H2 ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2

2024 JC2 PRELIMINARY EXAMINATIONS

BIOLOGY 9744/01

PAPER 1 **13 SEPTEMBER 2024**
MULTIPLE CHOICE **FRIDAY**

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, class and identification number on the MCQ Answer Sheet.

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.

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 scientific calculators is expected, where appropriate.

This document consists of **23** printed pages and **1** blank page.

1 What can be found in both eukaryotic and prokaryotic cells?

1 circular DNA

2 lipids

3 ribose

4 peptidoglycan cell wall

A 1, 2 and 3

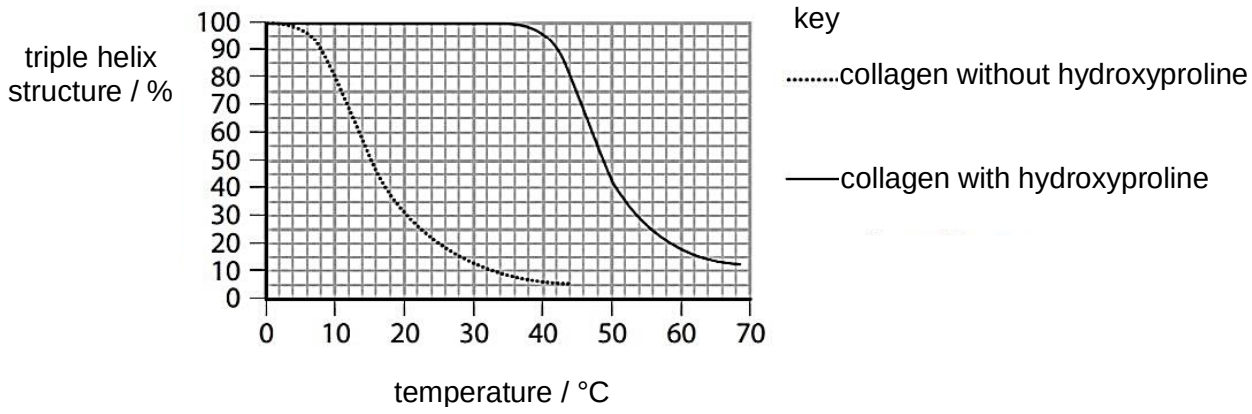
B 1, 2 and 4

C 2 and 3

D 3 and 4

2 Hydroxyproline is a component of collagen.

The graph shows the effect of temperature on the triple helix structure of collagen with and without hydroxyproline. The y-axis of the graph indicates the percentage of intact triple helix structure in a sample of collagen.



Which statement(s) explain(s) the importance of hydroxyproline in the structure of collagen?

1 Presence of hydroxyproline increases thermal stability of collagen as hydroxyproline facilitates formation of covalent cross-links within each triple helix structure.

2 At higher temperatures, collagen with hydroxyproline results in less triple helices present than collagen without hydroxyproline.

3 Hydroxyproline contributes to the extensive hydrogen bonds that hold the polypeptide chains of each triple helix structure.

A 1 only

B 3 only

C 1 and 2

D 2 and 3

3 One way of representing fatty acid chains is Cx : y, where Cx is the number of carbon atoms and y is the number of double bonds.

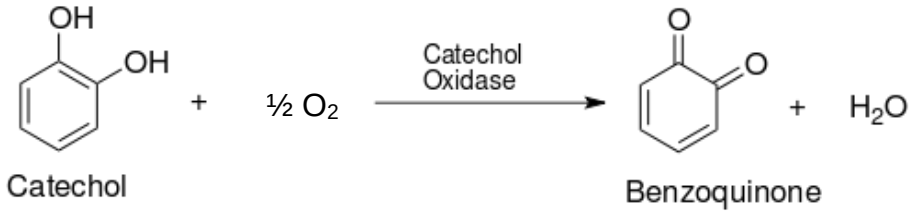
The table shows the percentage mass of eight different fatty acid chains found in four cell membranes, P, Q, R and S.

cell membrane	percentage mass of each fatty acid chain in the cell membrane							
	C10 : 0	C12 : 0	C14 : 0	C16 : 0	C18 : 0	C18 : 1	C18 : 2	C18 : 3
P	1	2	2	21	35	29	2	1
Q			2	23	19	45	3	1
R		2	3	23	21	43	4	
S	1	2	4	22	2	52	11	1

Which of the following about the four cell membranes (P, Q, R and S) is correct?

	most fluid	least fluid
A	R	P
B	R	Q
C	S	Q
D	S	P

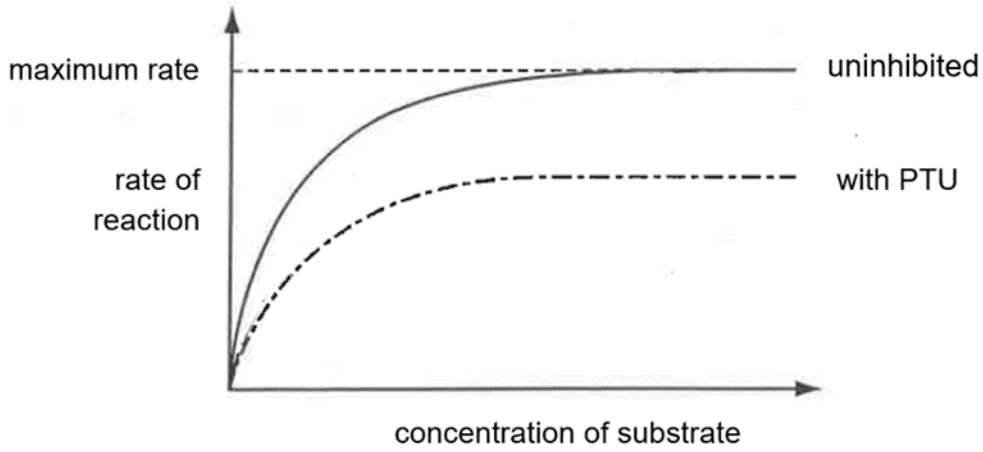
4 Catechol is oxidised to benzoquinone, as shown in the equation, resulting in darkening of peeled fruits.



Catechol oxidase is an enzyme which is inhibited by parahydroxybenzoic acid (PHBA), which is structurally similar to catechol.

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.

The graph shows the rate of the reaction with and without PTU.



Which of the following statement(s) is/ are **not** correct?

1 PHBA acts as a competitive inhibitor because its structure is similar to benzoquinone.

2 PHBA acts as a competitive inhibitor, and in the presence of PHBA, the maximum velocity of the reaction cannot be restored by increasing the concentration of catechol.

3 PTU acts as a non-competitive inhibitor, preventing the formation of enzyme-substrate complex between catechol oxidase, catechol and O_2.

A 2 only

B 3 only

C 1 and 2

D 2 and 3

5 Some descriptions of possible similarities between two different cell types in an individual are listed.

1 They have identical genotypes.

2 They can divide repeatedly by mitosis.

3 They have the same ability to differentiate into different cell types.

Within an individual organism with cancer, which of these possible similarities would be expected to be true when comparing tumour cells with multipotent stem cells?

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 only

6 The ends of a eukaryotic chromosome contain a special sequence of DNA called a telomere. Human telomeres consist of repeating TTAGGG sequences.

When cells undergo mitotic division, some of these repeating sequences are lost. This results in the shortening of telomeric DNA.

What is a consequence of the loss of repeating DNA sequences from the telomeres?

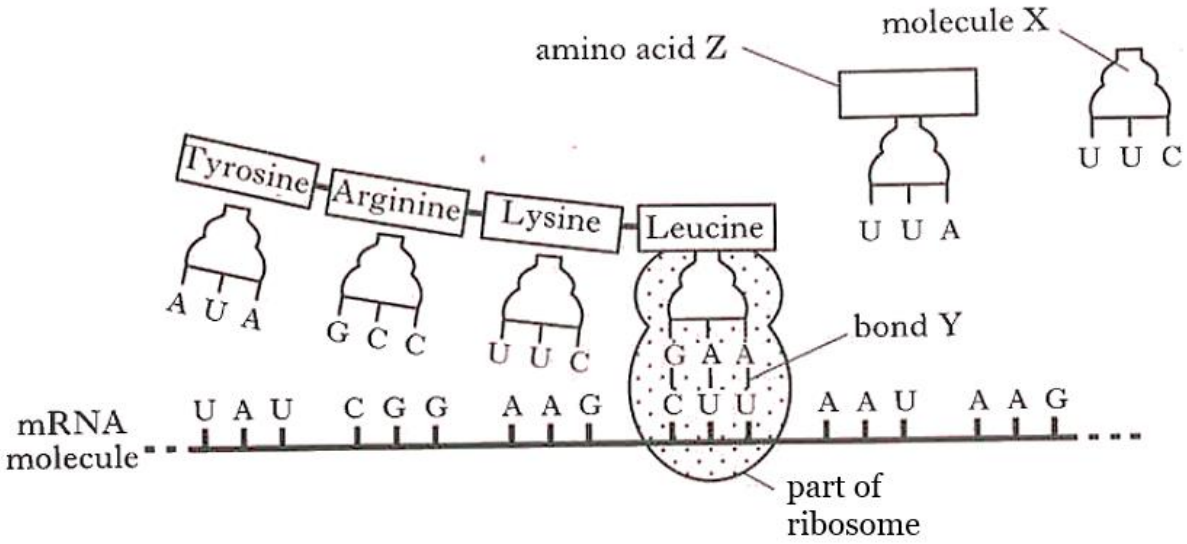
A The cell will begin the synthesis of different proteins.

B The cell will begin to differentiate as a result of the altered DNA.

C The number of mitotic divisions the cell can undergo will be limited.

D The production of mRNA will be reduced.

7 The diagram below shows events occurring during the synthesis of a protein that is secreted from a cell.



Which statements correctly describe the process shown?

1 During amino acid activation, lysine is likely to be attached to molecule X and the coupling reaction is catalysed by a group of enzymes called aminoacyl-tRNA synthetases.

2 Peptidyl transferase in the large subunit of ribosome catalyses the formation of bond Y.

3 The tRNA carrying the leucine amino acid is occupying the P site of the large subunit of the ribosome.

4 The sequences of the DNA bases on template strand that code for amino acid Z is AAT.

5 The codon UAU is closer to the poly A tail of the mRNA.

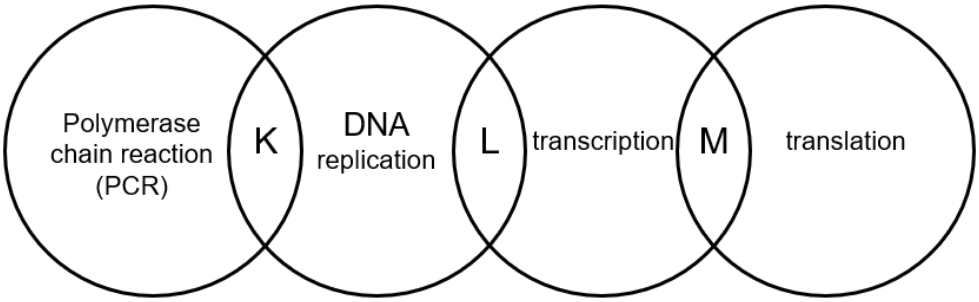
A 1 and 3

B 1, 2 and 5

C 1, 4 and 5

D 2, 3 and 4

8 Four processes that involved nucleic acids are shown in the diagram below.



Which features of these processes are represented by K, L and M?

	K	L	M
A	hydrogen bonds are broken	DNA as template strand	enzymes are involved
B	phosphodiester bonds are broken	template is read in 3' to 5' direction	can involve all three RNAs
C	primers are required	phosphodiester bonds are formed	template is read in 5' to 3' direction
D	double-stranded DNA denatures	happen in the nucleus only	complementary base-pairing occurs

9 'Viruses are **not** considered to be living organisms.'

Which statement supports the above argument?

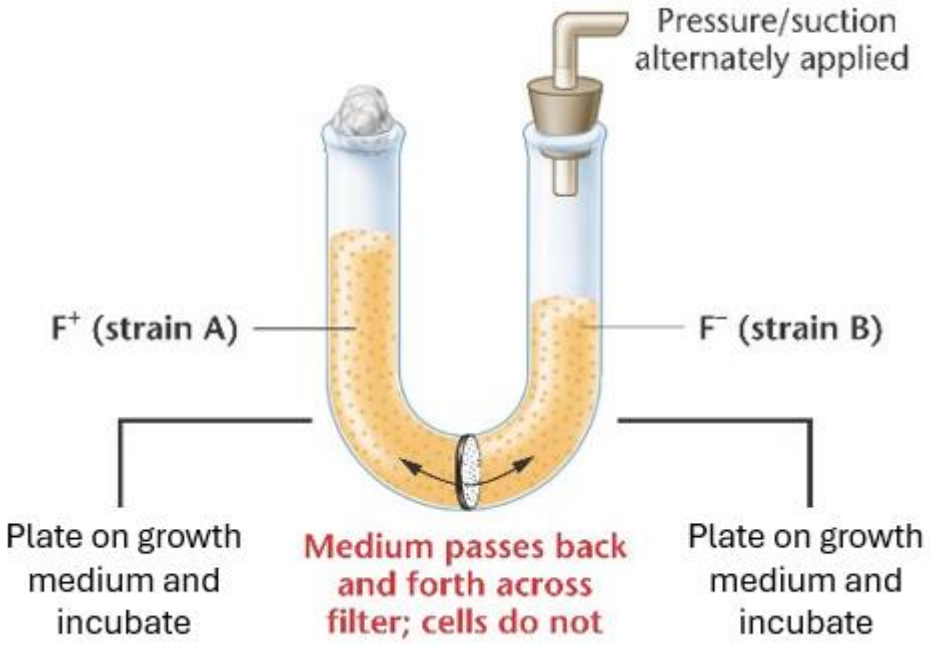
A Viruses are obligate parasite of living cells.

B Viruses are unable to multiply unless in the living cells of its host.

C Viruses carry coded information that can result in the production of polypeptides.

D Some viruses contain enzymes which may be used in their reproductive cycles.

10 In 1950, Bernard Davis conducted a classic experiment using a U-shaped tube, known as the U-tube experiment, to investigate the mechanisms of genetic exchange in bacteria.



The U-tube was divided by a fine filter that allowed the passage of molecules and viral particles but not cells. Davis first placed two different strains of bacteria in the same growth medium without any filter and he observed the growth of recombinant bacteria.

In a separate U-tube, he placed the two different strains of bacteria on either side of the filter. After allowing time for potential genetic exchange, he found that no genetic recombination occurred,

Based on the U-tube experiment conducted by Bernard Davis, which of the following statements about genetic recombination in bacteria is true?

A The experiment showed that specialised transduction occurred from F^+ donor cell to F^- recipient cells.

B The experiment provided evidence that generalised transduction occurred because the filter allowed the passage of viral particles.

C The U-tube experiment demonstrated that direct cell-to-cell contact is necessary for bacterial conjugation.

D The experiment concluded that DNA transfer in bacteria need to occur via transformation when bacteria are separated by a filter.

11 A mero-diploid is a haploid organism that is diploid for a small region of the chromosome, i.e. a partial diploid.

For example, a mero-diploid bacterium can have one I^- repressor gene in one *lac* operon and one I^+ repressor gene in the other *lac* operon.

I^+ is the wild type while I^- is a mutation which when expressed, produces a repressor that does not bind to the operator.

4 different mero-diploids, Q, R, S and T were investigated.

	lac operon 1	*lac* operon 2
Q	$I^+ + P + O^+ + Z^+ + Y^+ + A^+$	$I^+ + P + O^+ + Z^+ + Y^+ + A^+$
R	$I^+ + P + O^C + Z^+ + Y^+ + A^+$	$I^+ + P + O^+ + Z^+ + Y^+ + A^+$
S	$I^s + P + O^+ + Z^+ + Y^+ + A^+$	$I^+ + P + O^+ + Z^+ + Y^+ + A^+$
T	$I^+ + P + O^+ + Z^+ + Y^+ + A^+$	$I^- + P + O^+ + Z^+ + Y^+ + A^+$

- I^+, O^+, Z^+, Y^+ and A^+ are DNA sequences in the operon which have completely normal activity.
- P represents a normal promoter.
- O^C is a mutation specific on the operator region which will always prevent the binding of repressor protein to the operator region.
- I^s is a mutation which when expressed, produces a special repressor protein, which can still bind to the operator but not to allolactose.

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

1 For the *lac* operon, the capability of the repressor to bind to the operator region and prevent the transcription of structural genes depends on the conformation of the repressor protein and the operator.

2 In the presence of lactose, expression of the *lac* operon is possible in all of the above mero-diploid bacteria, Q, R, S and T.

3 R is the mero-diploid in which one of its *lac* operons will be always turned on.

A 1 only

B 1 and 2

C 2 and 3

D None of the above

12 The table shows a comparison of some aspects of the genomes of eukaryotes and prokaryotes in a descending order of biological complexity. Biological complexity refers to the number of parts that the organism is made up of.

organism	biological complexity	estimated genome size (base pairs)	estimated number of genes	gene density (number of genes per million base pairs)
Human		3 billion	25,000	6.5
Mouse		2.9 billion	30,000	10
Fruit fly		165 million	14,000	100
Rice plant		400 million	40,000	100
Roundworm		97 million	19,000	200
Yeast		12 million	6,000	520
Bacteria		4.6 million	4,400	950

Which statement can be concluded from the table?

A Biological complexity of an organism is correlated to the number of genes.

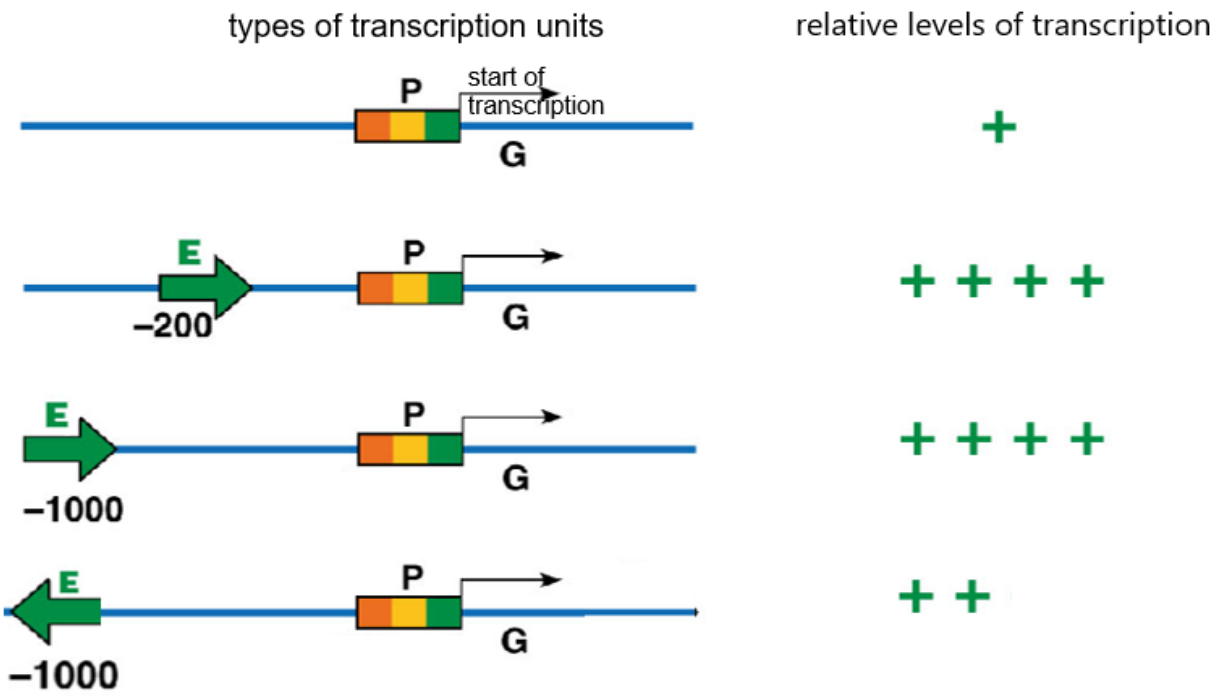
B Gene density is directly proportional to the biological complexity of an organism.

C More complex organisms tend to have larger genome sizes.

D More complex organisms have more introns and regulatory sequences.

13 A transcription unit is a sequence of DNA that codes for a single RNA molecule along with the regulatory sequences necessary for its transcription.

The diagram shows various types of transcription units and corresponding relative levels of transcription. The promoter, enhancer and coding sequences are represented by letters P, E and G respectively. The distance between the enhancer and the promoter is indicated by the number found below the E arrow where negative sign means upstream of the promoter, so – 200 below the E arrow means that the enhancer is 200 bases upstream of the promoter. The number of symbol '+' indicates the relative level of transcription.



With reference to the diagram, which statement is a valid conclusion?

A An enhancer is required for transcription.

B The relative level of transcription is increased only when the enhancer is located upstream of the promoter.

C The orientation of the enhancer does not affect the relative level of transcription.

D The relative distance between promoter and enhancer has no effect on the relative level of transcription.

14 The life cycle of a fly includes a transition from the larval to the pupal stage. When the larva is fully grown, it changes into a pupa that does not feed. In the pupa, the tissues that made up the body of the larva are broken down. New adult tissues are formed from the substances obtained from these broken-down tissues and from substances that were stored in the body of the larva.

The table shows the mean concentration of RNA in fly pupae at different ages.

age of pupa as percentage of total time spent as a pupa	mean concentration of RNA / µg per pupa
0	20
20	15
40	12
60	17
80	33
100	20

What is a possible explanation for the change in RNA concentration in the pupa at different ages?

A From 0 to 40% of the time spent as a pupa, RNA concentration decreases because it is broken down together with the tissues that are broken down.

B From 0 to 100% of the time spent as a pupa, RNA concentration increases because genes are transcribed to produce more RNA for translation into proteins to form new adult tissues.

C From 60 to 80% of the time spent as a pupa, RNA concentration increases as a result of activators binding to promoters of genes that code for proteins required for the formation of new adult tissues.

D Overall concentration of RNA at the start and the end of time spent as a pupa stayed the same because most RNAs are broken down when the pupa changes into an adult fly as no new protein needs to be synthesised.

15 The DNA sequence CCAAGAAGTCGACAAACA codes for the amino acid chain gly-ser-ser-ala-val-cys.

As a result of a single-base substitution, the sequence length of the amino acid chain is shortened from six to two amino acids.

Which base in the DNA sequence was changed by the mutation?

A A

B C

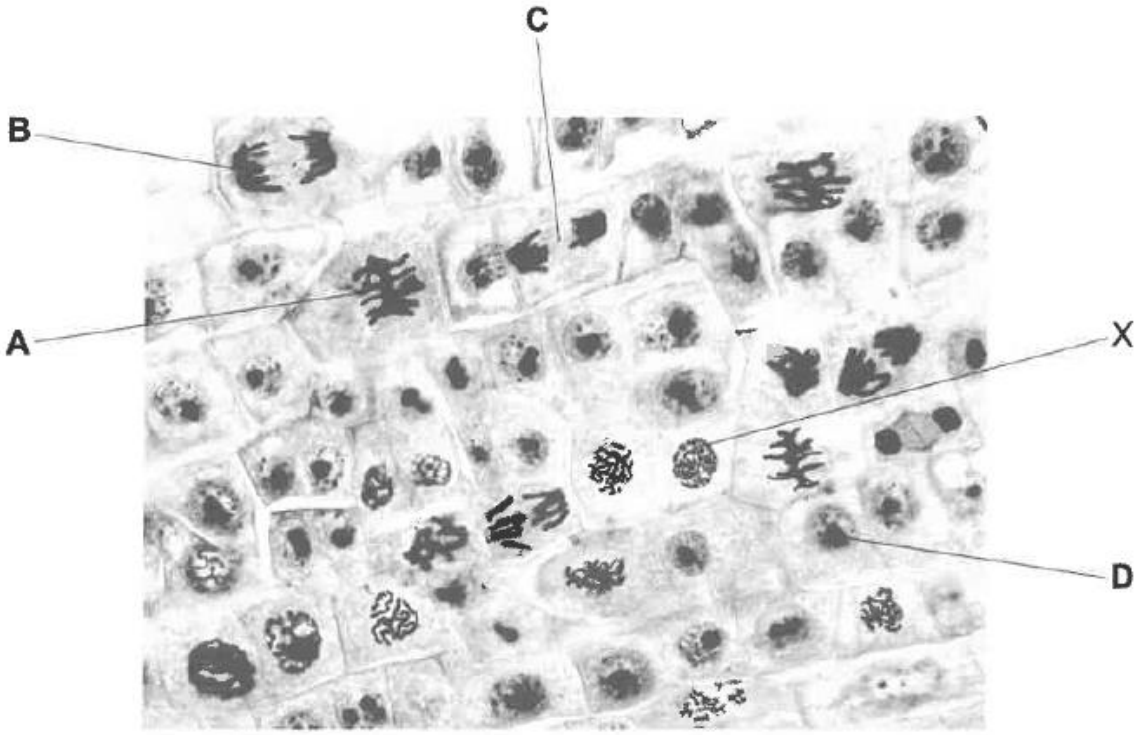
C G

D T

16 The photomicrograph shows a plant tissue where mitosis is occurring.

Cell X shows one of the main stages of mitosis.

Which labelled cell shows the next main stage of mitosis?



17 Male fruit flies have four pairs of homologous chromosomes. During meiosis, the chromosomes of each homologous pair are distributed randomly between the daughter cells. This process is called independent assortment.

How many different combinations of chromosomes are produced by independent assortment in male fruit flies?

A 4

B 8

C 16

D 32

18 The DNA in cells that are dividing is much more sensitive to damage by ionising radiation than the DNA in cells in interphase. There are mechanisms to repair damaged DNA but if these mechanisms cannot repair the DNA sufficiently, then the cell dies.

Which statements explain why ionising radiation is used to treat cancer?

1 Exposure to ionising radiation on its own does not increase the risk of cancer.

2 Dysregulation of the checkpoints of cell division is common in cancer cells and leads to uncontrolled cell division.

3 Proteins needed for DNA repair are often ineffective in cancer cells due to mutation of their genes.

A 1, 2 and 3

B 1 and 2

C 1 and 3

D 2 and 3

19 What is the correct sequence of events that finally leads to metastasis of cancer in the body?

1 Cells start to divide continuously.

2 The tumour develops a blood supply.

3 A mass of undifferentiated cells forms.

4 Cells stop responding to some signals.

A 1 → 2 → 3 → 4

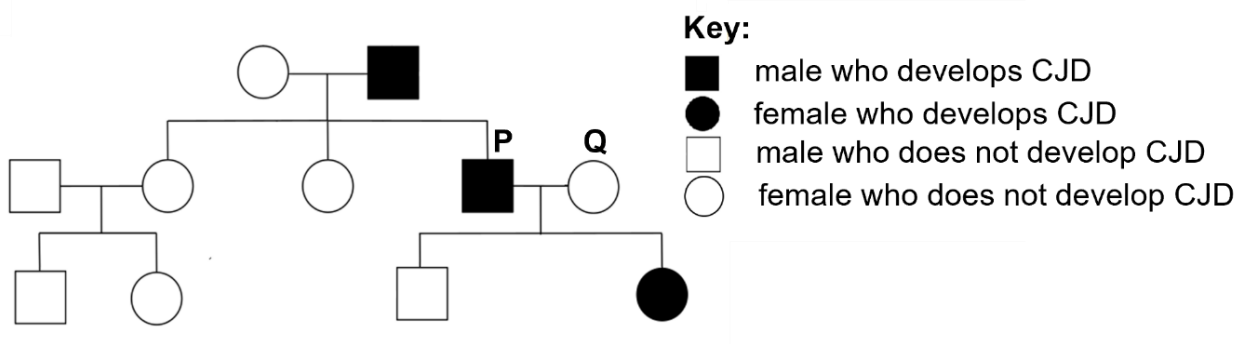
B 1 → 4 → 2 → 3

C 4 → 1 → 2 → 3

D 4 → 1 → 3 → 2

20 Creutzfeldt-Jakob disease (CJD) is a group of diseases that occurs in the brain. Familial CJD is one type of CJD that is caused by a dominant allele.

The family tree shows the occurrence of familial CJD in a family.



Individuals P and Q are expecting a pair of non-identical twins.

Which row provides the correct information about the inheritance of the disease as shown in this family tree?

	number of people heterozygous for the gene	probability that both twins, which P and Q are expecting, will be males who will develop CJD
A	3	0.25
B	3	0.0625
C	2	0.50
D	1	0.0625

21 A genetic cross involving two genes for flower characteristics was carried out using the sweet pea plant, *Lathyrus odoratus*.

- The gene involved in petal colour has two alleles, a dominant purple allele and a recessive maroon allele.
- The gene involved in fertility of anthers has two alleles, a dominant fertile allele and a recessive sterile allele.

A double homozygous dominant parent was crossed with a double homozygous recessive parent to obtain F1 offspring. The F1 offspring were then crossed with a double homozygous recessive plant (a test cross). The phenotypes of 200 test cross offspring were recorded.

phenotypes	Number of offspring
maroon petals fertile anthers	38
maroon petals sterile anthers	61
purple petals fertile anthers	63
purple petals sterile anthers	38

Which deductions can be made using the information provided?

1 A sweet pea plant that has maroon petals is more likely to have fertile anthers than a sweet pea plant with purple petals.

2 Four different genotypes were represented in the gametes produced by the F1 individual used in the test cross.

3 The genotype of the F1 offspring used in the test cross was known before the test cross was carried out.

4 The genotypes of the test cross offspring can be worked out.

A 2 only

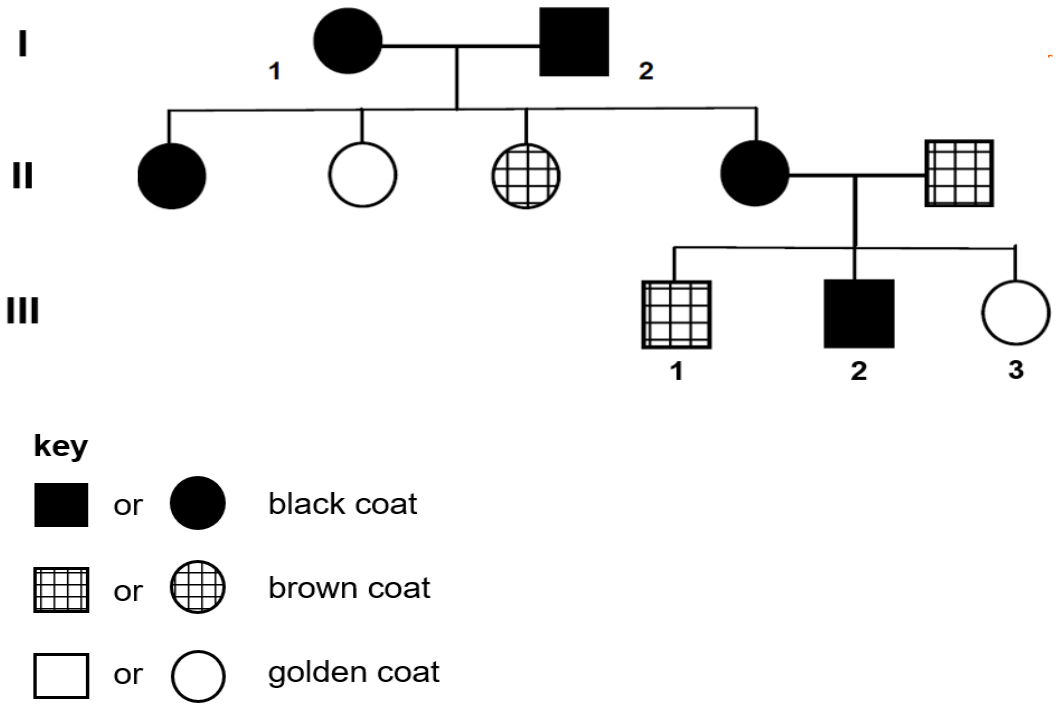
B 1 and 3

C 1 and 4

D 2, 3 and 4

22 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.



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

1 Genotypes of III-2 can be EeGg or EeGG.

2 The coat colours of Labrador Retriever dogs is an example of dominant epistasis.

3 Genotypes of III-3 can be Eegg.

4 When black-coated male (EeGg) mated with black-coated female (EeGg), the expected phenotypic ratio is 12 : 3 : 1.

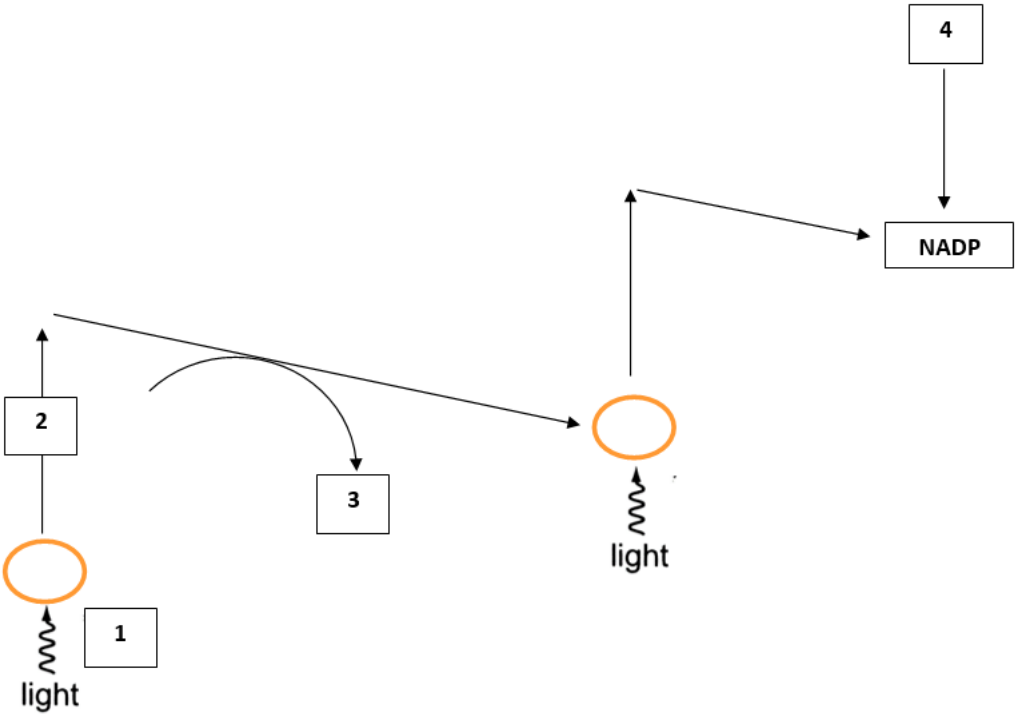
A 1 only

B 1 and 3

C 2 and 3

D 2 and 4

23 The diagram represents non-cyclic photophosphorylation.



What would be present at points 1, 2, 3 and 4?

	1	2	3	4
A	energy	electrons	ADP	hydrogen ions
B	electrons	energy	ATP	hydrogen atoms
C	energy	electrons	ATP	hydrogen ions
D	electrons	energy	ATP	electrons and hydrogen ions

24 Which substances are some of the final products of the Krebs cycle?

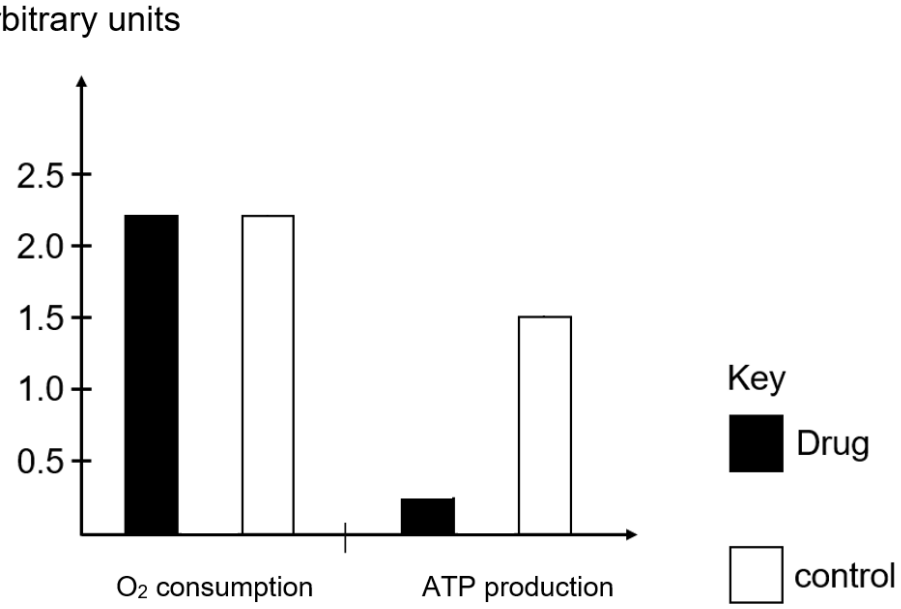
A ATP, reduced FAD and acetyl-CoA

B carbon dioxide, ADP and reduced NAD

C carbon dioxide, reduced NAD and ATP

D NAD, ATP and carbon dioxide

25 A drug can inhibit different proteins involved in respiration. Its effect on oxygen consumption and ATP production are recorded in the graphs below.



A student proposes the following inhibitory mechanisms of the drug.

1 Inhibits cytochrome oxidase, the enzyme catalysing the reduction of molecular oxygen to water.

2 Inhibits ATP synthase.

3 Provides an alternative pathway for protons to pass through the inner mitochondrial membrane.

4 Inhibits a dehydrogenase involved in glycolysis.

How many mechanism(s) is /are correct?

A 0

B 1

C 2

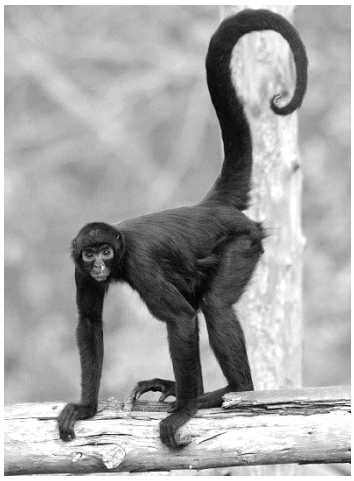
D 3

26 Signal transduction can take many steps.

Which row is true about signal transduction pathways?

	allow one type of signal molecule to give rise to more than one cellular response	allow different types of signal molecule to give rise to one cellular response	allow for multiple regulatory steps
A	✓	✓	✓
B	✓	✓	X
C	X	✓	✓
D	✓	X	X

27 Seahorses and spider monkeys both possess a prehensile tail as shown in the pictures below. The prehensile tail allows them to grasp and hold onto structures.



How many of the following statement(s) is/are correct?

1 The prehensile tail is a homologous structure derived from a recent common ancestor shared by the seahorse and spider monkey.

2 The seahorse and spider monkey evolved the prehensile tail independently due to similar selection pressures in their environment.

3 The prehensile tail is an example of convergent evolution due to both species sharing the same ecological niche.

4 The prehensile tail is an example of descent with modification, as the tail shows modifications in the two species over time.

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

28 Antibiotic-resistant strains of *Mycobacterium tuberculosis* are a major problem when treating tuberculosis. A new antibiotic, teixobactin, could be very effective at killing *M*. *tuberculosis* with only a small risk that the bacteria will evolve teixobactin resistance.

Penicillin and similar antibiotics bind to a single protein, but teixobactin binds to two lipids that are needed for the formation of the bacterial cell wall. Teixobactin binds to regions of the two lipids that do not vary across many different species of bacteria.

Which statements help to explain why the use of teixobactin is thought to be less likely to lead to the evolution of antibiotic resistance than the use of many other antibiotics, such as penicillin?

1 A single mutation can result in bacteria that are resistant to penicillin and similar antibiotics but at least two mutations are required to produce teixobactin-resistant bacteria.

2 Mutations can affect the structure of proteins but cannot affect the structure of lipids because only proteins are made of amino acids.

3 The lack of variation across many species of bacteria in the two lipids that bind to teixobactin suggest that the particular structure of these lipids is essential for successful bacterial cell wall formation.

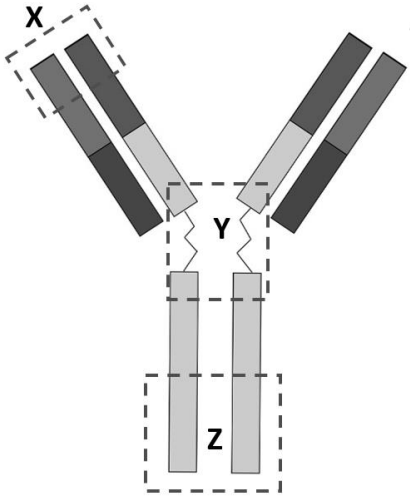
A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

29 The diagram shows an antibody molecule.



Which statements on formation of antibody diversity are **false**?

1 Multiple variable gene segments result in variation in region X.

2 Region Y shows the disulfide bridges that gives the flexibility for the antibody molecule to bind to different types of antigens.

3 Affinity maturation through the process of somatic hypermutation in region X occurs during the production of naïve B and T cells.

4 Class switching to other classes in region Z occurs to further diversify antibodies of the same specificity.

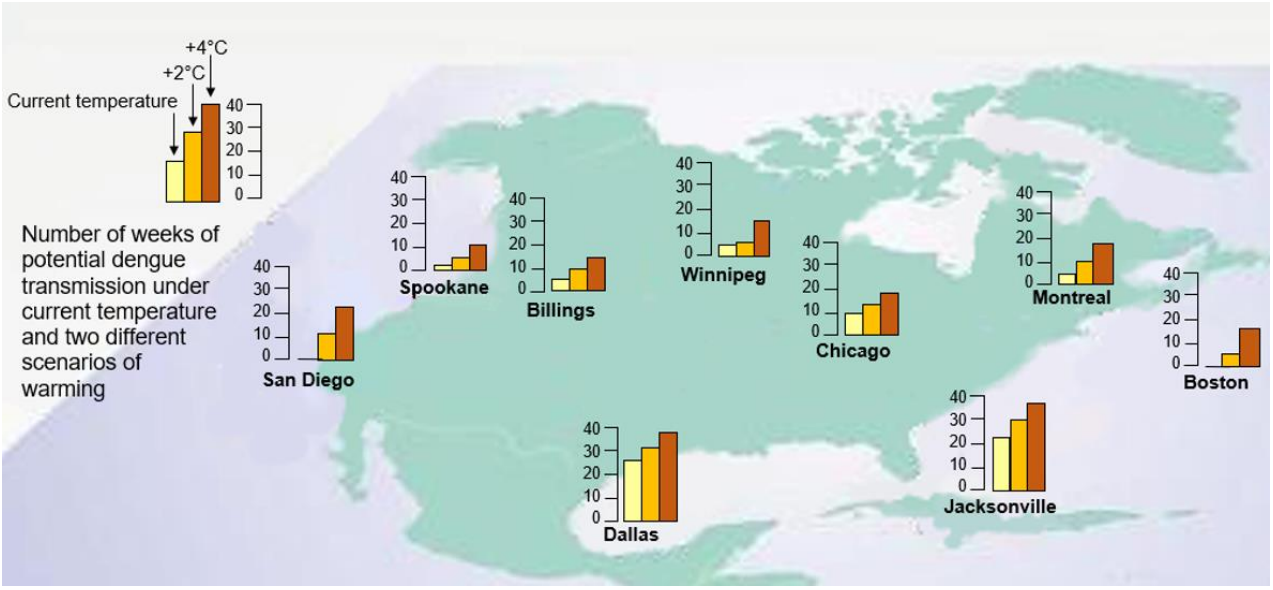
A 1 and 4 only

B 2 and 3 only

C 1, 3 and 4 only

D 2 only

30 The diagram shows the potential dengue transmission in case of temperature rise in different cities.



Which of the following statements **cannot** be inferred from the diagram?

1 An increase in temperature will increase the dengue transmission rate.

2 The severity of the dengue outbreak will vary across all the cities.

3 Spookane has the lowest dengue transmission because it is the coldest city.

4 When temperature increases from +2°C to +4°C in Boston, the number of weeks of potential dengue transmission will be tripled.

A 1 and 2

B 2 and 3

C 1 and 4

D 3 only

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