Anglo-Chinese Junior College

JC2 Biology Preliminary Examination
Higher 1

A Methodist Institution
(Founded 1886)

BIOLOGY **8876/01**

Paper 1 Multiple Choice 15 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 and index number in the answer sheet provided.

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 Question Paper.
The use of an approved calculator is expected, where appropriate.

1 How many statements about the nucleus are correct?

1 The nucleolus comprises entirely of heterochromatic DNA.

2 The nuclear pores facilitate the separate movement of rRNA and ribosomal proteins out of the nucleus.

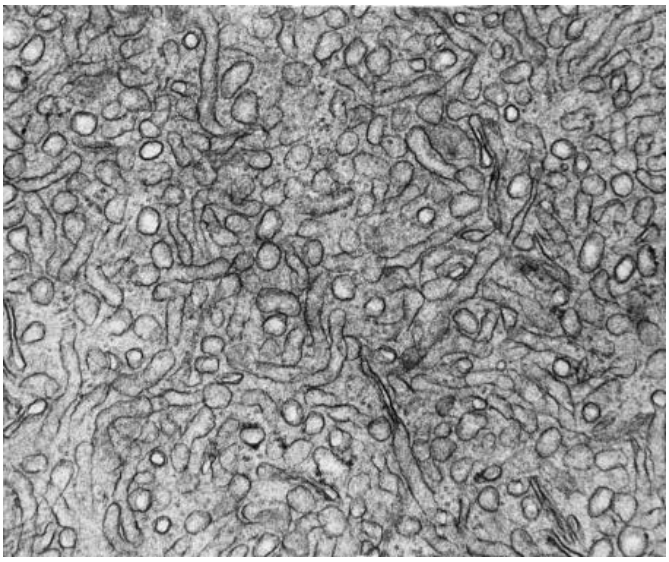
3 The nucleoplasm can only contain pre-mRNA and not mature mRNA.

4 The nuclear envelope will only disintegrate during apoptosis.

5 There will always be only one nucleolus per nucleus.

A None **B** 1 **C** 2 **D** More than 2

2 The electron micrograph shows a particular organelle within a eukaryotic cell.



Which statements about this organelle are correct?

1 The synthesis of proteins occurs on ribosomes that are attached to the membrane of this organelle.

2 This organelle is made up of multiple flattened sacs known as cisternae.

3 Post-translational chemical modification occurs in the lumen of this organelle.

4 In the liver, this organelle metabolises carbohydrates by breaking down glycogen to glucose.

A 1, 2, 3 and 4

B 1, 2 and 3 only

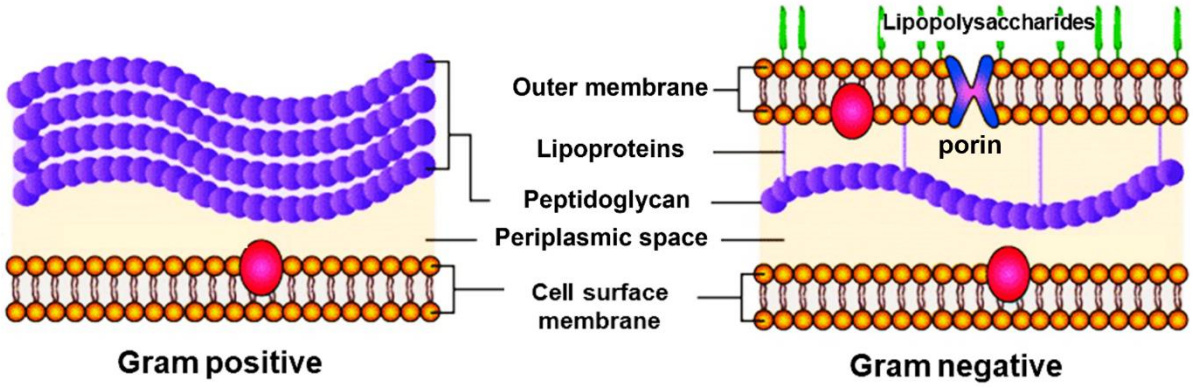
C 1 and 4 only

D 4 only

3 Gram staining can be used to distinguish between two groups of bacteria with different peptidoglycan cell wall structures. A blue-purple staining dye is first added to the cells, followed by the addition of alcohol to remove the staining dye. Due to the differential retention of the staining dye, the two groups of bacteria are known as Gram-positive and Gram-negative bacteria.

Gram-positive bacteria tend to appear blue or purple colouration as the staining dye can be retained within the cell. Gram-negative bacteria will appear pink or red as the staining dye is not retained.

The diagram shows the cell wall structures for both Gram-positive and Gram-negative bacteria.



Which statement does **not** explain the differential retention of the staining dye by the Gram-positive and Gram-negative bacteria?

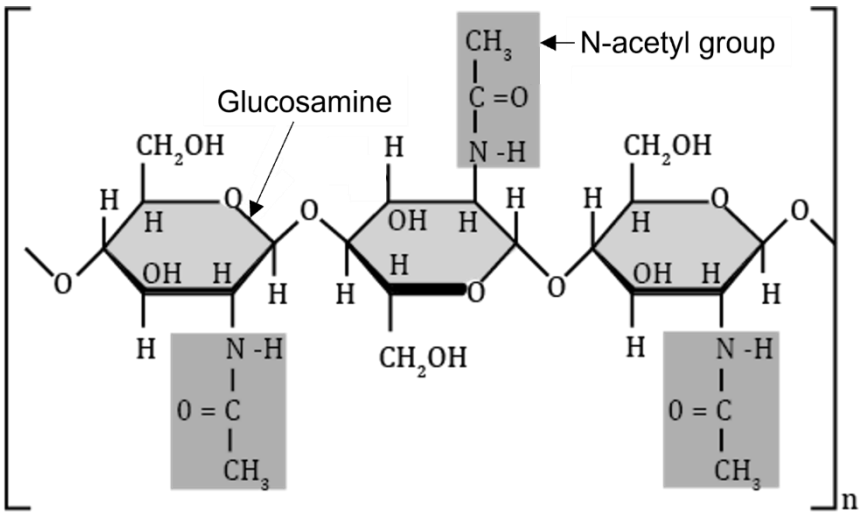
A The peptidoglycan layer is thicker in Gram-positive bacteria and hence more staining dye is retained as compared to Gram-negative bacteria.

B The peptidoglycan layer is thinner in Gram-negative bacteria and hence this group of bacteria tends to stain pink instead of blue or purple.

C The thicker layer of peptidoglycan in Gram-positive bacteria will prevent most of the staining dye from entering the cell.

D For Gram-negative bacteria, the outer membrane is disrupted by the addition of alcohol, exposing a thin peptidoglycan layer which allowed the staining dye to leave the cell wall.

4 Chitin is a polysaccharide that is made up of repeating units of N-acetyl-D-glucosamine. The diagram shows three repeating units of N-acetyl-D-glucosamine.



Which statement does **not** correctly compare chitin with other polysaccharides?

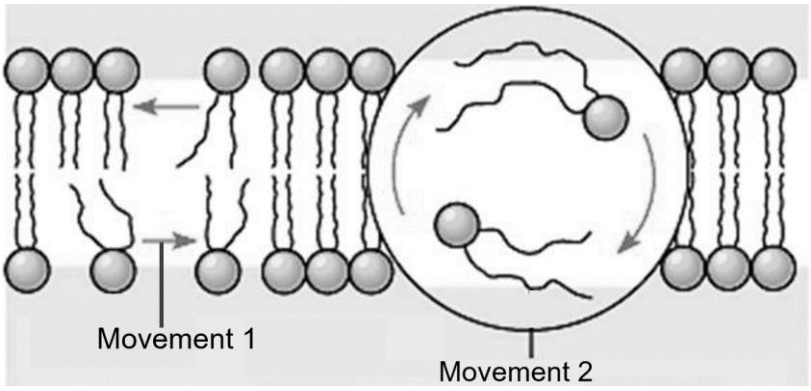
A Both chitin and cellulose have alternate monomers that are rotated 180° with respect to each other.

B Chitin likely exists in the form of straight chains, while amylose chains assume a helical form.

C Chitin contains β-1,4-glycosidic bonds whereas amylose contains α-1,4-glycosidic bonds.

D Both chitin and amylopectin comprise monomers that contain nitrogen atoms.

5 The diagram shows two types of movements that can occur within a phospholipid bilayer.



Which statement is correct?

A Movement 2 occurs more frequently than movement 1.

B Both movements 1 and 2 can also occur for proteins.

C When temperature decreases, movements 1 and 2 are reduced.

D Movement 1 is reversible but movement 2 is not.

6 The table shows the half-lives of two different thermostable enzymes that are commonly used in Polymerase Chain Reaction. The half-life reflects the time it takes to denature half the amount of the enzymes at 95°C. Each of these polymerases has four cysteine residues within their primary structure.

name of DNA polymerase	half-life at 95°C/ min
Taq polymerase	45
PFU polymerase	1140

Which statement can be concluded from the data provided?

A *Taq* polymerase is more thermostable than *PFU* polymerase as its half-life is about 25 times shorter than that of *PFU* polymerase.

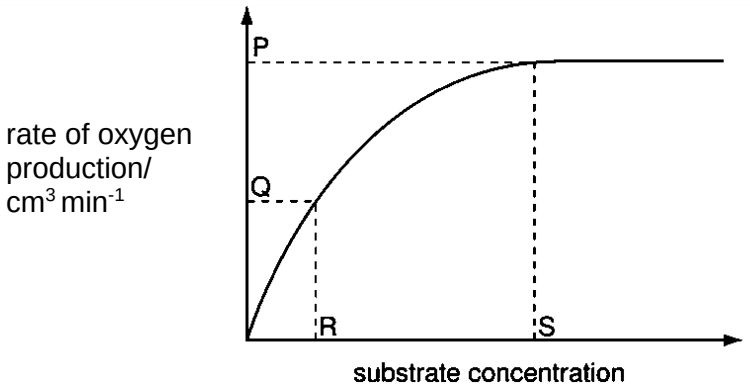
B It takes 1095 more minutes to denature 50% of a fixed amount of *PFU* polymerase as compared to the same amount of *Taq* polymerase.

C *PFU* polymerase is more thermostable than *Taq* polymerase as it has more disulfide bonds within its tertiary structure.

D Both enzymes are isolated from organisms that are found in the same thermal spring.

7 Catalase, an enzyme produced by liver tissue, breaks down hydrogen peroxide into water and oxygen.

To investigate the effects of changing hydrogen peroxide concentration on the rate of oxygen production, small cubes of fresh liver tissue were added to hydrogen peroxide solutions of different concentrations. The volume of oxygen produced per unit time from each reaction was recorded and the data was shown in a graph.



Which statement is correct?

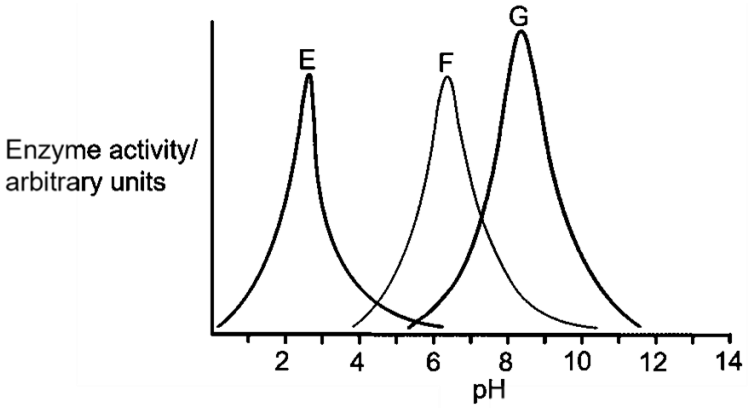
A At P, the rate of reaction is limited by the concentration of the substrate.

B At R, all the catalase active sites are saturated.

C At S, the enzyme concentration is the limiting factor.

D At Q, half the total volume of oxygen is collected from the reaction.

8 The graph shows the activity of enzymes E, F and G under different pH conditions.



Which statement is **not** a valid conclusion of these enzymes?

A The affinity between substrate and enzyme E is highest when the pH is 2.5.

B At pH 6.2, the kinetic energy of enzymes F and their substrates is the highest.

C Ionic and hydrogen bonds in these enzymes are affected when pH changes.

D Rate of reactions catalysed by enzyme F is higher than those catalysed by enzyme E and G at pH 6.

9 β cells in the islets of Langerhans of the pancreas release a hormone, insulin, when concentration of blood glucose in the body increases.

Type 1 and type 2 diabetes are both characterised by higher-than-normal concentration of blood glucose. In type 1 diabetes, the β cells produce little or no insulin. In many cases of type 2 diabetes, insulin is produced normally but is unable to bind to specific proteins on the cell surface membrane of particular cells types in the body. This is termed insulin resistance. Hence, glucose in the blood is not taken up by cells for cellular activities.

Recent experiments suggest that it may, in future, be possible to treat diabetes with adult stem cells from the patient's own bone marrow. However, such an approach is more suitable to treat type 1 rather than type 2 diabetes.

Which statement could explain why stem cell treatment will **not** work well for type 2 diabetes?

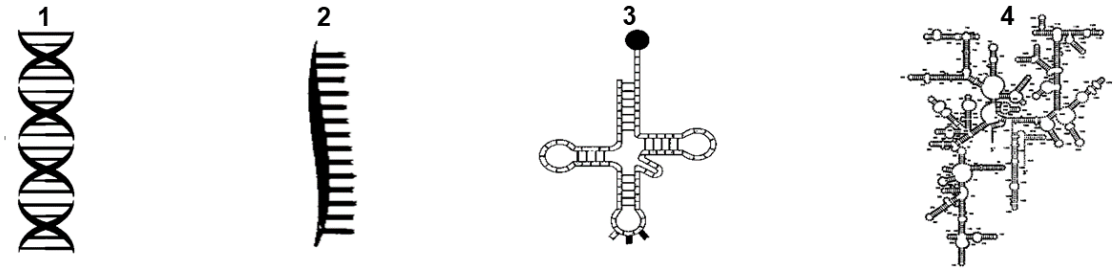
A An overproduction of insulin could happen as the stem cells differentiate to form β cells instead due to the plasticity of stem cells.

B All the cells of a type 2 diabetic patient are unresponsive to insulin hence it is much more difficult for stem cell therapy to replace all affected cells in the body.

C More needs to be understood about the various causes of type 2 diabetes as the disease has varying degree of severity.

D There is possible risk of rejection as the stem cells are delivered into the patient's body.

10 The diagram shows various nucleic acids found in a cell.



Which statement correctly describes these nucleic acids?

A 1 contains hydrogen bonds between adjacent deoxyribonucleotides which can be broken and reformed.

B 2 contains start and stop codons and each of these codon codes for an amino acid.

C 3 is formed by one of the 64 different amino-acyl tRNA synthetases.

D 4 has peptidyl transferase activity to catalyse formation of peptide bonds between adjacent amino acids.

11 Seven steps within semi-conservative DNA replication, beginning at an origin of replication, are listed. The steps are **not** listed in the correct sequence.

- A short sequence of ribonucleotides complementary to a segment of the single-stranded DNA is synthesised.
- A transient double-stranded break in the DNA is created ahead of the replication fork.
- An enzyme hydrolyses the short sequence of ribonucleotides, replacing it with deoxyribonucleotides.
- An enzyme unwinds and unzips the two strands of a DNA molecule.
- The gap between two DNA fragments is sealed via the formation of a phosphodiester bond.
- The two template strands are prevented from reannealing with each other.
- Free deoxyribonucleotides are added to the 3'-OH group of the newly synthesised strands.

What is the fourth step in the correct sequence of steps for this process?

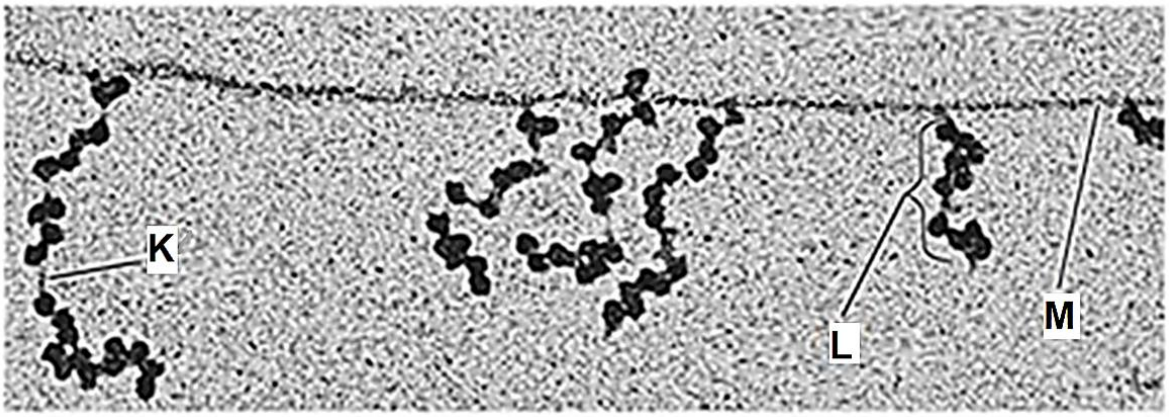
A A short sequence of ribonucleotides complementary to a segment of the single-stranded DNA is synthesised.

B A transient double-stranded break in the DNA is created ahead of the replication fork.

C Free deoxyribonucleotides are added to the 3'-OH group of the newly synthesised strands.

D The two template strands are prevented from reannealing with each other.

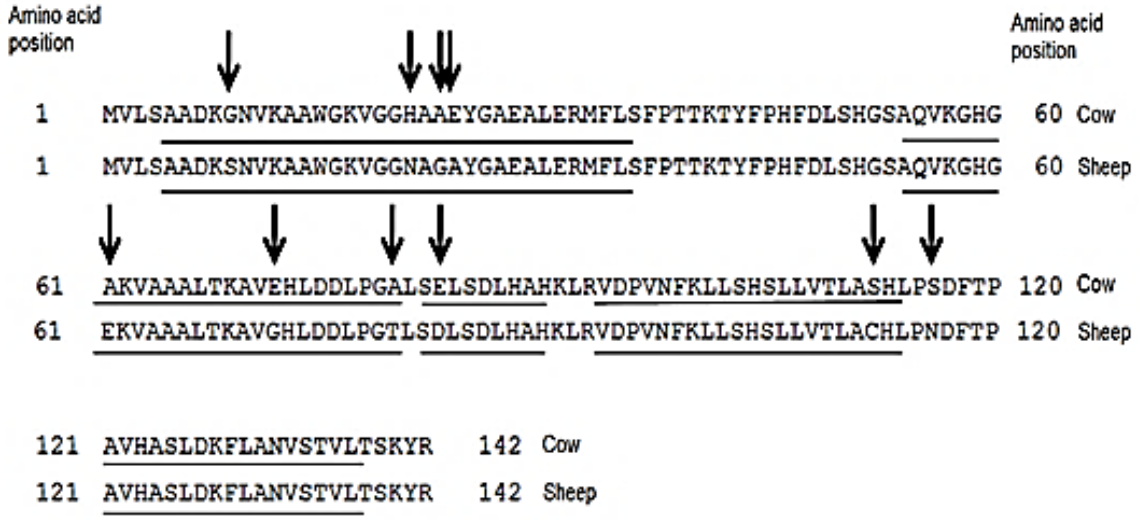
12 The diagram shows an electron micrograph of several labelled structures present in an organelle.



Which row correctly represents the organelle and the structures present in it?

	organelle	K	L	M
A	chloroplast	3' end of this molecule is the one furthest away from structure M	clusters of ribosomal subunits held together as a single ribosome	consists of a single strand of nucleotides in the absence of complementary base pairing
B	mitochondrion	5' end of this molecule is the one furthest away from structure M	clusters of ribosomes held together on an mRNA	consists of deoxyribonucleotides held together by phosphodiester bonds
C	nucleus	5' end of this molecule is the one furthest away from structure M	clusters of mRNA held together by a single ribosome	consists of amino acids held together by peptide bonds
D	nucleus	3' end of this molecule is the one furthest away from structure M	clusters of proteins held together on an mRNA	consists of amino acids in a chain ready to be folded into its native 3D conformation

13 The diagram shows the alignment of amino acid residues of the alpha haemoglobin chains of the cow and the sheep. There are a total of 142 amino acid residues in both the alpha chains of the cow and sheep. Regions of the polypeptide that form an alpha helix are underlined while positions where amino acid residues differ between the cow and the sheep alpha haemoglobin chains are marked with an arrow.



Which conclusion is consistent with the information provided?

A Differences in the amino acid residues between the two polypeptides are due to silent mutation brought about by the degeneracy of the genetic code.

B Differences in the amino acid residues between the two polypeptides are due to neutral mutation brought about by mutations in the introns.

C Differences in the amino acid sequences change the secondary structure of the protein.

D Differences in the amino acid sequence does not affect the function of the protein in both cow and sheep.

14 A cell culture was viewed before it entered mitosis and a total of 20 chromosomes were counted. Following division, the nucleus of one of the daughter cells was found to contain 21 molecules of DNA and the nucleus of the other daughter cell contained 19 molecules of DNA.

Which statement is the most likely explanation for this observation?

A During prophase, one of the homologous pairs failed to pair up.

B During interphase, one of the chromosomes failed to replicate properly.

C During anaphase, the sister chromatids of one chromosome failed to separate.

D During metaphase, the spindle fibres did not attach to the centromeres of two of the chromosomes.

15 Which statements explain the significance of the meiotic cell cycle?

1 Mutations give rise to new alleles and increase genetic variation in the gametes formed.

2 Independent assortment of homologous chromosomes during metaphase I allows for different combinations of maternal and paternal chromosomes in the different gametes formed.

3 Crossing over between non-sister chromatids of homologous chromosomes in metaphase I leads to the formation of new combinations of alleles on the chromosomes in the gametes.

4 Random fusion of gametes during fertilisation contributes to genetic variation in the offspring.

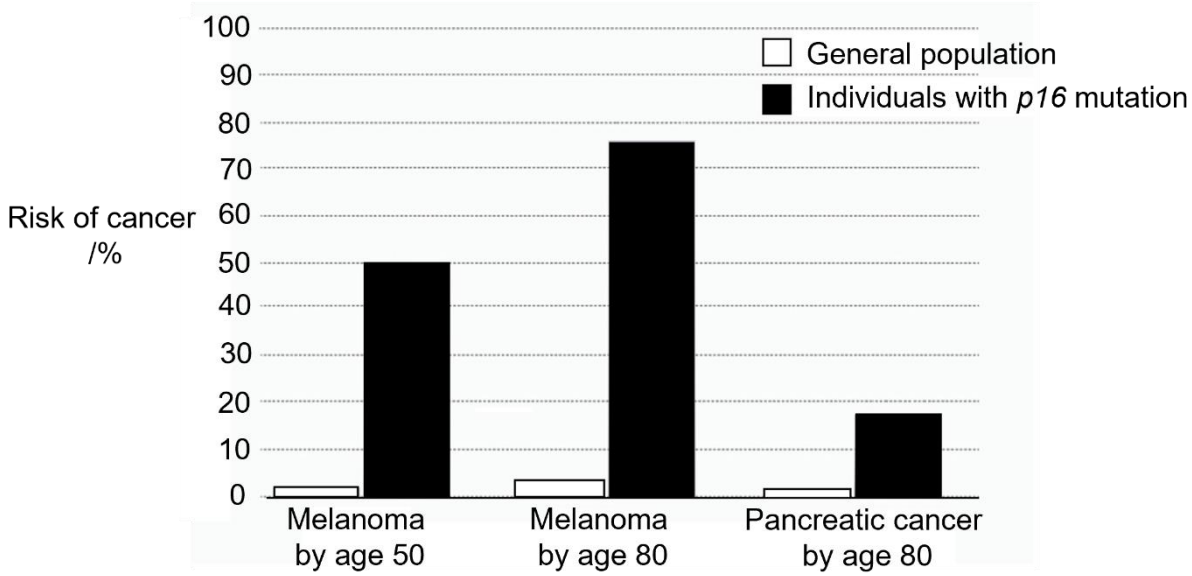
A 1, 2 and 4

B 2 and 3 only

C 3 and 4 only

D 2 only

16 The graph shows the correlation between mutations in the *p16* gene and the risk of getting melanoma (a type of skin cancer) and pancreatic cancer.



Which statement can be concluded based on the information given?

A Risk of getting melanoma increases with age due to increased sun exposure over a longer life span.

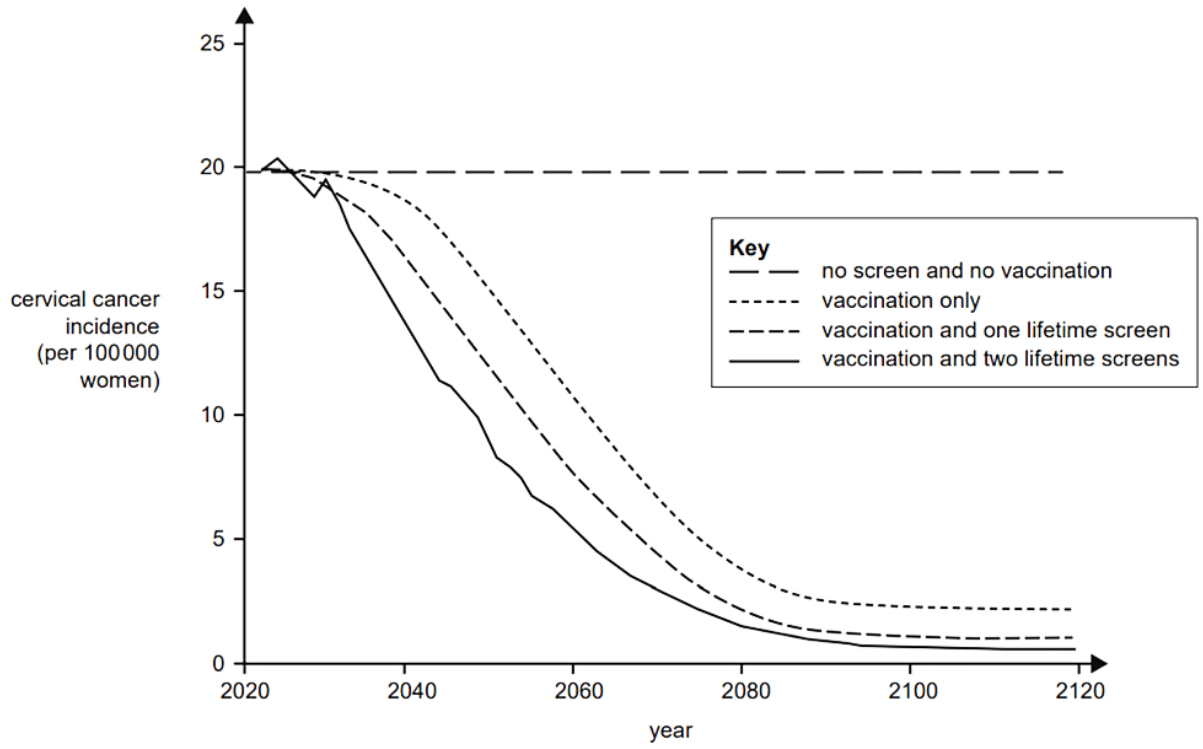
B p16 is a cell cycle checkpoint protein important in regulating cell division.

C Both alleles of *p16* gene in patients with melanoma are found to be mutated by age 50.

D By age 80, an individual with mutation in the *p16* gene will have a higher risk of developing either melanoma or pancreatic cancer compared to the general population.

[Turn over

17 A study was conducted to model the impact of a human papillomavirus (HPV) vaccination programme, with or without cervical cancer screening. HPV is the cause of most cervical cancers. The results of the modeling are shown in the diagram.



Which statement is supported by the information provided?

A The largest factor in reducing the incidence of cervical cancer in the long term is vaccination.

B Patients with compromised immune systems are more susceptible to HPV infection than healthy individuals.

C HPV produce proteins which inhibit tumour suppressor proteins and promote inappropriate cell division.

D Vaccination and one lifetime screen would be more effective than vaccination and two lifetime screens by 2060.

18 Twins are two offspring produced by the same pregnancy. Twins can be either monozygotic, meaning that they develop from one zygote which splits and forms two embryos, or dizygotic, where each twin develops from a separate egg and each egg is fertilised by a sperm.

Which statements about monozygotic and dizygotic twins are correct?

1 Monozygotic twins are genetically identical and they have the same sex unless there has been a mutation during development.

2 Dizygotic twins possess different proportions of maternal and paternal DNA while monozygotic twins have the same proportion of maternal and paternal DNA.

3 Monozygotic twins who had been separated at birth and spent their lives apart have a greater genetic difference compared to dizygotic twins.

A 1, 2 and 3

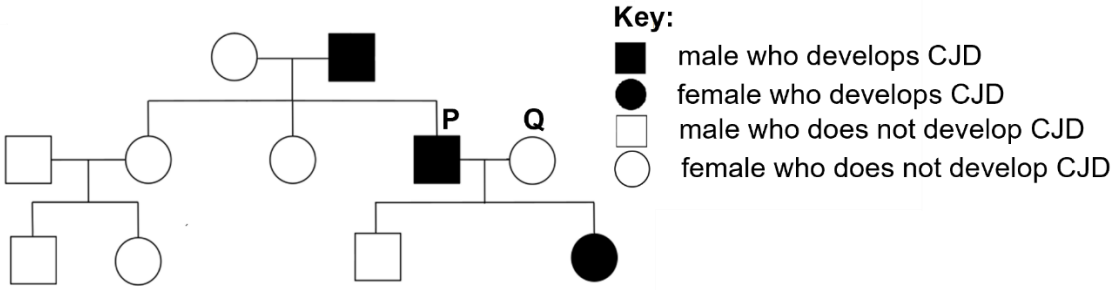
B 1 and 3 only

C 2 only

D 1 only

19 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 in this family?

	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	0.50
B	3	0.0625
C	1	0.50
D	1	0.0625

20 Domestic goats, *Capra hircus*, show a wide range of coat patterns and colours.

One gene involved in coat patterns and colours has multiple alleles. Four of these alleles are:

- A, the allele for white, is dominant to all others
- A^b, the allele for badgerface (stripes on face), and A^g, the allele for grey, are codominant
- a, the allele for black, is recessive to all others

A cross between a black goat and a white goat produced a white goat. This white offspring was crossed with a grey goat. The genotype of the grey goat was not known.

Which combination correctly shows all the possible offspring genotypes and phenotypes that could result from the cross between the white offspring and the grey goat?

A Aa (white), aa (black) only

B AA^g (white), A^ga (grey) only

C AA^g (white), AA^b (white), A^ga (grey), A^ba (badgerface)

D AA^g (white), Aa (white), A^ga (grey), aa (black)

21 Which processes occur in both light-dependent reactions and the Calvin cycle?

1 reduction
2 oxidation
3 phosphorylation
4 dephosphorylation
5 carboxylation
6 decarboxylation

A 1, 2, 4 and 5

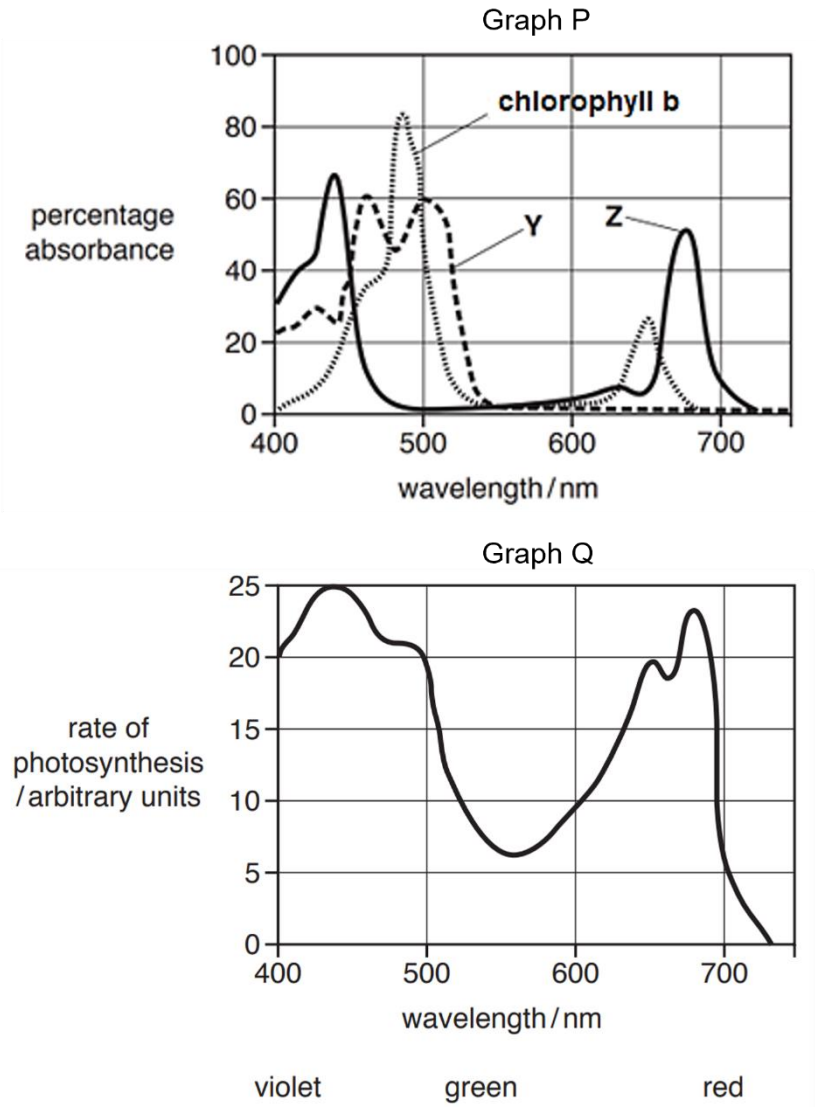
B 3, 4, 5 and 6

C 1, 2 and 3 only

D 1 and 2 only

22 Graph P shows the absorption spectra of three types of photosynthetic pigments, chlorophyll b, Y and Z, extracted from the leaves of a flowering plant.

Graph Q shows the action spectrum for photosynthesis for the same plant.



Which statement correctly relates the information shown in graphs P and Q to the knowledge and understanding of the light-dependent stage of photosynthesis?

A Non-cyclic photophosphorylation occurs at a wavelength of 700 nm, indicating that pigment Y is more likely to be chlorophyll a than pigment Z.

B The high absorption of blue light by chlorophyll b provides evidence that this is the primary electron donor of photosystem I.

C The poor absorption of green light by all three pigment types will provide only enough energy for cyclic photophosphorylation to occur.

D The presence of pigment Y extends the ability of the plant to absorb light in the blue-green part of the spectrum but not the yellow-green part of the spectrum.

[Turn over

23 2,4-Dinitrophenol (DNP) is a toxic compound which binds to the inner mitochondrial membrane and allows protons to cross the membrane. The transport of protons by DNP is not coupled to the synthesis of ATP.

Which effects will result from the exposure of cells to DNP?

1 The concentration of protons in the mitochondrial matrix will increase.

2 The formation of water from respiratory processes will occur at a slower rate.

3 The regeneration of NAD in the mitochondrial matrix will occur at a slower rate.

4 The phosphorylation of ADP will occur at a slower rate.

A 1, 2, 3 and 4

B 1 and 4 only

C 2 and 3 only

D 3 only

24 Lactic acid fermentation and ethanol fermentation are two metabolic pathways that take place under anaerobic conditions.

How many statements are true for both pathways?

1 The reactions occur in the cytoplasm.

2 Hydrogen carriers are oxidised.

3 Substrate-level phosphorylation takes place.

4 Products have the same number of carbon atoms as pyruvate.

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

25 Antibiotics is a group of chemicals which kill or inhibit the growth of bacteria.

To minimise the evolution of antibiotic resistance in bacteria, measures controlling the use of antibiotics in hospitals are implemented.

Which row correctly explains why the measure described is effective?

	measure controlling use of antibiotics	reason for its effectiveness
A	Every twelve months, the antibiotic used to treat a particular disease is switched to another antibiotic.	Mutant bacteria that developed resistance to the first antibiotic will no longer be selected for.
B	To treat diseases commonly caused by resistant bacteria, a combination of several antibiotics is used at the same time.	It is unlikely that exposure to multiple antibiotics will cause multiple mutations that confer resistance to all the antibiotics used.
C	A few types of antibiotics are reserved only for the treatment of severe infections.	Different bacteria vary in their resistance to different types of antibiotics.
D	The antibiotics used in a hospital are different from the ones used on animals in agriculture.	Antibiotics used on animals exert a weaker selection pressure on bacteria.

26 Which statement explains why the population is the smallest unit that can evolve?

A Allele frequencies do not change significantly over time in a population.

B Changes in allele frequencies in a population is maintained independently of other populations.

C Different populations are exposed to different selection pressures and are influenced by natural selection to varying extents.

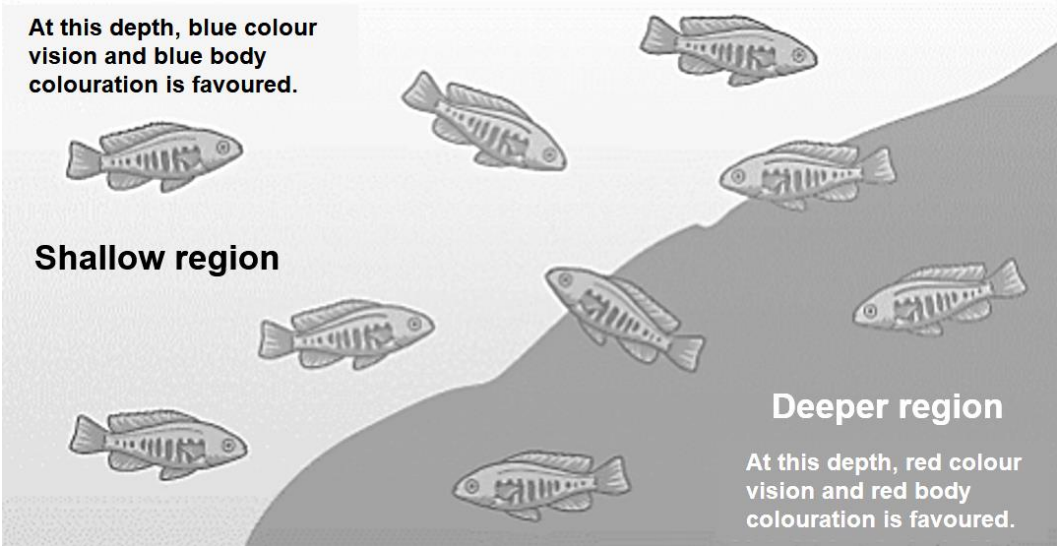
D A population is geographically separated from its neighbouring population, minimising the migration of individuals between the two populations.

27 The cichlid family of fishes living in Africa's Lake Victoria show variation in colour vision and body colouration.

In the cloudy waters of Lake Victoria, the shallow region of the lake is dominated by blue light. The deeper region of the lake, however, is dominated by red light due to selective light absorption by sediment particles. Cichlids with colour vision that allow them to see blue light better prefer to dwell in shallow waters of the lake, while cichlids with colour vision that allow them to see red light better dwell in the deeper waters. The ability to see the light colour that is dominant at the particular depth is thought to correlate with the cichlid's ability to survive.

Male cichlids also display a wide variation in body colouration. Males with blue body colouration appear brighter in the shallow waters and have greater reproductive success there, while males with red body colouration appear brighter in the deeper waters and experience greater reproductive success at these depths.

The diagram summarises the observations made about these cichlids.



Which statement does **not** correctly describe the cichlids of Lake Victoria?

A There is disruptive selection due to the selection of two distinct phenotypes.

B The non-random selection of mating partners has a significant role in the evolution of cichlids.

C The ability to find mates has a stronger effect on the evolution of body colouration in male cichlids over the need to escape from predators.

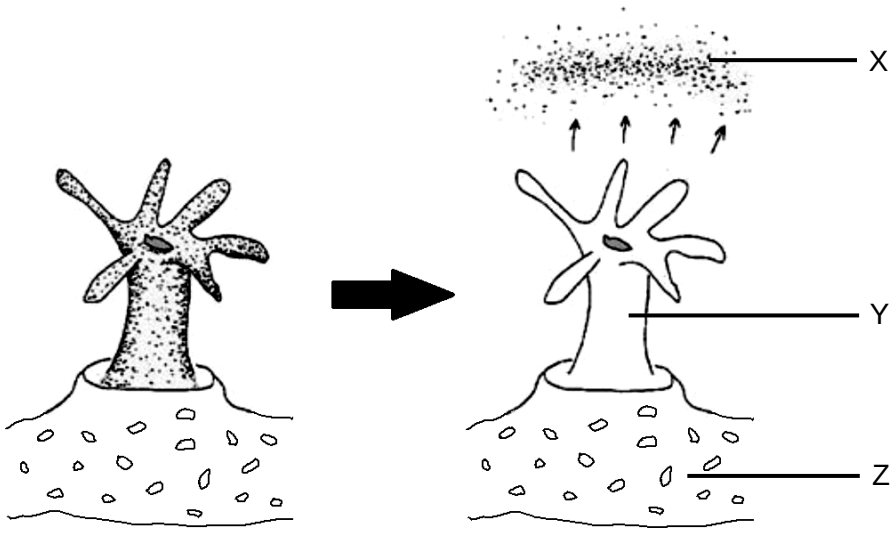
D The depth of water is the main selection pressure affecting the cichlid population.

28 Which human activities have directly contributed to global warming over the last few centuries?

1 The use of natural gas as an energy source for industrial processes.
2 The poaching of some species to obtain animal parts with claimed medicinal properties.
3 The improper discharge of factory wastewater into water bodies.
4 The replacement of primary rainforests with pastures for animal grazing.
5 The depletion of fish stocks due to increased human consumption.

A 1, 3, 4 and 5
B 1, 4 and 5 only
C 2, 3 and 4 only
D 1 and 4 only

29 The diagram shows the process of coral bleaching. Three structures are labelled X, Y and Z.



Which statement about the labelled structures is true?

A X is an organism which is capable of photosynthesis but not respiration.
B X is an organism which has a parasitic relationship to Y.
C Both X and Y are plant species.
D When greenhouse gas emissions increase, the mass of structure Z decreases.

30 *Wolbachia* is a genus of intracellular bacteria that can infect *Aedes* mosquitoes and is used to control the spread of viral dengue disease in human populations.

The interactions between *Wolbachia* and *Aedes* mosquitoes are listed.

- *Aedes* mosquitoes do not naturally carry *Wolbachia* in the wild.
- When male *Wolbachia*-carrying mosquitoes mate with female mosquitoes that do not carry *Wolbachia*, their resulting eggs do not hatch to form viable offspring.
- Females mosquitoes that carry *Wolbachia* can produce viable eggs after mating with males, regardless whether the males carry *Wolbachia*.
- Male mosquitoes with *Wolbachia* and male mosquitoes that do not carry *Wolbachia* compete equally for mates.
- *Wolbachia* is maternally transmitted, where both male and female offspring of *Wolbachia*-carrying females will only inherit *Wolbachia* from their mothers.

The National Environment Agency of Singapore released one batch of lab-grown *Wolbachia*-carrying male mosquitoes into the community.

Which outcome is **not** expected to occur?

A Decrease in severity of viral dengue disease in humans who become infected.

B Decrease in frequency of viral dengue disease in the human population.

C Decrease in incidence of humans suffering from mosquito bites.

D Decrease in number of *Wolbachia*-carrying mosquitoes over time.