| Civics Group | Index Number | Name (use BLOCK LETTERS) | **H1** |
|---|---|---|---|

**ST. ANDREW'S JUNIOR COLLEGE**
**2022 JC2 BLOCK TEST**

**H1 BIOLOGY** **8876/1**

# Paper 1: Multiple Choice

Thursday 7th July 2022 1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser (not supplied)
Soft pencil (type B or HB is recommended)

**READ THESE INSTRUCTIONS FIRST**

Do not open this booklet until you are told to do so.

Write your name, civics group and index number on the multiple choice answer sheet in the spaces provided.

There are **30** questions in 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 multiple choice answer sheet.

**INFORMATION TO CANDIDATES**

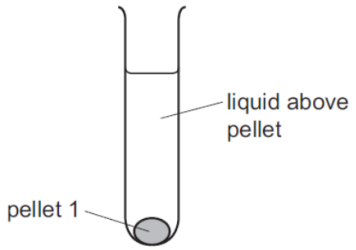
Each correct answer will score one mark. A mark will not be deducted for wrong answer. Any rough working should be done in this booklet.

At the end of the examination, submit both question paper and multiple choice answer sheet.

This document consists of **19** printed pages.

**[Turn over**

**1** A scientist carried out an experiment to separate cell structures in animal cells. The cells were lysed to release the cell structures. This extract was transferred into a centrifuge tube and then spun in a centrifuge. The heaviest cell structure sank to the bottom, forming pellet 1, as shown in the diagram.




The liquid above pellet 1 was poured into a clean centrifuge tube and spun in the centrifuge at a higher speed to separate the next heaviest cell structure. This cell structure sank to the bottom, forming pellet 2.

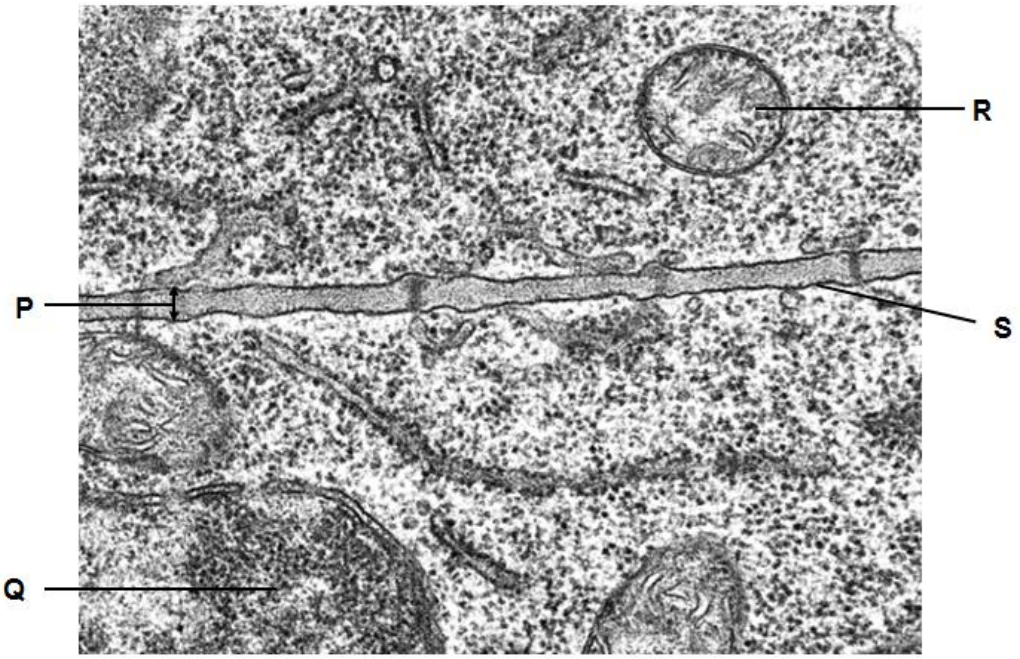
This procedure was repeated twice more to obtain pellet 3 and pellet 4, each containing a single type of cell structure.

Which row shows the order in which the cell structures were collected?

| | Pellet 1 | Pellet 2 | Pellet 3 | Pellet 4 |
|---|---|---|---|---|
| **A** | Nucleus | Lysosomes | Mitochondria | Ribosomes |
| **B** | Nucleus | Mitochondria | Lysosomes | Ribosomes |
| **C** | Ribosomes | Lysosomes | Mitochondria | Nucleus |
| **D** | Ribosomes | Mitochondria | Lysosomes | Nucleus |

**Explanation:**
Pellet 1 should contain the largest cell organelle (nucleus) and cell debris
Students should work from pellet 4 backwards to figure out the cell structures in pellet 3 and 2 respectively
Pellet 4 should contain ribosomes (smallest organelle)
Hence Pellet 2 contains mitochondria (ave size 0.5–3μm) and Pellet 3 contains lysosomes (ave size 0.1–1.2 μm)

**2** The figure below shows an electron micrograph with two plant cells.




Which of the following statements correctly describe the labelled structures?

1. **R** contains circular DNA and is found in both prokaryotic and eukaryotic cells.
2. **P** has a fluid mosaic structure and regulates the movement of substances between the two plant cells.
3. **S** acts as a selective permeable barrier.
4. **Q** contains enzymes which play an important role in cell division.

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

**Explanation:**

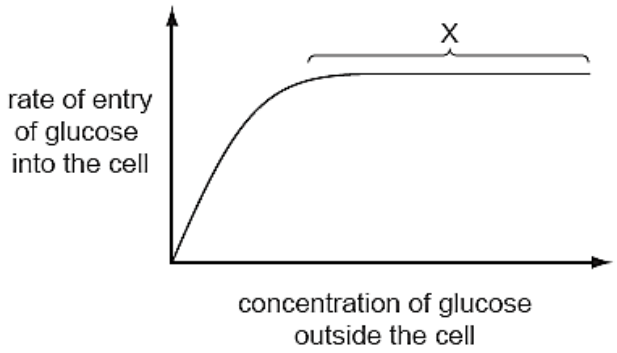
**R** is a mitochondrion → does have circular DNA, but only found in eukaryotic cells.

**P** is the cellulose cell wall, not the phospholipid bilayer.

**S** is the plasma membrane, hence is selectively permeable.

**Q** is the nucleus, it contains enzymes like DNA polymerase, helicase, ligase which are involved in DNA replication, which has to occur prior to cell division. It also contains RNA polymerase which transcribes genes whose products trigger the start of cell division.

**3** The graph shows how the rate of entry of glucose into a cell changes as the concentration of glucose outside the cell changes.




What is the cause of the plateau at X?

**A** The cell has used up its supply of ATP.
**B** All the carrier proteins are saturated with glucose.
**C** The carrier proteins are denatured and no longer able to function.
**D** The concentrations of glucose inside and outside the cell are equal.

**Explanation:**

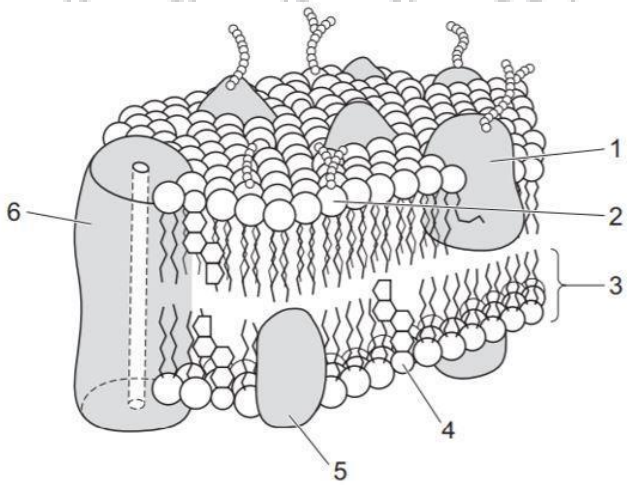
Graph shows that as concentration of glucose outside the cell increases, the rate of entry ot glucose into the cell increases until a plateu. This implies that the movement of glucose is a passive process (i.e. does not require ATP), hence option A is wrong.

Glucose is a polar molecule, and require a hydrophilic channel to pass through the hydrophobic core of the membrane. Hence, the rate of entry will reach a maximum when the carrier/channel protein becomes saturated with glucose when glucose concentration outside the cell becomes sufficiently high.

Option C is wrong because if carrier proteins are denatured, the rate of glucose entry into the cell will decrease drastically instead of being at maximum.

Option D is wrong because the rate of glucose entry into the cell will become zero when the concentration of glucose inside and outside the cell are equal.

**4** The diagram shows the structure of the cell membrane with molecules labelled 1 to 6.

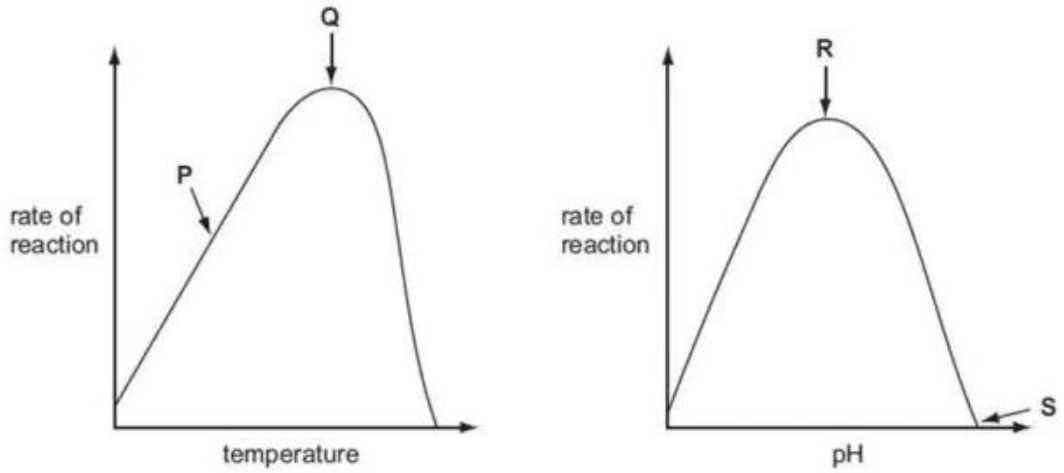



Which row correctly identifies function of two of the numbered molecules?

| | molecule | function | molecule | function |
|---|---|---|---|---|
| **A** | 1 | Cell-to-cell adhesion ✓ | 4 | stabilizes the membrane ✓ |
| **B** | 2 | acts as a receptor ✓<br>Glycolipid functions as a receptor for cell-cell communications | 5 | active transport ✗<br>no hydrophilic channel present for transport |
| **C** | 3 | facilitated diffusion ✗<br>phospholipid bilayer acts as a barrier to prevent diffusion of charged and polar molecules | 4 | regulates the fluidity of the membrane ✓ |
| **D** | 6 | active transport ✓ | 5 | acts as a receptor ✗<br>receptors have to face the exterior surface of the plasma membrane |

**ANS: A**

**5** The graphs show the effects of temperature and pH on enzyme activity.




Which of the following is true?

**A** At **P**, hydrophobic interactions are formed between the enzyme and substrate.
**B** At **Q**, the kinetic energy of substrate and enzyme is the highest.
**C** At **R**, hydrogen bonds in the enzyme break.
**D** At **S**, peptide bonds in the enzyme break.

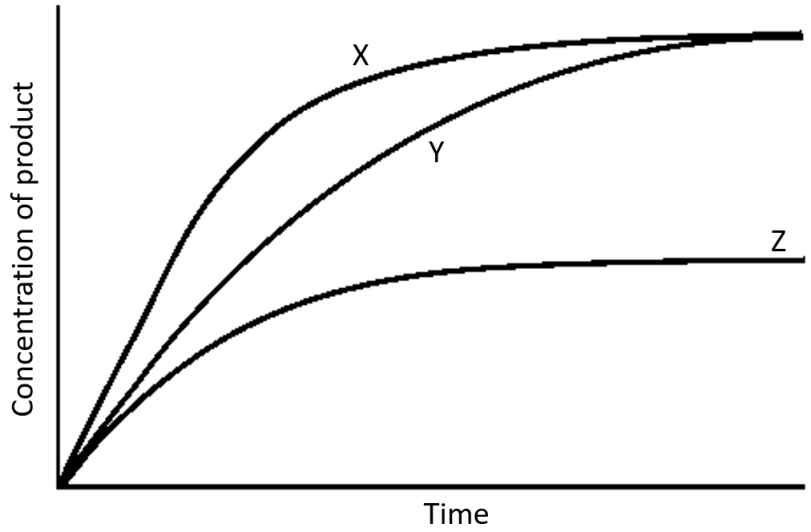
**Explanation:**
Option B is wrong because kinetic energy of substrate and enzyme continues to increase beyond Q as temperature increases.

Option C is wrong because R is the optimum pH of the enzyme, where all the bonds between R groups are intact.

Option D is wrong because denaturation of proteins (whether it is due to high temperature, or huge deviation from optimum pH) only breaks the non-covalent bonds between R groups (e.g. ionic bonds, hydrophobic interactions and hydrogen bonds). Peptide bonds are not broken during denaturation.

**6** Graph Y shows the progression of an enzyme-catalysed reaction carried out at 20°C, with 1.0 moldm$^{-3}$ of substrate, 0.2 moldm$^{-3}$ of enzyme, and at its optimum pH.

Graphs X and Z show the progression of the same enzyme-catalysed reaction, but with one or more changes in the experimental condition.




Which of the following correctly identifies the change(s) in experimental condition resulting in Graphs X and Y?

| | Graph X | Graph Z |
|---|---|---|
| **A** | 0.4 moldm$^{-3}$ of enzyme is used | Temperature is decreased to 10°C |
| **B** | 2.0 moldm$^{-3}$ of substrate is used | Temperature is decreased to 10°C |
| **C** | Temperature is increased to 30°C | 0.5 moldm$^{-3}$ of substrate is used |
| **D** | 0.1 moldm$^{-3}$ of enzyme is used | pH is increased by 2. |

**Explanation**:

Graph X has a higher rate of enzyme activity, but produced the same concentration of product. Hence, it can be due to more enzyme being added, or increased temperature, but not increase in substrate concentration.

Graph Z has a rate of enzyme reaction, or produced a lower concentration of products. Hence, it can be due to complete denaturation of enzyme due to increased pH before all the substrate has been converted into product, or due to decreased concentration of substrate. A decrease in temperature alone will only slow down the rate of reaction, but the graph should still reach the maximum concentration of product formed eventually, rather than reach a plateu.

**7** Complete digestion of polysaccharides requires all the glycosidic bonds between the monomers to be broken. Amylase only breaks α-1,4 glycosidic bonds.

Which row shows how completely amylase can digest molecules of cellulose, amylopectin or amylose?

| | polysaccharide | | |
|---|---|---|---|
| | cellulose | amylopectin | amylose |
| **A** | – | ++ | + |
| **B** | – | + | ++ |
| **C** | + | ++ | – |
| **D** | ++ | – | + |

key

– no digestion

\+ some digestion

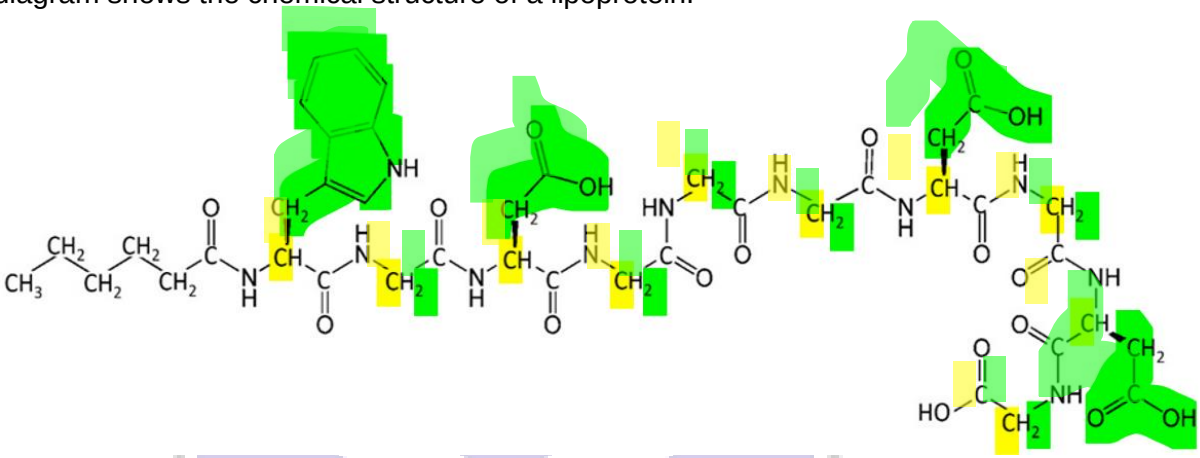
++ most digestion

ANSWER: B

**Explanation:**

Monomers of cellulose are linked by -1,4 glycosidic bonds, which are not hydrolysed by amylase. Amylopectin is highly branched; each branch point can be acted upon by an amylase enzyme for quick digestion. Amylose is unbranched, and can only be digested from the two ends → slower than amylopectin digestion.

**8** The diagram shows the chemical structure of a lipoprotein.



How many amino acid residues are there in this lipoprotein?

**A** 9
**B** 10
**C** 11
**D** 13

**Explanation:**

Central carbons are highlighted in yellow. R groups are highlighted in green. Counting of central carbons and/or R groups will give the number of amino acid residues.

**9** Information about the enzymes that catalyse reactions in respiration is shown in the table below.

| Enzyme | Information |
|---|---|
| Fructose 1,6-bisphosphate aldolase | • Four identical subunits<br>• Changes to anyone of the subunits means that the enzyme cannot function |
| Hexokinase | • One subunit<br>• Active site changes shape to enclose the reactants |
| Phosphofructokinase | • Four identical subunits<br>• Has allosteric sites in addition to an active site |
| Phosphoglucose isomerase | • Two identical subunits<br>• Has a cytokine function (i.e. cell signaling molecule) when secreted into the external medium |
| Pyruvate kinase | • Four identical subunits<br>• ATP acts as an inhibitor to regulate glycolysis |
| Triosephosphate isomerase | • Two identical subunits<br>• Each subunit has 14 alpha helices and 8 beta-pleated sheets |

A student made the following deductions using the information provided in the table:

- Phosphoglucose isomerase, when secreted, can have a non-catalytic role.

- Only three of the six enzymes display quaternary protein structure.
- The active site of phosphofructokinase will change shape to allow the enzyme to act as a regulator in glycolysis.
- Each enzyme is coded for by one gene.
- The reaction catalysed by hexokinase is an induced-fit mechanism.

How many of the student's deductions are correct and can be supported using the information provided?

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

**Explanation:**

A student made the following deductions using the information provided in the table:

- Phosphoglucose isomerase, when secreted, can have a non-catalytic role.

  Correct; it also functions as a cytokine (to bind to target cells and stimulate specific cellular responses via cell signaling)

- Only three of the six enzymes display quaternary protein structure.

  Wrong; All are quaternary except hexokinase (one subunit)

- The active site of phosphofructokinase will change shape to allow the enzyme to act as a regulator in glycolysis.

  Correct; Recall allosteric site of PFK can be bound to inhibitors (ATP) or activators (ADP). That changes the active site of PFK to decrease or increase rate of glycolysis respectively

- Each enzyme is coded for by one gene.

  Correct; Recall One gene → One polypeptide. All the quaternary enzymes have identical subunits. Therefore, only one gene is required.

- The reaction catalyzed by hexokinase is an induced-fit mechanism.

  Correct; ALL enzymes exhibit induced-fit mechanism in their catalytic functions

**10** Which set of statements correctly describes haemoglobin?

| | | | |
|---|---|---|---|
| **A** | four polypeptide chains, forming a globular chain ✘ | Each haem group can carry two oxygen molecules ✘ | Polar R groups of amino acids point towards the centre of the protein ✘ |
| **B** | four polypeptide chains, each consists of α-helices and β-pleated sheets ✘ | iron ions can associate with oxygen forming oxyhaemoglobin | Non-polar R groups of amino acids point towards the centre of the protein |
| **C** | four polypeptides held together by hydrogen bonds, ionic bonds and hydrophobic interactions | iron ions in the molecule can bind reversibly with oxygen | Non-polar R groups of amino acids point towards the haem binding site |
| **D** | polypeptide chains coil into helical structures, which folds to form a spherical molecule | Each haem group can carry one oxygen molecule | Polar R groups of amino acids point towards the haem binding site ✘ |

**Explanation:**

Option A: the four polypeptides do not form a "globular chain". Each haem group can carry one oxygen molecule. Polar R groups will point towards the exterior of the protein.

Option B: haemoglobin does not contain β-pleated sheets.

Option D: Should be non-polar R groups that point towards haem-binding site, to provide a hydrophobic environment for the binding of the non-polar haem group.

**11** The mechanism of action of four drugs that inhibit DNA replication is stated below:

- Drug 1 inhibits the action of DNA ligase.
- Drug 2 resembles the shape of a DNA nucleotide but does not have a free 3' hydroxyl group.
- Drug 3 attaches irreversibly to origin of replication.
- Drug 4 binds irreversibly to the active site of DNA polymerase.

Which option correctly matches the drug(s) to the effect on DNA replication?

| | Daughter strands of varying lengths are synthesized. | Daughter DNA molecules fragment more easily. | Phosphodiester bonds cannot be formed. | Template strand becomes inaccessible by the enzyme. |
|---|---|---|---|---|
| **A** | 4 | 3 | 2 | 1 |
| **B** | 2 | 4 | 3 | 1 |
| **C** | 2 | 1 | 4 | 3 |
| **D** | 3 | 2 | 1 | 4 |

**Explanation:**

Drug 1 will cause Okazaki fragments to remain fragments, hence the double-stranded daughter DNA will be more prone to breaking because multiple points require only a single-stranded break to fragment the DNA molecule.

Drug 2 acts as a nucleotide analogue which can be incorporated into a growing DNA strand, but will terminate the replication because new nucleotides cannot be added. This will result in random termination of replication, producing strands of varying sizes (depending on when the Drug 2 is added to the growing strand).

Drug 3 prevents unwinding and unzipping of the DNA double helix, preventing DNA polymerase from binding to the templates.

Drug 4 prevents the function of DNA polymerase, which is to catalyse the formation of phosphodiester bonds between adjacent nucleotides.

**12** DNA replication in eukaryotes involves the following processes.

- RNA primer molecules are added to each template strand at origins of replication.
- DNA polymerase attaches to primers and synthesises new strands of DNA in a 5' to 3' direction.
- One strand, called the leading strand, is synthesised in continuous long sections.
- The other strand, called the lagging strand, is synthesised in short sections.
- RNA primers are replaced by DNA nucleotides on both strands.

Which statement explains the difference in the way in which the two strands of a DNA molecule are synthesised?

**A** The DNA templates are anti-parallel.
**B** The replication of DNA is semi-conservative.
**C** **A** base pairs with **T** and **C** bases pairs with **G**.
**D** Fewer RNA primers are needed on the leading strand.

**Explanation:**

All the options are true, but only option A explains why leading strand is synthesised continuously while lagging strand is synthesised discontinuously in the form of Okazaki fragments.

**13** Which of the following statement(s) is/are true about transcription?

1. Helicase unwinds and unzips the DNA double helix.
2. Deoxyribonucleoside triphosphates complementary to the template strand forms hydrogen bonds with it.
3. RNA polymerase catalyses the formation of phosphodiester bonds between adjacent nucleotides.
4. Elongation of the polynucleotide continues until the stop codon, UGA, UAA or UAG, is reached.

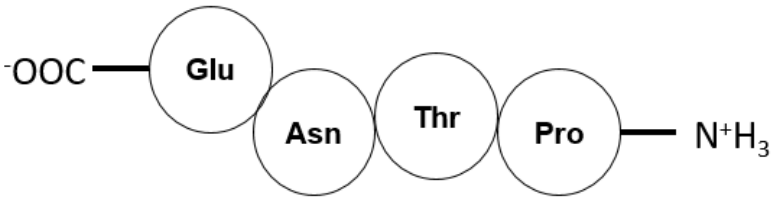
**A** 3 only
**B** 2 and 3 only
**C** 3 and 4 only
**D** All of the above

**Explanation:**
1. Helicase is not involved in transcription; it is for DNA replication.
2. It is ribonucleoside triphosphates, as transcription prodces RNA.
4. Termination of transcription is due to (i) transcription of termination sequence and subsequent formation of hairpin loop (prokaryotes) or (ii) transcription of polyadenylation sequence, which is recognized by an endonuclease which cleaves the RNA transcript (eukaryotes).

**14** The table below shows the anticodon sequences for four amino acids.

| Amino acid | Anticodon (3' – 5') |
|---|---|
| Asparagine (Asn) | UUA |
| Glutamic acid (Glu) | CUU |
| Proline (Pro) | GGA |
| Threonine (Thr) | UGG |

A cell makes a polypeptide with the amino acid sequence:




What was the sequence of bases on the strand of the DNA that codes for this polypeptide chain?

**A** 5' – TTCATTGGTAGG – 3'

**B** 5' – CCTACCAATGAA – 3'

**C** 5' – GGATGGTTACTT – 3'

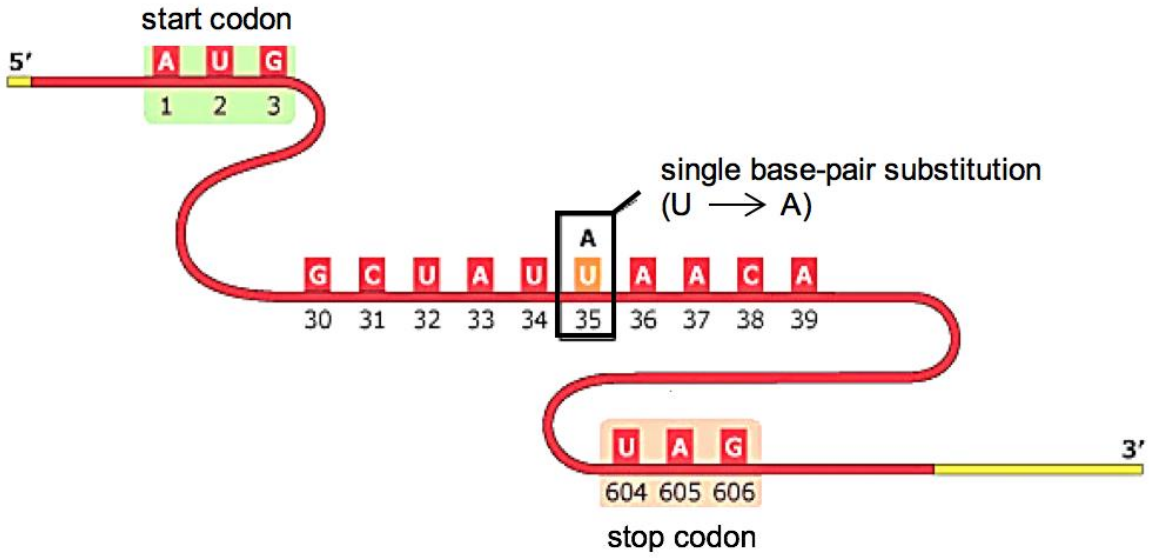
**D** 5' – AAGTAACCATCC – 3'

**Explanation:**
Proteins are synthesized from the N-terminus to the C-terminus. Hence, students need to "flip" the amino acid sequence to Pro-Thr-Asn-Glu. Failing to do this will result in students choosing option C.

Students who chose option B did not read the question carefully and thought that the anticodons in the table were mRNA codons instead.

Students who chose option D thought that the anticodons were mRNA codons AND forgot to "flip" the amino acid sequence to start from N-Ter to C-Ter.

**15** The diagram shows part of the sequence of an mRNA. A single base-pair substitution in the DNA resulted in a change from uracil (U) to adenine (A) at position 35 of the mRNA.




Which statement would be the result of this single base-pair substitution?

**A** Missense mutation causing a single amino acid change in the protein.
**B** Frameshift mutation resulting in extensive incorporation of wrong amino acid residues from the point of mutation.
**C** Nonsense mutation resulting in early termination of translation.
**D** Silent mutation resulting in no change in the amino acid sequence due to degeneracy of the genetic code.

**Explanation:**
UAA is a stop codon. This will result in premature termination of translation.

**16** Which of the following are examples of chromosomal aberration?

1. Insertion of ten consecutive bases in the promoter, resulting in reduced transcription.
2. Protein cap does not bind to telomeres, resulting in end-joining of chromosomes.
3. Deletion of 150 bases, resulting in production of a protein that is 50 amino acid residues shorter than usual.
4. Failure of cytokinesis following mitosis, resulting in a tetraploid daughter cell.
5. Non-disjunction at meiosis, resulting in a missing chromosome 14 in the zygote upon fertilization.

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

**Explanation:**

1 and 3 are examples of gene mutations as they only affect a single gene.

**17** Each of these descriptions of a stage in mitosis in an animal cell is incomplete.

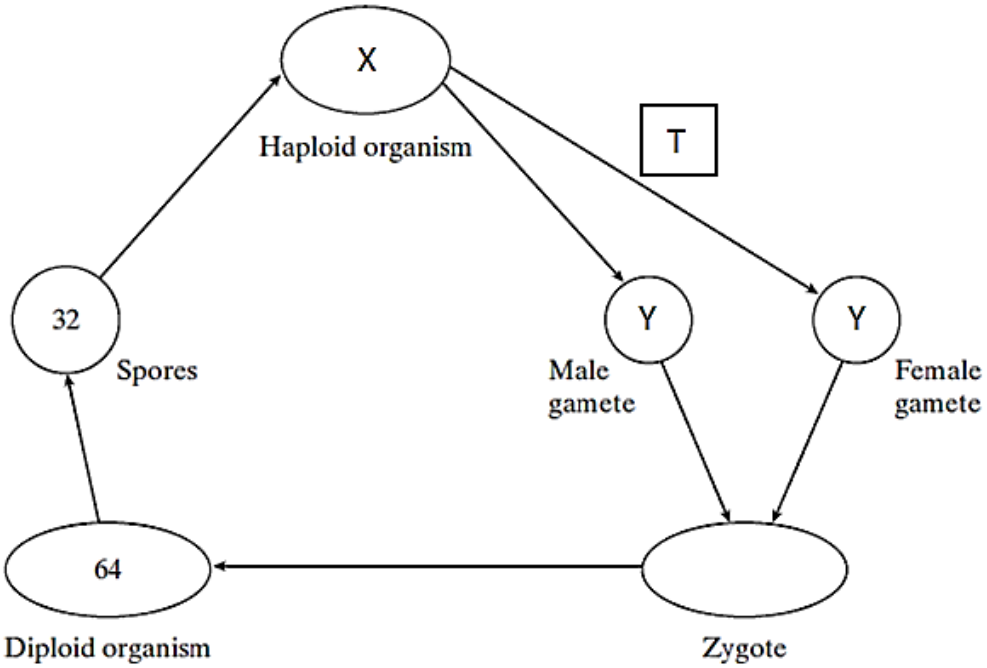
1. centromeres separate and move to the poles of the cell
2. chromatin condenses, centrioles migrate to the poles of the cell
3. chromosomes become less condensed
4. sister chromatids joined by centromeres align at the equator of the cell

Which row completes the description of each mitotic stage?

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **A** | Nuclear envelop and nucleolus reform | Sister chromatids are pulled apart by shortening of spindle microtubules | Centromeres bind to spindle microtubules | Spindle microtubules appear between centrioles and nuclear envelop disappears |
| **B** | Centromeres bind to spindle microtubules | Nuclear envelop and nucleolus reform | Spindle microtubules appear between centrioles and nuclear envelop disappears | Sister chromatids are pulled apart by shortening of spindle microtubules |
| **C** | Spindle microtubules appear between centrioles and nuclear envelop disappears | Centromeres bind to spindle microtubules | Sister chromatids are pulled apart by shortening of spindle microtubules | Nuclear envelop and nucleolus reform |
| **D** | Sister chromatids are pulled apart by shortening of spindle microtubules | Spindle microtubules appear between centrioles and nuclear envelop disappears | Nuclear envelop and nucleolus reform | Centromeres bind to spindle microtubules |

**Explanation:**
Statement 1 is anaphase, which also involves sister chromatids being pulled apart.
Statement 2 is prophase, which also involves formation of spindle and nuclear envelop disappearing.
Statement 3 is telophase, which also involves nuclear envelop and nucleolus reforming.
Statement 4 is metaphase, which also involves binding of microtubules to all centromeres.

**18** The diagram shows the life cycle of an organism. The numbers show how many chromosomes are present in one cell at each stage of the life cycle.




Which of the following correctly shows the type of division and number of chromosomes?

| | Type of cell division | Number of chromosomes | |
|---|---|---|---|
| | T | X | Y |
| **A** | Mitosis | 16 | 8 |
| **B** | Meiosis | 16 | 16 |
| **C** | Meiosis | 32 | 16 |
| **D** | Mitosis | 32 | 32 |

**Explanation:**
2n = 64; n = 32

Gametes are haploid, hence contain 32 chromosomes. So that when they fuse during fertilization, it restores the diploid number in the zygote.

Hence, the haploid organism that grows from the haploid spores must have undergone mitosis to produce the haploid gametes, because mitosis produces daughter cells that have the same number of chromosomes as the parent cells.

**19** Induced pluripotent stem cells are stem cells that can be generated directly from adult stems cells under the influence of molecular signals.

Which of the following statements are **true**?

**I** An induced pluripotent stem cell can differentiate into any cell including the extra embryonic tissue. F

**II** Induced pluripotent stem cell has active telomerase activity.

**III** An induced pluripotent stem cell has specialized function. F

**IV** Induced pluripotent stem cells gives rise to genetically identical cells for tissue repair.

V Induced pluripotent stem cells have the same developmental potential as embryonic stem cells.

**A** I , III & V only

**B** II , IV & V only

**C** II, III & IV only

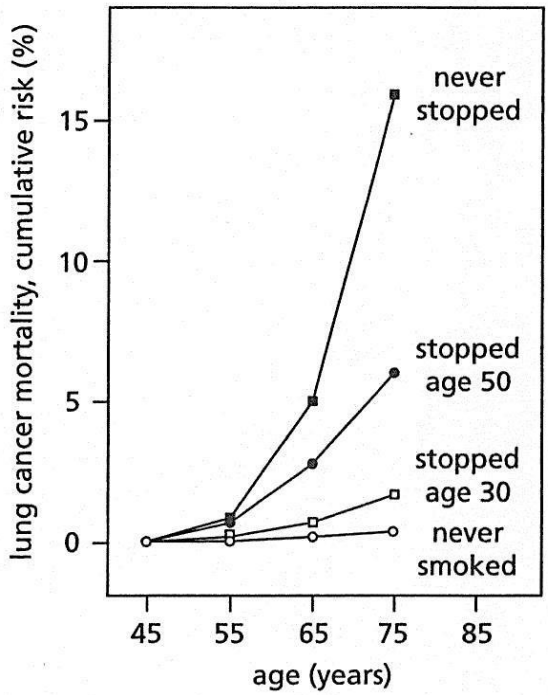
**D** III, IV & V only

**Explanation:**

Statement I should be **"**An induced pluripotent stem cell can differentiate into any cell **excluding** the extra embryonic tissue."

Statement III is false because all stem cells are unspecialised cells.

**20** Mortality due to lung cancer was followed in groups of males in the United Kingdom for 50 years. The cumulative risk of dying from lung cancer as a function of age and smoking habits for four groups of males is shown in the figure.




Which of the following can be inferred from the graph?

1. Smoking is the leading cause of lung cancer mortality.
2. The earlier an individual stops smoking, the lower his probability of dying from lung cancer.
3. A majority of individuals who never stopped smoking will die from lung cancer.
4. There is little risk of a non-smoker dying of lung cancer.

**A** 1 and 2 only

**B** 3 and 4 only

**C** 2 and 4 only

**D** 1, 2 and 4 only

**Explanation:**
The cumulative risk in the question may be interpreted as the probability that an individual will die of lung cancer. Statement 3 is not true because individuals who never stopped smoking only has a 16% chance of dying of lung cancer.

**21** In lentils, the seed coat pattern is determined by a gene with 3 alleles, $C^M$, $C^S$ and $C^C$, whose phenotypes are marbled, spotted and clear respectively. Four crosses were repeated many times. The crosses and the outcomes of these crosses are shown in the table below.

| cross | parents | offspring phenotype and ratio |
|---|---|---|
| **1** | marbled x marbled | 3 marbled : 1 clear |
| **2** | spotted x clear | all spotted |
| **3** | marbled x marbled | 3 marbled : 1 spotted |
| **4** | clear x clear | all clear |

From the data, it is possible to conclude that,

**A** two thirds of the marbled offspring in cross 3 are heterozygous.
**B** the marbled parents in cross 1 have the same genotype as the marbled parents in cross 3.
**C** spotted is recessive to clear.
**D** all of the clear offspring are heterozygous.

**Explanation:**
Cross 1: the two marbled parents are heterozygous for marbled allele and clear allele, and marbled allele is dominant to clear allele.
Cross 2: spotted is dominant to clear → hence option C is wrong.
Cross 3: the two marbled parents are heterozygous for marbled allele and spotted allele, and marbled allele is dominant to spotted allele → when combined with Cross 1's results, this makes option B wrong.
Cross 4: confirms that clear allele is the most recessive → hence option D is wrong as clear offspring must be homozygous for the recessive clear allele.

Option A genetic diagram:

| | | | | | |
|---|---|---|---|---|---|
| Parental phenotype | marbled | x | marbled | | |
| Parental genotype | $C^MC^S$ | x | $C^MC^S$ | | |
| Gametes | $C^M$ | $C^S$ | x | $C^M$ | $C^S$ |
| Offspring genotypes | $C^MC^M$ marbled | $C^MC^S$ marbled | | $C^MC^S$ marbled | $C^SC^S$ spotted |

Out of the 3 marbled offspring, 2 of them are heterozygous.

**22** In the breeding season, male Anole lizards court females by bobbing their heads up and down while displaying a colorful throat patch. Both characteristics are controlled by genes found on separate chromosomes. Anoles prefer to mate with lizards, which bob their heads fast and have red throat patches. These two alleles are dominant over their counterparts, slow bobbing and yellow throats.

A male lizard heterozygous for head bobbing and homozygous for the red throat patch mates with a female that is also heterozygous for head bobbing but has yellow throat patches.

What percentage of the offspring has fast bobbing and red throat phenotype?

**A** 25%
**B** 50%
**C** 75%
**D** 100%

**Explanation**
Let F represent the allele for fast head bobbing.
Let f represent the allele for slow head bobbing.
Let R represent the allele for red throat patch.
Let r represent the allele for yellow throat patch.

| | | | |
|---|---|---|---|
| Parental phenotype | Fast head bobbing, red throat patch male | x | Fast head bobbing, yellow throat patch female |
| Parental genotype | FfRR | x | Ffrr |
| Gametes | FR fR | x | Fr fr |
| Offspring genotypes | FFRr FfRr FfRr | | rrRr |
| | 3 Fast head bobbing, red throat patch : | | 1 Slow head bobbing, red throat patch |

**23** Scientists who are trying to distinguish the contributions of genetic and environmental factors to human phenotypes, often make use of the study of twins.

Monozygotic twins grown from a single fertilized egg that split into two.

Dizygotic twins develop from two different eggs, each fertilized by a different sperm.

Twins can be divided into four groups, **P, Q, R** and **S** as shown in the table below.

| Twins | Grow up together in the same household | Grow up apart in different families and households |
|---|---|---|
| Monozygotic | **P** | **Q** |
| Dizygotic | **R** | **S** |

For groups **P, Q, R** and **S**, which of the following options shows the correct comparisons between the members of a pair of twins for the genetic and environmental factors that affect the phenotype?

| | **Factors** | **P** | **Q** | **R** | **S** |
|---|---|---|---|---|---|
| **A** | genetic | different | different | identical | identical |
| | environmental | different | similar | different | similar |
| **B** | genetic | identical | identical | different | different |
| | environmental | similar | similar | different | different |
| **C** | genetic | identical | different | identical | different |
| | environmental | different | different | similar | similar |
| **D** | genetic | identical | identical | different | different |
| | environmental | similar | different | similar | different |

**Explanation:**
Monozygotic twins are genetically identical, dizygotic twins are not genetically identical.
Growing up in the same household implies similar environmental effect exerting on their genes.

Hence, group P will have identical genetic effect and similar environmental effect.
Group Q will have identical genetic effect and different environmental effect.
Group R will have different genetic effect and similar environment effect.
Group S will have different genetic effect and different environmental effect.

**24** Northern elephant seals, *Mirounga angustirostris*, were nearly hunted to extinction in the 1890s, with only about 20 individuals left at the end of the century. The population has now grown to more than 120 000.

In the 1890s, Southern elephant seals, *Mirounga leonina*, were not as severely hunted and currently there are estimated to be 600 000 Southern elephant seals.

Which of the following statements are correct?

1. Northern elephant seals would show less genetic variation than Southern elephant seals.
2. Northern elephant seals would be subjected to greater selection pressures than Southern elephant seals.
3. Nouthern elephant seals would experienced greater genetic drift than Sorthern elephant seals.
4. The mutation rate in Northern elephant seals would have been greater than in Southern elephant seals.

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

**Explanation:**

Statemen 1: Northern elephant seals experienced a bottleneck effect → loss of alleles → lower genetic diversity.

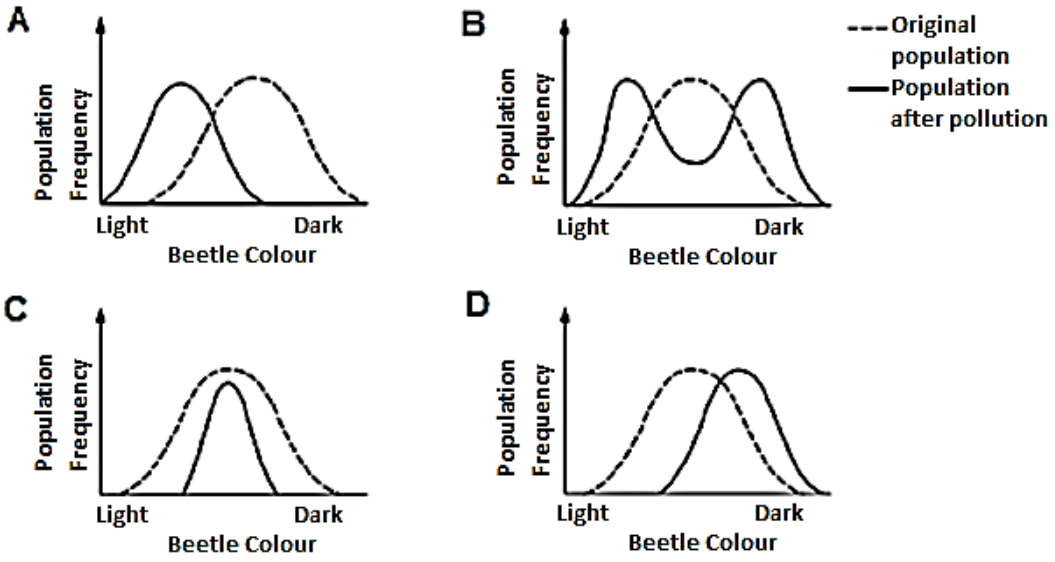
Statement 2 cannot be concluded because selection pressures depend on the biotic and abiotic environment the elephants are in, which is not given in the question.

Statement 3: Smaller populations are affected more by genetic drift because chance events can alter allele frequencies more drastically in a small population than a larger population.

Statement 4: mutation rate is affected by presence of mutagens in the environment, which the question does not provide info on.

**25** In a hypothetical population of beetles, there is a wide variety of colour, matching the range of coloration of the tree trunks on which the beetles hide from predators. The graphs below illustrate four possible changes to the beetle population as a result of a change in the environment due to pollution that darkened the tree trunks.

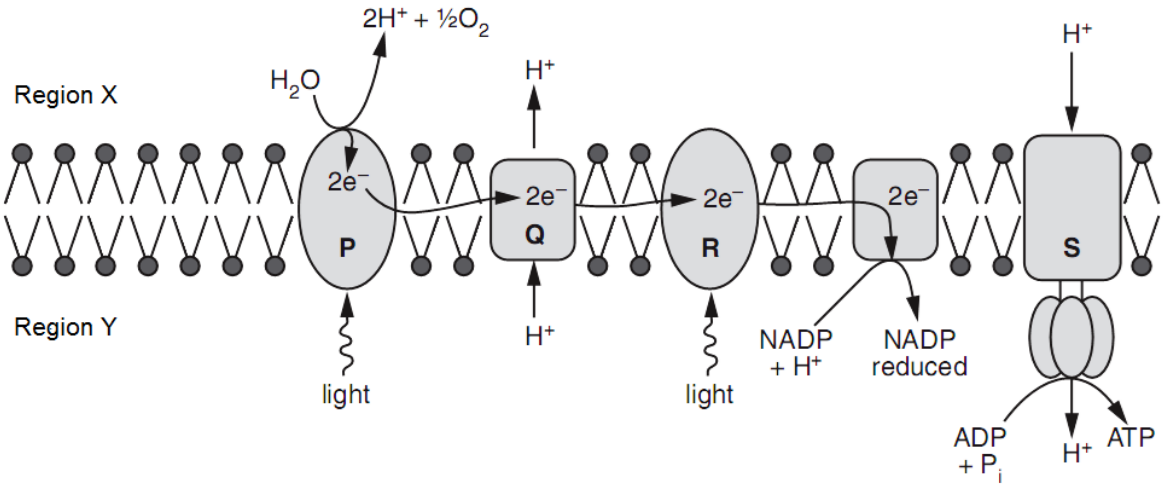
Which of the following graphs includes the most likely change in the coloration of the beetle population after pollution?




**ANSWER: D**

**Explanation:**
Darkened tree trunks favors darker beetle colour due to better camouflage from predators (the selection pressure). As a result, the population will undergo directional selection in favor of the darker phenotype.

**26** The figure represents a cross section of a part of the thylakoid membrane, showing some components which are involved in the light-dependent stage of photosynthesis.




Which statement about the components in the light-dependent stage is true?

**A** An inhibitor which blocks the electron flow through R would inhibit the production of oxygen at P.

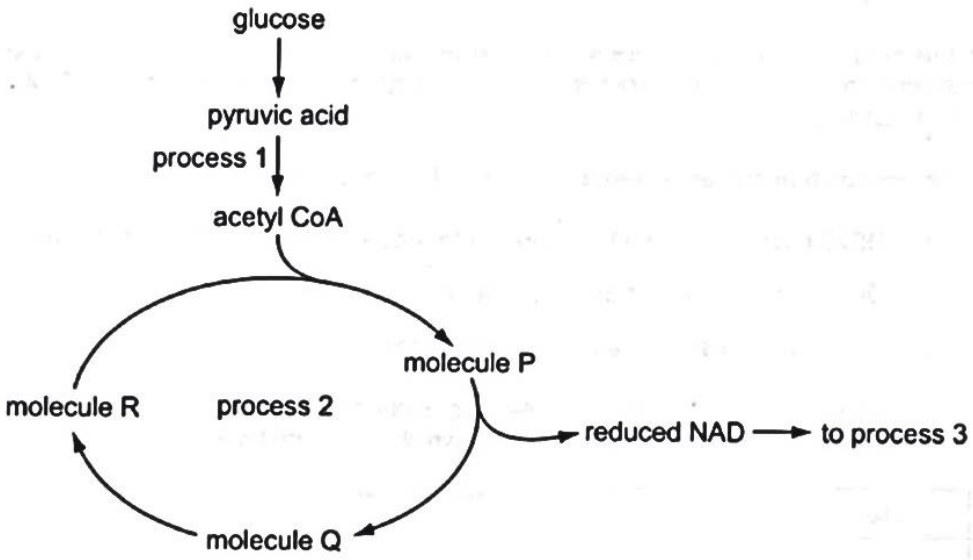
**B** In structures P and R, electrons are passed from one pigment molecule to another until it reaches chlorophyll a.

**C** Region X is expected to have a higher pH than Region Y.

**D** There is a non-cyclical flow of electrons through structures P, Q, R and S.

**Explanation:**
B - P and R are photosystems and photons not electrons are pass from pigment molecule to another
C - Higher conc of H+ → lower pH
D – Electrons are not passed through structure S.

**27** The diagram shows a summary of aerobic respiration.




Which of the following statements is correct?

**A** Process 1 occurs in the mitochondrial matrix and processes 2 and 3 occur on the inner mitochondrial membrane.

**B** Processes 1 and 2 occur in the mitochondrial matrix and process 3 occurs on the inner mitochondrial membrane.

**C** Process 1 occurs in the cytoplasm, process 2 occurs in the mitochondrial matrix and process 3 occurs on the inner mitochondrial membrane.

**D** Processes 1 and 2 occur in the cytoplasm and process 3 occurs in the mitochondrial matrix.

**Explanation**:
Process 1: link reaction
Process 2: Krebs cycle
Process 3: Oxidative phosphorylation

**28** Between June and August 2019, 500 million bees died in Brazil. Researchers attributed the mass death event to the use of pesticides in agriculture, as pesticides weaken the immune system of bees.

Approximately one-third of crop plants worldwide rely on pollination by bees. Pollination is required for plant sexual reproduction. Bees pollinate plants while collecting nectar and pollen from the flowers of the plants. Bees can only pollinate plants whose flowers are the correct shape for their bodies and mouth parts to reach the nectar and pollen.

A student made the following deductions from the information.

1. Crop harvests will decline with declining bee population.
2. Bees evolve different body shapes and mouth parts in response to the available flower shapes in the environment.

3. The prolonged use of pesticides will result in bee populations becoming more susceptible to parasite infection.
4. More than one selection pressure is acting on the bee populations.

How many of the deductions made by the student is/are correct?

**A** 1

**B** 2

**C** 3

**D** 4

**Explanation**:
Statements 1 and 4 are correct.

Statement 2 is wrong because the phrasing makes it align more with Lamarck's theory instead.

Statement 3 is wrong because the prolonged use of pesticides would favor individuals which are more resistant to the pesticide. Over time, bee populations will become more and more resistant to the pesticide.

**29** Which of the following statements below describe problems associated with the human-induced accelerated melting of the Arctic ice sheets?

1. Late-summer droughts and increased stress on freshwater supply
2. Loss of coastal cities, mangroves and wetlands
3. Release of ancient pathogens that could bring back eradicated diseases
4. Sea water pH rising beyond levels that corals can survive in, leading to bleaching events
5. Exacerbates global warming due to increased carbon dioxide and methane being released

**A** 3 and 4 only

**B** 2, 3 and 5 only

**C** 1, 2, 3 and 5 only

**D** All of the above

**Explanation:**
There would be an initial increase in annual water flows due to the rapid melting of the Arctic ice, followed by a decrease in the flows due to a decrease in the water volume stored in glaciers and snow packs. Such a situation would result in initial floods and eventually long drought periods in the regions that are dependent on melting of glaciers for their water supply.

Melting ice sheets add extra water into the ocean, causing rise in sea levels which can wash away/cover low-lying coastal areas, mangroves and wetlands.

When permafrost thaws, so do ancient bacteria and viruses in the ice and soil. These newly-unfrozen microbes could make humans and animals very sick. Scientists have discovered microbes more than 400,000 years old in thawed permafrost.

Corals experience bleeching when there is ocean acidification, i.e. when the pH decreases, not increases.

Melting of permafrost releases the trapped methane into the atmosphere. Decomposition of thawing organic matter also releases carbon dioxide. These are greenhouse gasses.

**30** Some of the risk factors affecting the epidemiology of dengue disease are listed:

1. Having previously been infected with a different serotype of the virus
2. Having a genetic susceptibility to the virus
3. Living in a region where mosquitoes carry a more virulent form of the virus
4. Living near open sewers
5. Having a chronic disease such as diabetes

Some of these risk factors increase the probability of being infected with the virus while others increase the risk of developing severe dengue disease following infection.

Which of these risk factors increase the probability of developing severe dengue disease following infection?

**A** 3 and 5 only

**B** 2, 3 and 4 only

**C** 1, 2 and 5 only

**D** 1, 2, 3 and 5 only

**Explanation:**

1. A person who has been infected with a different serotype is at a higher risk of severe dengue disease due to antibody-dependent enhancement.
2. Some genes cause a person to be more susceptible to developing severe dengue disease while other genes give protective resistance against the severe forms of dengue disease.
3. Some serotypes are considered more virulent than others (e.g. DENV2 is considered most severe)
4. Living near open sewers where mosquitoes breed only increases your chance of getting bitten and being infected by DENV.
5. Yes. It just is. Diabetic patients are a higher risk of developing dengue shock syndrome and severe dengue disease; this is called co-mobidity.

**END OF PAPER**