H2 ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2

2022 JC2 PRELIMINARY EXAMINATIONS

BIOLOGY 9744/01

PAPER 1 **20 SEPTEMBER 2022**
MULTIPLE CHOICE **TUESDAY**

WORKED SOLUTIONS

1 HOUR

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and identification number on the MCQ Answer Sheet.

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.

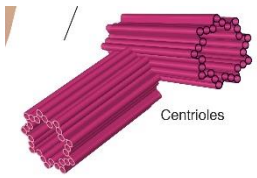
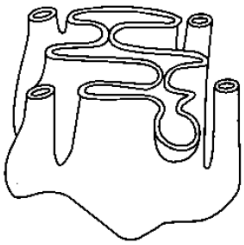
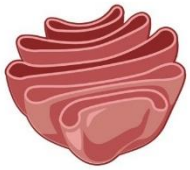
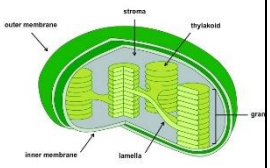
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

The use of scientific calculators is expected, where appropriate.

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

1 Four students, A, B, C and D, observed a root hair cell from a plant using an electron microscope. They were asked to confirm the presence or absence within the cell of described cellular structures.

Which student made the correct set of observations?

	area near the nucleus containing a pair of structures that are composed of microtubules *centrioles*  	a network of tubes and sacs with each tube and sac *(cisterna)* bounded by a single membrane *(smooth) endoplasmic reticulum* 	a stack of elongated, curved sacs with each sac *(cisterna)* bounded by a single membrane *Golgi body* 	structure with a double membrane containing stacks of flattened sacs *(thylakoids)* *chloroplast* 
	*Centrioles are only found in animal cells but **not** in higher plant cells.* *(Higher pants are plants that have specialised tissues for conducting water, minerals, and photosynthetic products through the plant. In contrast, lower plants do not have roots and produce spores to reproduce, rather than flower*	*Found in a typical eukaryotic cell*	*Found in a typical eukaryotic cell*	*Present in eukaryotic photosynthetic cells e.g. leaf cells. Root hair cells do not undergo photosynthesis.*
A	✓	×	×	✓
B	×	✓	✓	✓
C	×	✓	✓	×
D	✓	✓	×	×

✓= present
× = absent

2 Which statement provides evidence that viruses are **not** living organisms, according to the cell theory?

A Complete viruses are assembled from components synthesised within cells, such as proteins and nucleic acids.

This statement seems to suggest that viruses are living organisms since they are made up of same biomolecules as living organisms & does not give the idea of acellular; B is the better answer

B During some stages of the reproductive cycle of a virus, the virus may only be present as nucleic acids.

We can infer that virus does not have a cellular organisation as it exists just as RNA/DNA

C Many viruses are smaller than the smallest prokaryotic cells.

While this statement is true on its own, size is not a criteria to decide whether something is living or non-living. Size also does not relate to cell theory, thus this does not suggest viruses are non-living

D Viruses lack internal membranes such as endoplasmic reticulum.

Bacteria cells also lack internal membrane, but they are still living. So having/ not having internal membrane is not a criteria to decide whether something is living or non-living. Internal membranes also does not relate to cell theory, thus this does not suggest viruses are non-living

*Many candidates selected the incorrect options A and C. In evaluating the options, the key aspect of the cell theory that these candidates had overlooked was that **all cells come from pre-existing cells.***

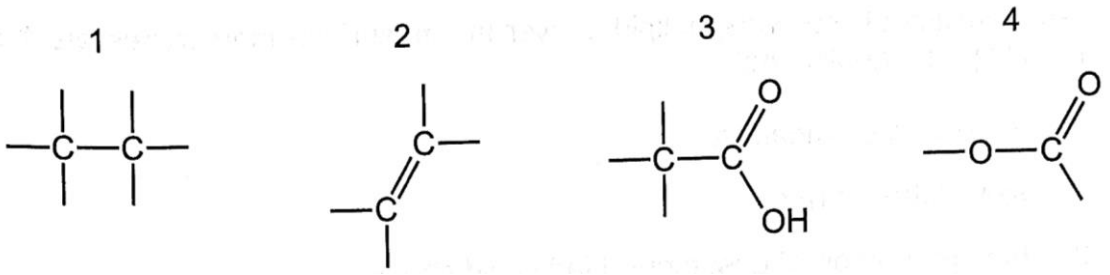
*The **Cell Theory** states that:*

*(a) Cells are the **smallest, basic unit of life**. It is the basic unit of structure and function in all living organisms and is three-dimensional in nature.*

*(b) **All organisms are made of cells**. Living organisms can be unicellular, consisting of a single cell, or complex, multicellular organisms, consisting of billions of cells.*

*(c) **All cells come from pre-existing cells** via cell division and involves the passing of hereditary information encoded in DNA from one generation to the next.*

3 Four types of structure found in biomolecules are shown.

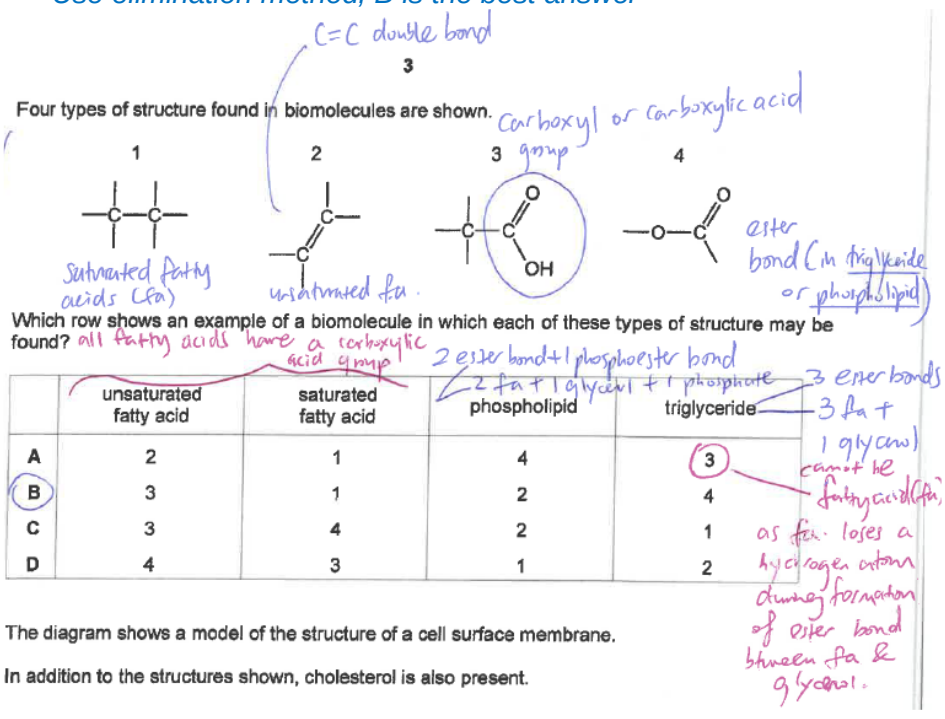


Which row shows an example of a biomolecule in which each of these types of structure may be found?

	unsaturated fatty acid	saturated fatty acid	phospholipid	triglyceride
A	2	1	4	3
B	3	1	2	4
C	3	4	2	1
D	4	3	1	2

Explanation

- *1 – saturated hydrocarbon, 2 – unsaturated hydrocarbon, 3 – carboxylic acid, 4 – ester bond*
- *Unsaturated FA may contain 1, 2, 3*
- *Saturated FA may contain 1 and 3*
- *Phospholipid may contain 1, 2 and 4*
- *Triglyceride may contain 1, 2, 4. Triglyceride cannot be 3 because the COOH groups of the fatty acid chains are used to form ester bonds*
- *Use elimination method, B is the best answer*



4 A peptide section of an insulin molecule was hydrolysed by two proteases, trypsin and chymotrypsin.

- Trypsin breaks the peptide bonds at the carboxyl terminals of lysine (lys) and arginine (arg).
- Chymotrypsin breaks the peptide bonds at the carboxyl terminals of phenylalanine (phe), tryptophan (trp) and tyrosine (tyr).

The hydrolysis was performed separately using:

i. both enzymes, or

tyr- leu-val-cys-gly-glu-arg -gly-phe -phe -tyr -thr-pro-lys- ala
7 fragments, each fragment between 6 and 1 a.a

ii. trypsin only, or

tyr-leu-val-cys-gly-glu-arg -gly-phe-phe-tyr-thr-pro-lys -ala
3 fragments, each fragments are either 7 or 1 a.a

iii. chymotrypsin only.

Tyr -leu-val-cys-gly-glu-arg-gly-phe- phe -tyr -thr-pro-lys-ala
5 fragments, each fragment between 8 and 1 a.a, ie 2 fragments & 3 a.a

The sequence of amino acid residues in the peptide is shown below:

(amino terminal) tyr-leu-val-cys-gly-glu-arg-gly-phe-phe-tyr-thr-pro-lys-ala (carboxy terminal)

Which statement concerning the products of hydrolysis is correct?

A Fewer than half of the fragments from hydrolysis (i) are single amino acids.
Not true because 4 out of 7 are single amino acids.

B Hydrolysis (ii) yields one fewer fragment than hydrolysis (iii).
Not true because hydrolysis (ii) yields two fragment fewer than hydrolysis (iii).

C Hydrolysis (ii) yields one more dipeptide than hydrolysis (iii).
Not true because both hydrolysis (ii) & (iii) have no dipeptide. A dipeptide is two amino acid long.

D With hydrolysis (i), all fragments formed are seven or fewer amino acid residues long.

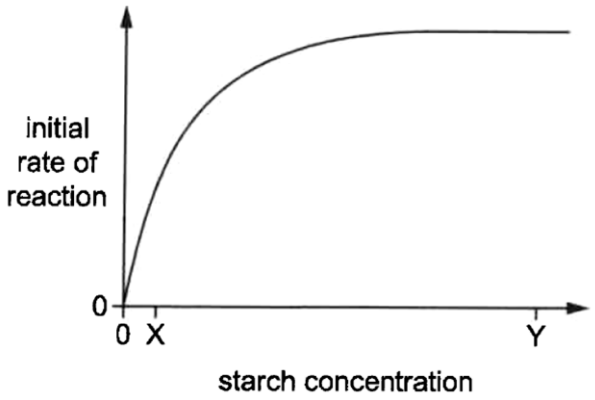
5 Which row correctly describes the structure of collagen?

A	covalent bonds hold the polypeptides within the triple helices together	about one third of the amino acids in a molecule are glycine	collagen does not have a quaternary structure
B	each of the three polypeptide strands forms a right-handed helix	there is a high proportion of the amino acids proline and glycine	the triple helices are soluble in water
C	the polypeptides in a triple helix are held together by hydrogen bonds	the triple helices are cross bonded to one another by hydrogen bonds	the glycine side chains are always on the outside of the helix
D	three polypeptide helices are twisted together into a right-handed triple helix	triple helices cross bond to one another with staggered ends	every third amino acid in a polypeptide is usually glycine

A	~~covalent bonds~~ (H bonds) hold the polypeptides within the triple helices together	about one third of the amino acids in a molecule are glycine (true)	collagen ~~does not~~ have a quaternary structure
B	each of the three polypeptide strands forms a left ~~right~~-handed helix	there is a high proportion of the amino acids proline and glycine (true)	the triple helices are soluble in water ~~(true)~~ false
C	the polypeptides in a triple helix are held together by hydrogen bonds (true)	the triple helices are cross bonded to one another by ~~hydrogen bonds~~ covalent cross links	the glycine side chains are always on the ~~outside~~ hidden in the centre of the helix
D	three polypeptide helices are twisted together into a right-handed triple helix	triple helices cross bond to one another with staggered ends	every third amino acid in a polypeptide is usually glycine

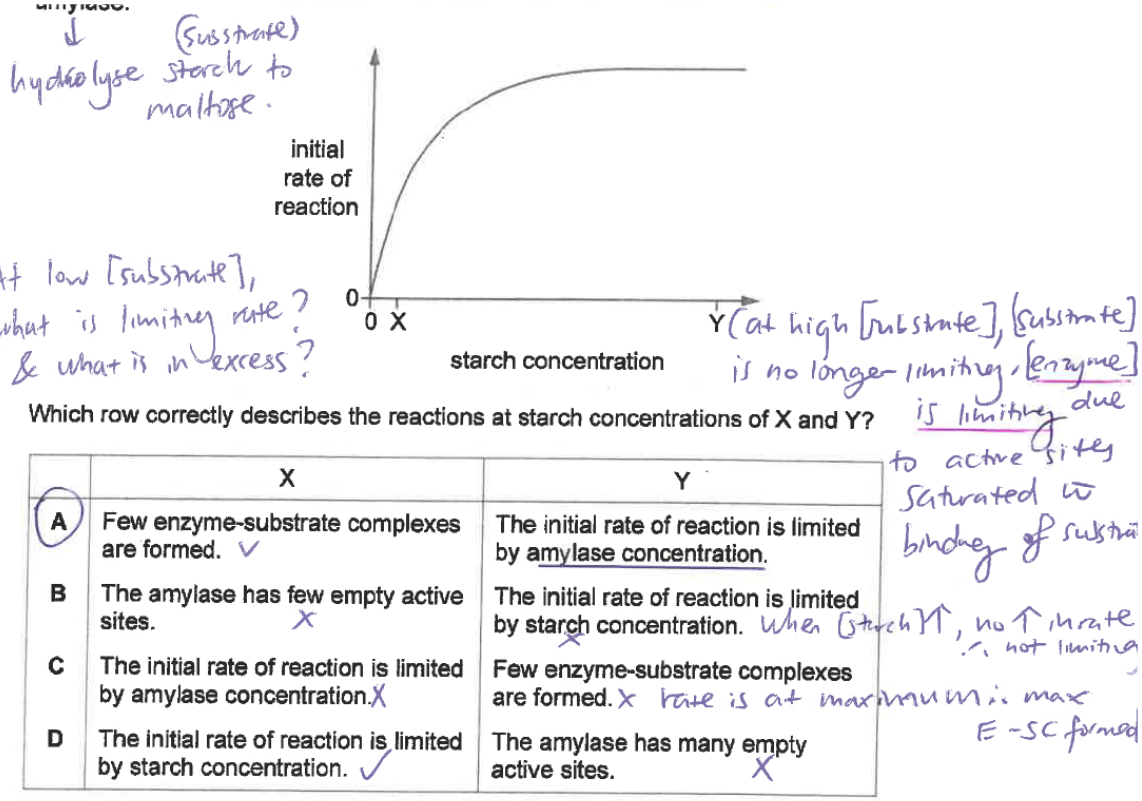
*A significant number of candidates incorrectly selected option **B**. This suggested confusion between the individual polypeptides of a collagen molecule, which each form a left-handed helix, and the triple helix of polypeptide strands, which is right-handed.*

6 The graph shows the effect of starch concentration on the initial rate of reaction of the enzyme amylase.



Which row correctly describes the reactions at starch concentrations of X and Y?

	X	Y
A	Few enzyme-substrate complexes are formed.	The initial rate of reaction is limited by amylase concentration.
B	The amylase has few empty active sites.	The initial rate of reaction is limited by starch concentration.
C	The initial rate of reaction is limited by amylase concentration.	Few enzyme-substrate complexes are formed.
D	The initial rate of reaction is limited by starch concentration.	The amylase has many empty active sites.



7 Biomolecules that are specific to particular types of cell, including stem cells, are known as cell markers. These markers can be proteins, glycoproteins or glycolipids. Some examples are listed.

- Zygotic stem cells are positive for ZScan4 and OCT4 but negative for CD34 and CD45.
- Embryonic stem cells at the 32-celled stage are positive for OCT4 and negative for ZScan4, CD34 and CD45.
- Blood stem cells that give rise to white blood cells are positive for CD34 and negative for ZScan4 and OCT4.
- In later developmental stages, some blood stem cells become positive for CD45.
- Differentiated blood cells are negative for ZScan4, OCT4 and CD34 but most types are positive for CD45.

Which statement is consistent with the information provided above?

A Cells with the CD45 cell marker are multipotent.

B Cells with the OCT4 cell marker are totipotent.

C Cells with the CD34 cell marker are multipotent.

D Cells with the ZScan4 cell marker are pluripotent.

- Zygotic stem cells **(totipotent)** are positive for ZScan4 and OCT4 but negative for CD34 and CD45.
- Embryonic stem cells **(pluripotent)** at the 32-celled stage are positive for OCT4 and negative for ZScan4, CD34 and CD45.
- Blood stem cells **(multipotent)** that give rise to white blood cells are positive for CD34 and negative for ZScan4 and OCT4.
- In later developmental stages, some blood stem cells become positive for CD45.
- **Differentiated** blood cells are negative for ZScan4, OCT4 and CD34 but most types are positive for CD45.

1 Cells with the CD45 cell marker are multipotent.

Incorrect. Should be fully differentiated i.e. no potency

2 Cells with the OCT4 cell marker are totipotent.

Incorrect. Should be pluripotent. Totipotent cells have BOTH ZScan4 and OCT4

3 Cells with the CD34 cell marker are multipotent.

Correct. Look at 3rd bullet point

4 Cells with the ZScan4 cell marker are pluripotent.

Incorrect. Should be cells with both ZScan4 and OCT4 are totipotent

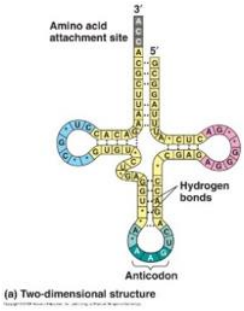
8 The hydrogen bonds formed by DNA and RNA are important for binding:

1 the shape of a folded polynucleotide
tRNA consist of a single strand which folds back upon itself via hydrogen bonds between complementary stretches of bases to form a specific 3D structure

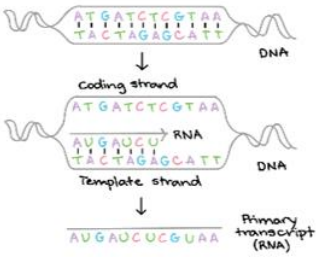
2 a temporary binding of codons during transcription
complementary base-pairing occurs via hydrogen bonds between bases on the DNA template strand and newly added RNA nucleotides to form codons on mRNA

3 polynucleotide chains in a stable shape during storage
Two strands of DNA (polynucleotide chains) are held together through complementary base-pairing via hydrogen bonds to form a stable double-helix. Allows genetic information to be stably stored within DNA.

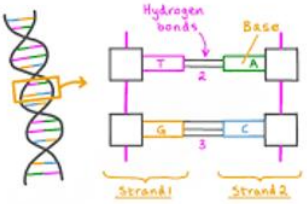
4 proteins and nucleotide permanently together
Hydrogen bonds form between ribosomal proteins and rRNA to permanently bind them together to form ribosomal subunits.



tRNA



mRNA during transcription



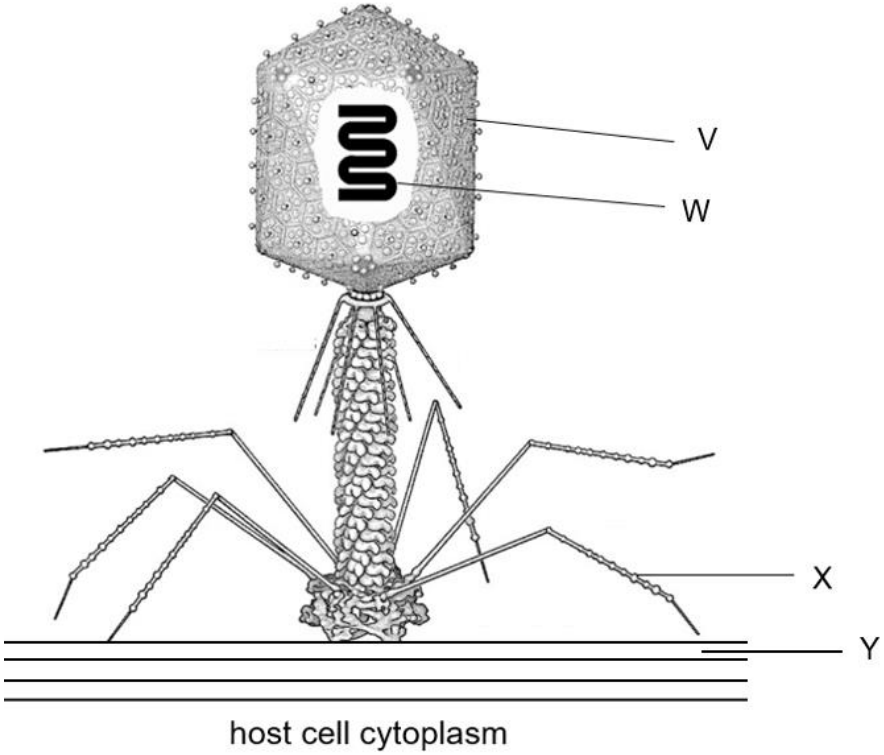
DNA double helix

ribosomal subunit made up of rRNA and ribosomal proteins permanently bound together

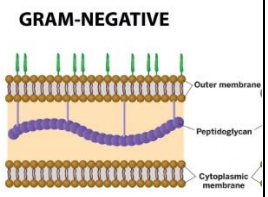
For which of these polynucleotide molecules are the examples of hydrogen bonding specifically important?

	Example of hydrogen bonding			
	1	2	3	4
A	DNA	tRNA	rRNA	mRNA
B	rRNA	mRNA	DNA	tRNA
C	tRNA	DNA	mRNA	rRNA
D	tRNA	mRNA	DNA	rRNA

9 The diagram shows a T4 bacteriophage attaching to its host cell.



Which combination correctly identifies the constituents of the lettered components?

	V *Capsid. Made up of subunits capsomers which are proteins.*	W *T4 genome is a double stranded linear DNA*	X *Tail fibre is made up of proteins.*	Y *Tail fibres attach to the outer membrane of E.coli, a gram negative bacterium* 
A	lipids	DNA nucleotides	amino acids	lipids
B	amino acids	RNA nucleotides	lipids	peptidoglycan
C	amino acids	DNA nucleotides	amino acids	lipids
D	lipids	RNA nucleotides	lipids	peptidoglycan

10 Some of the enzymes involved in the reproductive cycle of HIV are listed.

1 RNA polymerase
2 integrase
3 protease
4 reverse transcriptase

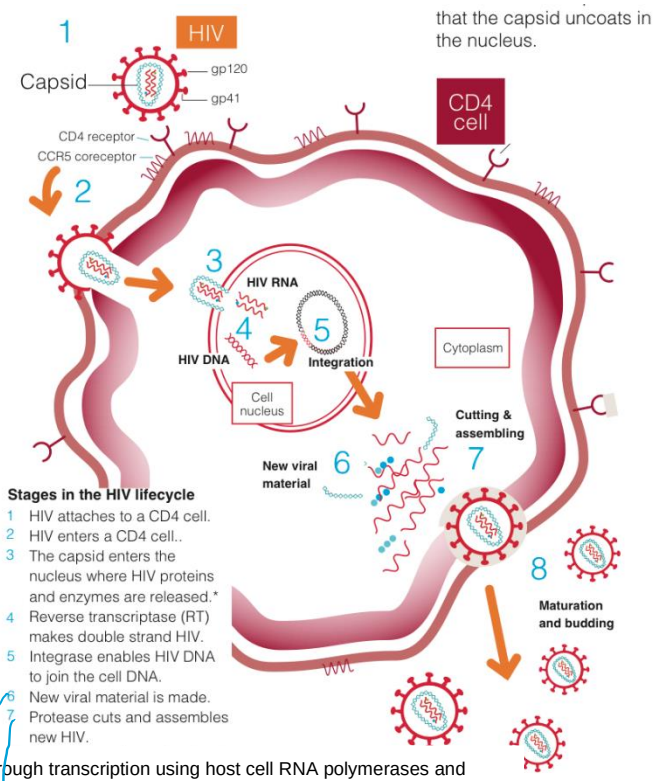
What is the order in which the enzymes function after the entry of HIV into a host cell?

A 1 → 4 → 3 → 2

B 3 → 4 → 2 → 1

C 4 → 1 → 2 → 3

D 4 → 2 → 1 → 3



that the capsid uncoats in the nucleus.

Through transcription using host cell RNA polymerases and translation using host cell ribosomes

HIV proteases cleaves the non-functional polyproteins into individual functional proteins and enzymes.

11 Which of the following correctly describe conjugation?

A Conjugation combine DNA from two bacterial cells into the genome of one.

Incorrect. At the end of conjugation, both donor and recipient cells become F+ cells. This means both contain F plasmid at the end of conjugation. However this does not mean the recipient cell combines its DNA (including chromosomal DNA) with the DNA of the recipient cell or vice versa.

B Both strands of F plasmid are transferred from one bacterium to another.
Incorrect. Only one strand of the F plasmid from the F+ donor cell enters the F^- recipient cell through the conjugation tube.

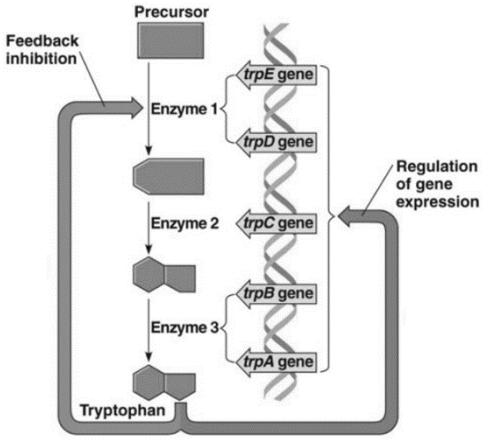
As the transfer occurs, each original strand of F plasmid in the donor and recipient cell acts as a template for the synthesis of a complementary strand → new double-stranded F plasmid in both donor and recipient cells.

C Both donor and recipient bacteria will be genetically identical at the end of conjugation.

Not necessary. Only plasmids are transferred during conjugation. Even though the donor and recipient cells both become F+ cells, this only means both contain F plasmid at the end of conjugation. They may still not be genetically identically because their chromosomal DNA may still differ or one bacterium may have another type of plasmid (not F plasmid) which is not transferred to the other bacterium during conjugation.

D Lysis of bacteria cells does not occur.
Correct. Transfer of DNA via conjugation does not require/ cause donor/ recipient bacteria cells to lyse.

12 In bacteria cells, levels of tryptophan can be controlled via two mechanisms shown in the figure below.



Which statements are true?

1 Excess tryptophan binds to enzyme 1 and operator of *trp* operon.

False. Excess tryptophan can bind to enzyme 1 but NOT to the operator. See explanation for option 3.

2 Levels of tryptophan is controlled through regulation of enzyme production and enzyme activity.

True. Regulation of gene expression determines levels of enzyme produced to synthesise tryptophan. Feedback inhibition determines whether enzyme 1 is active or inactive to synthesise tryptophan.

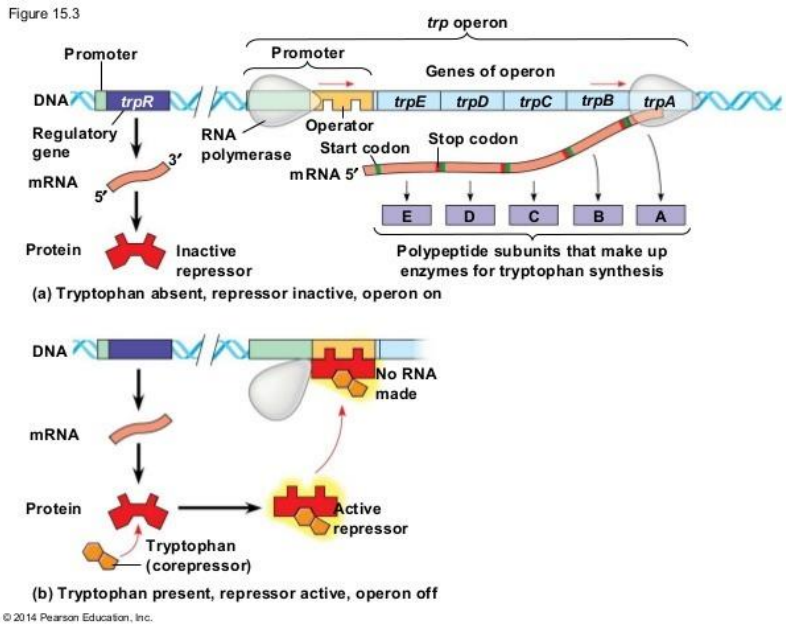
3 The *trp* repressor is activated when it binds with tryptophan.

True. When excess tryptophan binds to trp repressor, trp repressor is activated and it binds to operator to prevent RNA polymerase from binding to promoter → inhibit transcription of enzymes involved in synthesizing tryptophan.

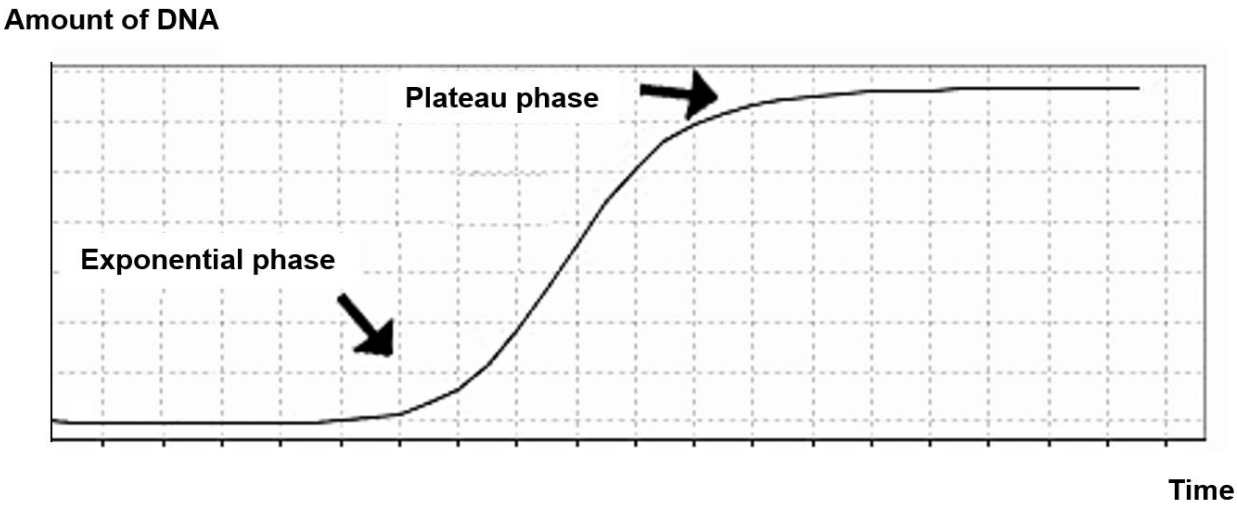
4 Enzymes 1, 2 and 3 are translated from one mRNA.

True. Genes A,B,C,D, E are all structural genes found in the trp operon. Their transcription is controlled by one promoter. Transcription of these genes produces a single polycistronic mRNA.

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



13 During PCR, the amount of DNA synthesised can be traced using fluorescence measurements as shown in the following plot. The process initially goes through an exponential phase, followed by a plateau phase eventually.



Which of the following statement is correct?

A During the exponential phase, the number of DNA molecules synthesized after 15 cycles is 15^2.

Incorrect. Should be 2^{15}. The amount of DNA doubles i.e increases exponentially with each PCR cycle.

No. of molecules of DNA formed = 2^n
where n is the number of cycles of PCR that have already occurred

B During the exponential phase, DNA primers are rapidly used up.

Correct. During exponential phase, many PCR cycles occur, of which the annealing stage will use up primers as they attach to the DNA template strands.

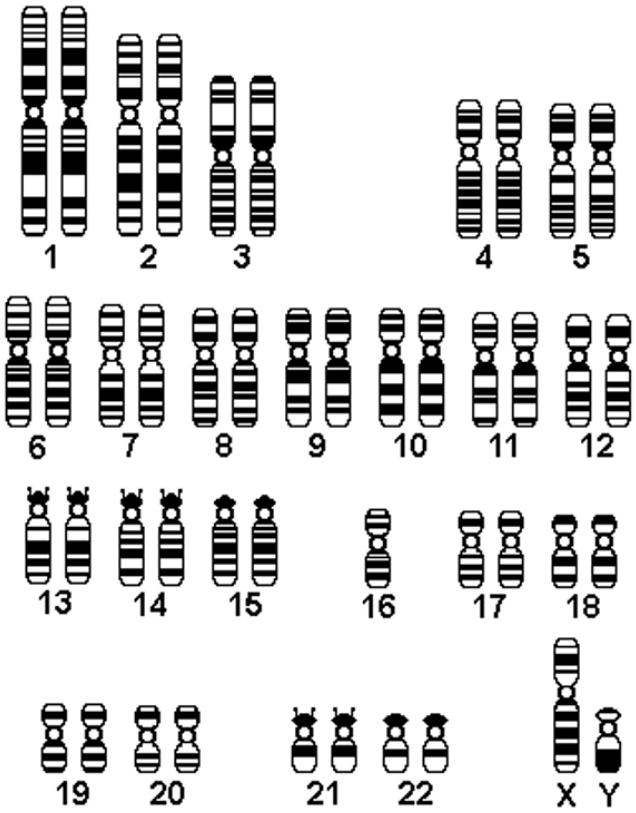
C During the plateau phase, the temperature is maintained constantly at 72^0C for extension.

Incorrect. Plateau phase only shows amount of DNA not increasing/ remaining constant with time. There is no information on what temperature / stage the PCR reaction mixture is at.

D During the plateau phase, *Taq* polymerase might be denatured or the reaction mixture might be depleted of ribonucleotides.

*First part of the statement is correct. Second part is incorrect. Plateau phase shows amount of DNA not increasing/ remaining constant with time. This probably means PCR reaction has stopped either due to Taq polymerase being denatured [after being subjected to 96^oC during denaturation stage for many cycles] or **deoxyribonucleotides** being depleted. PCR uses deoxyribonucleotides which are monomers of DNA, for extension of primers. NOT ribonucleotides.*

14 The diagram shows a type of chromosomal aberration in humans.



Which of the following correctly identifies the type of chromosomal aberration and a possible cause?

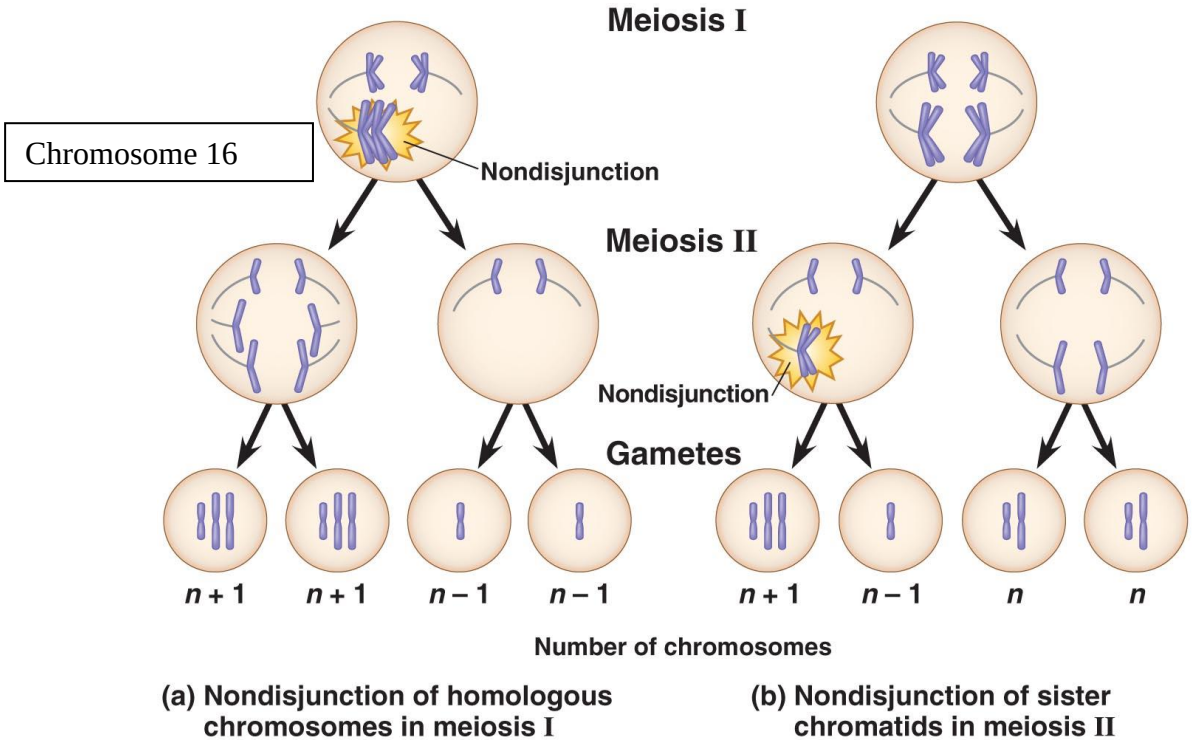
	type of chromosomal aberration	possible cause
A	aneuploidy	non-disjunction during meiosis I of father's gametic cell, resulting in a sperm cell missing one chromosome
B	polyploidy	non-disjunction during meiosis I of father's gametic cell, resulting in a sperm cell with an extra set of chromosomes
C	aneuploidy	non-disjunction during meiosis II of mother's gametic cell, resulting in an egg cell with a missing set of chromosomes
D	polyploidy	non-disjunction during meiosis II of mother's gametic cell, resulting in an egg cell missing one chromosome

Aneuploidy is a condition where one or several chromosomes are present in extra copies or deficient in numbers. Polyploidy is a condition where there is extra set/s of chromosomes.

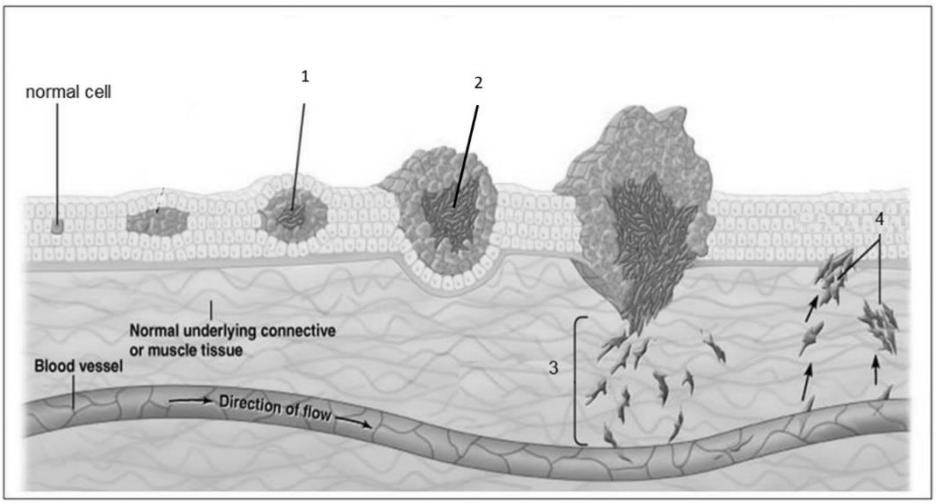
Diagram shows only one chromosome present for chromosome 16. So the chromosomal abnormality shown is aneuploidy (option A and C)

Non-disjunction can occur in either parent during meiosis I (unequal separation of homologous chromosomes or meiosis II (unequal separation of sister chromatids) to result in a gamete missing chromosome 16 i.e. (n-1) gamete which can then be fertilised by a normal gamete (n) to result in the chromosomal abnormality (2n-1) shown in the diagram

Note: n is the number of chromosomes in a single set. For humans, n = 23 , which comprises of chromosome 1 to 22 and a sex chromosome (either X or Y chromosome)



15 The figure below shows some of the stages in the development of cancer.

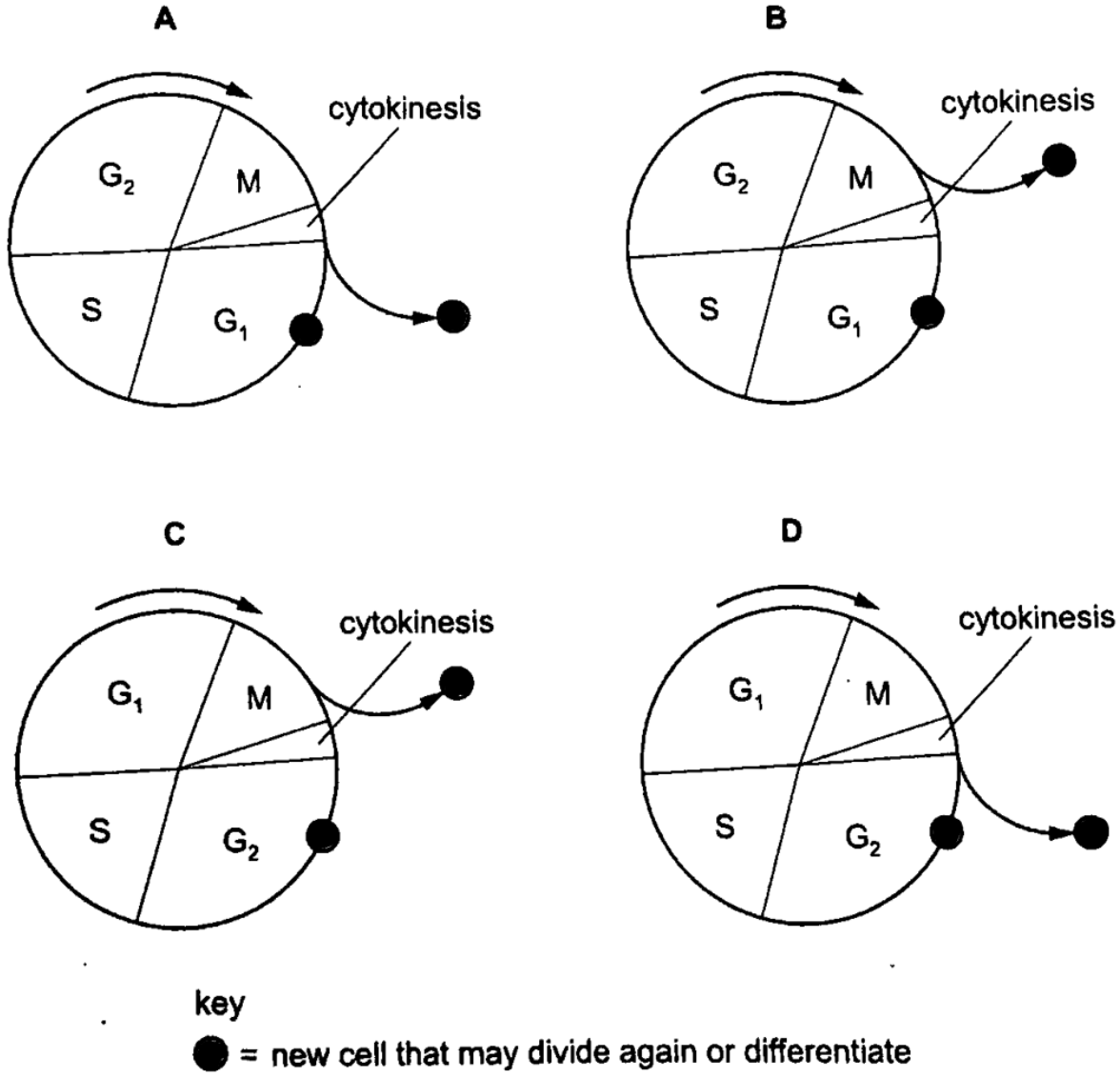


Which of the following correctly identifies the possible processes that occur in 1-4?

	1	2	3	4
A	cell escapes apoptosis *Correct*	loss of density-dependent inhibition *See explanation in option B*	loss of cell-cell adhesion *See explanation in option B*	metastasis *Correct. Step 4 shows the spread of cancerous cells to other parts of the body. known as metastasis*
B	rate of cell division exceeds rate of cell death *Correct*	cell escapes apoptosis *Correct*	loss of density-dependent inhibition *Wrong. Density dependent inhibition is the idea that normal cells stop dividing when they come into contact with each other in a crowded environment. Cancer cells grow freely over one another and over normal cells.* *Step 3 shows loss of cell-cell adhesion rather than density-dependent inhibition*	loss of cell-cell adhesion *Wrong. See explanation in option A*

C	rate of cell division exceeds rate of cell death *Correct*	cell escapes apoptosis *Correct*	angiogenesis *Wrong. Angiogenesis is the formation of blood vessels which is not shown any where in the diagram*	metastasis *Correct*
D	cell acquires ability to stop cell cycle *Wrong. In cancer formation, the ability to stop cell cycle is **lost***	loss of density-dependent inhibition *Correct*	angiogenesis *Wrong. See explanation in option C*	loss of cell-cell adhesion *Wrong. See explanation in option A*

16 Which diagram correctly represents the mitotic cell cycle? A



M (mitosis) occurs after G2 [option A and B] and a new cell (one of the daughter cells) would come out after cytokinesis when two daughter cells are produced.

M is primarily nuclear division and cytokinesis completes the cell division part.

17 A scientist used a light microscope to examine a range of human cells and the structures they contained.

The figure below represents a structure seen in one of the cells.

Which row correctly links the cell type of the above cell and the process of which the structure is showing?

	cell type	process
A	skin	cross-phosphorylation of intracellular tails of receptors
B	liver	dimerisation of receptors
C	testes	pairing of homologous chromosomes
D	bone marrow	formation of spindle fibres

The process is pairing of homologous chromosomes as well as crossing over between non-sister chromatids of homologous chromosomes. Since crossing-over takes place in meiosis I, and produces gametes, cell type is therefore one that is found in the reproductive organ.

18 An unspotted black female dog was crossed with a spotted black male dog.

She gave birth to six puppies of four different phenotypes: unspotted black, unspotted red, spotted black and spotted red. As the puppies got older, these phenotypes did not change.

Some of the phenotypes of the puppies were different from the phenotypes of either of their parents.

What is needed to explain the appearance of these new phenotypes?

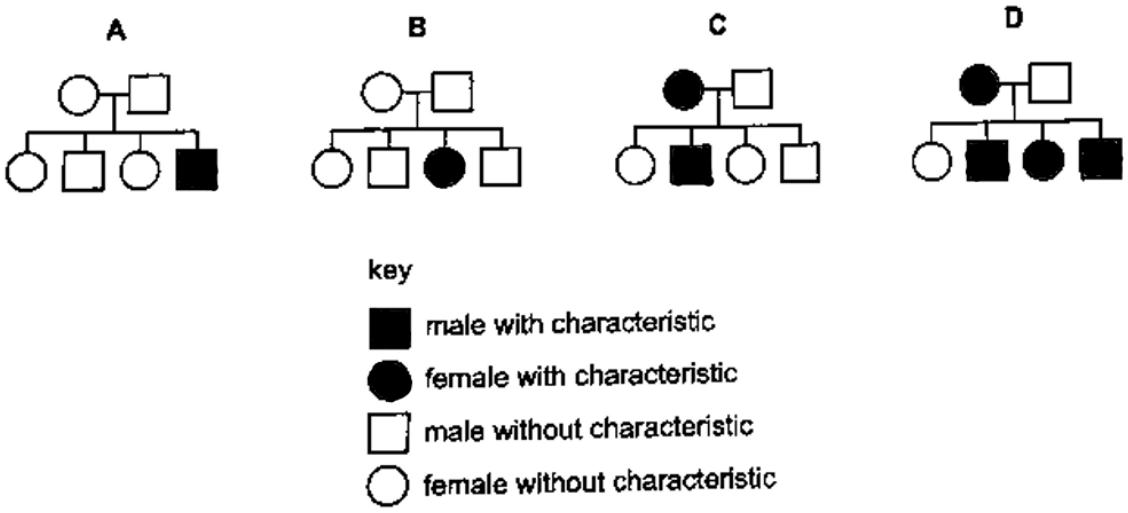
A sex linkage and meiosis
No context of reciprocal cross to derive sex-linkage. No information about the gender of the puppies. Information about the parents' gender cannot be used to imply sex-linkage because with or without the information, the fertilisation is only possible between male and female gametes.

B multiple alleles and random fertilisation
While it is true that random fertilisation helps to generate the gametes with many different types of allelic combinations, it is also clear that this case cannot be a multiple alleles case. For each phenotype such as colour of body and presence of spots, there are only two variants. For colour of body, it is either black or red and for the presence of spots, it is spotted or unspotted. For each of the gene coding for the phenotype, two variant alleles are sufficient to cover the two different types we see in this case.

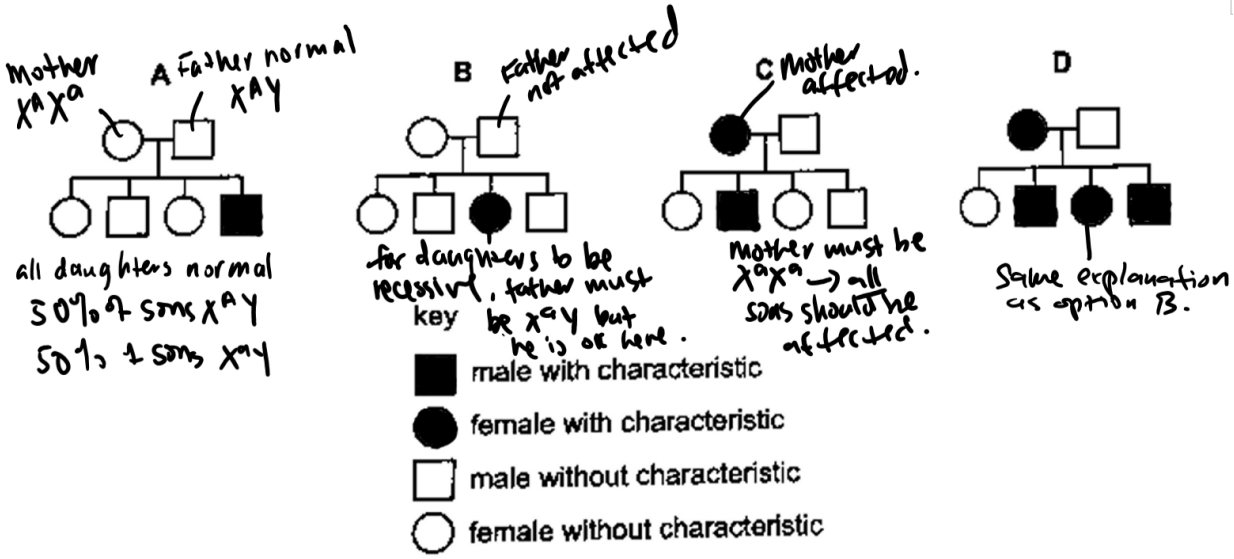
C environmental factors and random fertilisation
"As the puppies got older, these phenotypes did not change." This statement helps us to deduce that the phenotypes have stronger genetic links and little environmental influence.

D random fertilisation and meiosis
Unspotted x spotted is a cross between heterozygote (thus showing a dominant trait) and homozygous recessive (that's why showing a recessive trait). Black x black, yet the offspring show black and red body colours, so this is likely heterozygote x heterozygote. Thus the phenotypes of offspring is one that can be explained why the genetic variation generated by the processes in meiosis such as cross-over and independent assortment and segregation of homologous chromosomes and subsequently random fertilization.

19 Which diagram shows inheritance of a characteristic that could be caused by a recessive X-linked allele? A



Explanation:



20 Which statement uses genetic terms correctly?

A For a gene with multiple alleles, whether each allele is dominant or recessive is independent of the other alleles.
Statement is not correct because whether each allele is dominant or recessive, it is DEPENDENT of the presence of other alleles. Take the example of the Himalayan rabbits.

B For a gene with two codominant alleles, the genotypic ratio in a population is always the same as the phenotypic ratio.

Complete Dominance (Mouse Coat Colour)

Phenotype	Black	Black	Brown
Genotype	BB	Bb	bb

1 : 2 : 1 genotypic ratio
3 phenotypic ratio

Co-dominance (Chicken Feathering)

Phenotype	Black	Speckled	White
Genotype	C^BC^B	C^BC^W	C^WC^W

C Homologous chromosomes have the same sequence of gene loci and the same alleles at the same loci.
*Not correct. While homologous chromosomes have same sequence of gene loci, they **may not have the same alleles**. Each homologue comes from different parents. A heterozygote for example have different alleles for the same gene. The sister chromatids of a double-arm chromosome will have the same alleles after semi-conservative DNA replication unless crossing over happens between non-sister chromatids of the homologous chromosomes and that the homologues carry different alleles from each other in the first place.*

D For the two genes that show dominant epistasis, when two heterozygotes interbreed, there is a greater variety of phenotypes than another pair that does not show epistasis.
Not correct. For the pair of genes that does not show epistasis (thus follow normal Mendelian inheritance pattern), 9:3:3:1 ratio will be observed between two heterozygotes. For the pair that shows dominant epistasis, modified ratio like 12:3:1, 13:3, 15:1 will apply and they have two or three classes of phenotypes as compared to the usual four.

21 Nine-banded armadillos are small mammals that have been used to study inheritance because they give birth to quadruplets (four offspring) that are all genetically identical.

Four genetically identical offspring were kept in exactly the same environmental conditions and consumed the same mass and type of food.

A study of 120 different phenotypic characteristics found that some of these characteristics showed variation.

What could **not** explain the variation in some of the phenotypic characteristics observed?

A During development in the mother's body, each embryo received different oxygen and food supplies from the placenta.

B Each of the four cells from the original fertilised cell received a different proportion of cell organelles during cytokinesis.

C The food provided after the offspring were no longer feeding from their mother did not meet all of their growth requirements.

D The position of each of the embryos inside the uterus of the mother provided a different space for the growth of the embryo.

*Candidates were required to identify factors that could **not** explain the phenotypic variation observed. The information in the question clearly stated that the offspring were genetically identical, were kept in exactly the same environmental conditions and consumed the same mass and type of food. Potential explanations of phenotypic variation must therefore relate to differences occurring in the uterus of the mother during development of the offspring since, after birth, conditions for all offspring were the same. Options A, B and D are all in vivo experiences of the embryos which were not controlled.*

22 Which of the following about anaerobic respiration in muscle cells is **false**?

A Pyruvate is used as a hydrogen acceptor to regenerate NAD.
True. Pyruvate is reduced directly by NADH to form lactate and NAD is regenerated for glycolysis.

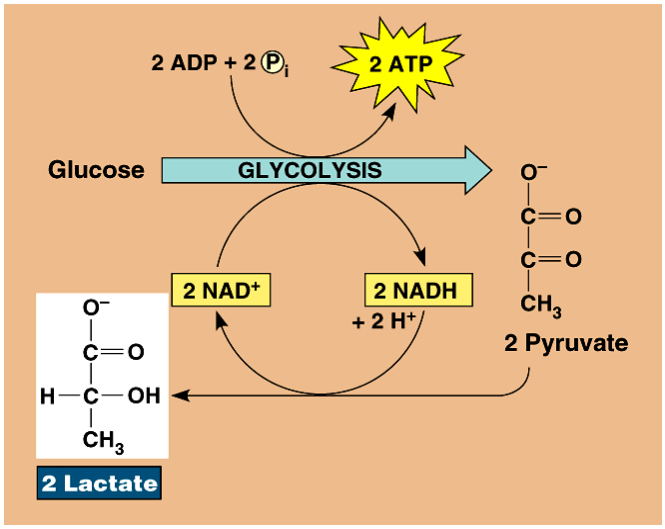
B Formation of ATP is dependent on substrate-level phosphorylation only.

True. During anaerobic respiration, only glycolysis occurs to generate net 2 ATP per glucose molecule via substrate level phosphorylation.

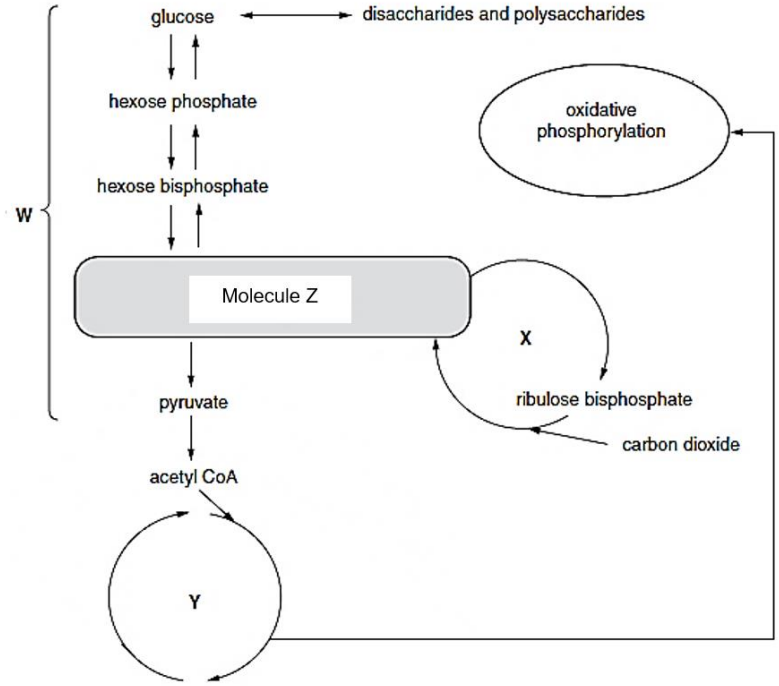
C Lactate retains a lot chemical energy.
True. That is why anaerobic respiration produces only a net 2 ATP per glucose molecule while aerobic respiration produces net 38 ATP per glucose.

D Decarboxylation of pyruvate occurs to form lactate.
False. Decarboxylation i.e. removal of carbon to form carbon dioxide does not occur during anaerobic respiration in muscle cells. Pyruvate and lactate are both 3C compounds.

Decarboxylation only occurs during anaerobic respiration in yeast cells, converting 3C pyruvate to 2C ethanal.



23 The diagram represents some of the reactions that take place in a plant cell.



W = glycolysis , X = Calvin cycle , Y = Krebs cycle
How many statement(s) is / are **false**?

1 Only W and X can take place in the absence of oxygen.
True. Glycolysis occurs during anaerobic respiration to generate ATP. Calvin cycle does not require oxygen. Kreb cycle can only occur in the presence of oxygen.

2 Molecule Z is triose phosphate.
True. Molecule Z is glyceraldehyde-3-phosphate (G3P)/ phosphoglyceric acid (PGA) is a common molecule in glycolysis and Calvin cycle.

3 W, X and Y are separated by membranes, allowing for the maintenance of different conditions for enzymes to function.
True. W(glycolysis) occurs in the cytoplasm. X (Calvin cycle) occurs in the stroma of the chloroplast, Y occurs in the matrix of the mitochondrion. ***Compartmentalisation*** *with membranes allows these reactions to occur seperately.*

4 Only X requires ATP.
False. W and X require ATP. In glycolysis (W), Phosphorylation of glucose (6C) to fructose/ hexose bisphosphate (6C) requires energy. In Calvin cycle, carbon reduction and RuBP regeneration requires energy.

Question asks how ***MANY*** *statements are false.*

A 1

B 2

C 3

D 4

24 Which of the following occur in the specific signaling pathway which will lead to an increase production of glycogen *[this means increase uptake of glucose into cell for conversion to glycogen via insulin signalling pathway]* in the liver cells of a healthy human?

1 increase in cyclic AMP production

cAMP is not involved in insulin signalling pathway

2 activation of protein kinases

Signal transduction in insulin signalling pathway involved activation of phosphorylation cascade / series of protein kinases

3 activation of receptor tyrosine kinases by glucagon

*Should be activation of receptor tyrosine kinases by **insulin***

4 activation of phosphatases

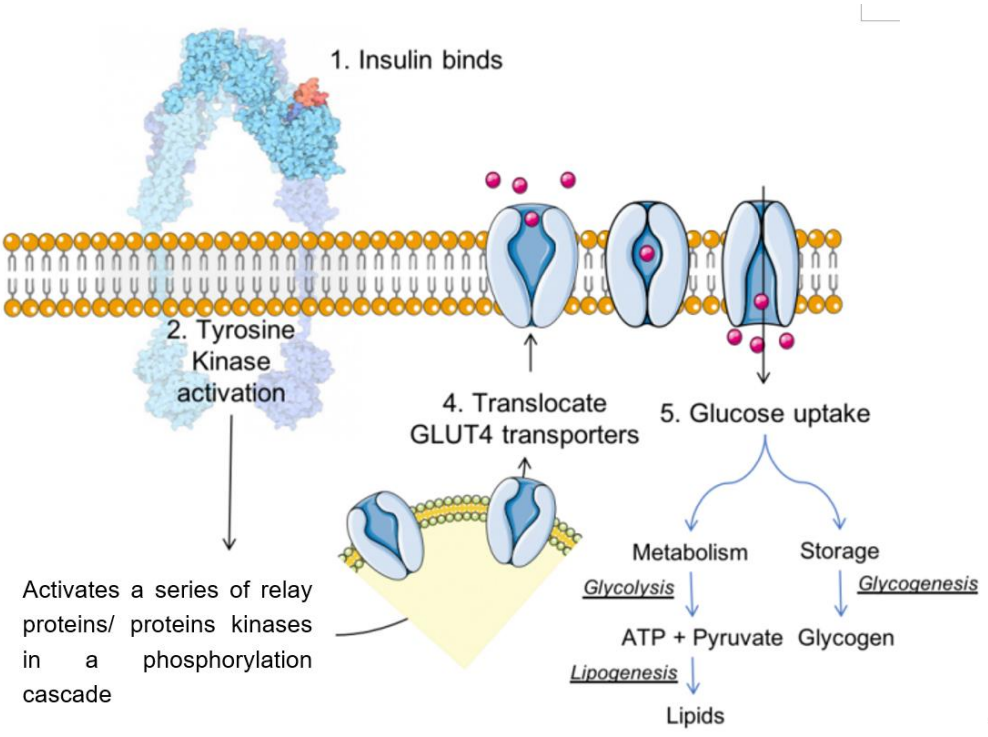
dephosphorylation of protein kinases by protein phosphatase will result in signal termination ➔ switching off the insulin signalling pathway → less production of glycogen

A 2 only

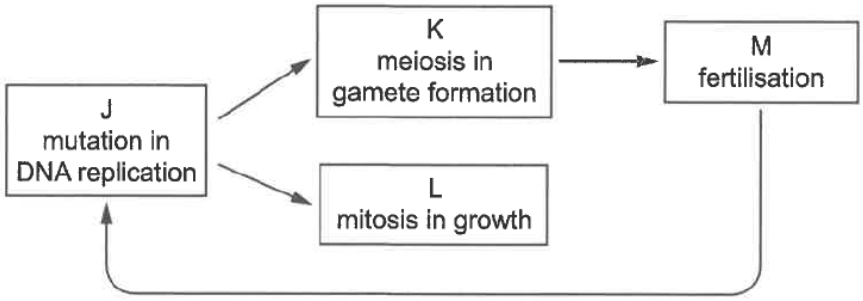
B 1 and 4

C 2 and 3

D 1, 2 and 3



25 Which processes contribute variation to the evolution of complex organisms?



A J, K, Land M

B J, K and M only

C J and M only

D K and L only

J : mutation in DNA replication produces new alleles, increasing genetic variation.
K : meiosis: crossing over during prophase I results in new combination of alleles and independent assortment of homologous chromosomes during metaphase I produces gametes with different combination of chromosomes.
L: mitosis produces genetically identical cells with same type and number of chromosomes, genetic stability is maintained.
M: random fusion of gametes with different combination of chromosomes increases genetic variation.

26 The blackcap, *Sylvia atricapilla*, is a small songbird. It is a summer visitor to parts of Germany, where it breeds.

Many blackcaps overspend the winter (overwinter) in southern Europe, particularly in Spain. As a result of many people putting out food for birds in their gardens, some birds can also overwinter in the UK.

Scientists measured the genetic variation between blackcaps from two forest sites in Germany, 800 km apart. Both sites included birds that had overwintered in different countries such as Spain and UK. The measurements were made shortly after the birds returned from their winterfeeding grounds.

The measurements of genetic variation showed that:

- birds that overwintered in the same country (either Spain or the UK) shared many alleles, even though they were living 800 km apart in Germany in the summer
- birds that overwintered in different countries (Spain or the UK) shared fewer alleles, even though they were living in the same forest in Germany in the summer
- the genetic differences between the birds that overwintered in Spain suggested that they no longer breed with those that overwintered in the UK.

Which statement does **not** describe how the blackcaps could evolve into two distinct species?

A The blackcaps spent their winters in different countries that had different selection pressures in the different environments acting on them.
The blackcaps overspent their winters in the respective countries so ended up breeding in the countries they were spending their winters in. The blackcaps that survived the winters better in the different environments had selective advantage and thus better able to survive, reproduce and pass on the alleles that code for the selective advantage to their offspring.

B The blackcaps breeding in the same forest in Germany in summer were showing sympatric speciation as the blackcaps that overwintered in Spain no longer breed with those that overwintered in the UK.
The blackcaps overspent their winters and flew back to Germany to continue their breeding seasons. So although the blackcaps are in the same forest in Germany, they displayed behavioural isolation i.e. recognising the mating calls of the blackcaps that overspend winter at the same place, thus sympatric speciation occurring.

C The blackcaps that overwintered in Spain could not interbreed with those that overwintered in the UK because of geographical isolation resulting in allopatric speciation.
The blackcaps overspent their winters in Spain and UK respectively were already starting their breeding season in Spain and UK respectively. The large distance between Spain and UK would be facilitating allopatric speciation.

D Founder effect caused independent accumulations of mutations within the gene pools of the blackcaps that overwintered in Spain and UK which contributed to the speciation of the blackcaps.
Although there were movement of the blackcaps across continents, there was no total separation of a smaller population from the parental population because the blackcaps still gathered back at the same forest sites in Germany.

27 Which of these statements explaining about biogeography could be correct?

1 the linking of the present-day distributions of organisms with past movements of continental plates *correct*

2 study of the distribution of living things and how they are affected by abiotic factors like oceans, rivers, mountains, valleys and climate *correct*

3 study of oceans, rivers, mountains, valleys and climate and how they caused natural selection in one population *incorrect biogeography focus on the distribution of living things. This statement only looked at one population, not how the distributions of many populations have occurred.*

A 1 only

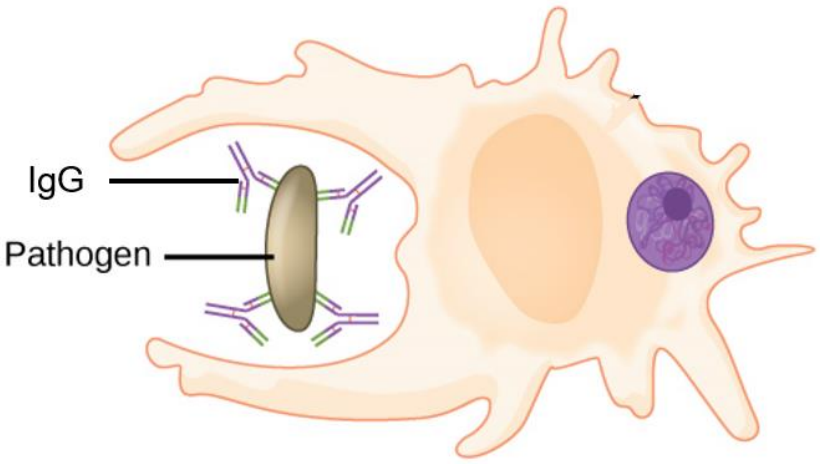
B 2 only

C 1 and 2 only

D 1, 2 and 3

28 What processes are shown in the figure below to result in the elimination of the pathogen ?

Presence of pseudopodia suggests phagocytosis is occurring



Opsonisation is the process of binding of antibodies to the antigens on pathogen. Fc receptors on the surface of phagocytes will bind to the Fc portion of antibodies, resulting in the triggering of phagocytosis and destruction of pathogen.

*Antibodies **agglutinate** / clump together pathogens by causing **many** of the pathogens to be engulfed at the same time [NOT shown in the diagram]*

A agglutination, phagocytosis

B opsonisation, phagocytosis

C apoptosis, opsonisation, neutralisation,

D agglutination, apoptosis, neutralisation, opsonisation

29 The transmission of dengue disease virus from an infected to an uninfected person can be described in four steps.

step 1 A female mosquito feeds on an infected person when that person has a high temperature.

step 2 ……

step 3 After 8-12 days, the virus spreads to cells of other organs, including the salivary glands.

step 4 The mosquito bites an uninfected person and viruses pass into the person's blood with the mosquito's saliva.

Which statement is correct for the missing step 2?

A Viruses taken in with the blood meal enter the cells lining the mosquito's gut and multiply there.

B Viruses taken in with the blood meal move from the mosquito's gut into the salivary duct and multiply there.

C Viruses taken in with the blood meal multiply in the cavity of the mosquito's gut.

D Viruses taken in with the blood meal pass between the cells of the mosquito's gut wall and multiply in the blood stream

15

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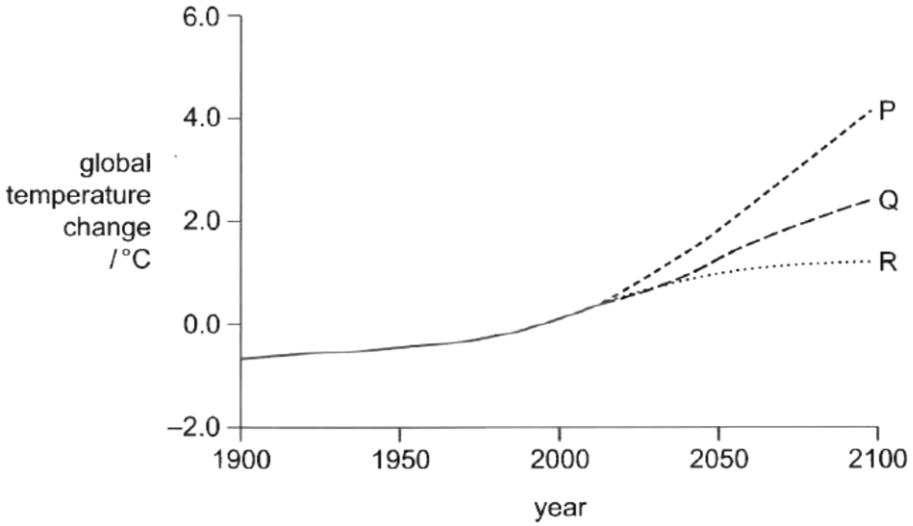
D Viruses taken in with the blood meal pass between the cells of the mosquito's gut wall and multiply in the blood stream.

30 The graph shows the predicted change in global temperatures using three different models, P, Q and R. Model Q assumes that no new factors act to influence the rate of climate change.

The predictions of models P and R can be explained using some of the following statements.



1 An increased global temperature and reduced rainfall will lead to an increase in forest fires. *Thus reducing area of forest carbon sink, forest fires also released more greenhouse gases and in turn further increase global temperature.*

2 Permanently frozen soil and sediment in the Arctic will begin to thaw as global temperatures increase. *When permafrost thaws, this releases carbon dioxide and methane into the atmosphere, contributing to rising greenhouse gas levels, which accelerates global warming via positive feedback loop.*

3 Rising sea temperatures will cause increase growth of photosynthetic algae. *Algae takes up carbon dioxide during photosynthesis, so the extent of increase in atmospheric carbon dioxide is lower → less GHG emissions → less trapping of heat → smaller increase in global temperatures*

4 Rising sea temperatures will reduce the solubility of greenhouse gases in the oceans. *Yes, see below para on explanation.*

Which of these statements support prediction of models P and R?

	Statements that support prediction P	Statements that support prediction R
A	1, 2 and 4	3
B	1 and 3	2 and 4
C	2	1, 3 and 4
D	3 and 4	1 and 2

Physical oceanography: pg 13

- The ocean **"solubility pump"** removes atmospheric carbon dioxide as air mixes and dissolves it into the upper ocean. Carbon dioxide is *more soluble in cold water*, so at high latitudes where surface cooling occurs, carbon dioxide-laden water sinks to the deep ocean and becomes part of the deep ocean circulation "conveyor belt", where it stays for hundreds of years.

- Eventually, mixing brings the water back to the surface at the opposite end of the conveyor belt in regions distant from where the carbon dioxide was first absorbed, e.g. the tropics. In the tropical regions, however, warm waters cannot retain as much carbon dioxide and carbon dioxide is transferred back into the atmosphere.