**HWA CHONG INSTITUTION**
**JC2 Preliminary Examinations**
**Higher 2**

| | | | |
|---|---|---|---|
| **CANDIDATE NAME** | | **CT GROUP** | **21S7___** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CENTRE NUMBER** | | | | | **INDEX NUMBER** | | | |

# BIOLOGY

**9744/01**

Paper 1 Multiple Choice

**20 September 2022**

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.

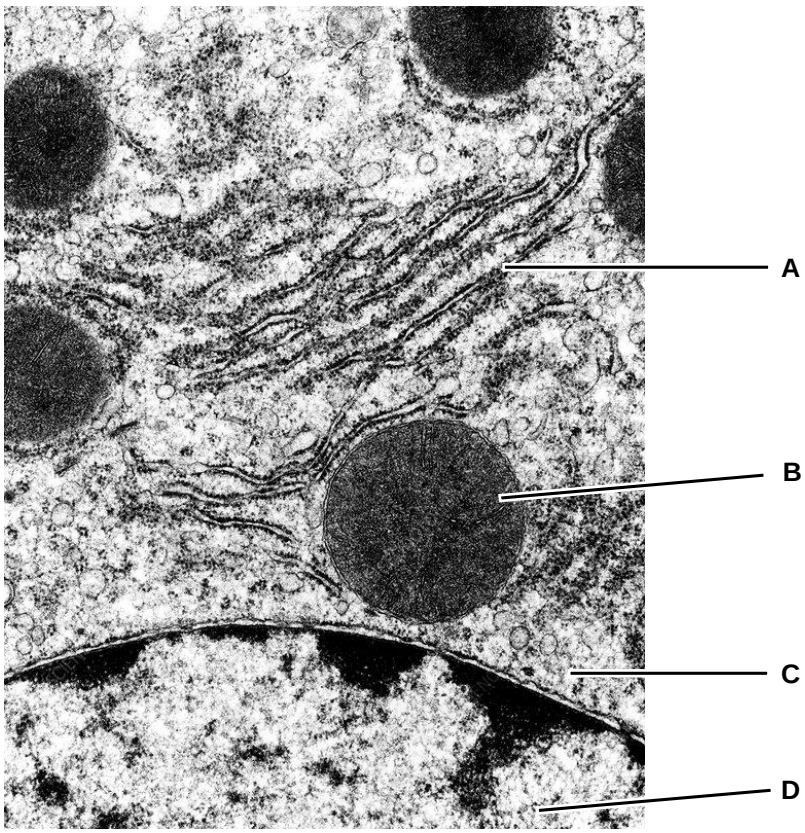
## INFORMATION FOR CANDIDATES

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.

**1** The electronmicrograph shows part of a eukaryotic cell with structures labelled **A**, **B**, **C** and **D**.




Which statement is correct?

**A** Rough endoplasmic reticulum divides the cytoplasm into compartments and is studded with numerous ribosomes, which synthesise proteins.

**B** Mitochondrion is an energy transducer where fats and sugars are reduced to produce ATP.

**C** Cytoplasm is an aqueous matrix containing proteins and DNA for transcription.

**D** Euchromatin is a loosely coiled form of chromatin that is associated with proteins called histones.

**2** What are the essential structural features of viruses?

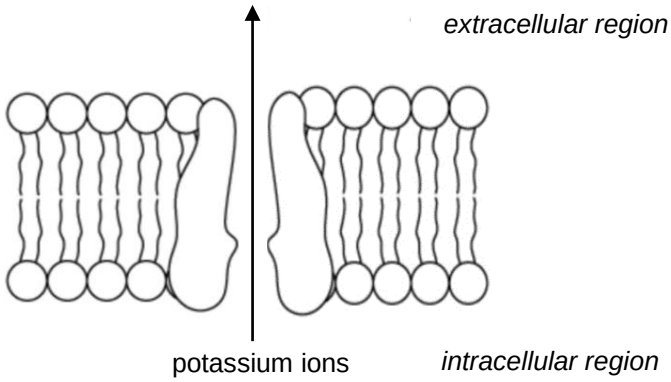
1 non-cellular
2 protein coat
3 both DNA and RNA
4 either DNA or RNA

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

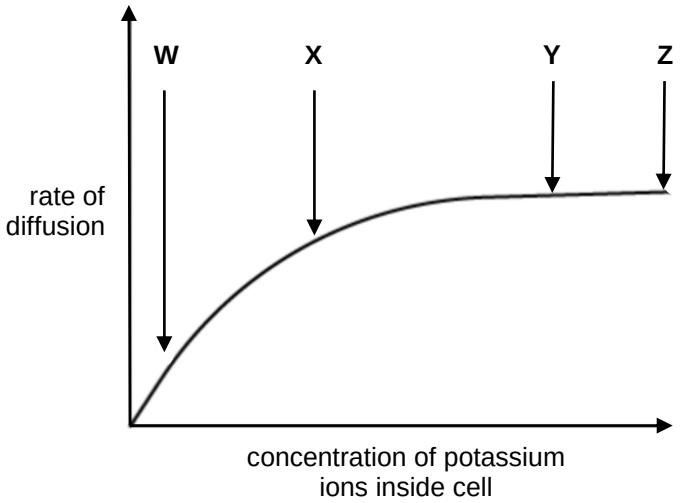
**3** Which row correctly describes the primary, secondary, tertiary and quaternary structures of some proteins?

| | primary structure | secondary structure | tertiary structure | quaternary structure |
|---|---|---|---|---|
| **A** | determines the folding of the polypeptide | depends on hydrogen bonding between the side-chains of amino acids | defines the overall shape and folding of the protein | formed when two or more identical polypeptides join together |
| **B** | defines the order of amino acids in the polypeptide | usually forms immediately after polypeptide synthesis | is held together by all the types of bonding that occur in proteins | found in globular proteins such as haemoglobin but never in fibrous proteins |
| **C** | involves covalent bonds only | involves hydrogen bonding | essential for the function of enzymes and receptors | formed when two or more polypeptides join together |
| **D** | involves peptide bonds between the side-chains of amino acids | involves folding between local regions within a polypeptide molecule | changes reversibly when bound to non-competitive inhibitors | can involve hydrogen bonds, covalent bonds and hydrophobic interactions |

**4** The diagram shows part of a cell surface membrane. The arrow shows the path taken by potassium ions when they diffuse through the membrane out of a cell.



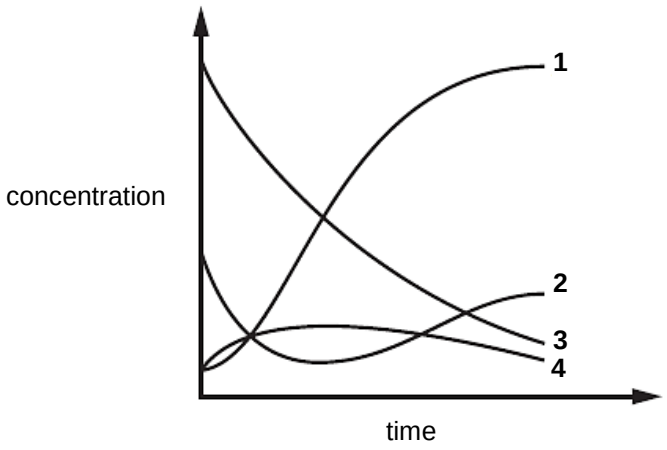

The graph shows how the rate of diffusion of potassium ions across the cell surface membrane is affected by the concentration of potassium ions within the cells.




Which row is correct?

| | region **W** to **X**: limiting factor on the rate of diffusion | region **Y** to **Z**: limiting factor on the rate of diffusion |
|---|---|---|
| **A** | concentration of potassium ions inside the cell | number of potassium channels |
| **B** | number of potassium channels | concentration of potassium ions outside the cell |
| **C** | concentration of potassium ions inside the cells | slower rate of potassium ions passing through the channels |
| **D** | concentration of potassium ions outside the cell | minimum rate of potassium ions passing through the channels |

**5** The graph shows how the concentration of components of an enzyme-catalysed reaction changes with time.




Which row is correct?

| | enzymes with empty active sites | substrates | products | enzyme-substrate complexes |
|---|---|---|---|---|
| **A** | 1 | 2 | 4 | 3 |
| **B** | 2 | 3 | 1 | 4 |
| **C** | 4 | 1 | 3 | 2 |
| **D** | 3 | 4 | 2 | 1 |

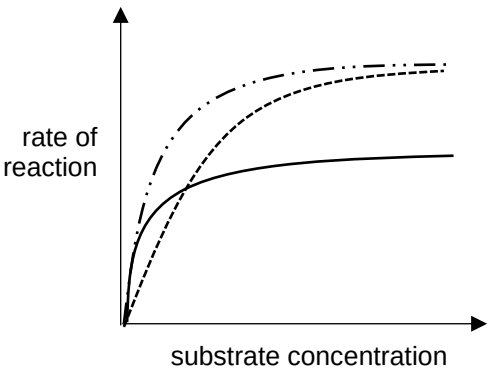
**6** Catechol oxidase is an enzyme found in fruits that oxidises catechol into a quinone, which causes browning.

Commercial catechol oxidase could be inhibited by the following chemicals:

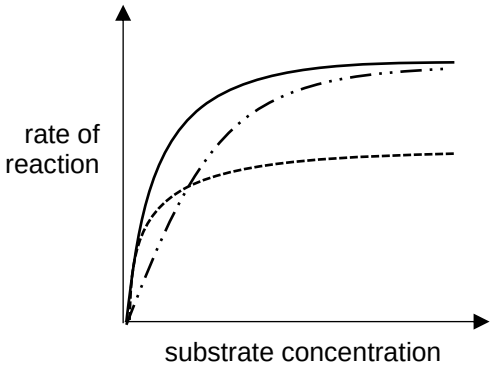
- parahydroxybenzoic acid (PHBA), a chemical structurally similar to catechol
- pheynlthiourea (PTU), which binds to a copper atom in the enzyme away from the active site.

Which graph correctly shows the activity of the two inhibitors?

**A**



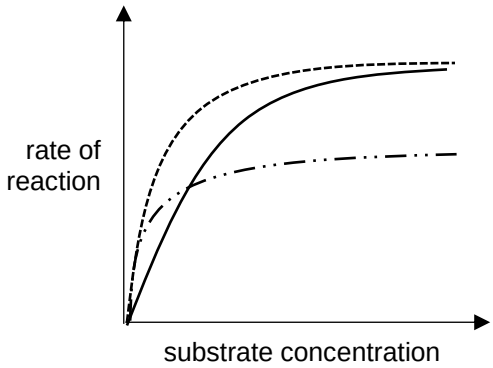

**B**



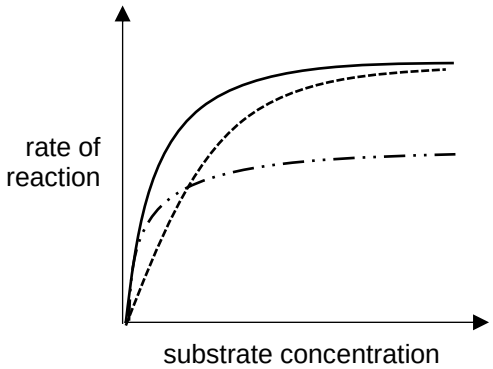

key:

No inhibitors
PHBA
PTU

**C**




**D**




**7** Which statements are **true** about stem cells?

1 Stem cells extracted from any tissue can immediately differentiate into skin cells with the introduction of appropriate transcription factors.

2 One potential side effect of any stem cell-based therapy is the formation of a tumour.

3 Human embryonic stem cells are removed at an early stage of embryonic development from a region of the blastocyst known as the inner cell mass.

4 Any stem cell can develop into a whole organism when implanted into the uterus.

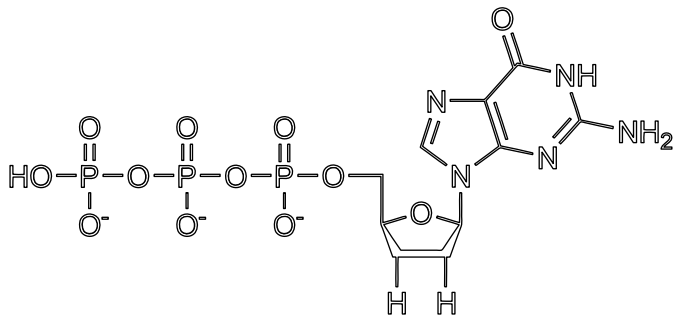
**A** 1 and 2

**B** 2 and 3

**C** 1, 3 and 4

**D** 2, 3 and 4

**8** The diagram shows the structure of a nucleotide that can fit the active site of DNA polymerase.



Which statement predicts the effect that the nucleotide has on DNA replication?

**A** The nucleotide cannot be added to the 3' end of the growing DNA strand.

**B** The nucleotide can be added to the 3' end of the growing DNA strand but will not allow the next nucleotide to be added to it.

**C** The nucleotide can be added to the 3' end of the growing DNA strand and will also allow the next nucleotide to be added to it.

**D** The nucleotide can be added to the 3' end of the growing DNA strand and will also allow the next nucleotide to be added to it, but it will be replaced by upstream DNA synthesis later.

**9** Some of the stages of transcription in a eukaryotic cell are listed.

1 TATA box binding protein binds to the promoter on DNA.

2 A poly(A) signal is transcribed.

3 RNA polymerase dissociates from the transcription initiation complex.

4 Twenty-three nucleotides of RNA are synthesised allowing the transcription initiation complex to move away from the core promoter.

5 General transcription factors and RNA polymerase bind at promoter on DNA, forming the transcription initiation complex.

Using the information provided above, what is the order in which these stages occur?

**A** 1 → 5 → 2 → 3 → 4

**B** 1 → 5 → 4 → 3 → 2

**C** 5 → 1 → 4 → 3 → 2

**D** 5 → 4 → 1 → 2 → 3

**10** During metaphase of mitosis, a scientist stains the chromosomes of a diploid animal cell with fluorescent dye to allow the telomeres to be observed.

This cell has 26 chromosomes.

How many telomeres will the scientist observe?

**A** 26 **B** 52 **C** 78 **D** 104

**11** Three parts of a chromosome and their functions are listed.

| part | | function | |
|---|---|---|---|
| p1 | centromere | f1 | holds the coils of DNA together |
| p2 | histone proteins | f2 | holds two chromatids together |
| p3 | telomere | f3 | prevents loss of genes |

Which row shows the correct match of all the parts with their functions?

| | | | |
|---|---|---|---|
| **A** | p1 and f1 | p2 and f2 | p3 and f3 |
| **B** | p1 and f2 | p2 and f1 | p3 and f3 |
| **C** | p1 and f2 | p2 and f3 | p3 and f1 |
| **D** | p1 and f3 | p2 and f1 | p3 and f2 |

**12** Casein is a major protein found in mammalian milk. The two flowcharts show the pathways for production of casein.

Fig. 1a shows the pathway for the production of casein when the mammals are producing milk.

Fig. 1b shows the pathway when the mammals are not producing milk.

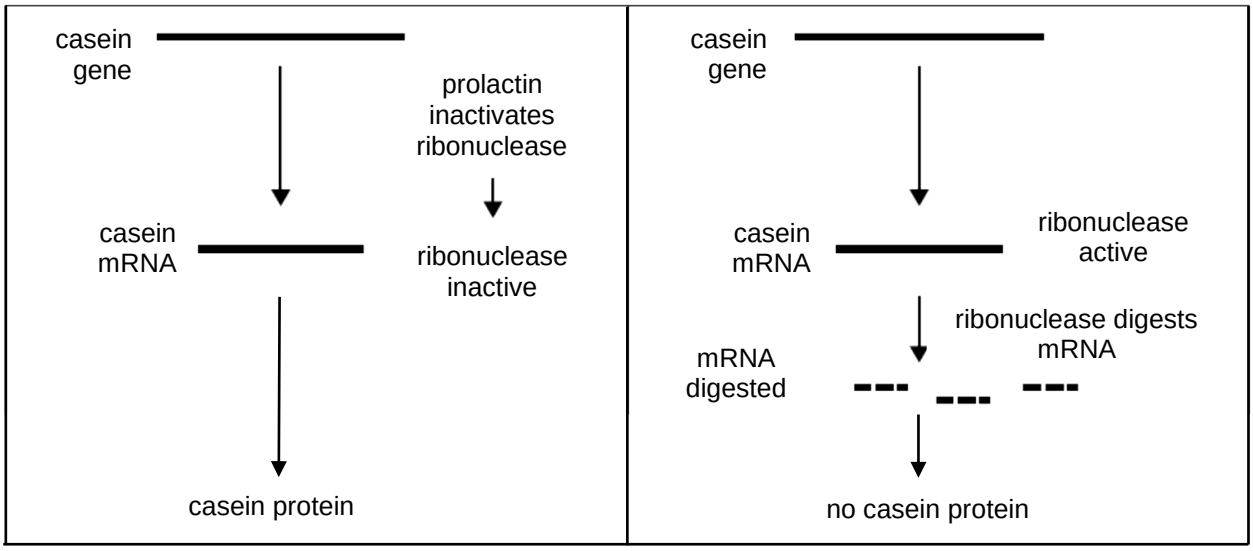



Fig. 1a

Fig. 1b

Which conclusion can be made from the information provided?

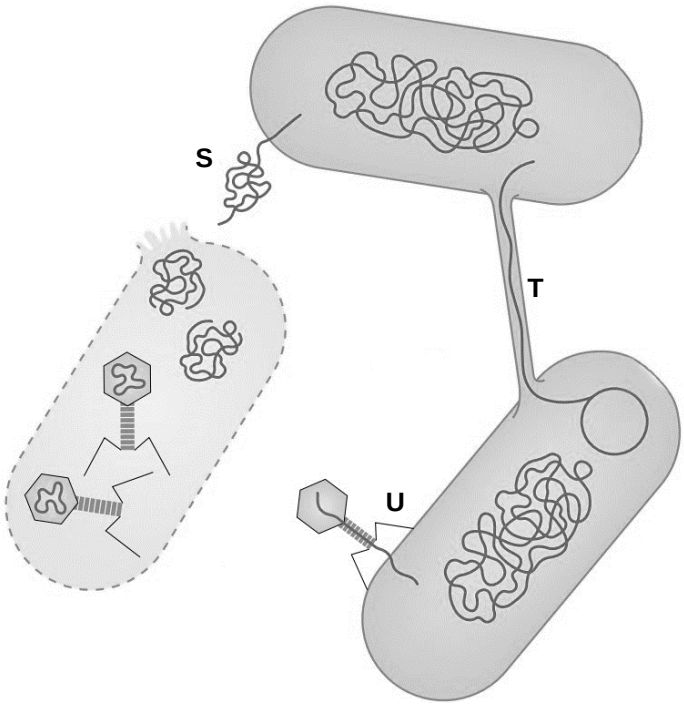
**A** Ribonuclease controls expression of the casein gene at the transcriptional level.

**B** Casein is a repressor protein for milk production in mammals.

**C** The hormone prolactin allows for the expression of the casein gene.

**D** Mammals produce milk only in the absence of the hormone prolactin, which acts as a repressor protein.

**13** 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

**14** Which row correctly describes the metabolism of lactose and tryptophan in *E. coli* cells?

| | *lac* operon | *trp* operon |
|---|---|---|
| **A** | repressible operon | inducible operon |
| **B** | codes for enzymes involved in anabolic pathway | codes for enzymes involved in catabolic pathway |
| **C** | allolactose is a corepressor | tryptophan is an inducer |
| **D** | transcription occurs in the presence of lactose | transcription occurs in the absence of tryptophan |

**15** Factor V is a protein circulating in blood that is necessary for proper blood clotting.

A single mutation to the *Factor V* gene leads to the replacement of amino acid arginine with glutamine. This forms an abnormal Factor V which remains active and leads to excessive clotting.

The table shows the mRNA codons for both arginine and glutamine respectively.

| amino acid | mRNA codon |
|---|---|
| arginine | CGU, CGC, CGA, CGG, AGA, AGG |
| glutamine | CAA, CAG |

Which correctly describes the events leading up to the formation of the abnormal Factor V?

**A** A single pyrimidine substitution.

**B** A single purine substitution.

**C** A single pyrimidine insertion.

**D** A single purine deletion.

**16** A student sets out to compare DNA from monkeys living in different parts of Bukit Timah Nature Reserve. During the course of research, he amplified a 500 bp sequence from the monkey's mitochondrial genome using PCR.

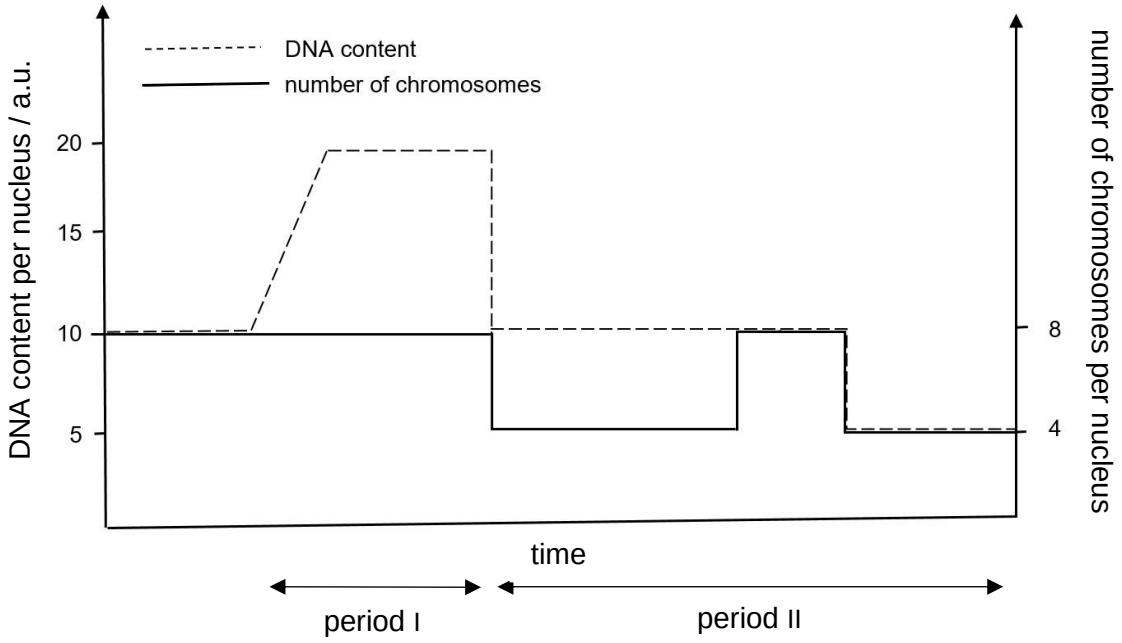
The flow chart shows the steps taken by the student.

step 1 – isolate mitochondrial DNA (mtDNA) from each monkey's hair follicles.
↓
step 2 – amplify the mtDNA at a precise location.
↓
step 3 – verify that mtDNA amplification was successful using gel electrophoresis.
↓
step 4 – sequence the mtDNA fragments from the gel and compare the samples.

Which row is correct?

| | step | description |
|---|---|---|
| **A** | 1 | requires the extraction of linear, double-stranded DNA from follicular cells |
| **B** | 2 | usually requires a reaction mixture containing two single-stranded DNA primers |
| **C** | 3 | verifies that mtDNA amplification is successful if two bands appear upon staining of the agarose gel with methylene blue |
| **D** | 4 | requires the application of single-stranded, radioactively-labelled probes. |

**17** The diagram shows the DNA content and the number of chromosomes in a nucleus of a cell at various stages of a cell cycle.




Which statement is true regarding the diagram?

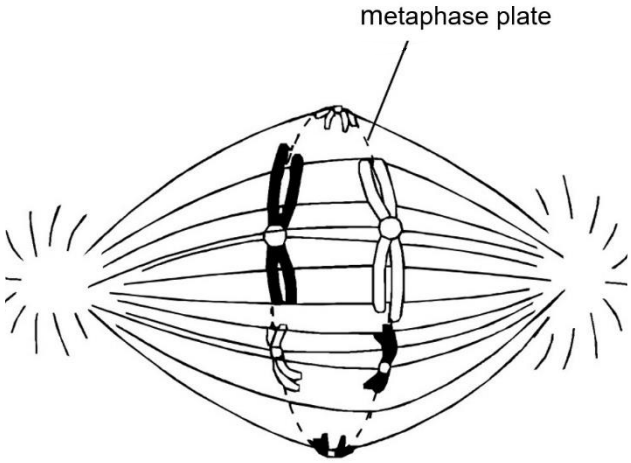
**A** S and $G_1$ phases of interphase occur in period I of the cell cycle.

**B** Processes leading to genetic variation occurs only in period II of the cell cycle.

**C** Equational division only occurs during period II of the cell cycle.

**D** Genetically identical daughter cells are produced in period II of the cell cycle.

**18** The diagram shows a newly discovered cell undergoing cell division. This cell contains 20 µg of DNA before undergoing interphase.




Which statement is correct?

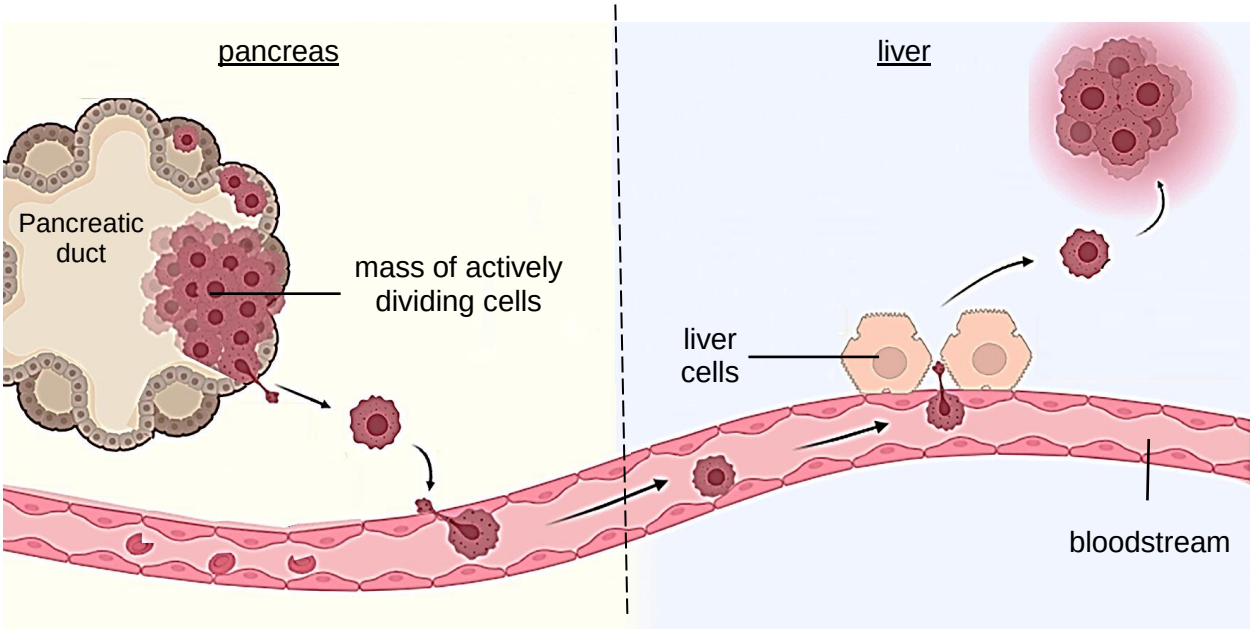
**A** In the next stage of cell division, the polar microtubules in the cell start to slide past one another, elongating the animal cell.

**B** Crossing over has occurred between two pairs of homologous chromosomes in this diploid cell.

**C** The cell contains six chromosomes at the end of telophase I of meiosis.

**D** Cytokinesis will occur after meiosis II to produce four haploid cells, each containing 5 µg of DNA.

**19** The diagram illustrates some processes in the development of cancer in humans.




Which statements are correct?

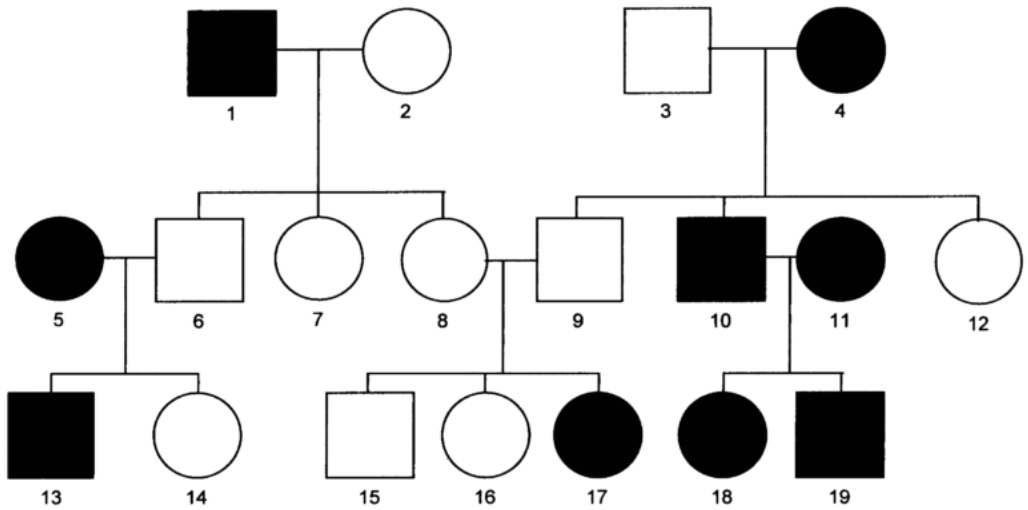
1 The mass of actively dividing cells in the pancreatic duct displays a lack of contact inhibition.

2 The bloodstream allows the pancreatic cells to migrate from the pancreas to the liver to form a secondary tumour.

3 The mass of cells in the liver undergoes repeated rounds of cell division, giving rise to clones of malignant cancer cells which may invade the surrounding tissues in the liver.

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

**20** The pedigree of a family with a novel disease causing mutation is shown.




Which is the correct mode of inheritance?

**A** sex-linked recessive

**B** sex-linked dominant

**C** autosomal recessive

**D** autosomal dominant

**21** The table shows the results of an early investigation into the genetic control of phenotypic variation.

The dry masses of 5493 bean seeds collected from many plants were classified into nine categories.

| mass of bean / mg | 51-150 | 151-250 | 251-350 | 351-450 | 451-550 | 551-650 | 651-750 | 751-850 | 851-950 |
|---|---|---|---|---|---|---|---|---|---|
| number of beans | 5 | 38 | 370 | 1676 | 2255 | 928 | 187 | 32 | 2 |

Which statement correctly describes these data and could account for the variation shown?

**A** The phenotypic variation is continuous and could be the result of two unlinked genes acting on their own.

**B** The phenotypic variation is continuous and could be the result of several unlinked genes acting on their own.

**C** The phenotypic variation is discontinuous and could be the result of two linked genes acting on their own.

**D** The phenotypic variation is discontinuous and could be the result of several linked genes acting on their own.

**22** Both the genes for body colour and wing length in fruit flies are found on chromosome 2.

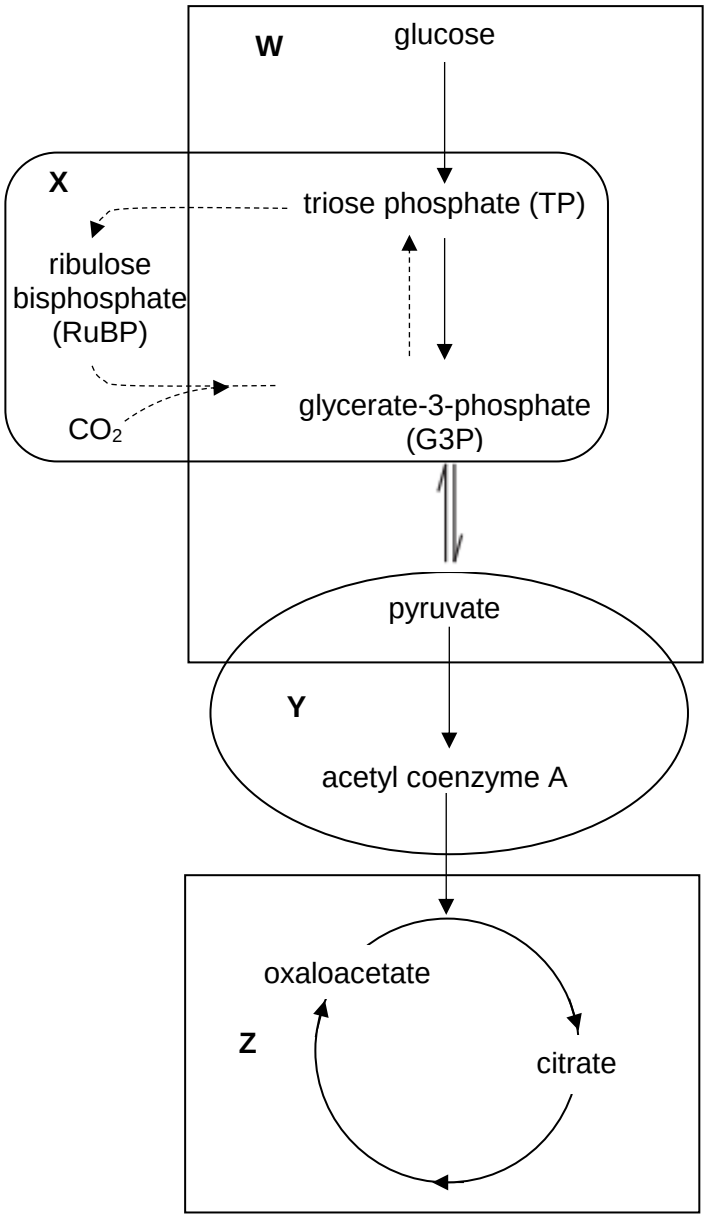
Pure breeding *Drosophila* flies with brown bodies and vestigial wings were crossed with pure breeding *Drosophila* flies with black bodies and long wings. All offspring in the F1 generation had brown bodies with long wings.

The F1 generation was crossed with flies with black bodies and vestigial wings and a total of 400 offspring were obtained.

Which row is correct?

| | brown body, vestigial wings | black body, vestigial wings | brown body, long wings | black body, long wings |
|---|---|---|---|---|
| **A** | 27 | 173 | 170 | 30 |
| **B** | 103 | 101 | 97 | 99 |
| **C** | 172 | 30 | 34 | 164 |
| **D** | 73 | 27 | 226 | 74 |

**23** Some metabolic pathways that take place in a plant cell are shown below. Processes **W**, **X**, **Y** and **Z** are labelled.




Which statement is correct?

**A** Process **W** results in the net formation of two molecules of NADH and two molecules of ATP.

**B** Process **X** involves the formation of ATP from decarboxylation.

**C** Process **Y** occurs in the cytoplasm and involves pyruvate dehydrogenase with the removal of one carbon dioxide.

**D** Process **Z** involves the reduction of coenzymes NAD and FAD using up ATP in the process.

**24** How many statement(s) regarding alcoholic fermentation and lactic acid fermentation are correct?

1 Alcoholic fermentation involves the loss of one carbon dioxide molecule in the conversion of a molecule of pyruvate to ethanol.
2 Lactic acid fermentation involves pyruvate as the electron donor for the reduction process.
3 The products of both processes can eventually be completely oxidized in the presence of oxygen.

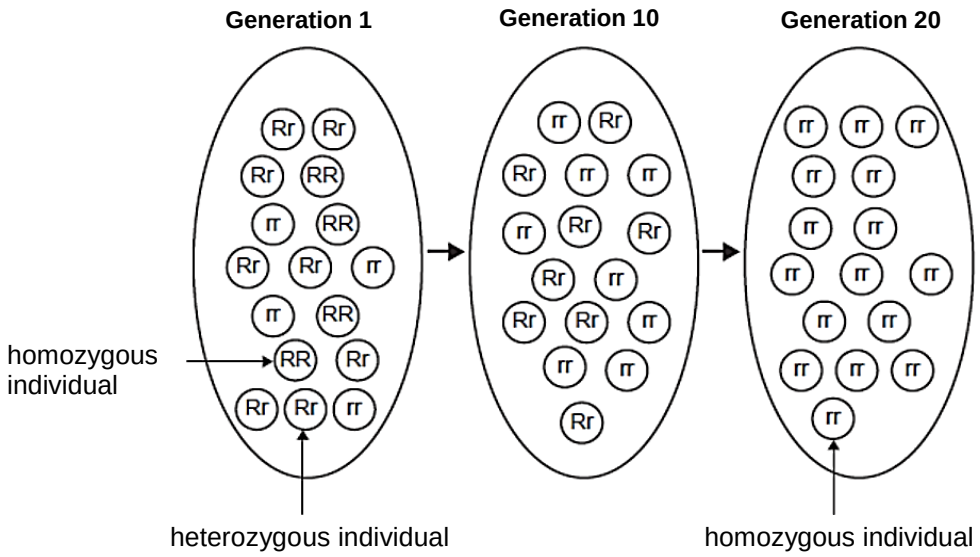
**A** 0 **B** 1 **C** 2 **D** 3

**25** Signal transduction can take many steps. The activation of a protein kinase cascade is part of the signal transduction pathway.

Which row is true about the signal transduction pathway?

| | allows for amplification of a signal for a response of larger magnitude | allows for amplification of a signal for more than one cellular response | allows for multiple regulatory steps |
|---|---|---|---|
| **A** | √ | √ | √ |
| **B** | √ | × | × |
| **C** | × | √ | √ |
| **D** | × | × | × |

**26** The diagram shows the gene pool of a population over 20 generations.




What is a possible conclusion that can be made?

**A** Genetic diversity is increasing in this population.

**B** Individuals with the genotype RR had a selective advantage in this population.

**C** The frequency of each allele is equal in Generation 1 but not in other generations.

**D** New advantageous alleles for this gene were introduced as individuals joined this population.

**27** Soay sheep, a primitive breed of domesticated sheep, live wild on the small and remote Scottish island of Hirta.

Studies have shown that the mean size of an adult Soay sheep has been decreasing over the past thirty years.

Which statements could explain the decrease in mean size of adult Soay sheep on Hirta?

1 Stabilising selection is occurring, with the largest and smallest sheep being selected against.
2 Small lambs are less likely to survive their first winter than large lambs.
3 Climate change has led to milder winters, so smaller lambs are surviving to adulthood.
4 Food has become scarcer and smaller sheep need less food than larger sheep.

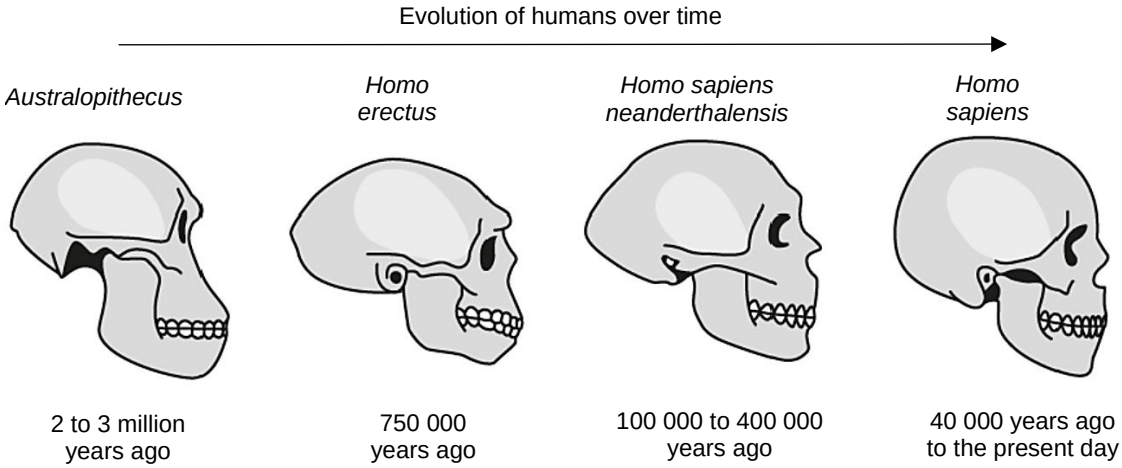
**A** 1 only

**B** 1 and 3 only

**C** 2 and 4 only

**D** 3 and 4 only

**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 recent common ancestor of *Homo sapiens*.

4 There is a greater variety of human fossils in younger rocks.

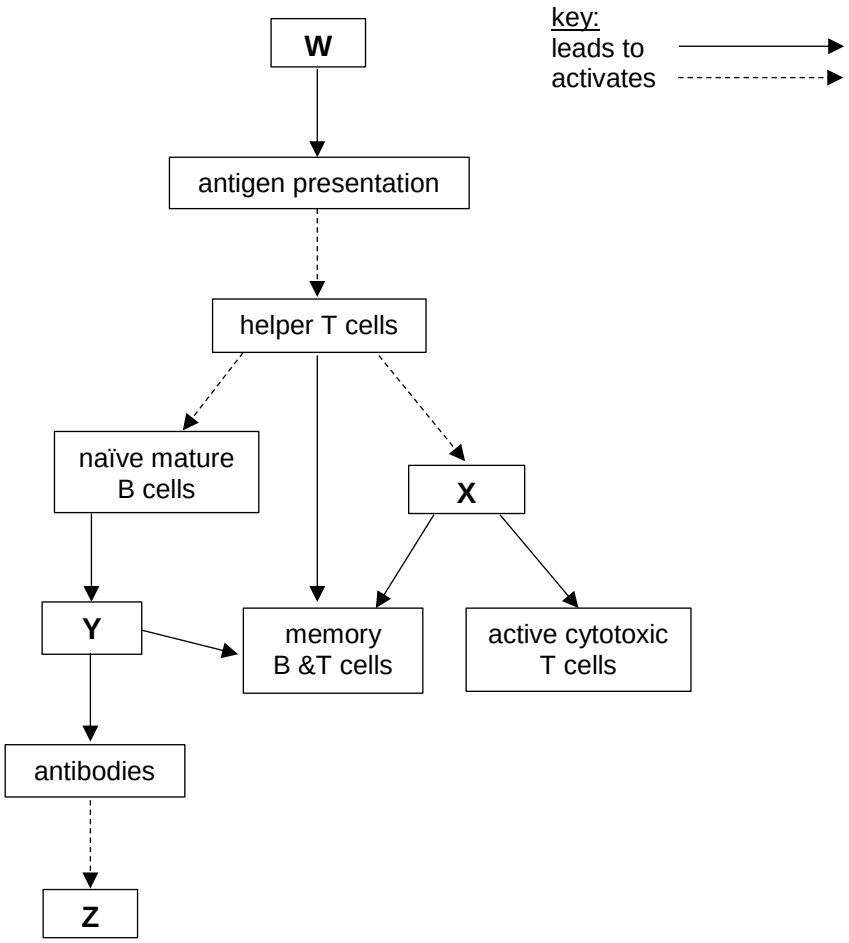
**A** 1 and 2

**B** 3 and 4

**C** 1, 2 and 3

**D** 2, 3 and 4

**29** The flowchart of an immune response is shown, where **W**, **X**, **Y** and **Z** are components involved in the immune response.




Which statement is correct?

**A** **W** is a HIV provirus that infected a T cell in an immunocompromised patient.

**B** **X** is a cytotoxic T cell that is activated to remove circulating pathogens.

**C** **Y** is formed when B cells undergo somatic recombination after activation by T helper cells.

**D** **Z** are proteins that associate together to result in lysis of pathogenic bacteria.

**30** Chikungunya is an infection caused by the chikungunya virus (CHIKV). CHIKV is spread in humans via two types of mosquitoes – *Aedes albopictus* and *Aedes aegypti*.

When chikungunya was first identified in 1952, it had a low level of circulation in West Africa, with infection rates linked to rainfall. Beginning in the 1960s, periodic cycles of outbreak and dormancy were documented in Africa and Asia, with the *Aedes aegypti* as the main vector.

However, in 2005, re-emergence and outbreaks of chikungunya were recorded in Africa, Asia and the Americas. Genetic analysis of the 2005 variant of CHIKV showed a change in the viral coat protein, allowing for the virus to multiply more easily in mosquito cells. This mutation allowed the virus to use the *Aedes albopictus* as a vector.

Four explanations by scientists to explain the spread of CHIKV from Africa to Asia and Americas are listed:

1 Increased rainfall from climate change leading to increase in mosquito larval habitats.
2 *Aedes albopictus* had a selective advantage over *Aedes aegypti* as a vector because they occupy the same ecological niche.
3 Increased global temperatures leading to an increased geographical range of *Aedes* mosquito to temperate regions.
4 Decreased overwintering success of mosquitoes leading to longer life cycles of mosquito, leading to more offspring produced by the mosquitoes.

Which of the statements are possible to explain the 2005 outbreak of chikungunya?

**A** 1 and 2

**B** 1 and 3

**C** 2 and 3

**D** 3 and 4

**---END OF PAPER---**