Anglo-Chinese Junior College

JC2 Biology Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

BIOLOGY **9744/01**
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.

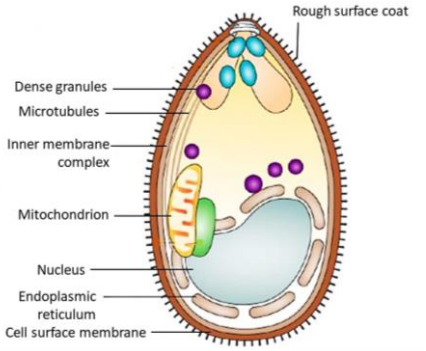
4 The nuclear envelope will only disintegrate during apoptosis.

5 There will always be only one nucleolus per nucleus.

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

AOA

2 Protozoans are single-celled eukaryotic organisms that can either be free-living or parasitic. *Plasmodium falciparum,* which causes the disease malaria, is an example of a parasitic protozoa. The diagram shows the basic cellular structures of *P. falciparum* at a particular stage of its life cycle.



Which features are shared between *P. falciparum* and typical bacterial cells?

1 presence of cell wall

2 able to carry out protein synthesis

3 energy production within cell

4 chromosome(s) found within nucleus

5 unicellularity

A 1, 2, 3 and 5

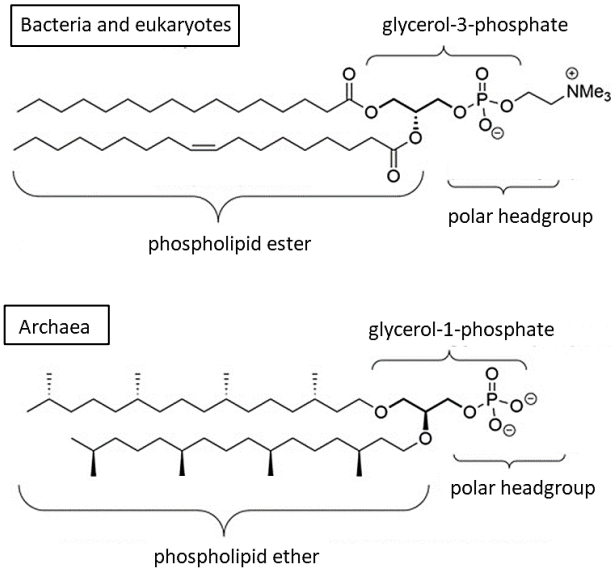
B 1, 2 and 5 only

C 1, 3 and 4 only

D 2, 3 and 5 only

Low AOB

3 Archaea are single-celled organisms. The phospholipids within the cell surface membrane of Archaea differ significantly from bacteria and eukaryotes. For instance, Archaeal phospholipids are composed of highly-methylated and saturated hydrocarbon chains that are connected to glycerol via ether bonds instead of ester bonds, and are therefore not prone to hydrolysis. Ethers are characterised by C-O-C linkages. The diagram shows the basic structure of phospholipids in Archaea, bacteria and eukaryotes.



Many species of Archaea can survive in water and in environments with very harsh conditions such as high temperatures or strong acids.

Which statement does **not** explain how the phospholipids within Archaeal cell surface membrane allow them to thrive in water or extreme conditions?

A Methyl groups on the phospholipids enhance the blockage of water penetration through the membrane.

B The presence of ether rather than ester bonds contributes to their chemical stability, particularly at high temperatures and extreme pH values.

C Close packing of Archaea lipids confer low permeability of the cell surface membrane to protons hence there is very low proton influx in acidic conditions.

D Archaea has a different glycerol backbone within the phospholipid structure hence making it structurally more stable under extremely high temperatures.

High AOB

4 Which row correctly matches the structural properties to the biomolecules?

	α-1,4-glycosidic bonds	β-1,4-glycosidic bonds	branched structure	interchain H-bonds
A	cellulose	amylopectin	glycogen	amylose
B	amylopectin	cellulose	amylose	cellulose
C	glycogen	amylose	amylopectin	cellulose
D	amylose	cellulose	amylopectin	amylose

AOA

5 Scurvy is a disease caused by vitamin C deficiency. Left untreated, scurvy can result in bleeding gums, loosened teeth and bleeding under the skin. Treatment for the condition includes significantly increasing the intake of vitamin C in the diet.

Vitamin C is the essential cofactor for two enzymes, prolyl hydroxylase and lysyl hydroxylase, which are required for collagen synthesis. These enzymes catalyse the hydroxylation of proline and lysine residues of procollagen.

Which statement best explains why vitamin C deficiency can lead to scurvy?

A Active sites of prolyl hydroxylases and lysyl hydroxylases will not be complementary to their substrates.

B There would not be sufficient vitamin C to catalyse the hydroxylation of proline and lysine residues.

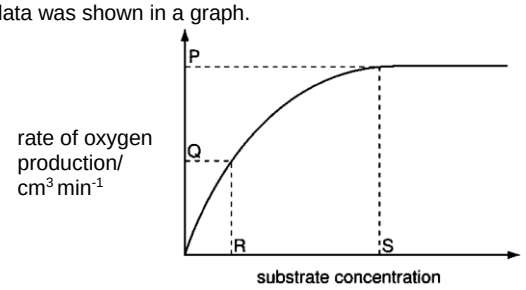
C Hydroxylation of all residues are important as it markedly increase the conformational stability of the collagen triple helix.

D Lack of hydroxylation of residues on collagen affects the stability of tropocollagen and the proper formation of collagen fibrils.

Low AOB

6 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.

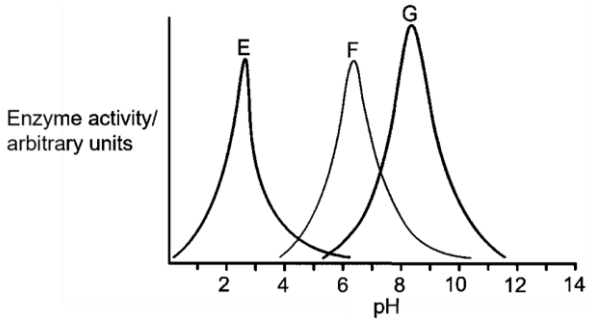
B At R, all the catalase active sites are saturated.

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

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

Low AOB

7 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 enzyme E 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.

Low AOB

[Turn over

8 Type 1 and type 2 diabetes are both characterised by higher-than-normal concentrations 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 does not bind to the insulin receptors of the cells around 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 for treating 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 glucagon could happen as the stem cells differentiate to form α cells instead due to plasticity.

B Cells in the body have dysfunctional insulin receptors hence it is more difficult to replace all of them.

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.

High AOB

9 Seven steps within semi-conservative DNA replicaion, 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 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.

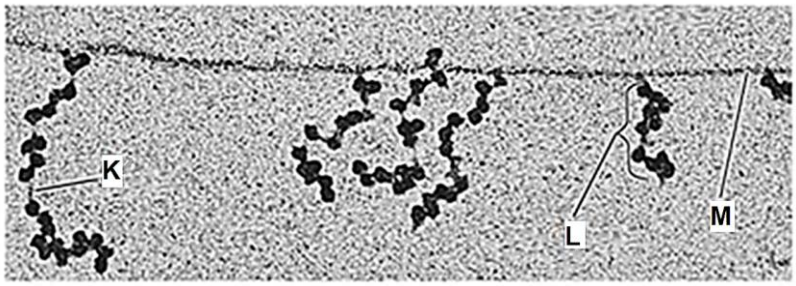
B A transient double-stranded break in the DNA is created ahead of the replication fork.

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.

AOA

10 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

Low AOB

11 Hepatitis C virus (HCV) infects and replicates in human cells. HCV has a positive-sense RNA and its reproductive cycle does not involve integration into host genome.

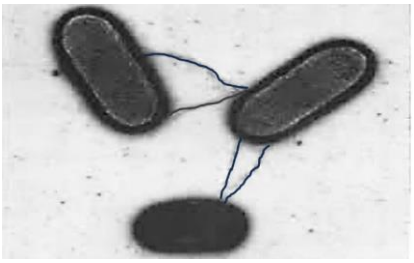
Which protein complexes are most likely needed for HCV replication?

1 DNA-dependent RNA polymerase
2 reverse transcriptase
3 ribosomes
4 RNA-dependent RNA polymerase

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

Low AOB

12 The photomicrographs show two different processes that occur in bacteria.



Process 1

Process 2

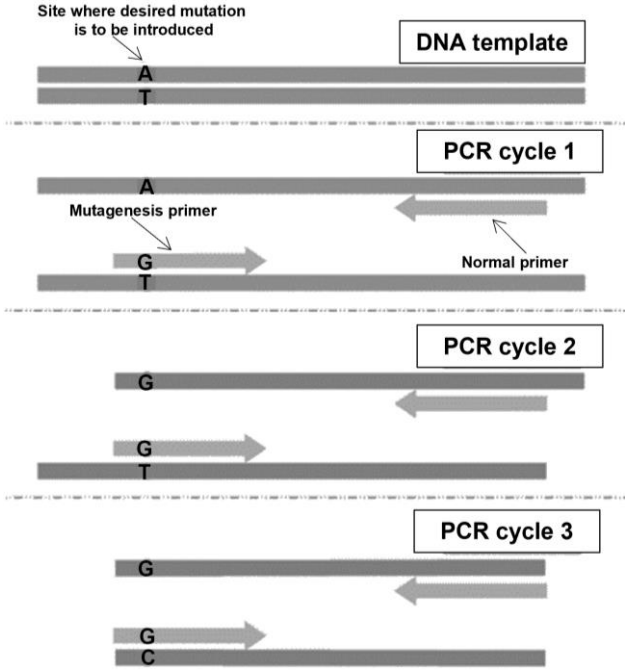
Which statements about the two processes are correct?

1 Both processes involve semi-conservative DNA replication.
2 Both processes always involve the transfer of the bacterial chromosome and plasmids.
3 Process 1 is a form of horizontal gene transfer but process 2 is not.
4 Process 1 results in an increase in the number of genetically different bacteria whereas process 2 results in an increase in the number of genetically identical bacteria.

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

AOA

13 Mutagenic oligonucleotide-directed polymerase chain reaction (MOD-PCR) is a modified version of PCR in which base substitution mutation is introduced into the amplified DNA sequences. The diagram shows the steps involved in MOD-PCR.



Which statement is **not** consistent with the information about MOD-PCR?

A MOD-PCR only causes mutations in the regions that the forward and reverse primers can anneal to.

B MOD-PCR allows for mutations to occur at precise locations in the amplified DNA sequence.

C The mutagenesis primer is the primer that contains the intended base to be substituted to.

D If the primer contains a nucleotide which cannot base pair with the template strand, annealing is affected.

High AOB

14 Which statements about gene expression in eukaryotic cells are correct?

1 Acetylation of histones leads to the decondensation of heterochromatin to euchromatin for transcription to take place.

2 General transcription factors and RNA polymerase are prevented from binding to heavily methylated promoters.

3 Gene expression is usually regulated by a combination of several regulatory proteins acting together on the gene, which allows for greater flexibility in the control of gene expression.

4 There are different cell types in a multicellular organism as different sets of cells express specific genes due to differences in the DNA sequences present.

A 1, 2, 3 and 4

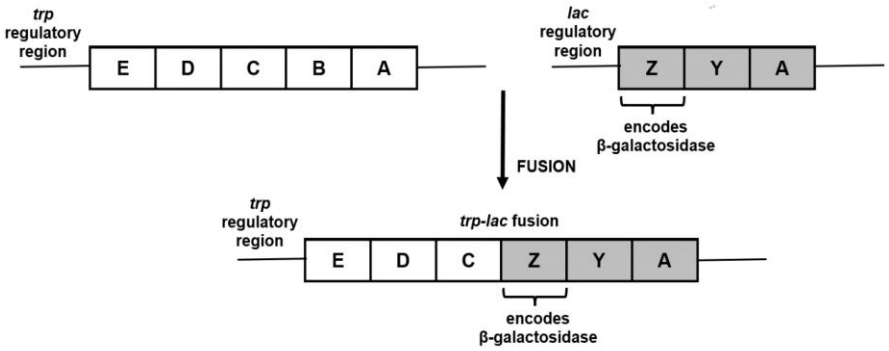
B 1, 2 and 3 only

C 1, 3 and 4 only

D 2 and 3 only

AOA

15 The diagram shows the process of fusion between some components of the *trp* and *lac* operons.



Which statement explains the proper functioning of the *trp-lac* hybrid operon?

A In the absence of tryptophan, β-galactosidase will be synthesised.

B In the presence of tryptophan, enzymes needed for lactose hydrolysis are synthesised in large amounts.

C The lac repressor protein is unable to bind to the operator if lactose is present.

D When both lactose and tryptophan are present, the hybrid operon will be transcribed at a very high rate.

Low AOB

16 Mosaic Klinefelter syndrome is a human genetic condition where some of the cells in the patient have the usual number of sex chromosomes (XY), and other cells have an extra copy of the X chromosome (XXY). Affected males have an incomplete sexual development, resulting in symptoms characteristic of the syndrome.

Which statement correctly explains the genetic basis for a patient suffering from mosaic Klinefelter syndrome?

A The patient's mother contributed an ovum with one additional X chromosome due to non-disjunction occurring in meiosis I.

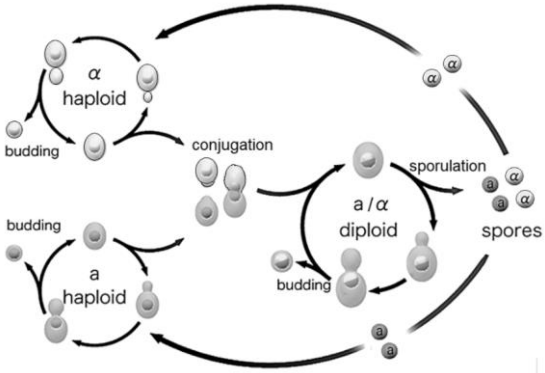
B The patient's mother contributed an ovum with one additional X chromosome due to non-disjunction occurring in meiosis II.

C The patient's father contributed a sperm with one additional X chromosome due to non-disjunction occurring in meiosis I.

D Non-disjunction occurred during mitosis in the patient's cells at an early stage of fetal development.

Low AOB

17 Yeast is a eukaryotic, unicellular fungi which exists in two mating forms, an "a" form and an "α" form. The diagram shows the reproductive cycle of yeast, which goes through both a haploid and a diploid stage. The three processes of budding, conjugation and sporulation occur during the reproductive cycle.



Which description of the yeast reproductive cycle is correct?

A Budding results in the production of genetically varied cells for sexual reproduction.

B Conjugation occurs when two yeast cells fuse without a change in the ploidy of the fused cell.

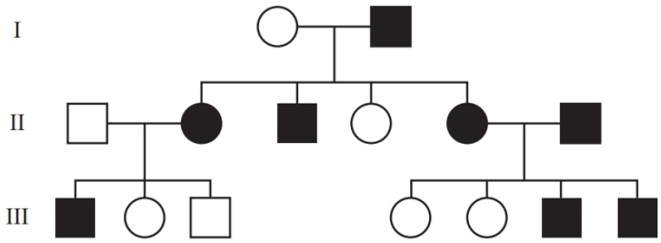
C Sporulation involves the meiotic division of diploid cells to form haploid spores.

D Only diploid yeast cells can undergo mitotic division while haploid yeast cells are not able to.

Low AOB

[Turn over

18 In the pedigree, shaded individuals have a particular genetic trait.



Which mode of inheritance of the trait is correct?

A X-linked dominant

B X-linked recessive

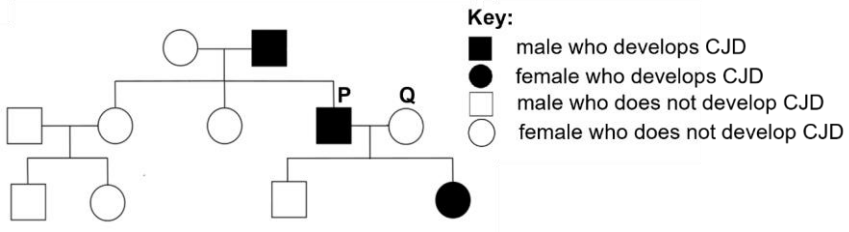
C autosomal recessive

D autosomal dominant

Low AOB

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.



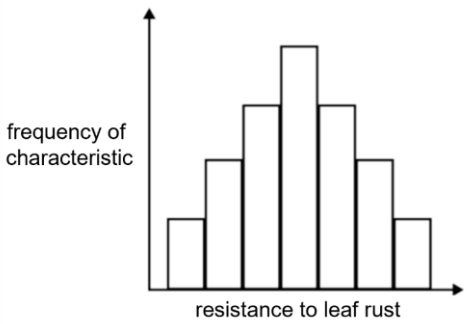
Individuals P and Q are expecting a pair of non-identical twins.

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

High AOB

20 Members of a barley plant species show varying levels of resistance to the leaf rust, *Puccinia hordei*. The diagram shows the distribution of a population of barley plants with regards to resistance to leaf rust.



How many statements are consistent with the inheritance of resistance to leaf rust in barley plants?

1 discontinuous variation showing discrete phenotypes
2 variation of phenotypes is influenced by environmental factors
3 polygenic inheritance determined by the cumulative effects of several genes on multiple loci
4 inheritance due to one or two major genes, each having a single pair of alleles

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

Low AOB

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

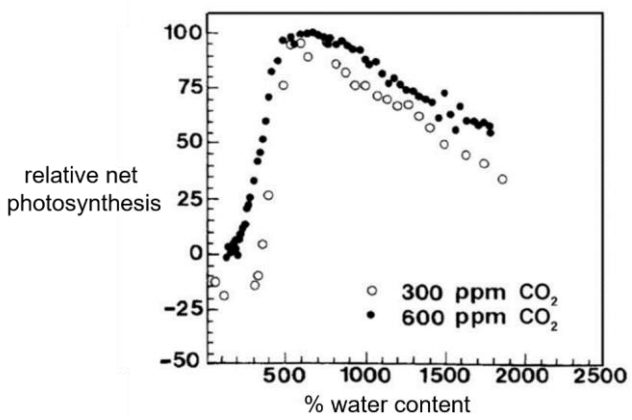
1 reduction
2 oxidation
3 phosphorylation
4 dephosphorylation
5 carboxylation
6 decarboxylation

A 1, 2, 4 and 5
B 3, 4, 5 and 6
C 1, 2 and 3 only
D 1 and 2 only

AOA

[Turn over

22 The graph shows the relationship between net photosynthesis and water content in a species of moss known as *Sphagnum fuscum* at two CO_2 concentrations. Constant conditions were maintained for temperature, light intensity and humidity.



Which statement can be concluded from the graph?

A If the carbon dioxide concentration is increased to 750 ppm, the graph would be directly above that of 600 ppm.

B Water availability cannot be a limiting factor as both experiments showed a decrease in relative net photosynthesis instead of a plateau.

C The moss will still gain biomass between percentage water content of 800% to 1500%.

D Beyond 600 ppm of CO_2, light intensity and temperature have become the limiting factor for photosynthesis in moss.

Low AOB

23 Which statement about the Krebs cycle is **not** correct?

A Each round of the Krebs cycle will yield one molecule of GTP which is used to generate one molecule of ATP.

B Decarboxylation occurs twice for each round of the Krebs cycle.

C The Krebs cycle involves a series of redox reactions.

D Three rounds of the Krebs cycle will yield three molecules of reduced NAD.

AOA

24 The insulin signaling pathways of a normal person and a patient are studied. The patient has a mutation in the gene coding for the insulin receptor, resulting in the inability of insulin molecules to bind to insulin receptors on his cells.

Which statement is true?

A The presence of insulin in the patient would cause an increase in the concentration of receptor molecules.

B Insulin receptors on the patient's cells would show an increased number of phosphorylated tyrosine residues.

C The patient is diabetic and should be given regular injections of glucagon upon meal intake.

D Reduced glucose-specific carrier molecules in the patient's cells resulted in inappropriately elevated blood glucose after a meal.

Low AOB

25 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.

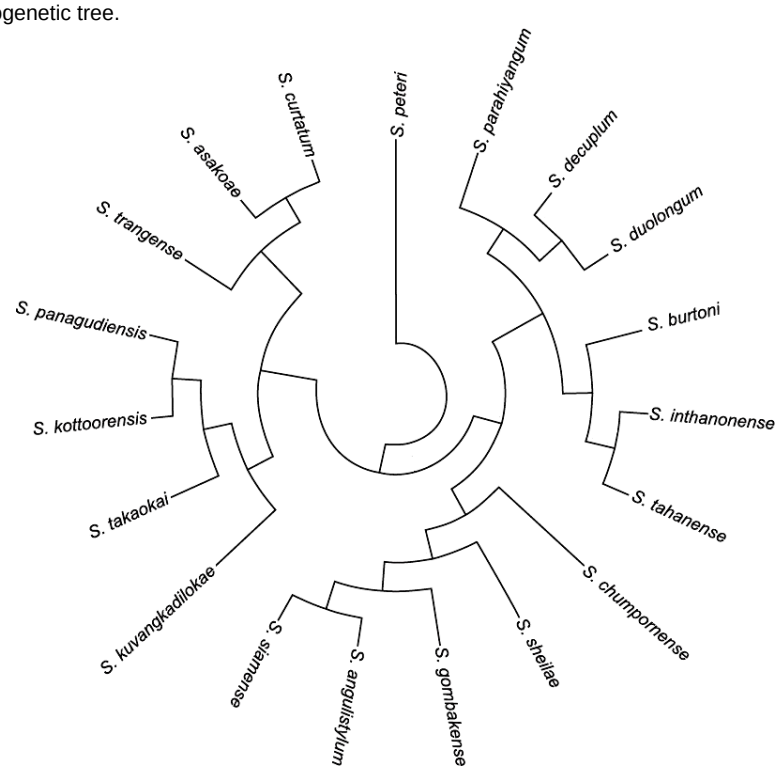
B Changes in allele frequencies in a population is maintained independently of other populations.

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.

AOA

26 The phylogeny of 19 species of black flies of the genus *Simulium* is shown in a radial phylogenetic tree.



Which statement can be concluded based on the phylogenetic tree?

A *S. peteri* is the ancestral species from which the 18 other species evolved from.

B *S. curtatum* diverged from *S. asakoae* at about the same time when *S. panagudiensis* diverged from *S. kottoorensis*.

C *S. panagudiensis* is more closely related to *S. kuvangkadilokae* than to *S. trangense*.

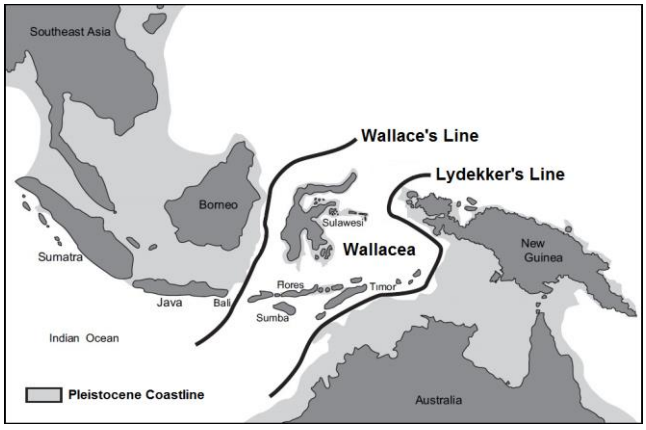
D *S. tahanense* is more closely related to *S. parahiyangum* than to *S. duologum*.

Low AOB

Commented [DHJC1]: S. tahanense share same most recent common ancestor as S parahiyangum & S. duologum and and info that it s more close related to one and not the other cannot be concluded based on tree.

27 The map shows two biogeographical lines that were once drawn up by European naturalists Alfred Russel Wallace and Richard Lydekker in the region between Southeast Asia and Australia.

During the prehistoric Pleistocene Epoch lasting from 2 million years till 10,000 years ago, there were periods of ice ages where sea levels were lower. The Pleistocene coastline during these ice ages is also indicated on the map.



The islands found west of the Wallace's line are rich in biodiversity, represented by many species common with the Southeast Asian mainland such as tigers, rhinoceros, apes and other placental mammals. To the east of Lydekker's line, many marsupial mammals and birds exclusive to Australia populate these regions.

The islands of Wallacea found between the two lines, including Sulawesi and the nearby islands, are relatively species-poor. Only some birds, reptiles and insect species of Asian or Australian origin are found there. Flightless birds and freshwater fishes common to Asia or Australia are not found on these islands.

Which statement explains the geographical distribution of species in the region shown in the present day?

A Placental mammals and marsupial mammals were able to interbreed during the Pleistocene ice ages.

B The many islands of Wallacea allow for the rapid evolution of new species through allopatric speciation.

C All bird species found in the region shown are able to overcome geographical isolation which resulted from the presence of water bodies.

D The common ancestor of placental mammals and marsupial mammals existed in a period when the land masses of Southeast Asia and Australia were joined together.

High AOB

[Turn over

28 Changes in the immunoglobulin genes of a B cell can occur from development till B cell activation.

How many statements are true?

1 Immunoglobulin genes can only be found in lymphocytes.

2 DNA rearrangements of the different V, D or J genes occur in immature B cells.

3 Somatic hypermutation changes the V regions of antibodies such that they have a higher affinity to the antigen.

4 Class switching allows mature B cells to switch among different classes of antibodies to interact with different antigens.

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

AOA

29 *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 (NEA) 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.

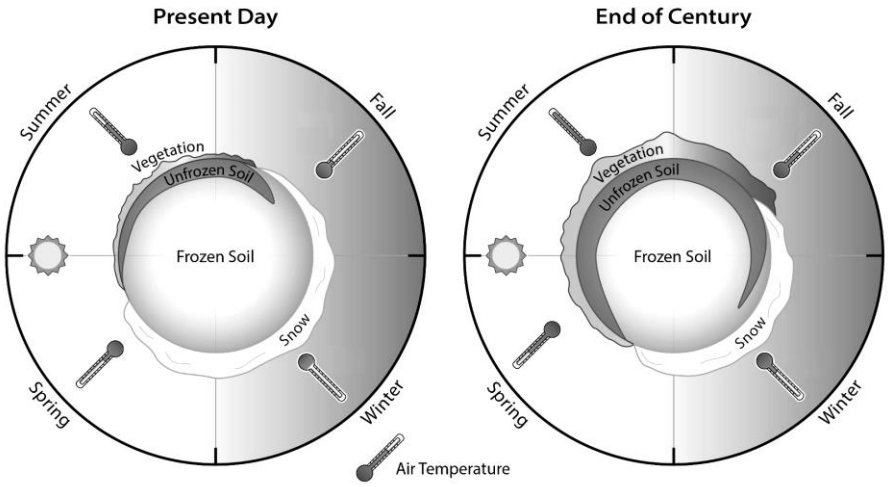
B Decrease in frequency of viral dengue disease in the human population.

C Decrease in incidence of humans suffering from mosquito bites.

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

High AOB

30 The diagram shows the seasonal changes to air temperature, snow depth, soil freeze and thaw, and vegetation productivity at a high-latitude region. A comparison is made between the situation at present and the predicted situation by the end of the 21st century (year 2100).



Which description is consistent with what is predicted by year 2100?

A Air temperatures will increase in some seasons but not others.

B Changes to vertical plant distribution will lead to more vegetation growth in this high-latitude region.

C The reflection of longwave radiation from the earth surface will increase.

D Vegetation productivity increases due to a longer period favouring growth.

Low AOB