EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examination 2023
General Certificate of Education Advanced Level
Higher 2

H2 Biology **9744/01**

Paper 1 Multiple Choice **22 September 2023**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use paper clips, glue or correction fluid/tape.
Write your name, civics group and registration number on the Answer Sheet in the spaces 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 booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **22** printed pages and **2** blank pages.

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Answer **all** questions.

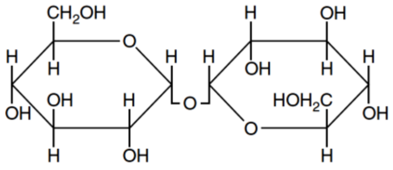
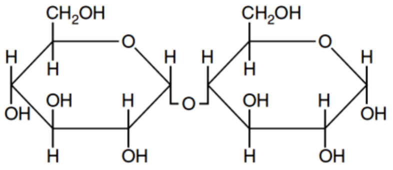
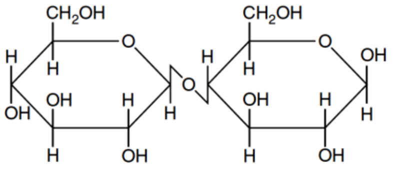
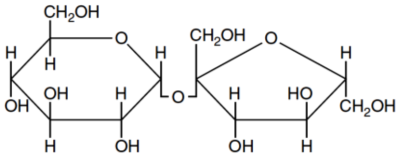
1 Disaccharides are formed following synthesis from monosaccharides or as a result of polysaccharide hydrolysis.

Cellobiose, maltose, sucrose and trehalose are four different disaccharides found in nature.

Some features of these disaccharides are listed.

- Cellobiose is formed from the hydrolysis of the polysaccharide cellulose.
- Sucrose is composed of glucose and fructose.
- Trehalose is a non-reducing disaccharide that is synthesised from two α-glucose molecules.
- Maltose is formed from the hydrolysis of amylose, a component of starch.

Which column correctly identifies each disaccharide?

	A	**B**	**C**	**D**
	cellobiose	maltose	sucrose	trehalose
	maltose	cellobiose	trehalose	maltose
	sucrose	trehalose	cellobiose	cellobiose
	trehalose	sucrose	maltose	sucrose

Option A – sucrose cannot be made of two glucose joined by β-glycosidic bonds, cellobiose should be two glucose joined by β-glycosidic bonds which is not the case.
Option B – we can eliminate this choice based on the diagrams for maltose cellobiose and trehalose.
Option C – we can eliminate via sucrose, trehalose and , maltose.

2 When hydrolysed, which molecules have products containing carboxyl groups?

1 phospholipids
2 polysaccharides
3 proteins

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

Phospholipids have fatty acid hydrocarbon tails, hence there are carboxyl groups in these molecules. Proteins are made up of amino acids which have carboxyl and amino groups.

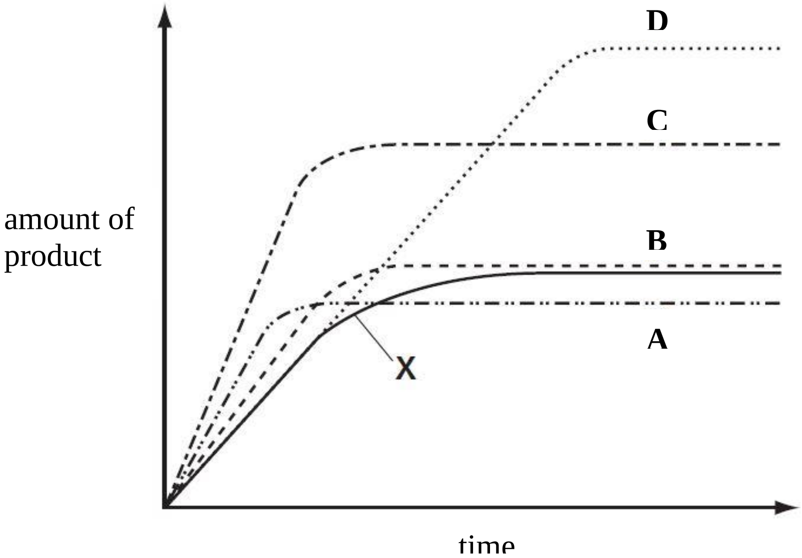
3 How many different polypeptides, each of 100 amino acids, can be made if the number of different amino acids available is 10?

A 100^{10} **B** 10^{100} **C** 1000 **D** 10

Since there are only 10 amino acids available, the total number 100-amino acid polypeptides would be 10^{100}. This is similar to having 4 nucleotides bases but each codon is only made up of 3 nucleotide bases. Thus we can have 4^3 possible codon combinations.

4 The curve **X** shows the activity of an enzyme at 20°C. Curves **A**, **B**, **C** and **D** show the effect of different conditions on the activity of the enzyme.

Which curve shows the effect of increasing the temperature by 10°C and adding extra substrate?



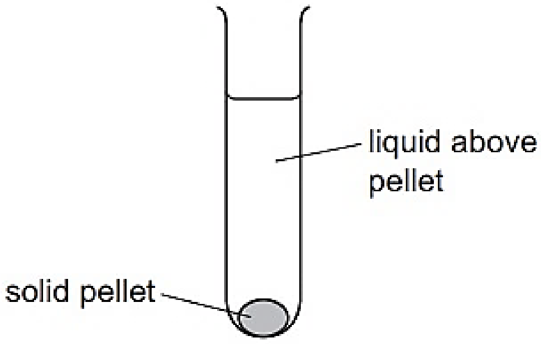
Answer: C

Increasing the temperature by 10^0C and increasing the substrate would double the initial rate of the reaction and raise the amount of product produced compared to **X**.

5 A scientist carried out an experiment to separate the organelles in an animal cell by density.

The scientist mixed the cells with a buffer solution which had the same water potential as the cells. The cells were lysed with a blender to release the organelles.

The mixture was filtered and then spun in a centrifuge at a high speed to separate the heaviest organelle. This sank to the bottom, forming a solid pellet, 1.



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 organelle. This organelle sank to the bottom, forming a solid pellet, 2.

He repeated this procedure twice more to obtain pellet 3 and pellet 4, each containing a single type of organelle.

What is the most likely function of the organelle extracted in pellet 4?

A digestion of old organelles
B production of mRNA
C production of ATP
D catalyse bond formation in polypeptides

Pellet 1 likely nuclei – for production of mRNA
Pellet 2 likely mitochondria – production of ATP
Pellet 3 likely lysosomes – digestion of old organelles
Pellet 4 likely ribosomes – catalysing bond formation in polypeptides

6 Studies have shown that the formation of stable flattened stacks of membranes are essential for the proper functioning of the Golgi body. This structure is maintained by a microtubule network and a group of peripheral and integral proteins found on the cytoplasmic surface of Golgi membranes.

In some diseases, such as certain types of cancer and some neurodegenerative diseases, the structure of the Golgi body is fragmented as shown in the diagram below. The fragments are unlinked and are dispersed in the cytoplasm of the cell.

Which statements are possible inferences from the given information?

1 Fragmented Golgi bodies contain non-functional glycosyltransferases, which results in hyperactive glycoproteins linked to cancer.

2 Fragmented Golgi bodies are a consequence of mutated Golgi membrane proteins, resulting in the loss of attachment sites for cisternae to stack.

3 Fragmented Golgi bodies may result in the loss of attachment sites for transport vesicles from the rough endoplasmic reticulum, leading to unmodified proteins which are non-functional.

4 Fragmented Golgi bodies may result in reduction of sorting and processing of proteins for the maintenance of nerve cells, leading to their degeneration.

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

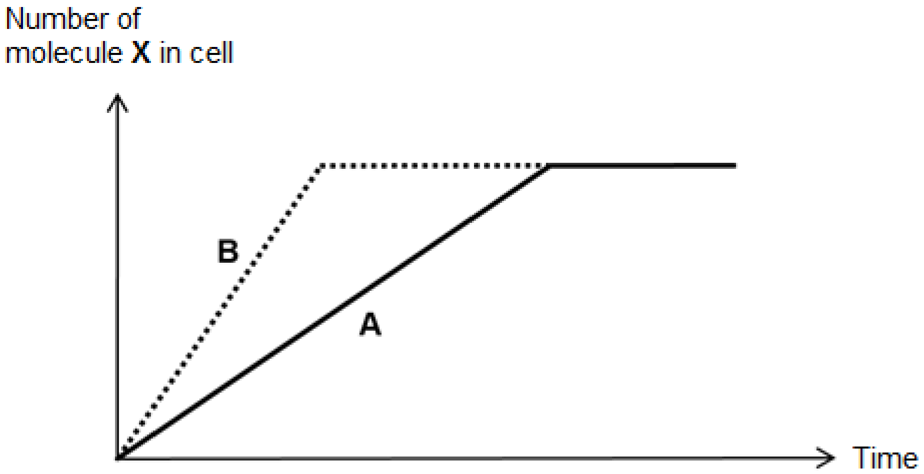
Statement 1 – not possible since non-functional glycosyltransferases will not give rise to hyperactive glycoproteins

Statement 2 – possible since first paragraph referenced peripheral and intrinsic proteins being responsible for maintenance of Golgi structure.

Statement 3 – possible since the Golgi body is the recipient of transport vesicles from the rough endoplasmic reticulum.

Statement 4 – possible since Golgi body is responsible for the sorting and processing of proteins.

7 Graph **A** shows the transport of molecule **X**, with the help of carrier proteins, over time.



A student predicted that the alteration of one variable would result in graph **B**.

Which row shows the correct transport process and the correct alteration in variable that would result in graph **B**?

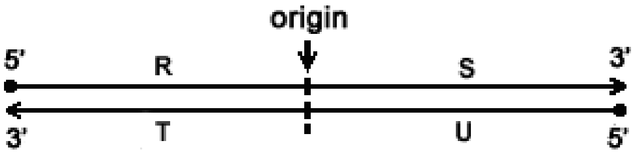
	Transport process	Alteration resulting in graph **B**
A	facilitated diffusion	increase in concentration of X outside cells
B	active transport	increase in concentration of X in cells
C	facilitated diffusion	increase in number of carrier proteins
D	active transport	increase in environmental temperature to 90°C

Option A – not possible since graph is showing increase of X inside the cell.

Option B – not possible since this would be against a concentration gradient, which should be an increase in concentration outside the cell.

Option D – not possible since this may denature the carrier protein and decrease the transport (much shallower gradient than A) instead of increasing the transport of X (steeper gradient)

8 If DNA synthesis is initiated at the indicated origin of replication as shown in figure below.



Which segments of single-stranded DNA are templates for the synthesis of Okazaki fragments?

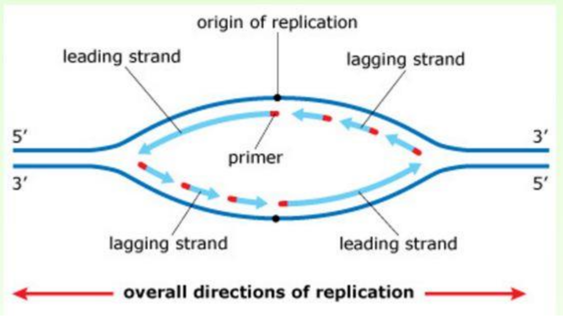
A **R** and **U**

B **S** and **T**

C **R** and **T**

D **S** and **U**

Segments S and T serve as templates for the respective lagging strands as shown below.



9 An antibiotic, edeine, was isolated. It inhibits protein synthesis but has no effect on either DNA synthesis or RNA synthesis. When added to a mixture containing fully intact organelles, edeine stops translation after 10s.

Analysis of the edeine-inhibited mixture showed that no polyribosomes remained by the time protein synthesis had stopped. Instead, all the mRNA accumulated together with small ribosomal subunit and initiator tRNA.

What step in protein synthesis does edeine inhibit?

A It interferes with chain termination and release of the peptide.

B It inhibits the binding of amino acyl-tRNAs to the A-site in the ribosome.

C It blocks the translocation of peptidyl-tRNA from the A-site to the P-site of the ribosome.

D It prevents the formation of the translation initiation complex, which contains the initiator tRNA and both ribosomal subunits.

Absence of polyribosomes indicates possible failure of assembly of translation initiation complex. Further information suggested this was likely since all the mRNA associated only with small ribosomal subunit and initiator tRNA.

10 The codons UGU and UGC code for the amino acid cysteine, which can form disulfide bonds in a polypeptide.

The codon UGG codes for the amino acid tryptophan, which does not contain a sulfur atom.

UGA is a stop codon.

On the template DNA strand, the DNA triplet code for the 10th amino acid in a particular polypeptide is ACA.

Which single base substitution(s) in this triplet code will result in **no** disulfide bond being formed with the 10th amino acid in the polypeptide?

A ACC and ACG

B ACG and ACT

C ACT and ACC

D ACG only

Original DNA code – ACA, mRNA codon UGU, which codes for cysteine.
Option A - ACC gives mRNA codon UGG (coding for tryptophan) but ACG will give mRNA codon UGC (coding for cysteine).
Option B – ACG gives mRNA codon UGC (coding for cysteine) but ACT will give mRNA codon UGA (stop codon)
Option C – Both ACT and ACC will give mRNA codons UGA and UGG (stop codon and tryptophan respectively)
Option D – ACT gives only a stop codon

11 The graphs show various measurements taken from mitotic stages of metaphase and beyond. The graphs are all to the same scale.

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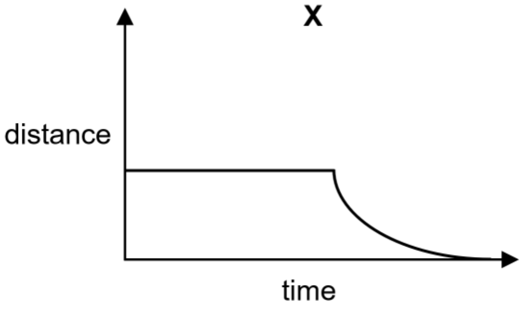
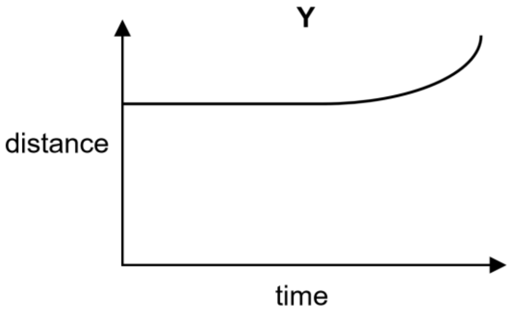
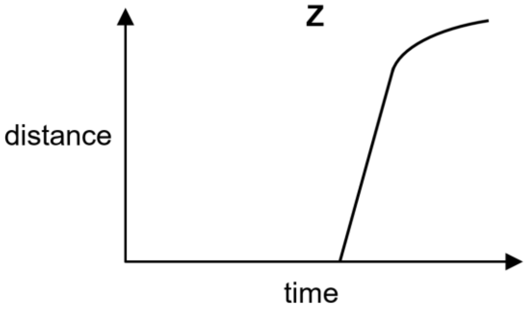






Which row correctly describes each graph?

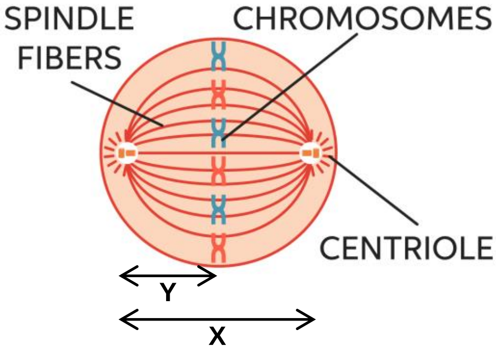
	X	**Y**	**Z**
A	distance between centrioles	distance between sister chromatids	distance of centromere to pole of cell
B	distance between centrioles	distance of centromere to pole of cell	distance between sister chromatids
C	distance of centromere to pole of cell	distance between centrioles	distance between sister chromatids
D	distance of centromere to pole of cell	distance between centrioles	distance between centrioles

Explanation:

X shows a constant distance until anaphase, which is half the constant distance shown in **Y**. Hence, **X** must be the distance of centromere to pole of the cell as all the chromosomes are aligned individually along the metaphase plate, which is half the distance between the two centrioles that form the mitotic spindle.

Thus, **Y** must be the distance between centrioles, as the constant portion of the graph is twice that of **X**.

Z seems to show a constant distance at zero before anaphase, since the sister chromatids are still joined at the centromere, and the distance between sister chromatids only increases from anaphase onwards.



For answer key only:

Taken from 2017 NYJC H1 Bio Prelim P1 Q10

12 A diploid cell from a certain organism contains *x* amount of DNA and 38 chromosomes and can undergo either mitosis or meiosis.

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During which stage(s) would 2*x* amount of DNA and 76 chromosomes be found in each cell?

A Anaphase of mitosis only.

B Anaphase of meiosis I only.

C Anaphase of mitosis and anaphase of meiosis I.

D Anaphase of mitosis and anaphase of meiosis II.

Explanation:

After DNA replication (during S phase), the diploid cell will have 2*x* amount of DNA and 38 chromosomes, ready for mitosis or meiosis. However, during anaphase of mitosis, the centromere of each chromosome divides, and sister chromatids separate to form daughter chromosomes. Hence, the number of chromosomes per cell briefly doubles to 76 during anaphase and telophase of mitosis.

This does not happen in meiosis I, since only homologous chromosomes are separated during anaphase I, and not sister chromatids. As a result, daughter cells resulting from meiosis I are now haploid with *x* amount of DNA and 38 chromosomes per cell.

13 When a patient is diagnosed with cancer, the diagnosis will include the stage of the cancer. There are typically five stages, characterised as follows:

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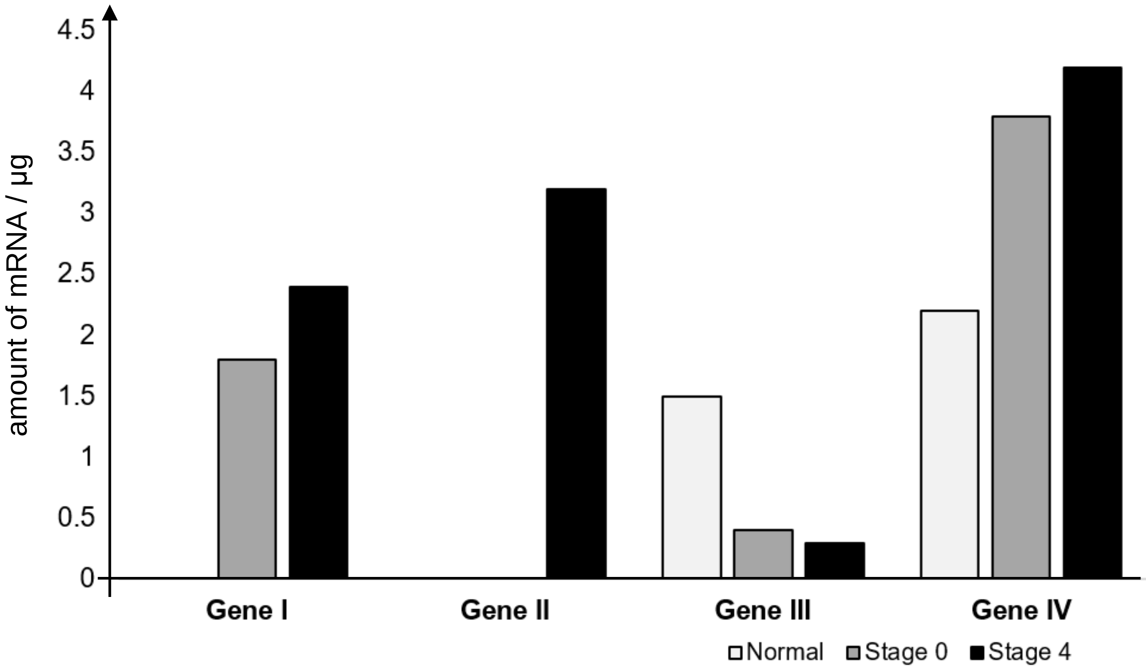
stage	description
0	Small localised tumour mass which has not spread to nearby tissues.
1	Small localised tumour mass that has not grown deeply into nearby tissues. It has not spread to the lymph nodes or other parts of the body.
2 and 3	Larger tumour mass which has grown more deeply into nearby tissues. It may have also spread to lymph nodes but not to other parts of the body.
4	Cancer has spread to other organs or parts of the body.

The expression of four genes, **I** to **IV**, was studied in three different individuals:

- Normal (not suffering from cancer)
- Stage 0 cancer
- Stage 4 cancer

All four genes have been implicated in cancer development. The amount of mRNA transcribed from each gene in a somatic cell was quantified, and the results are shown below.



Which of the following correctly identifies genes **I** to **IV**?

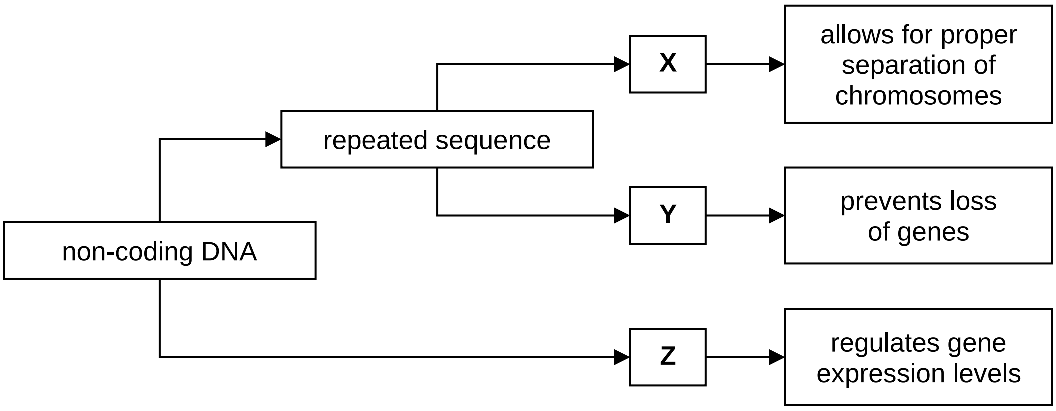
	Gene **I**	Gene **II**	Gene **III**	Gene **IV**
A	telomerase gene	gene involved in metastasis	tumour suppressor gene	proto-oncogene
B	gene involved in metastasis	telomerase gene	tumour suppressor gene	proto-oncogene
C	gene involved in metastasis	telomerase gene	proto-oncogene	tumour suppressor gene

D	telomerase gene	gene involved in metastasis	proto-oncogene	tumour suppressor gene

Explanation:

- Gene **I** – not expressed in normal cells, but highly expressed in tumour and cancer cells. This is likely something that removes the limitation on the number of divisions a cell can undergo, and hence is most likely to be the gene encoding telomerase.
- Gene **II** – highly expressed in cancer cells, but not expressed at all in normal or tumour cells. This must be related to the final stage of cancer (stage 4), which is spreading, or metastasis.
- Gene **III** – mRNA level is about 1.5 μg in normal cells, but decreases to 0.4 μg in tumour cells, and 0.3 μg in cancer cells. This means that the decrease in expression level of this gene contributes to tumour formation and cancer, and hence, this must be a tumour suppressor gene that has undergone a loss-of-function mutation.
- Gene **IV** – mRNA level is about 2.2 μg in normal cells, but this increases to above 3.8 μg in tumour cells and 4.2 μg in cancer cells. Using the same logical deduction as gene **III**, this means that increased expression of gene **IV** contributes to tumour formation and cancer, and hence, it must be proto-oncogene that has undergone a gain-in-function mutation.

14 The flowchart shows the classification of several regions of non-coding eukaryotic DNA, **X**, **Y**, and **Z**.



How many of the following statements correctly describe **X**, **Y**, and **Z**?

1 Regions **X** and **Y** are made up of transcriptionally active tandem repeat sequences.

2 Regions **X** and **Y** are always associated with proteins, but DNA at region **Z** is only associated with proteins during gene expression.

3 Region **Z** may involve DNA bending but region **Y** shortens during every round of DNA replication.

4 Regions **X**, **Y**, and **Z** are conserved throughout the life of the organism.

A one **B** two **C** three **D** four

Explanation:
X = centromere; **Y** = telomere; **Z** = distal control element (enhancer/silencer).
(1) False – centromeres and telomeres are **not** transcriptionally active (they are not transcribed).

(2) False – centromeres and telomeres are associated with specialised proteins (centromeric histones and telomere-binding proteins) and DNA in the control elements are also wrapped around histone proteins.

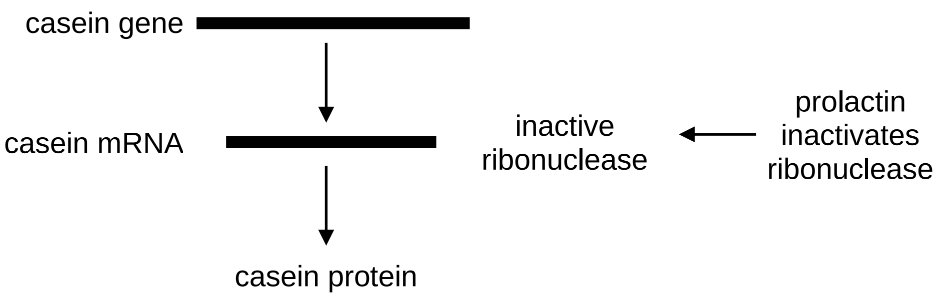
(3) True – specific transcription factors bound to distal control elements (enhancer/silencer) will cause the spacer DNA to bend to bring the activator-enhancer or repressor-silencer complex in close proximity to the promoter region.

(4) False – telomeres are not conserved as they are shortened with every round of DNA replication, and once the telomeres reach a critical length the cell either undergoes replicative senescence or apoptosis.

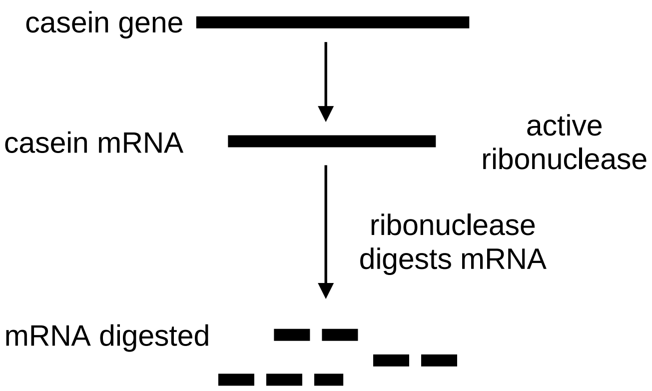
Source: 2018 VJC Prelim H2 Bio Q9

15 Casein is a major protein found in mammalian milk.

When the mammal is producing milk, the biochemical pathway for the production of casein can be represented as shown in the diagram below.



When the mammal is not producing milk, the biochemical pathway can be represented as shown in the diagram below.



Given the above information, which row shows the correct level of regulation and valid conclusion about casein gene expression?

	level of regulation	conclusion about casein production
A	post-transcriptional	Casein protein cannot be produced without the presence of prolactin.
B	post-transcriptional	Casein mRNA is hydrolysed by ribonuclease into its constituent ribonucleotides.

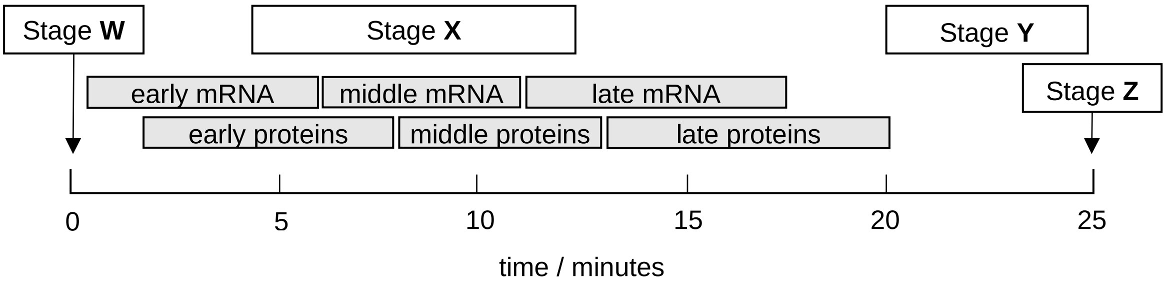
C	translational	The hormone prolactin allows the expression of the casein gene.
D	translational	Ribonuclease prevents casein gene expression by acting as a translational repressor.

Explanation:
First, the post-transcriptional modifications that occur on the pre-mRNA involve 3 processes: 5' capping, splicing, and 3' polyadenylation. The 'casein mRNA' shown in the diagram is **mature mRNA** that has already undergone these processes, and hence, options A and B are incorrect.

Second, the half-life of mRNA serves as an important mechanism to control gene expression at the translational level. The longer the half-life of mRNA, the longer it can serve as a template for translation. In the presence of the hormone prolactin, the ribonuclease is inactivated, and casein mRNA can be translated. However, in the absence of prolactin, ribonuclease is activated and digests mRNA into its constituent ribonucleotides.
Translational repressors act by blocking initiation of translation by preventing the assembly of the ribosomal subunits, or by blocking translation during the elongation phase. Thus, ribonuclease does not function as a translational repressor as it does not interfere with translation machinery.

Modified from 2018 TJC Prelim H2 Bio P1 Q14

16 The diagram below shows the various stages of the reproductive cycle of a T4 bacteriophage, as well as phage mRNA and protein production.



Which statements correctly describe the events that occur in stages **W** to **Z**?

1 During stage **W**, T4 phage tail fibres bind to specific molecules on the bacterial cell wall and the viral genome enters the cell via contraction of the tail sheath.

2 During stage **X**, T4 phage replicates its RNA genome using host cell RNA polymerase.

3 During stage **Y**, structural proteins, such as the capsid head, tail, base plate, and tail fibre proteins, assemble to form mature T4 phages.

4 From 11 to 20 minutes, mRNA coding for enzymes required to liberate the mature phage particles in stage **Z** are synthesised.

A 1 and 3

B 2 and 3

C 1, 2 and 4

D 2, 3 and 4

Explanation:

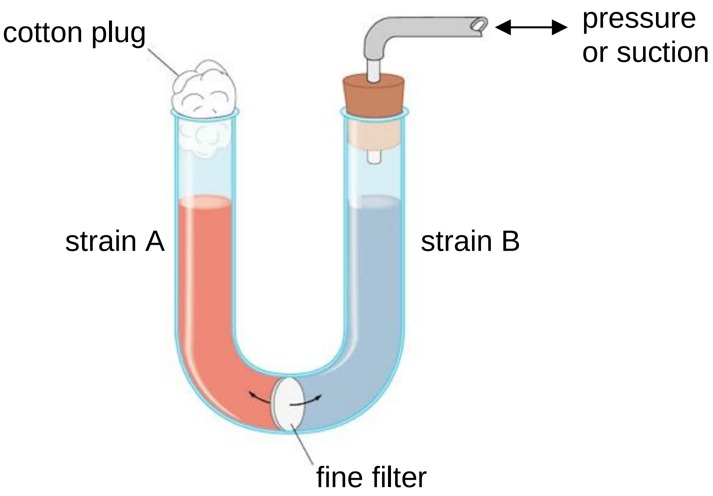
(1) True – attachment + penetration stage of T4 phage lytic cycle.
(2) False – T4 phage genome is made of DNA not RNA.
(3) True – structural protein synthesis in preparation for assembly/maturation (stage **Y**).
(4) False – time quoted is wrong; should be 11 to 17.5 minutes.

Taken from 2017 HCI Prelim H2 Bio P1 Q11

17 To investigate gene transfer between bacteria, two strains of the same species of nitrogen-fixing bacteria were each placed in one arm of a U-tube with a fine filter separating them. Nitrogen fixing bacteria are capable of converting atmospheric nitrogen, N_2, into ammonia, NH_3, which can then be used for metabolic processes.

The liquid medium may be transferred between the arms of the tube by applying pressure or suction. The fine filter has a pore size of 0.1 µm, and particles that are larger than the filter pore size would not be able to pass through the fine filter. It is known that the sizes of particles that are present in the liquid medium are as such:

type of particle	size / µm
bacteria	1 – 10
bacteriophages	0.025 – 0.2
DNA	0.002



(Question continued on next page)

Strain B has *nif*$^+$, which is a cluster of genes that codes for the ability to fix nitrogen. Strain A has *nif*$^-$, which indicates that the *nif*$^+$ cluster of genes has undergone a loss-of-function mutation.

After several hours of incubation, bacterial cells were taken from the left arm of the tube and plated on minimal medium that lacks a usable source of nitrogen. Growth of colonies was observed.

Which pair of rows correctly identifies and explains the processes responsible for gene transfer between strains A and B?

	processes	explanation

A	binary fission	Newly divided bacteria cells from strain B are small enough to pass through the fine filter and enter the left arm of the tube.
	transduction	A fragment of bacterial DNA containing the *nif*$^+$ gene cluster was packaged into the phage capsid head.
B	conjugation	The sex pili of the donor bacteria cell can pass through the fine filter to pass the *nif*$^+$ gene cluster to the recipient bacteria cell.
	transduction	A fragment of bacterial DNA containing the *nif*$^+$ gene cluster was packaged into the phage capsid head.
C	conjugation	The sex pili of the donor bacteria cell can pass through the fine filter to pass the *nif*$^+$ gene cluster to the recipient bacteria cell.
	transformation	DNA fragments containing the *nif*$^+$ gene cluster can freely pass through the fine filter to the left arm of the tube.
D	transduction	A fragment of bacterial DNA containing the *nif*$^+$ gene cluster was packaged into the phage capsid head.
	transformation	DNA fragments containing the *nif*$^+$ gene cluster can freely pass through the fine filter to the left arm of the tube.

Explanation:
This experiment shows that **transduction** (by bacteriophages) and **transformation** is responsible for the transfer of genes between strain A and strain B.

The particles must be small enough to pass through the pore of the fine filter. Given a pore size of 0.1 µm, only phages and DNA can pass through the filter, but bacterial cells are too large (even the smallest cells are 1 µm). Hence, binary fission and conjugation can be ruled out.

Modified from 2018 SAJC Prelim H2 Bio Q22

18 Some steps of respiration in yeast cells are shown below.

1 pyruvate → ethanal
2 pyruvate → acetyl-CoA
3 oxaloacetate → citrate
4 citrate → oxaloacetate

Which of the above steps involve **both** decarboxylation and dehydrogenation?

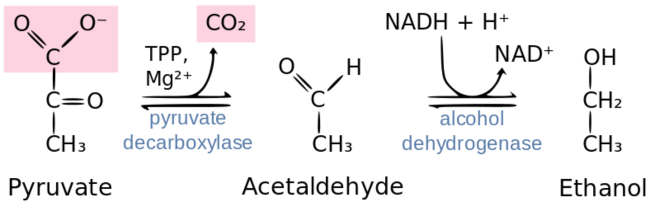
A 1 and 3

B 2 and 4

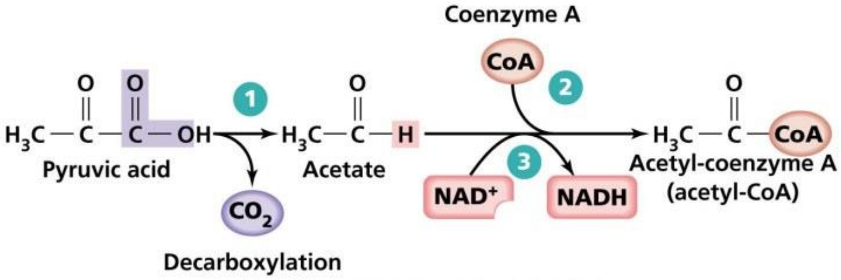
C 1, 2 and 4

D 2, 3 and 4

Explanation:
(1) In the alcohol fermentation pathway, pyruvate is decarboxylated to form ethanal. However, the dehydrogenation comes later in the conversion of ethanal (acetaldehyde) to ethanol:



(2) During link reaction, pyruvate (3C) undergoes decarboxylation (releasing CO_2), followed by oxidative dehydrogenation to form an acetyl group (2C) which is then attached to Co-enzyme A to form acetyl-CoA:



(3) Oxaloacetate (4C) has fewer carbon atoms than citrate (6C), so a decarboxylation reaction is not possible as the first step of the Krebs cycle.
(4) Citrate (6C) undergoes two oxidative decarboxylation steps to regenerate oxaloacetate (4C).

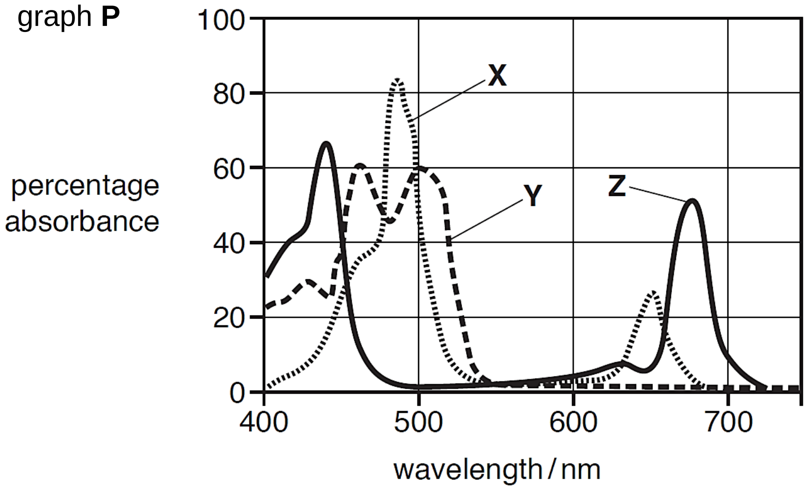
Modified from 2019 May/June CIE Pre-U Bio P1 Q6

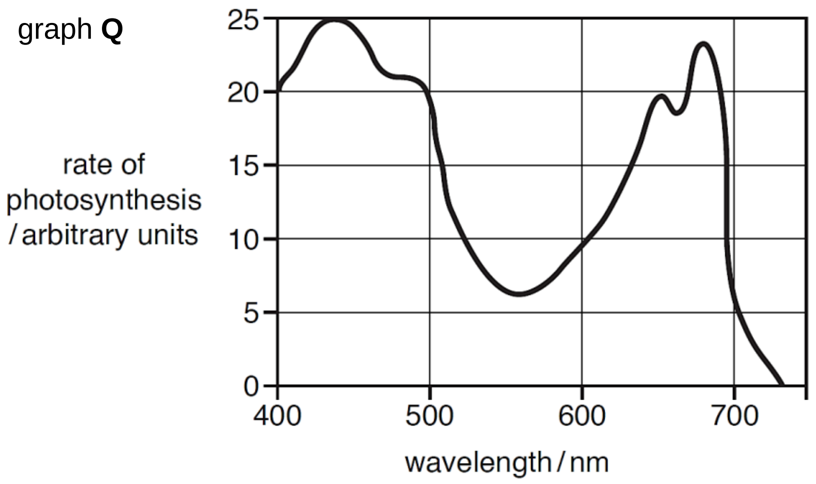
19 Visible light has wavelengths from approximately 380 nm (violet light) to 750 nm (red light).

Graph **P** shows the absorption spectra of three types of photosynthetic pigment, **X**, **Y**, and **Z**, which were extracted from the leaves of a flowering plant. **X** is known to be chlorophyll b.

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

graph **P**





Four students were asked to relate the information shown in graphs **P** and **Q** to their knowledge and understanding of the light-dependent stage of photosynthesis.

Which student's comment is correct?

student	comment
A	The high absorption of blue light by chlorophyll b provides evidence that this is the primary electron donor of photosystem 1.
B	The poor absorption of green light by all three pigment types will provide only enough energy for cyclic photophosphorylation to occur.
C	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.
D	Cyclic photophosphorylation occurs at a wavelength of 680 nm, indicating that pigment **Z** is more likely to be chlorophyll a than pigment **Y**.

Modified from 2015 May/June CIE Pre-U Bio P1 Q12

Explanation:

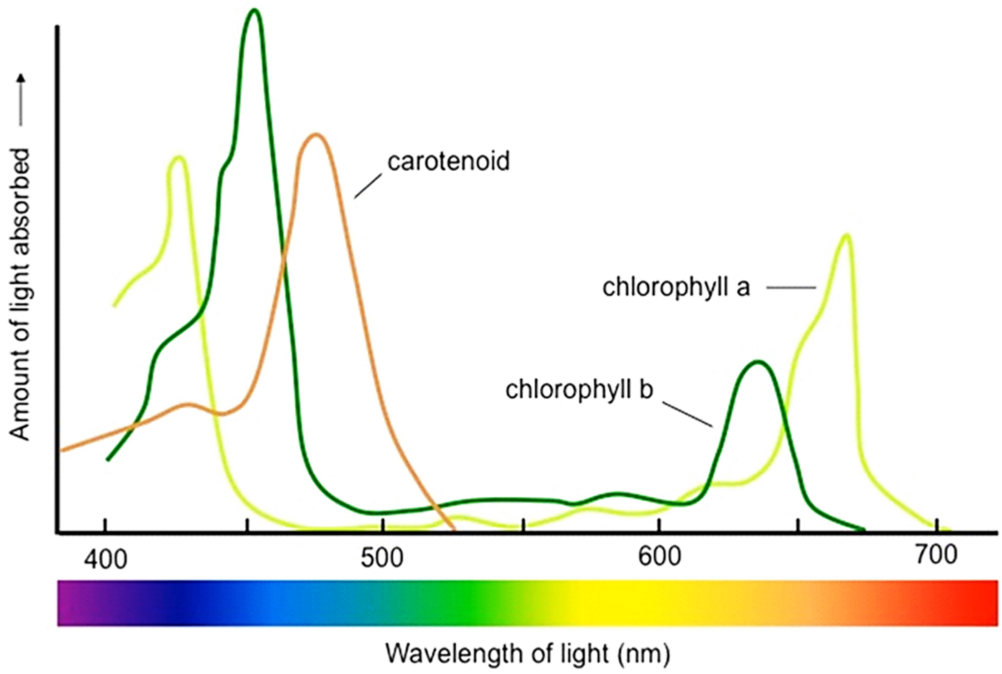
(A) False – high absorption of blue light by chlorophyll b provides no evidence that it is the primary electron donor in any photosystem.

(B) False – poor absorption of green light by all photosynthetic pigments likely does not provide enough energy for photoactivation, hence no photophosphorylation occurs.

(C) True – absorption spectrum of **Y** resembles that of carotenoids, which can help to extend the ability of the plant's absorption of light towards blue-green but does not extend into the yellow-green portion of the spectrum (see picture below).

(D) False – even though pigment **Z** is most likely to be chlorophyll a, cyclic photophosphorylation only involves photosystem I, which has P700 in its reaction centre instead of P680.

For answer key only:



20 In organisms with the same genotype, which of the following would cause phenotypic variation?

1 polygenes
2 continuous variation
3 different environments
4 mutation

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

Explanation

Statement 1 is incorrect. Organisms with same genotype would have the same polygenes / alleles of the polygenes. Such organisms therefore have the same phenotype as determined by the alleles of the polygenes. With statement 1 being incorrect, it will mean the answer lies between options A and B.

Statement 2 is incorrect. Phenotypic variation such as a population showing a range of phenotypes means that continuous variation is exhibited. It is therefore illogical to say that continuous variation causes phenotypic variation.

21 Duroc Jersey pigs are typically red, but a sandy variation is also seen. Crossing two different varieties of true-breeding sandy pigs produced F_1 offspring that were red. When these F_1 offspring were crossed with each other, they produced red, sandy and white pigs in a 9:6:1 phenotypic ratio.

Which row correctly shows the possible genotypes for each phenotype?

	red	sandy	white
A	AABB	AAbb	aaBB
B	AaBb	AaBB	aabb
C	Aabb	aaBB	aabb
D	AaBB	Aabb	aabb

Explanation

The genotype of F_1 is heterozygous (AaBb).

Crossing two F_1 pigs together will give rise to the following F_2 genotypic ratio of
9 A_B_ : 3 A_bb : 3 aaB_ : 1 aabb

As the F2 phenotypic ratio is 9 red : 6 sandy : 1 white , this would then mean that A_B_ gives rise to red pigs, the genotypes A_bb and aaB_ give rise to sandy pigs, and aabb give rise to white pigs.

22 Eye colour and wing type in *Drosophila* flies are determined by the R/r and N/n gene loci respectively. It is not known if these two genes are on different chromosomes or on the same chromosomes.

Test crossing some F_1 *Drosophila* flies gave the following results:

red eye, normal wing	59
purple eye, vestigial wing	43
red eye, vestigial wing	37
purple eye, normal wing	62

A χ^2 test was performed to test the significance of the difference between the observed and the expected results.

$$\chi^2 = \Sigma \frac{(O - E)^2}{E} \qquad v = c - 1$$

Where Σ = 'sum of…'
v = degrees of freedom
c = number of classes
O = observed 'value'
E = expected 'value'

degrees of freedom	*probability, p*						
	0.50	*0.20*	*0.10*	*0.05*	*0.02*	*0.01*	*0.001*
1	0.46	1.64	2.71	3.84	5.41	6.64	10.38
2	1.39	3.22	4.61	5.99	7.82	9.21	13.82
3	2.37	4.64	6.25	7.82	9.84	11.35	16.27
4	3.36	5.59	7.78	9.49	11.67	13.28	18.47

Which combination correctly describes the result of the χ^2 test?

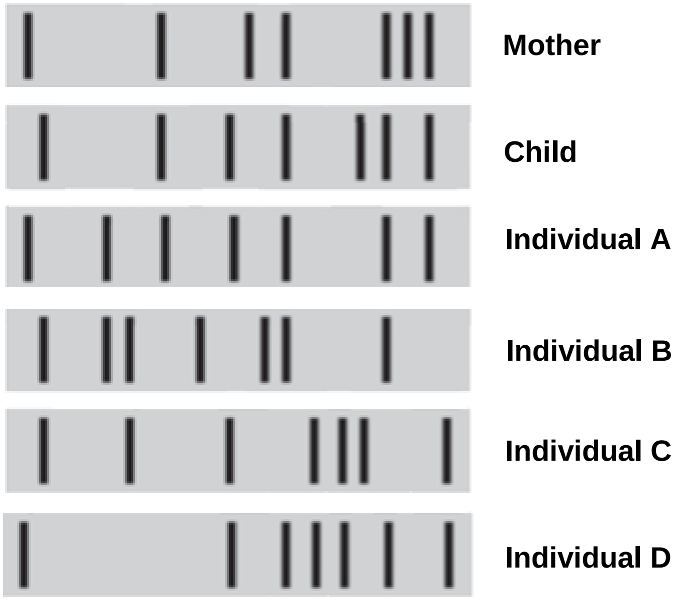
	probability	difference between observed and expected results	loci of genes
A	< 0.05	not significant	different chromosomes

B	< 0.05	significant	same chromosomes
C	> 0.05	not significant	different chromosome
D	> 0.05	significant	same chromosome

Explanation

The calculated chi-square value is 8.81 and df is 3. This means $0.02<p<0.05$. At 5% significance level, $p<0.05$. Therefore, the difference between observed and expected results is significant and the difference is due to other factors (i.e. linked genes in this context) and not chance alone.

23 The diagram below shows a DNA profile used to determine fatherhood in a paternity case.



Which individual is most likely to be the child's father?

A Individual A

B Individual B

C Individual C

D Individual D

Explanation

The child's band pattern will share similarity with his/her biological parents, whereby some bands will be the same as the mother's while other bands will be the same as the father's. Looking at the child's band pattern, the bands that do not match any bands in the mother's band pattern must match with the bands in his/her father's band pattern (i.e. individual C).

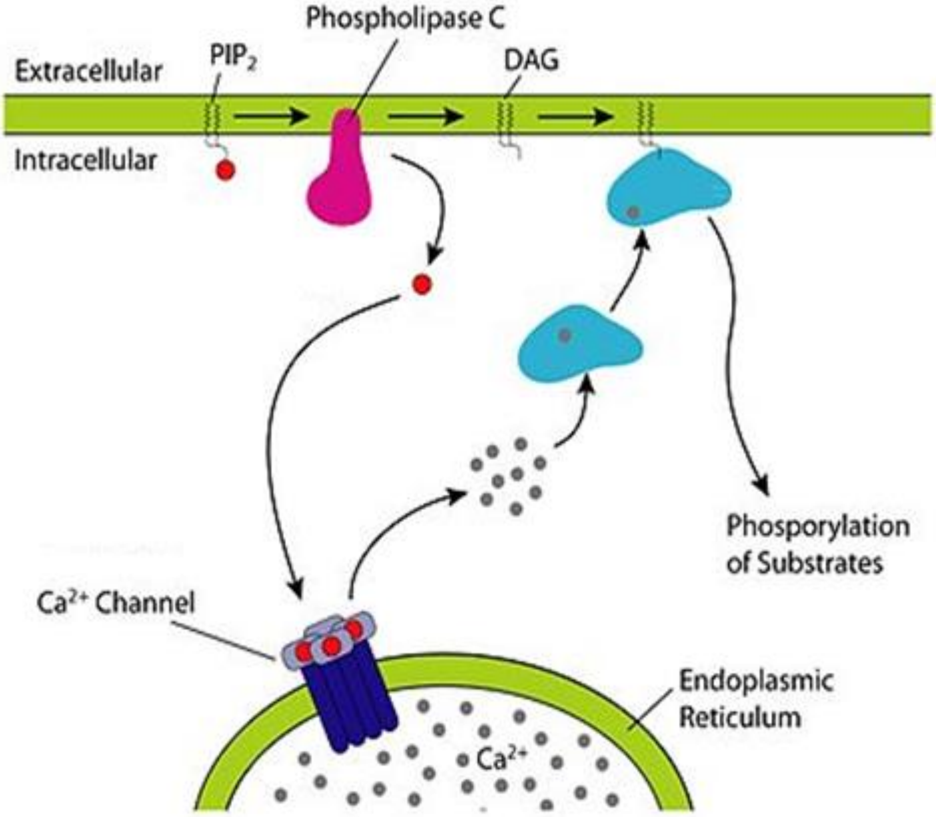
24 Which of the following is/are **not** true about blood stem cells?

1 They can be found in bone marrow.
2 They are unspecialised cells.
3 They are pluripotent.
4 They can be used as a source of undifferentiated cells.

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

Explanation
Statement 3 is incorrect. Blood stem cells are multipotent, not pluripotent.

25 The figure below shows part of a cell signalling pathway following ligand-receptor interaction.



How many of the following statement(s) is/are correct with regards to the above cell signalling pathway?

- This pathway is initiated after ligand binds to a receptor tyrosine kinase, thereby resulting in phosphorylation occurring during signal transduction.
- Calcium ions are second messengers.
- Phospholipase C, DAG and kinases serve as relay proteins in this pathway.
- The action of phospholipase C results in signal amplification.

A one

B two

C three

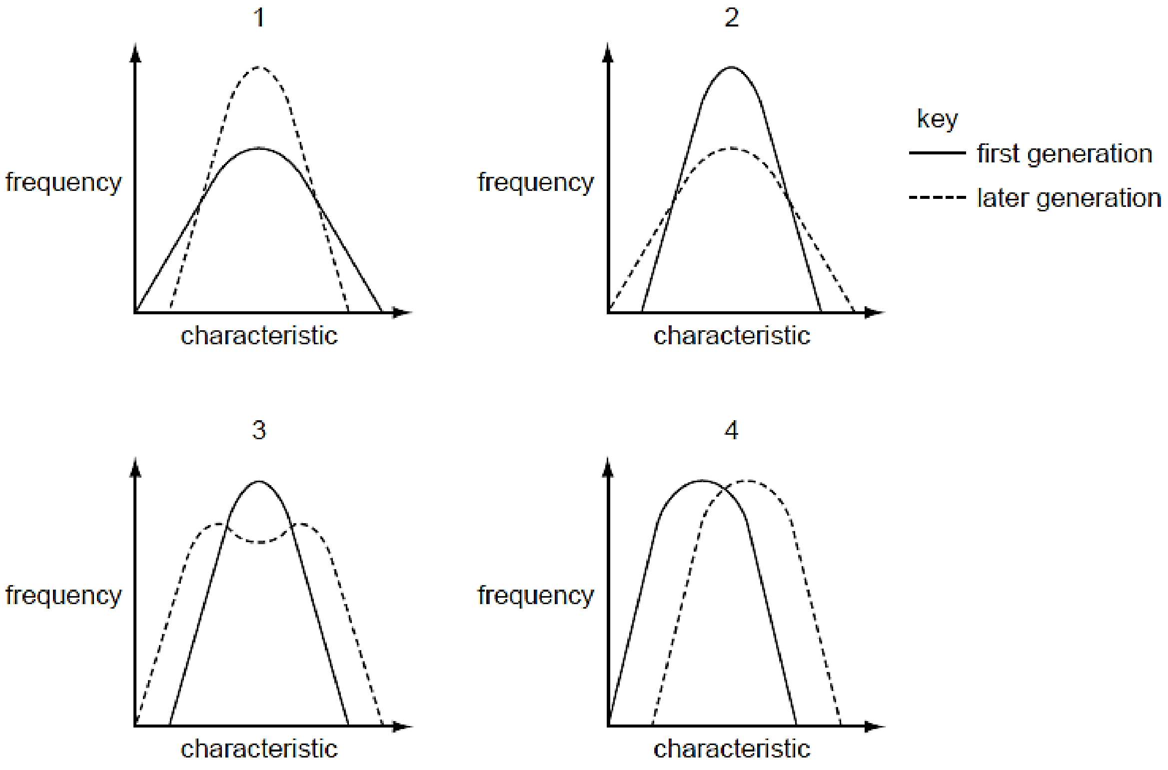
D four

Explanation

1st bullet point is incorrect. The diagram does not show the receptor, therefore it cannot be concluded the type of receptor involved in this signalling pathway.

3rd bullet point is incorrect. Based on the diagram, DAG is a lipid and not a protein molecule. Therefore, it is incorrect to refer to DAG as a relay protein.

26 The graphs show frequency of individuals against a measured characteristic in the first and a later generation of a species.



Which graph represents the correct type of natural selection?.

	directional	disruptive	stabilising
A	4	3	2
B	2	3	4
C	3	1	2
D	4	3	1

Explanation

Directional selection refers to one of the extreme phenotypes being favoured. This is illustrated by graph 4 where the later generation (dotted line) is moving to the other end.

Disruptive selection refers to the extreme phenotypes being favoured over the intermediate phenotype, and this is illustrated in graph 3.

Stabilizing selection refers to the average, or median trait being selected for, and this is shown in graph 1. Graph 2 shows deviation from the average trait, as illustrated by the later generation (dotted line in graph 2).

27 Polar bears, *Ursus maritimus*, and giant pandas, *Ailuropoda melanoleuca*, both belong to the family Ursidae.

How many of the following statements is **not** true about the classification of polar bears and giant pandas?

- They each belong to a different class.
- They each belong to a different genus.
- They both belong to the same order, carnivora.
- They both belong to the same phylum, chordata.

A one

B two

C three

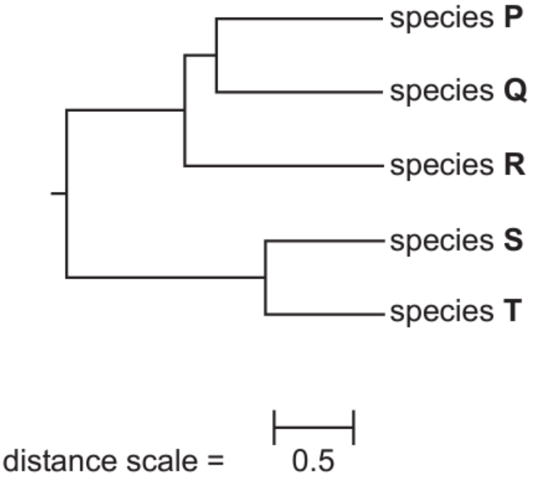
D four

Explanation

The levels of biological classification is as follows:
kingdom, phylum, class, order, family, genus, species. These levels of classification gets increasingly exclusive as we move from the kingdom level to species level. Therefore, together with the question information given that both polar bears and giant pandas belong to the same family, it will mean that they also belong to the same order, class, phylum and kingdom as well.

Based on the first part of the binomial nomenclature names *Ursus maritimus* and *Ailuropoda melanoleuca*, both polar bears and giant pandas belong to different genus of *Ursus* and *Ailuropoda* respectively.

28 A phylogenetic tree for five species is shown below.



The evolutionary distance between two species is calculated as the sum of the lengths of all the horizonal branches between the two species.

What is the estimated evolutionary distance between species **R** and species **T**?

A 2.0

B 4.0

C 8.0

D 16.0

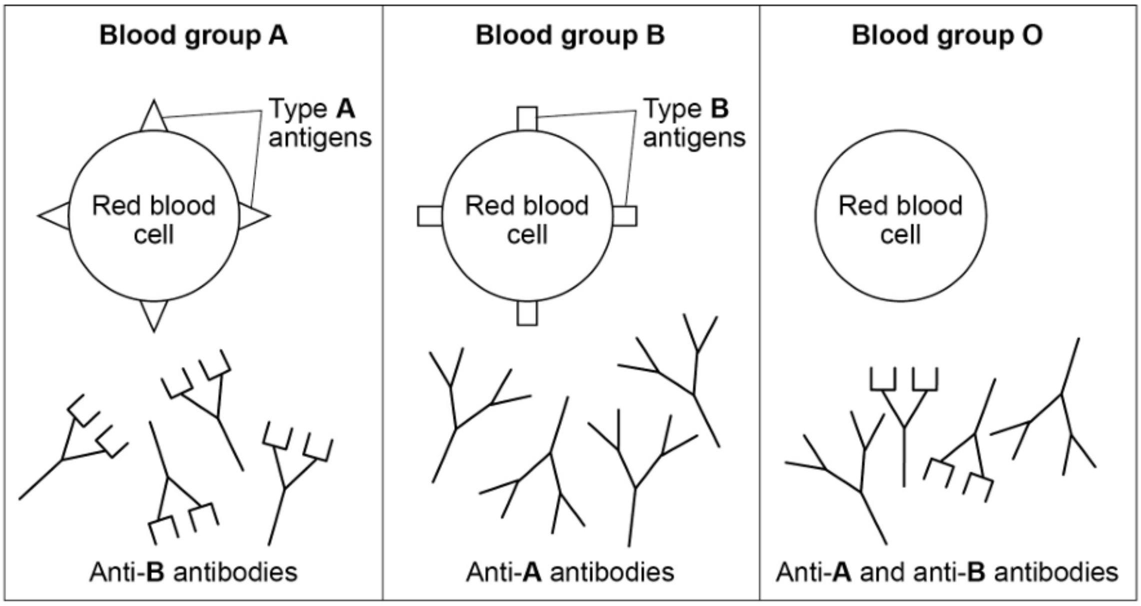
Explanation

To determine the evolutionary distance between species R and species T, one would need to pin-point when both species last shared a common ancestor / diverged from each other – that will refer to the very first node in the phylogenetic tree. Using a ruler to measure the “sum of all the horizontal branches between the two species” up to this very first node, the length will be 8 times that of the distance scale given, hence: 8 x 0.5 = 4.0.

29 A person’s blood group is determined by antigens present on the red blood cells. Antibodies in the plasma of the blood recipient can make some blood transfusions unsafe.

The following diagram shows:

- the red blood cells in people with different blood groups
- the antibodies produced by people of different blood groups.



Antibodies can bind to antigens that have complementary shapes. When antibodies bind to the antigens on the red blood cells, many red blood cells begin to clump together.

Based on the above information, which deduction is correct?

A Anti-A antibodies will cause the red blood cells from a person with blood group B to clump together.

B Anti-B antibodies from a person with blood type B will cause the red blood cells from a person with blood group O to clump together.

C Anti-A and anti-B antibodies will cause the red blood cells from a person with blood group AB to clump together.

D Person with blood group AB has anti-A and anti-B antibodies.

Explanation

(A) Incorrect. Anti-A antibodies has antigen-binding sites that are complementary in conformation to antigen A, and therefore can bind to antigen A on RBCs of a person with blood group A. A person with blood group B has antigen B on the RBCs, and therefore not complementary in conformation to anti-A antibodies.

(B) Incorrect. A person with blood group B has anti-A antibodies, not anti-B antibodies.

(C) A person with blood group AB has both antigen A and B on the RBCs. This means that both anti-A and anti-B antibodies can bind to the RBCs of a person with blood group AB, thereby causing clumping of the RBCs.

(D) Incorrect. It is a person with blood group O that produces anti-A and anti-B antibodies (as shown in the diagram given above in the question).

30 Which of the following sequence of events brought about by global warming is correct?

A growing of crops → burning of trees to clear land → increased methane production → global warming

B global warming → melting of permafrost → emergence of deadly diseases → possibility of increased mortality

C global warming → metabolism of insects in the tropics increases → size of insects increases → amount of pesticides required to kill insect pests increases

D global warming → calcium carbonate uptake by corals increases → coral bleaching → disruption of food web in ocean

Explanation of incorrect answers

(A) Burning of trees typically produce CO_2, not methane.

(C) The majority of ectotherms grow slower but mature at a larger body size in colder environments instead of warmer environments.

(D) Global warming will lead to increase in temperature of ocean waters, and this will place stress on corals. Under stress, coral bleaching will occur, but not calcium carbonate uptake. Calcium carbonate is needed for growth of corals and growth of corals does not happen when corals are under stress.