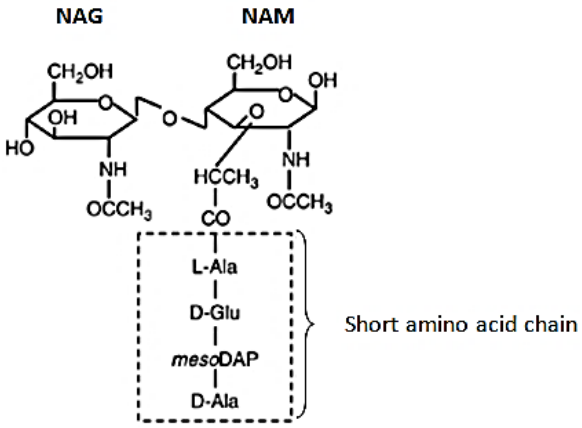
C The phospholipids of the human and mouse cells surface membranes do not mix.

D The proteins of human cell surface membranes can move further than those of mouse cells.

3 The peptidoglycan layer in bacterial cell walls is a crystal lattice structure formed from linear chains of two alternating amino sugars, N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM).



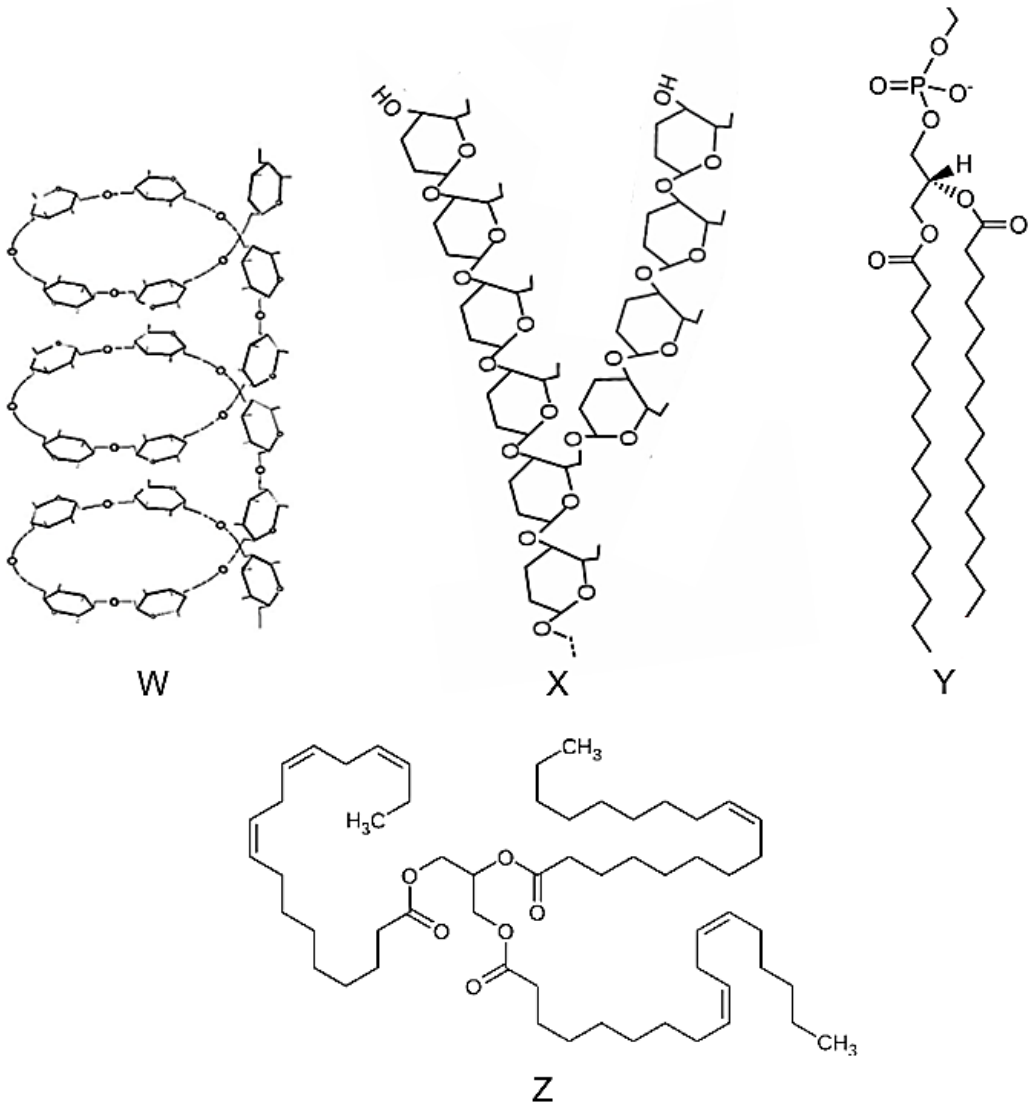
Each NAM is attached to a short amino acid chain. The figure below shows the molecular structure of NAM and NAG.



Which of the following statements correctly compares peptidoglycan and cellulose?

	similarity	difference
A	both contain β-1,4 glycosidic bonds	two different types of monomers are present in cellulose; one type of monomer is present in peptidoglycan.
B	monomers are rotated 180° to each other	cross-links between cellulose chains are hydrogen bonds; cross-links between carbohydrate chains in peptidoglycan are peptide bonds.
C	Both provide high tensile strength that resist osmotic lysis	Cellulose contains only C, H, O and N atoms; Peptidoglycan contains C, H, O, N and P atoms.
D	both comprise chains lying parallel to one another	β-glucose is found in cellulose; α-glucose is found in peptidoglycan.

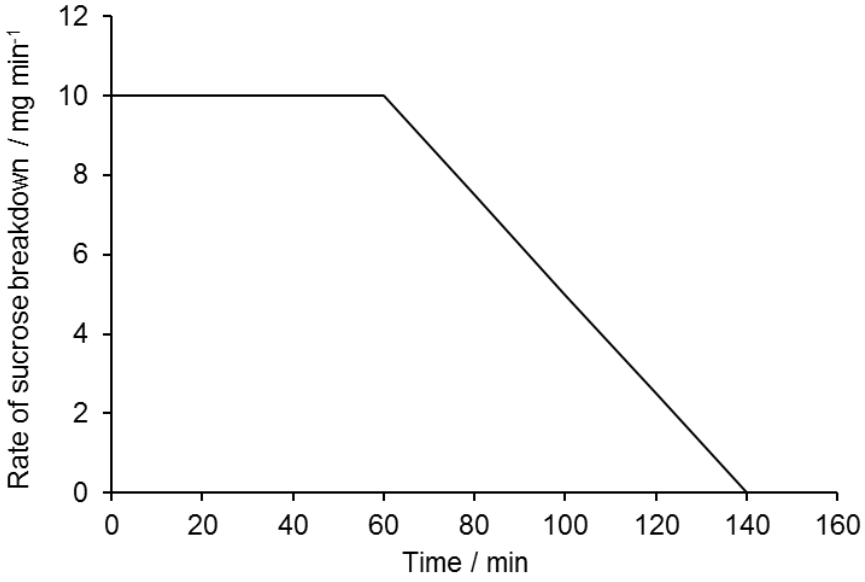
4 A student made observations of the structures and functions of the molecules W, X, Y and Z.



Which row correctly describes the structure and function of the specified molecule?

	molecule	structure	function
A	W	helical and unbranched	allows for the development of turgidity
B	X	helical and branched	allows for quick release of respiratory substrates
C	Y	long unsaturated chains	compartmentalizes enzymes
D	Z	branched and saturated	maintains osmotic potential in the cells

5 The graph shows the results of an investigation using invertase, an enzyme that breaks down sucrose into glucose and fructose. 1g of sucrose was dissolved in 100 cm^3 of water and 2 cm^3 of a 1% invertase solution was added.



Which conclusion can be drawn from this information?

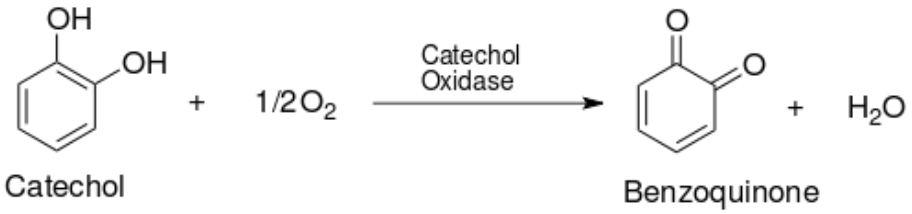
A Between 0 and 60 min, the concentration of the substrate remains constant.

B After 60 min, the concentration of enzymes becomes the limiting factor.

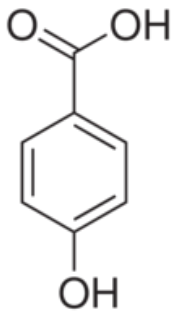
C At 140 min, some of the enzyme molecules are denatured.

D Between 60 and 140 min, the concentration of the substrate is the limiting factor.

6 Catechol is oxidized to benzoquinone, as shown in the equation, resulting in darkening of peeled fruits.



Catechol oxidase is an enzyme which is inhibited by parahydroxybenzoic acid (PHBA). The structure of PHBA is shown below.



Catechol oxidase is also inhibited by phenylthiourea (PTU) which binds to a copper atom in the enzyme. The copper atom is essential for the oxidative activity.

Which of the following statements are **not** correct?

I PHBA acts as a competitive inhibitor because its structure is similar to benzoquinone.
II PHBA acts as a competitive inhibitor, and in the presence of PHBA, the Michaelis constant, K_M of the reaction can be restored by increasing the concentration of catechol.
III PTU acts as a non-competitive inhibitor because it does not change the shape of the active site of catechol oxidase.
IV PTU acts as a non-competitive inhibitor, preventing the formation of enzyme-substrate complex between catechol oxidase, catechol and O_2.

A I and II only
B III and IV only
C I, II and III only
D I, II, III and IV

7 The diagram below shows the relative amounts of DNA in a Meselson and Stahl experiment that demonstrates semi-conservative DNA replication. ^{14}N and ^{15}N represents the type of nitrogen isotope present in the DNA strands.

Time / min	proportion of DNA / %	
	$^{14}N^{14}N$	$^{14}N^{15}N$
0	0	100
20	50	50
40	75	25
60	87.5	12.5
80	93.75	6.25

Which of the following statements are **false** about the process that occurred during the experiment?

I Each parental strand has the same number of nucleotides and base sequence as its daughter strand.
II DNA nucleotides and RNA nucleotides were used in the synthesis of each daughter strand.
III The number of $^{14}N^{15}N$ DNA molecules observed decreased by 50% with each successive generation.
IV ^{14}N was introduced only at the start of the experiment.
V Original strands of DNA at the start are no longer observed if the experiment is extended to 120 minutes.

A I, II
B I, III, V
C II, IV, V
D I, II, III, V

8 Fig. 8.1 and Fig. 8.2 are electron micrographs that show RNA synthesis. One of the diagrams depicts the process in a prokaryotic cell, while the other in a eukaryotic cell. The dark circular structures in Fig. 8.2 represent ribosomes.

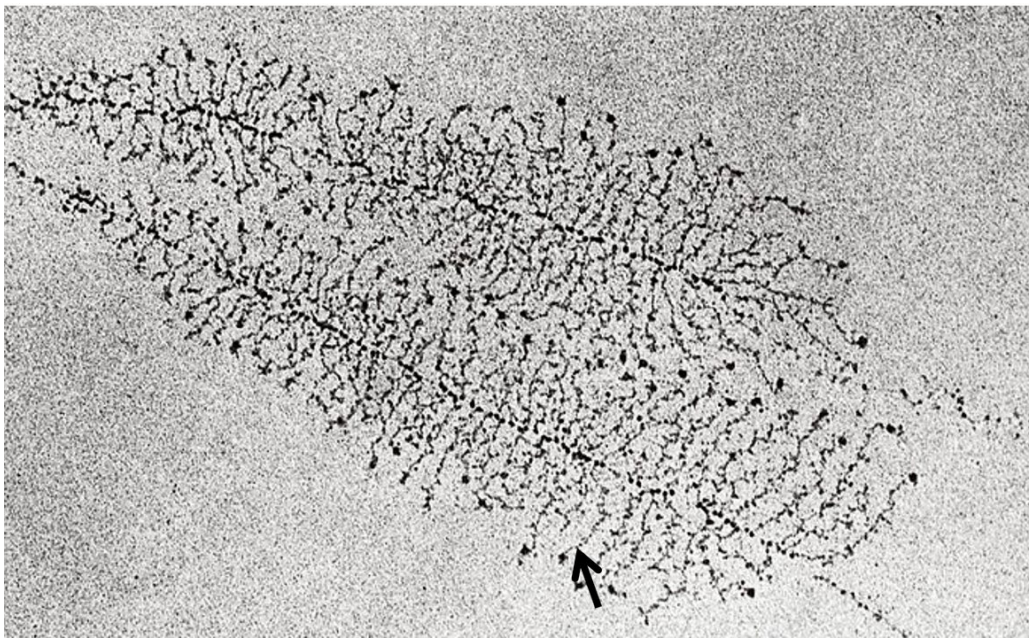


Fig. 8.1

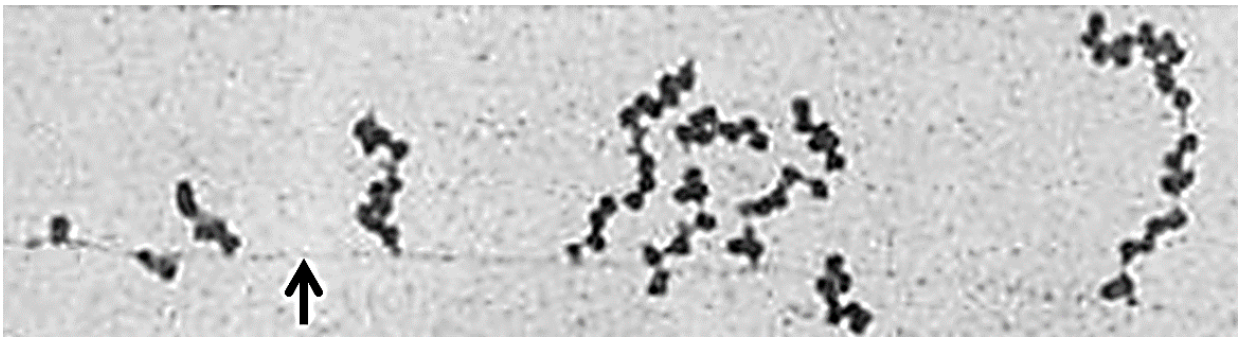


Fig. 8.2

Which of the following statement(s) is/are **false**?

I The arrow in Fig. 8.1 is pointing to a type of RNA while Fig. 8.2 is pointing to the chromosomal DNA.

II Fig. 8.1 shows transcription and translation occurring simultaneously in a membranous compartment within the cell.

III Polyribosomes and ribozymes are involved in the processes occurring in Fig 8.2 but not Fig 8.1.

IV Complementary base pairing occurs only in Fig 8.2.

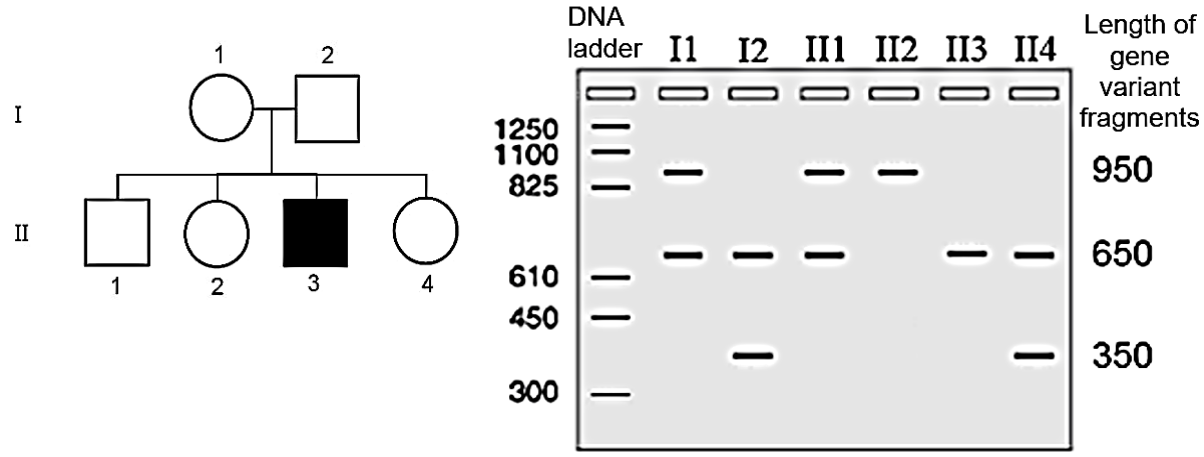
A II only

B II and IV only

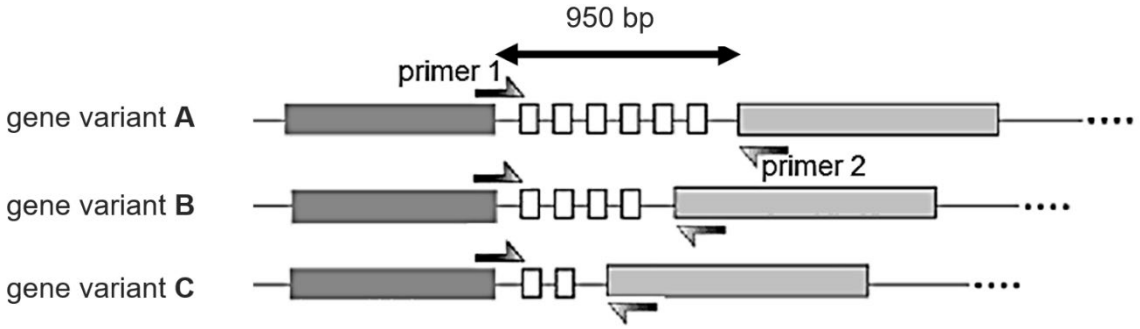
C I and III only

D All of the above

9 In a study of a genetic disorder involving one gene, the DNA from six members of a family was isolated, amplified by PCR and run on an agarose gel. The pedigree was constructed using information obtained from interviewing family members.



The results reveal that there are three variants of the gene. Each gene variant has a different number of repeats in one of its introns.



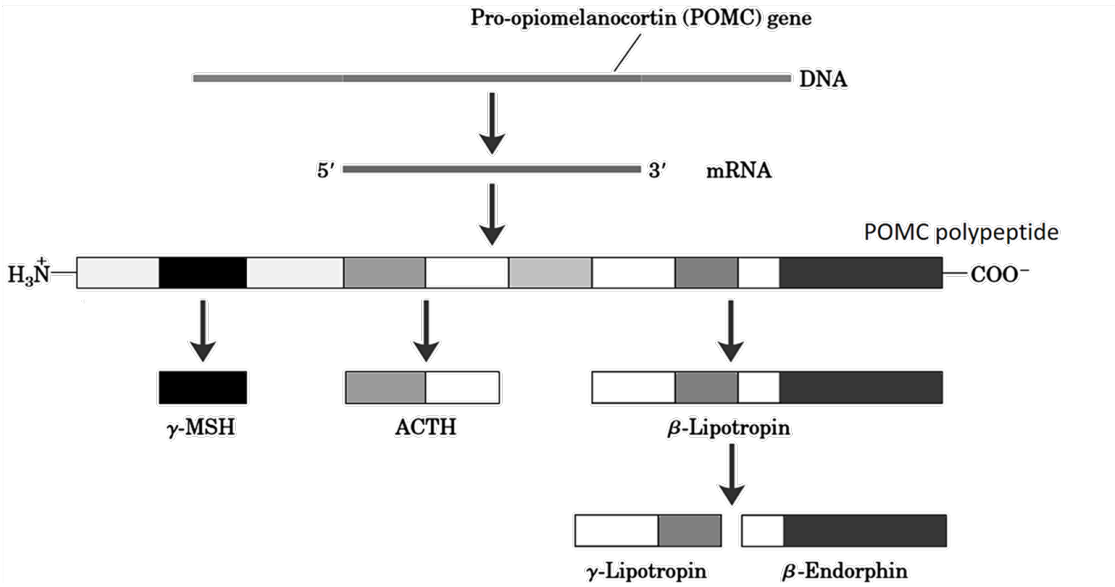
Given the above information, which of the statements are correct?

1 Gene variant **B** is associated with the disease phenotype.
2 It is possible for individuals I1 and I2 to have an affected offspring with gene variant **B** and **C** due to crossing over event during meiosis in individual I1.
3 Individual I2 is not the biological father of individual II2.
4 The pairs of primers used for each gene variant are complementary to each other.

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

10 The processing of pro-opiomelanocortin (POMC) polypeptide involves extensive proteolytic cleavage at sites shown to contain regions of amino acids with basic R-groups. The proteases that recognize these cleavage sites are tissue-specific.

Multiple hormones are produced such as adrenocorticotropic hormone (ACTH) and β–lipotropin in the anterior pituitary under the stimulation of corticotropin releasing hormone.
In the intermediate lobe of pituitary gland, γ–lipotropin and β–endorphin are produced under the stimulation of dopamine. The terminal residues of these peptide hormones are often glycosylated or acetylated.



Which statement is true?

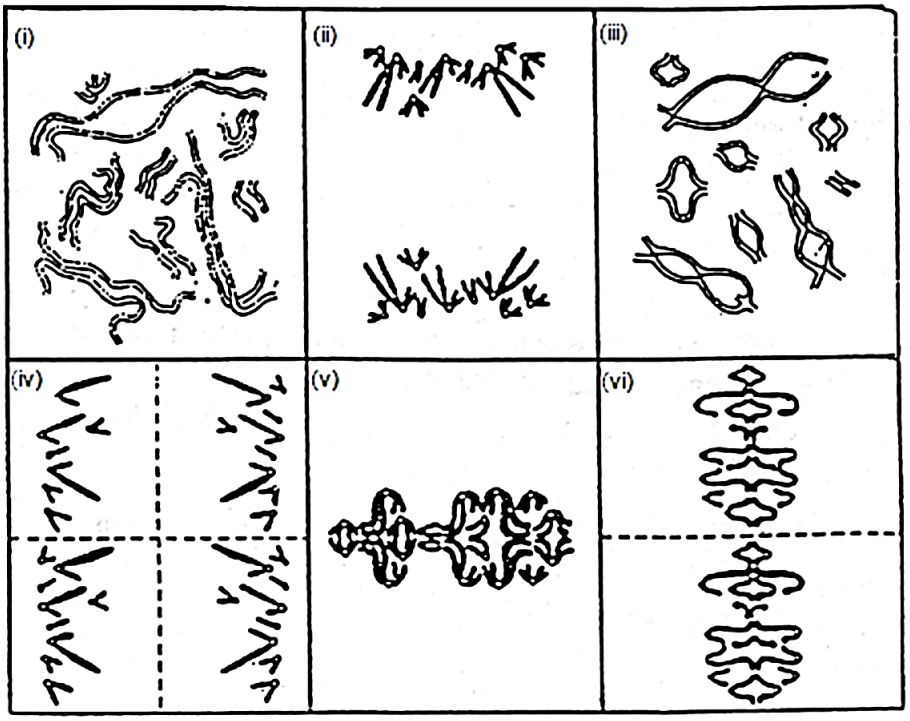
A The types of hormones formed in a specific tissue depend on the control of gene expression at the translational level.

B Specific chemical signals are required for the formation of unique peptide hormones in different tissues.

C The different hormones are formed by alternative RNA splicing.

D Parts of the amino acid sequence of POMC polypeptide can undergo rearrangement to form peptide hormones of varying length.

11 The figure below shows 6 stages of the process of meiosis occurring in a plant cell. (*2n = 18*)



What is the correct order of these 6 stages?

A (iii), (v), (ii), (vi), (iv), (i)

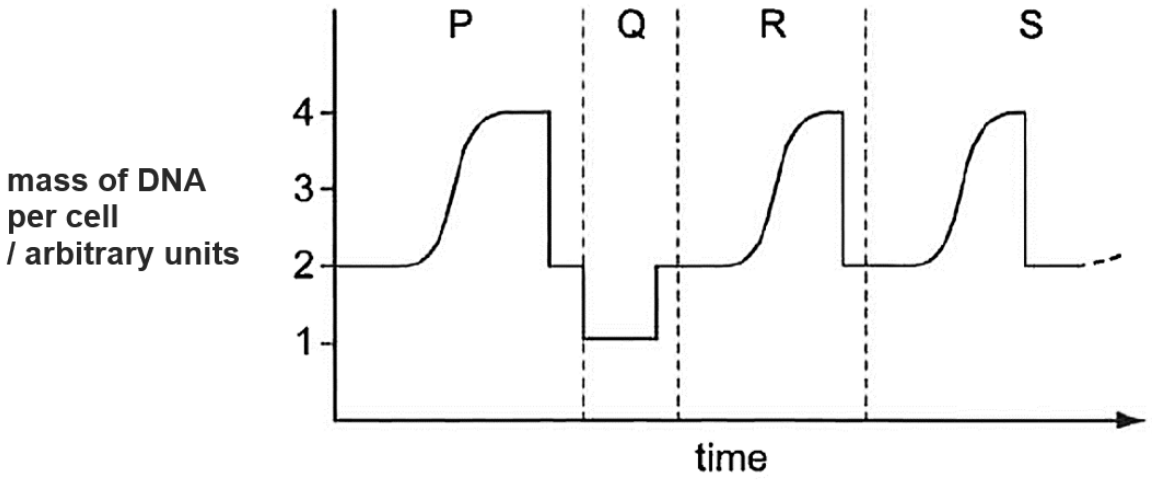
B (iii), (i), (v), (ii), (vi), (iv)

C (ii), (iii), (i), (v), (vi), (iv)

D (i), (iii), (v), (ii), (vi), (iv)

12 A single cell from a female mammal undergoes changes that result in an ovum being formed. If the ovum is fertilized then further changes occur to form an embryo.

The graph shows the changes in the mass of DNA per cell during these events.



During which stages might variation occur as a result of changes in the number of sets of chromosomes?

A P, Q and R

B Q, R and S

C P and Q only

D R and S only

13 In mice, two different genes are known to determine skin colour, one is known as the albino series and the other a black series. The table below shows how different allelic combinations result in different genotypes for each series and their corresponding phenotypes.

Albino series		Black series	
Genotype	**Phenotype**	**Genotype**	**Phenotype**
+/+	grey	+/+	normal grey
a/*a*	albino	*b*/*b*	black
a^m/a^m	medium light	*Y*/*Y*	yellow-dies (lethal)
a^e/a^e	extreme light	G^L/G^L	grey with light belly
		b^L/b^L	black with light belly

Which of the following correctly explain the genetic basis for coat colour in mice?

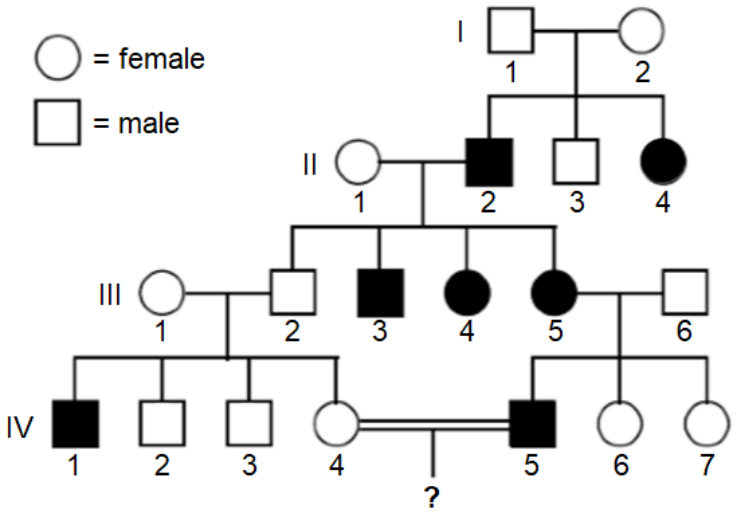
A Polygenic inheritance and epistasis

B Incomplete dominance and sex-linkage

C Multiple alleles and intergenic interaction

D Incomplete linkage of 2 autosomal genes

14 The diagram below shows the inheritance pattern of progressive retinal atrophy in Golden Retriever. The genetic disease is characterised by the bilateral degeneration of the retina, causing progressive vision loss culminating in blindness in these dogs.



If IV-4 mates with IV-5, what is the probability that their first offspring will be a normal female?

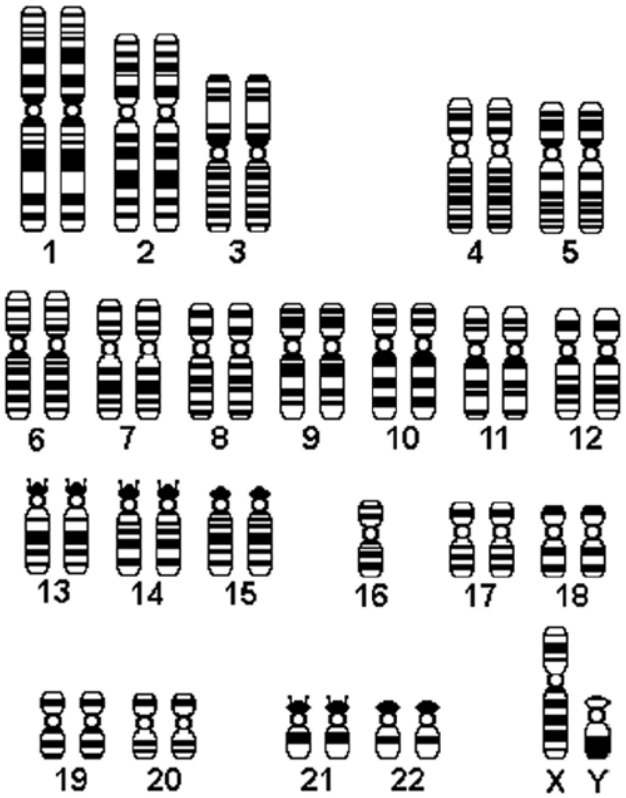
A 1/2

B 1/3

C 1/4

D 1/6

15 The diagram shows a type of chromosomal aberration in humans.

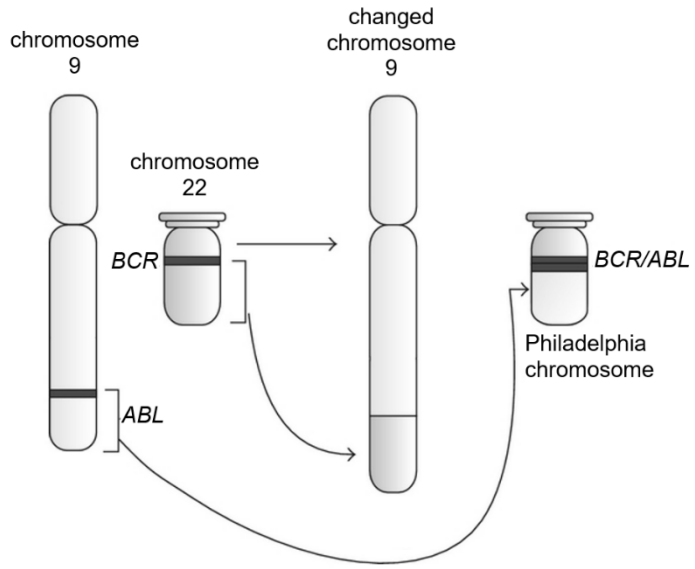


Which of the following correctly identified the type of chromosomal aberration and a possible cause?

	Type of chromosomal aberration	Possible cause
A	aneuploidy	Non-disjunction during meiosis I of father's gametic cell, resulting in a sperm cell with one missing chromosome.
B	polyploidy	Non-disjunction during meiosis I of father's gametic cell, resulting in a sperm cell with an extra set of chromosomes.
C	aneuploidy	Non-disjunction during meiosis II of mother's gametic cell, resulting in an egg cell with a missing set of chromosomes.
D	polyploidy	Non-disjunction during meiosis II of mother's gametic cell, resulting in an egg cell with one missing chromosome.

16 In normal cells, the *ABL* gene encodes an enzyme, tyrosine kinase, which is part of the cell signaling pathway leading to cellular proliferation.

The diagram shows a chromosomal translocation that forms the Philadelphia chromosome that contains the fusion *BCR/ABL* gene. This gene expresses an abnormal fusion protein. The presence of the Philadelphia chromosome is linked to the development of chronic myeloid leukaemia (CML), a cancer of the white blood cells.



Which statement is correct?

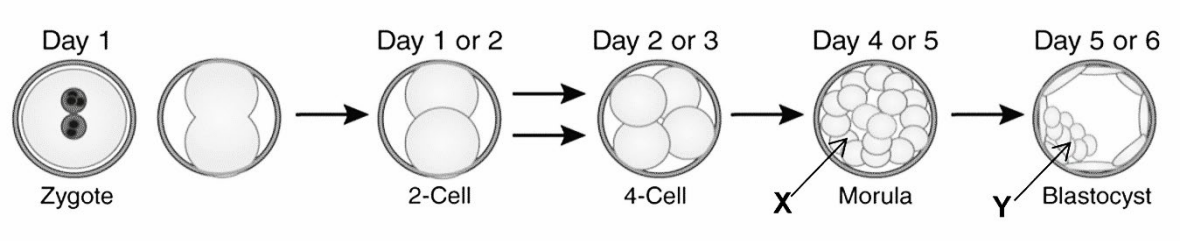
A The fusion *BCR/ABL* allele is recessive and it codes for a tumor suppressor protein.

B The BCR/ABL protein causes the rate of cell division to exceed the rate of cell death.

C Chromosomal translocation of both the copies of *ABL* gene is required before CML can develop.

D In CML, both angiogenesis and metastasis have to occur.

17 The figure below shows several stages in the development of an embryo.



Which of the following statements is true about the cells labelled **X** and **Y**?

A **X** is a pluripotent cell while **Y** is a multipotent cell.

B **X** can give rise to pluripotent cell while **Y** can give rise to multipotent cells.

C **Y** will develop into the entire fetus including its placenta.

D **X** can only give rise to totipotent cells but **Y** will give rise to pluripotent cells.

18 Which of the following occur in the specific signaling pathway which will lead to an increase in glucose uptake in the liver cells of a healthy human?

1 increase in cyclic AMP production
2 activation of protein kinases
3 activation of receptor tyrosine kinases by glucagon
4 activation of phosphatases

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

19 Dinitrophenol is a compound that can lodge within the thylakoid membranes of chloroplasts. Its presence provides an alternative route for H^+ ions to diffuse across the thylakoid membranes.

In what way would the Calvin cycle be affected in chloroplasts poisoned with dinitrophenol?

A No effect since Calvin cycle is an enzyme-controlled process.
B The rate of Calvin cycle would increase as pH in the stroma decreases.
C The rate of Calvin cycle would decrease with the accumulation of glycerate-3-phosphate.
D The rate of Calvin cycle would decrease with the accumulation of glyceraldehyde–3-phosphate.

20 Ribulose-1,5-bisphosphate carboxylase oxygenase (Rubisco) is an important enzyme in photosynthesis. An experiment was carried out to investigate the effect of oxygen (O_2) to carbon dioxide (CO_2) ratio on the amount of carbohydrates produced. The results are shown in the table below.

Experiment No.	Light intensity / lux	Amount of CO_2 available in stroma / %	Amount of O_2 available in stroma / %	pH	Amount of carbohydrates produced / arbitrary units
1	10	10	0.002	3	0.01
2	10	10	0.002	8	250
3	10	2	0.008	3	0.01
4	10	2	0.008	8	15

Which of the following statement(s) can be concluded from these experiments?

1 As the amount of O_2 increases, the rate of carbon fixation decreases.
2 The optimum pH of Rubisco is 8.
3 The active site of Rubisco was altered in pH 3, leading to a low amount of carbohydrates produced.

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

21 Which one of the following substances, when added, would directly result in a decline in ATP production in glycolysis?

1 A chemical that reduces NAD irreversibly.
2 An inhibitor that has a similar structure to glucose but cannot be broken down by respiratory enzymes.
3 A chemical that creates an anaerobic environment by reducing the oxygen in the environment.
4 A reagent that binds to the active site of ATP synthase permanently.

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

22 Which of the following about anaerobic respiration in muscle cells is **false**?

A Pyruvate is used as a hydrogen acceptor to regenerate NAD.

B Formation of ATP is dependent on substrate-level phosphorylation only.

C Lactate retains a lot of chemical energy.

D Decarboxylation of pyruvate occurs to form lactate.

23 Which of the following statements correctly accounts for the ability of Human Immunodeficiency Virus (HIV) to establish itself quickly in a human host?

I Interaction of gp41 with sialic acid receptors receptors trigger fusion and entry into the host cell

II Reverse transcriptase allows for the synthesis of viral dsDNA that is integrated into the host genome.

III Formation of an RNA template that is complementary to the genome of HIV allows for amplification in the synthesis of viral protein.

IV Protease action converts the provirus into a mature virus

A I and II

B I and III

C II and III

D I, III and IV

24 One hypothesis about the origin of viruses is that they existed before cellular life forms, later evolving into parasites of cellular organisms. Groups with an ancient, common origin tend to share conserved sequences of DNA or RNA.

Which observation about virus genomes supports the view that viruses existed before cellular life forms and only much later evolved into parasites?

A All viruses have genes that code for capsid components.

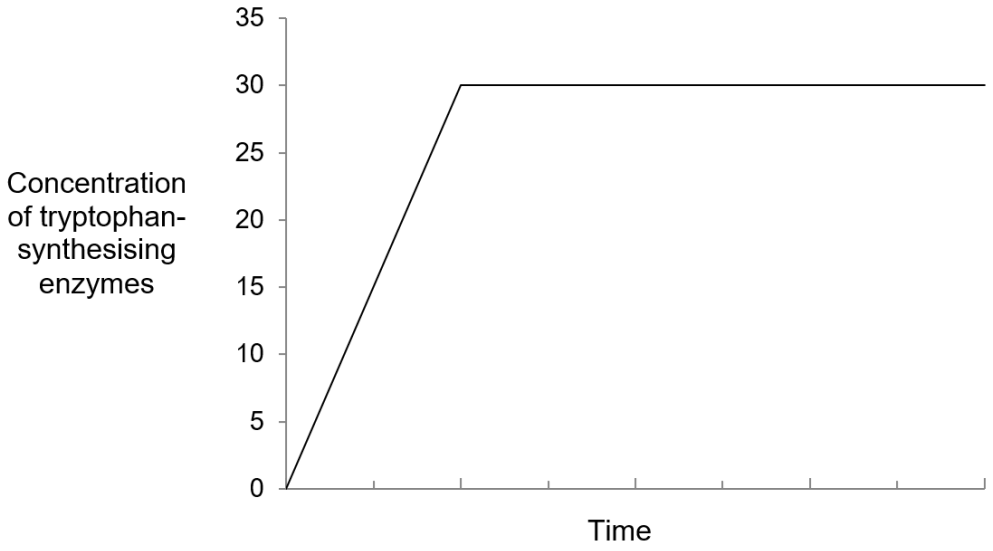
B Introns of eukaryotic genes have common features with viral genomes.

C Large virus genomes have genes that originate in host cells.

D Viral genomes have conserved genes not found in any other genomes.

25 The *trp* operon comprises the promoter, operator and structural genes. Some of these components could become non-functional.

An investigation was carried out to determine whether any of the components are non-functional. The graph shows the concentration of tryptophan-synthesising enzymes in a bacterial cell containing the *trp* operon. The cell was transferred from a medium containing tryptophan to another without tryptophan at the start of the experiment.



key

+	: Functional component	*pro*	: promoter
-	: Non-functional component	*o*	: operator
		sg	: structural genes
		trpR	: gene coding for trp repressor

Which of the following combinations could lead to the graph above?

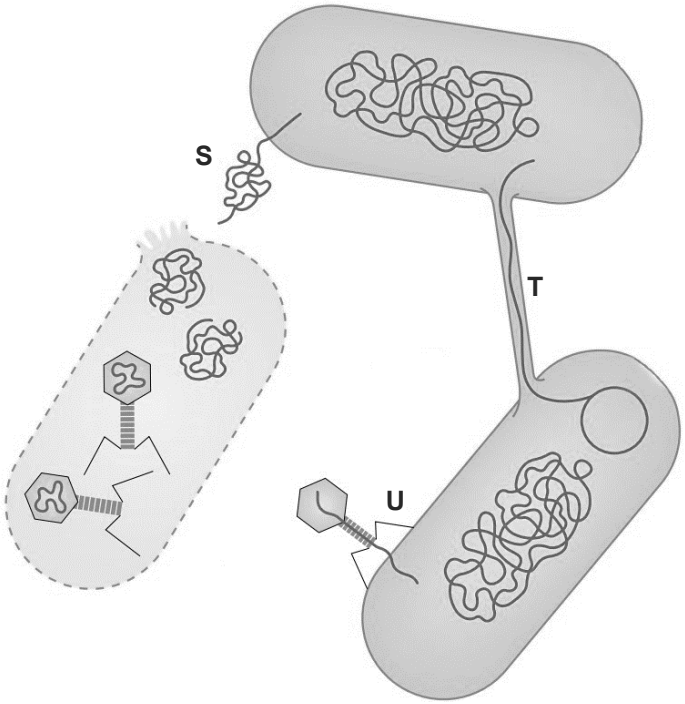
A $trpR^{-}\ pro^{+}\ o^{+}\ sg^{+}$

B $trpR^{-}\ pro^{+}\ o^{-}\ sg^{+}$

C $trpR^{+}\ pro^{-}\ o^{+}\ sg^{-}$

D $trpR^{+}\ pro^{+}\ o^{+}\ sg^{+}$

26 The diagram shows three processes, **S**, **T** and **U** by which genetic information can be exchanged between bacterial cells.



Which statements are correct?

1 Processes **S** and **U** involves the transfer of random DNA from donor to recipient bacterial cell.

2 Processes **S** and **T** involves the transfer of DNA that leads to an increased genetic variation in both donor and recipient bacterial cells.

3 Only processes **T** and **U** lead to an increase in the bacterial cell number.

4 All three processes require the exchange of chromosomal DNA between two bacterial cells to be homologous.

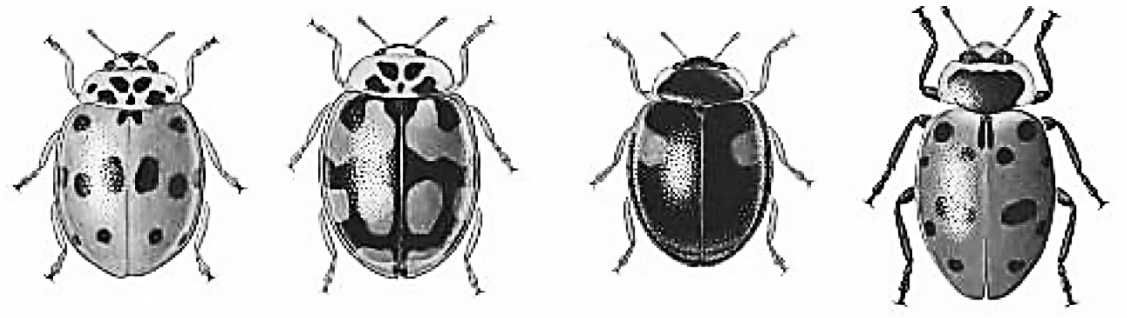
A 1 only

B 3 only

C 1 and 4

D 2 and 4

27 An entomologist collected four forms of ladybird beetles (*Coccinellidae*) from one habitat.



Each of the forms were of both sexes and when crossed together with the other forms. All crosses produced fertile and viable offspring. The offspring were all accounted for and they displayed one or more of the discrete colour forms shown above without intermediates.

What can be concluded from this investigation?

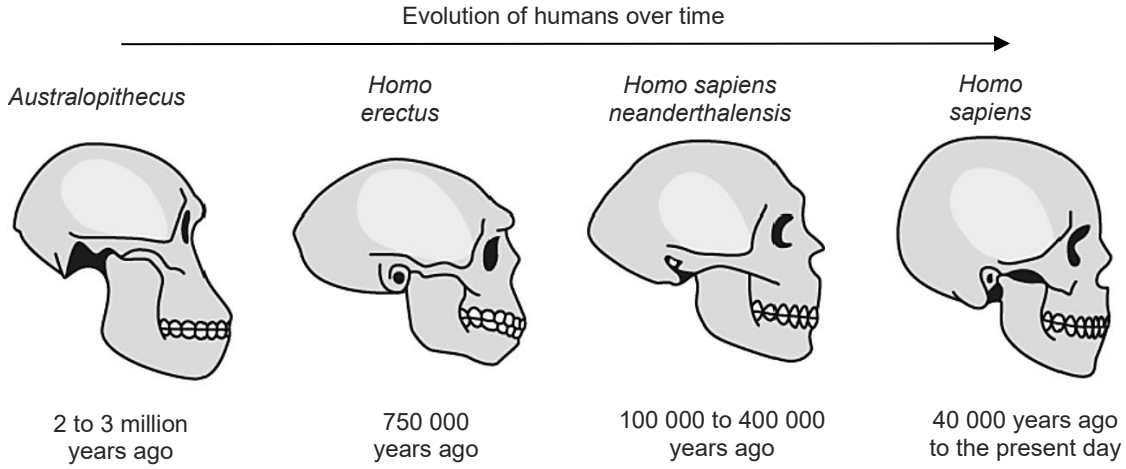
A The beetles are from four closely related species.

B Intermediate forms were selected against by the environment.

C The species shows discontinuous variation due to genetic polymorphism.

D The colour forms are not influenced by environment and are not under genetic control.

28 The diagram shows the evolution of humans using fossil records.



Which statements are correct?

1 As humans evolved, the volume of the skull progressively increased, showing descent with modification.

2 *Homo erectus* and *Homo sapiens neanderthalensis* existed at different time periods and hence were reproductively isolated.

3 *Australopithecus* was the most recent common ancestor of *Homo sapiens*.

4 The skulls of the different human species are analogous structures.

A 1 and 2

B 3 and 4

C 1, 2 and 3

D 2, 3 and 4

29 A monoclonal antibody specific for a virus was produced by identical plasma cells.

This antibody was treated with an enzyme to break the bonds between the variable and constant regions.

The separated variable and constant regions were then added to cells infected with the virus.

With regard to the experiment carried out, which statements are correct?

1 The constant regions would bind to different parts of the virus antigens.
2 The variable regions would all bind to the same part of the virus antigens.
3 The separated constant and variable regions cannot bind to the virus antigens.
4 Phagocytes will engulf the viruses.

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

30 Which effect of temperature increase on arctic ecosystems, will increase carbon dioxide in the atmosphere?

A Greater production of plants due to warmer temperatures and changing vegetation.
B Melting ice from glaciers and icebergs will cause sea levels to rise.
C Less ice and snow will cause incoming radiation to be absorbed more readily.
D Greater decomposition of organic matter currently stored in permafrost.