

H2ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2**2022 JC2 PRELIMINARY EXAMINATIONS**

BIOLOGY**9744/01****PAPER 1
MULTIPLE CHOICE
WORKED SOLUTIONS****20 SEPTEMBER 2022
TUESDAY****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.

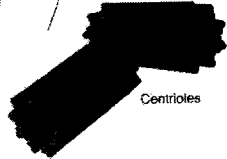
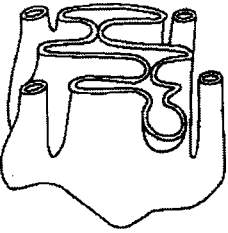

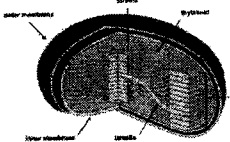
Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.

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?

	<p>area near the nucleus containing a pair of structures that are composed of microtubules</p> <p><i>centrioles</i></p>  <p>Centrioles</p>	<p>a network of tubes and sacs with each tube and sac (<i>cisterna</i>) bounded by a single membrane</p> <p><i>(smooth) endoplasmic reticulum</i></p> 	<p>a stack of elongated, curved sacs with each sac (<i>cisterna</i>) bounded by a single membrane</p> <p><i>Golgi body</i></p> 	<p>structure with a double membrane containing stacks of flattened sacs (<i>thylakoids</i>)</p> <p><i>chloroplast</i></p> 
	<p><i>Centrioles are only found in animal cells but not in higher plant cells.</i> <i>(Higher plants 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)</i></p>	<p><i>Found in a typical eukaryotic cell</i></p>	<p><i>Found in a typical eukaryotic cell</i></p>	<p><i>Present in eukaryotic photosynthetic cells e.g. leaf cells. Root hair cells do not undergo photosynthesis.</i></p>
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.

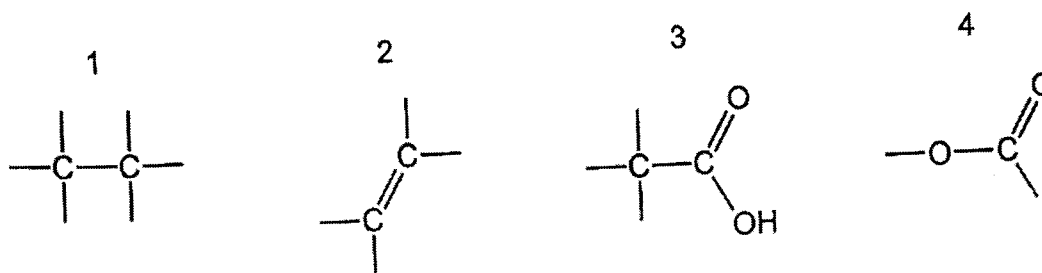
Bacteria cells also lack internal membrane, but they are still living. So having/ not having internal membrane is not a criteria to decide whether something is living or non-living. Internal membranes also does not relate to cell theory, thus this does not suggest viruses are non-living

*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

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? all fatty acids have a carboxylic acid group

	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

Handwritten notes: 2 ester bond + phosphoester bond, 2 fa + 1 glycerol + 1 phosphate, 3 ester bonds, 3 fa + 1 glycerol cannot be fatty acids, as fa loses a hydrogen atom during formation of ester bond between fa & glycerol.

The diagram shows a model of the structure of a cell surface membrane. In addition to the structures shown, cholesterol is also present.

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

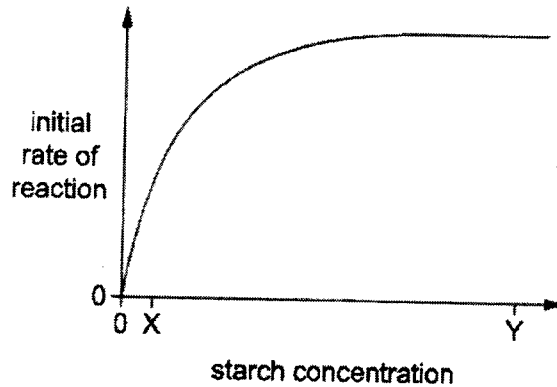
Which row correctly describes the structure of collagen?

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.

amylase
↓
hydrolyse starch to maltose (substrate)

At low [substrate], what is limiting rate? & what is in excess?

Y (at high [substrate], [substrate] is no longer limiting, [enzyme] is limiting due to active sites saturated w/ binding of substrate)

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 <u>amylase concentration</u> .
B	The amylase has few empty active sites. X	The initial rate of reaction is limited by starch concentration. When starch ↑, no ↑ in rate ∴ not limiting
C	The initial rate of reaction is limited by amylase concentration. X	Few enzyme-substrate complexes are formed. X rate is at maximum in max E-SC formed
D	The initial rate of reaction is limited by starch concentration. ✓	The amylase has many empty active sites. X

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.

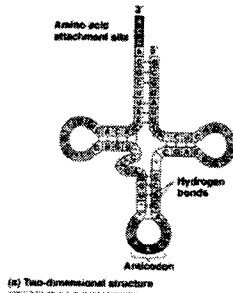
Correct. Look at 3rd bullet point

4 Cells with the ZScan4 cell marker are pluripotent.

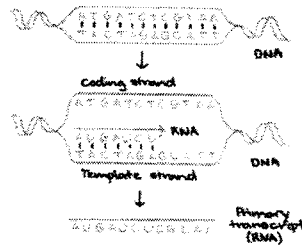
Incorrect. Should be cells with both ZScan4 and OCT4 are totipotent

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

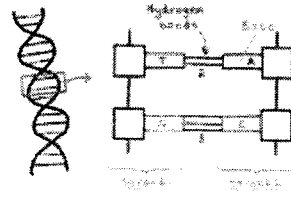
- 1 the shape of a folded polynucleotide
tRNA consist of a single strand which folds back upon itself via hydrogen bonds between complementary stretches of bases to form a specific 3D structure
- 2 a temporary binding of codons during transcription
complementary base-pairing occurs via hydrogen bonds 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

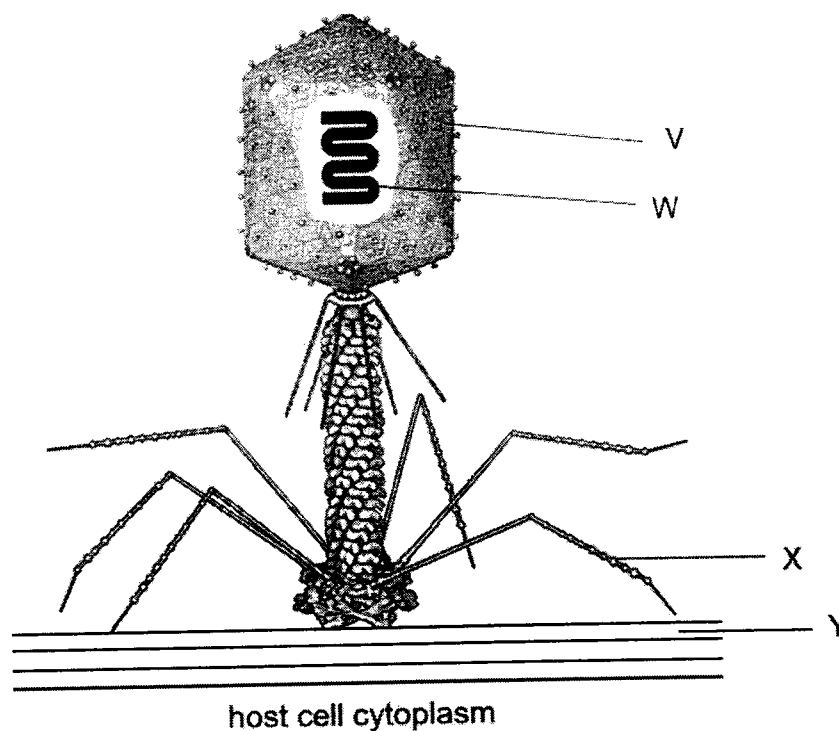


ribosomal subunit made up of rRNA and ribosomal proteins permanently bound together

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 <i>Capsid. Made up of subunits capsomers which are proteins.</i>	W <i>T4 genome is a double stranded linear DNA</i>	X <i>Tail fibre is made up of proteins.</i>	Y <i>Tail fibres attach to the outer membrane of E.coli, a gram negative bacterium</i>
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

GRAM-NEGATIVE

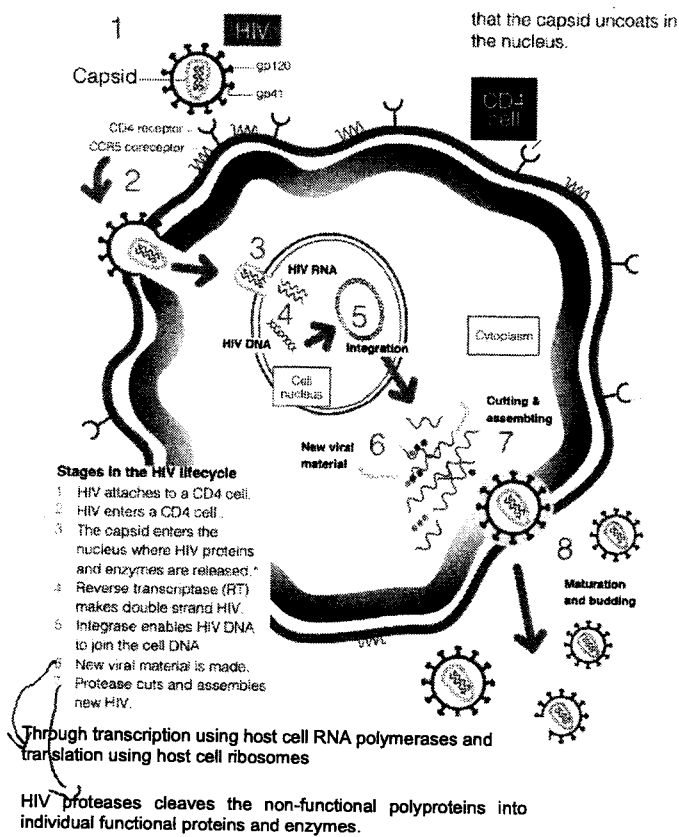


10 Some of the enzymes involved in the reproductive cycle of HIV are listed.

- 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



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.

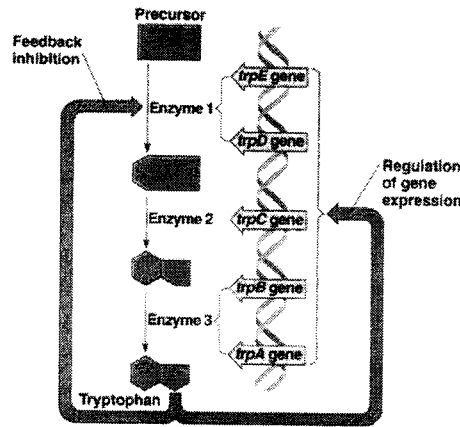
- C** Both donor and recipient bacteria will be genetically identical at the end of conjugation.

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 identical 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.

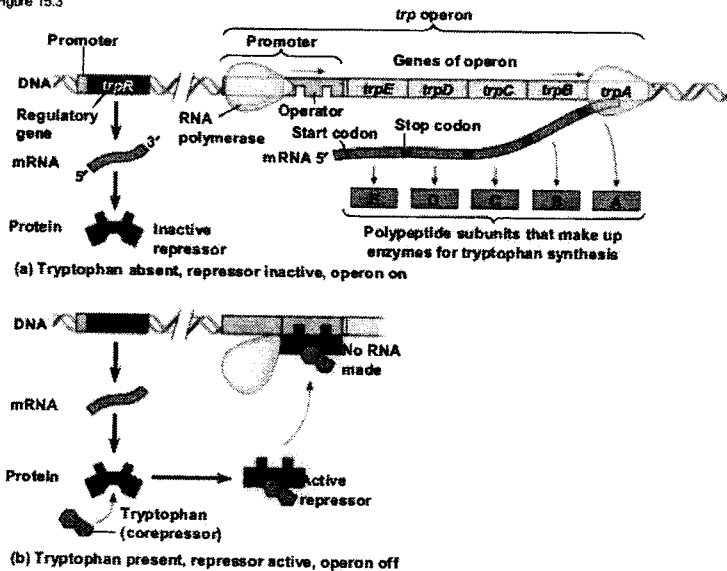


Which statements are true?

- 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

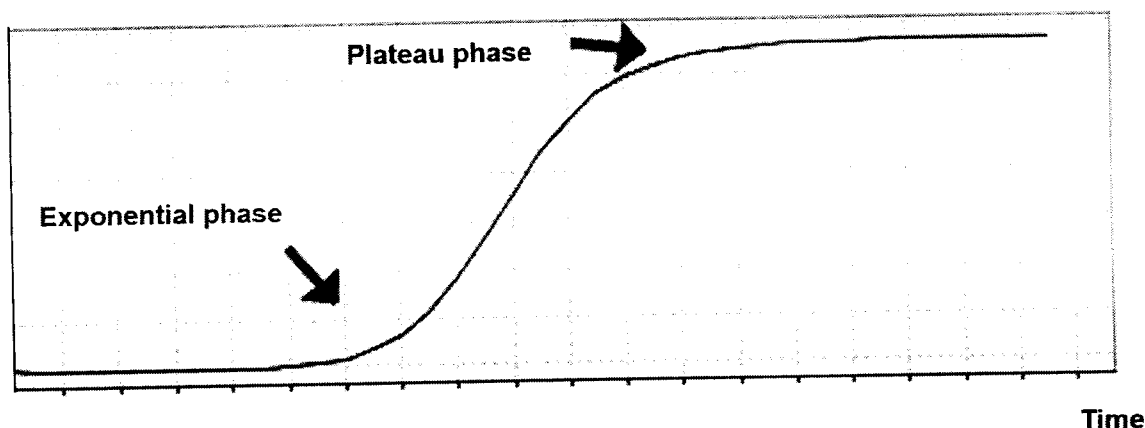
Figure 15.3



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- 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.

Amount of DNA



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.

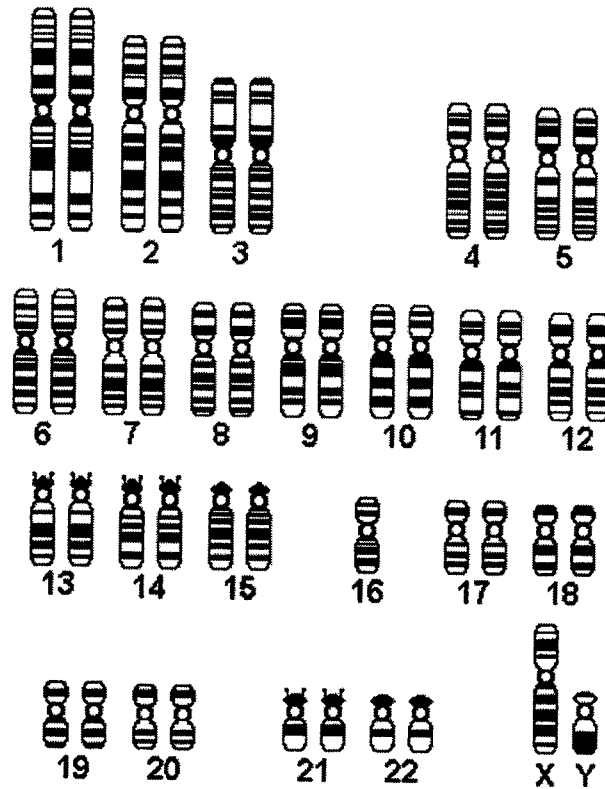
- C During the plateau phase, the temperature is maintained constantly at 72°C for extension.

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°C 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?

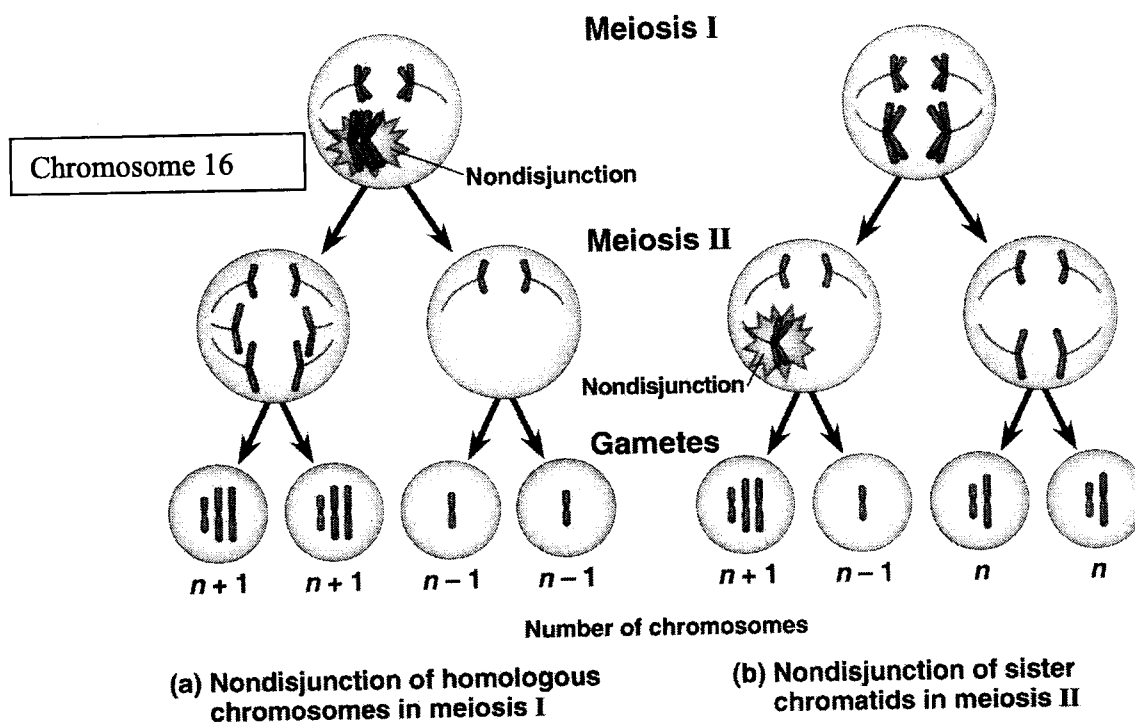
	type of chromosomal aberration	possible cause
A	aneuploidy	non-disjunction during meiosis I of father's gametic cell, resulting in a sperm cell missing one chromosome
B	polyploidy	non-disjunction during meiosis I of father's gametic cell, resulting in a sperm cell with an extra set of chromosomes
C	aneuploidy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

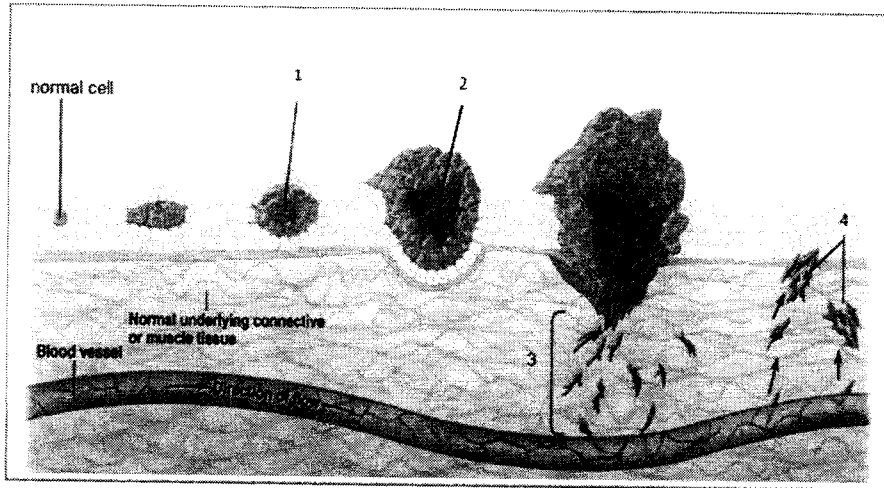
Diagram shows only one chromosome present for chromosome 16. So the chromosomal abnormality shown is aneuploidy (option A and C)

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.

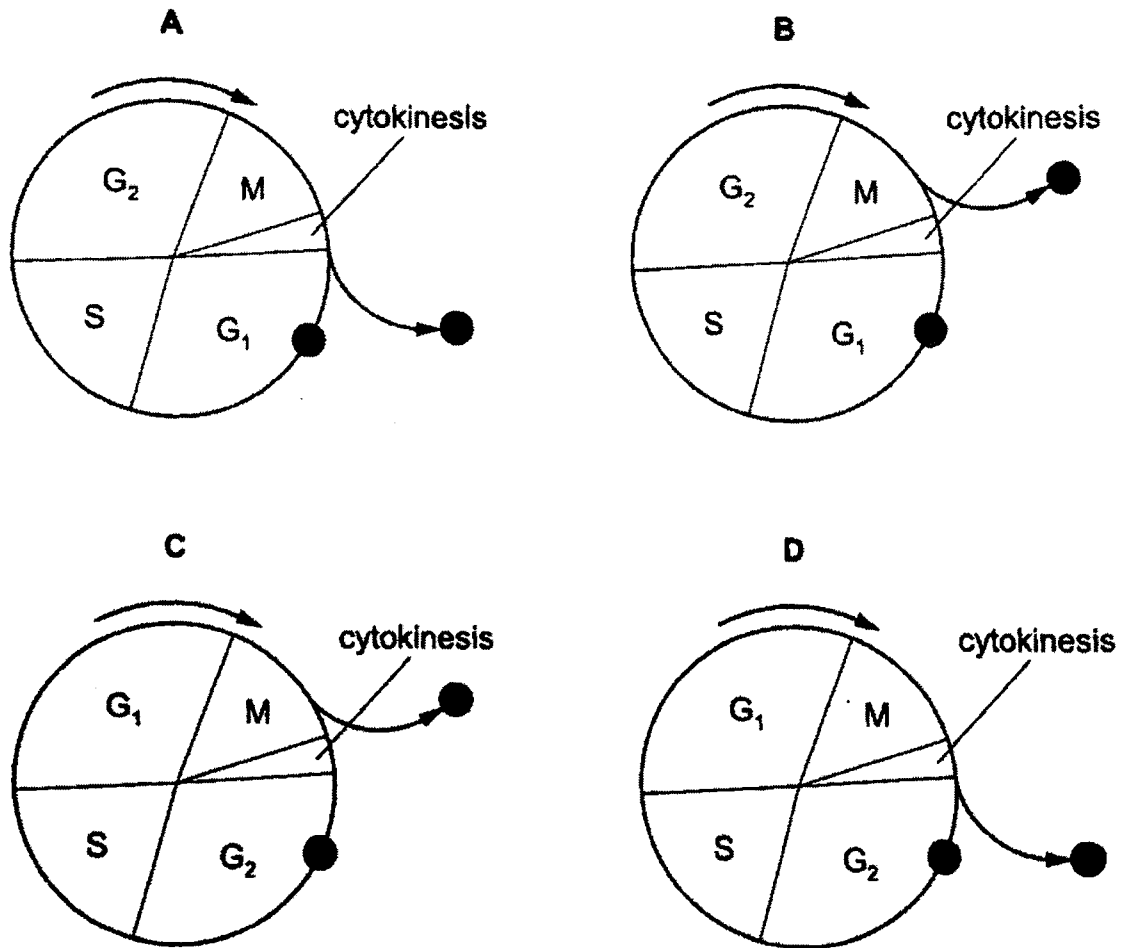


Which of the following correctly identifies the possible processes that occur in 1-4?

	1	2	3	4
A	<p>cell escapes apoptosis <i>Correct</i></p>	<p>loss of density-dependent inhibition <i>See explanation in option B</i></p>	<p>loss of cell-cell adhesion <i>See explanation in option B</i></p>	<p>metastasis <i>Correct. Step 4 shows the spread of cancerous cells to other parts of the body. known as metastasis</i></p>
B	<p>rate of cell division exceeds rate of cell death <i>Correct</i></p>	<p>cell escapes apoptosis <i>Correct</i></p>	<p>loss of density-dependent inhibition <i>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.</i></p> <p><i>Step 3 shows loss of cell-cell adhesion rather than density-dependent inhibition</i></p>	<p>loss of cell-cell adhesion <i>Wrong. See explanation in option A</i></p>

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

16 Which diagram correctly represents the mitotic cell cycle? A



key

● = new cell that may divide again or differentiate

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.

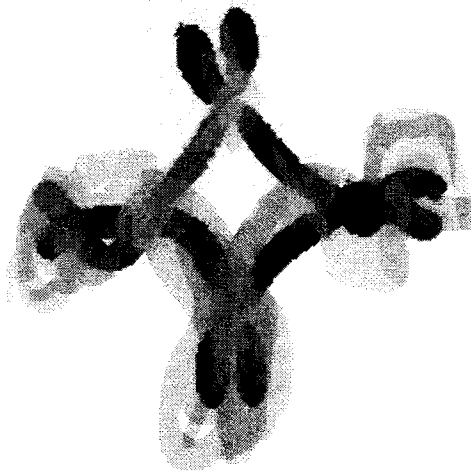
The figure below represents a structure seen in one of the cells.



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.

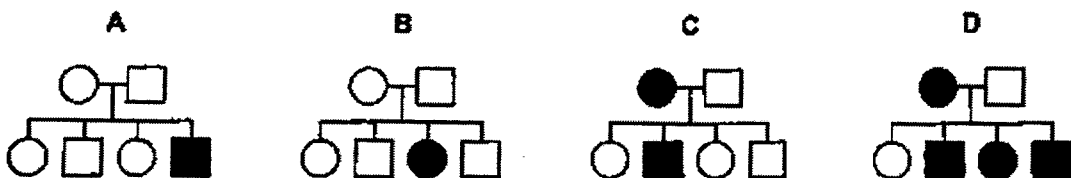
- C** environmental factors and random fertilisation

"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.

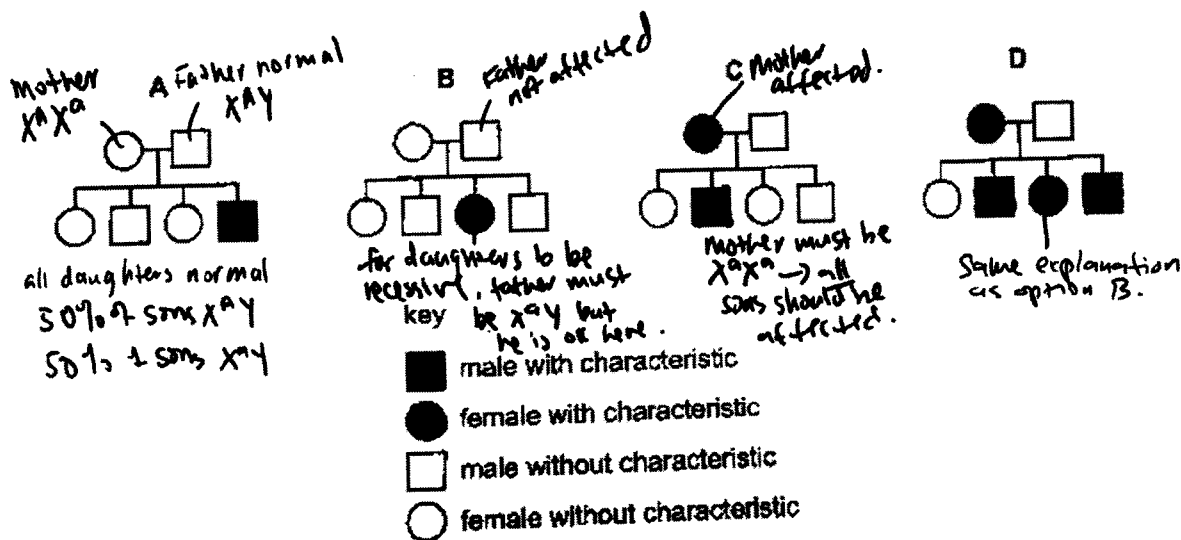
- 19 Which diagram shows inheritance of a characteristic that could be caused by a recessive X-linked allele? **A**



key

- male with characteristic
- female with characteristic
- male without characteristic
- female without characteristic

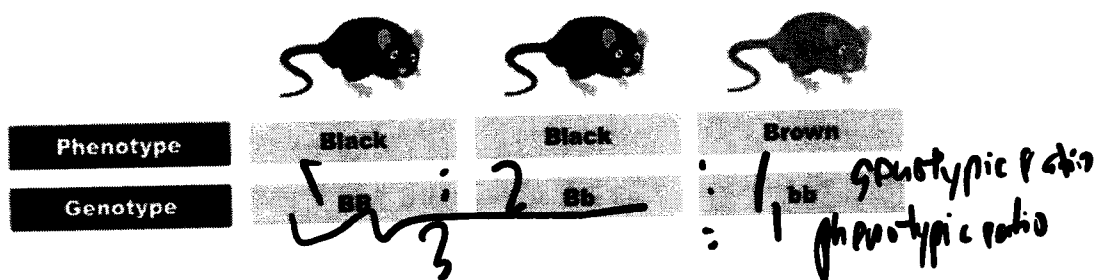
Explanation:



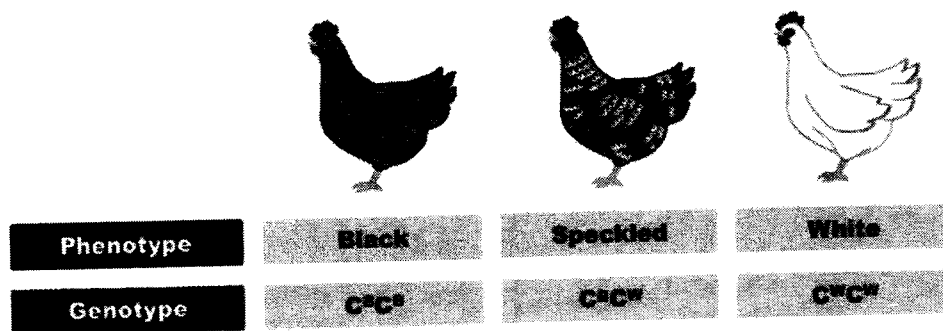
20 Which statement uses genetic terms correctly?

- 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)



Co-dominance (Chicken Feathering)



- 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?

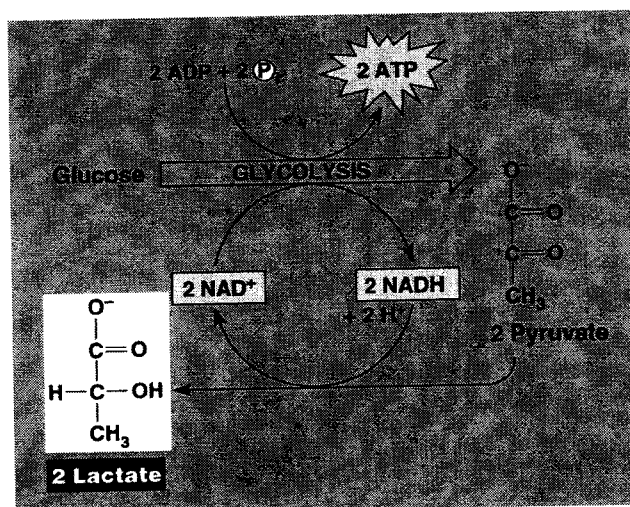
- A** During development in the mother's body, each embryo received different oxygen and food supplies from the placenta.
- B** Each of the four cells from the original fertilised cell received a different proportion of cell organelles during cytokinesis.
- C** The food provided after the offspring were 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.*

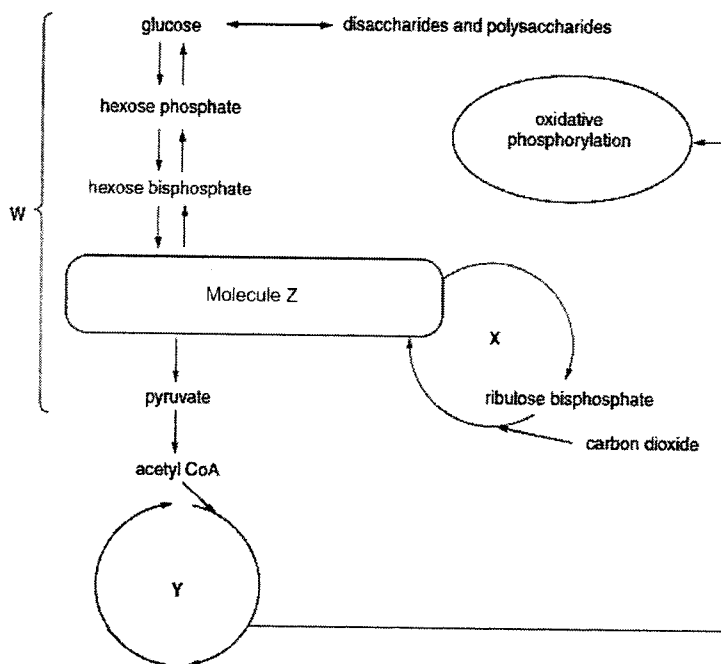
22 Which of the following about anaerobic respiration in muscle cells is **false**?

- 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. Krebs 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 separately.*
- 4 Only X requires ATP.
False. W and X require ATP. In glycolysis (W), Phosphorylation of glucose (6C) to fructose/hexose biphosphate (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

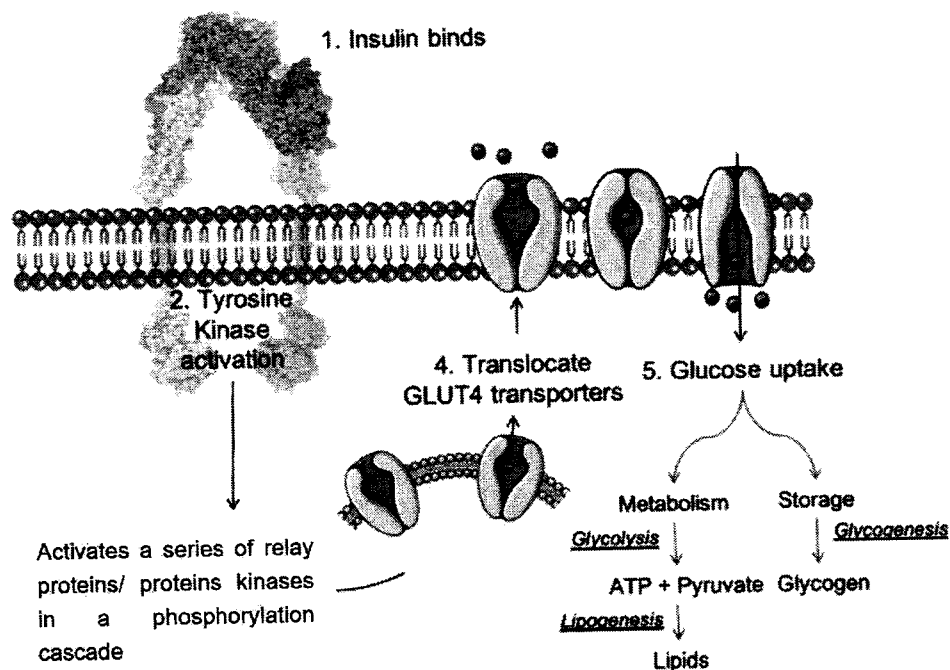
*dephosphorylation of protein kinases by protein phosphatase will result in signal termination
→ switching off the insulin signalling pathway → less production of glycogen*

A 2 only

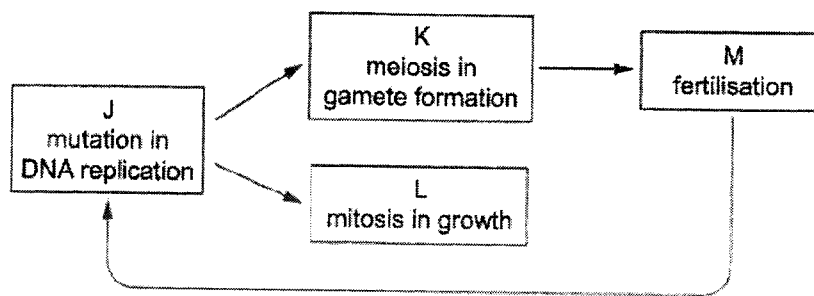
B 1 and 4

C 2 and 3

D 1, 2 and 3



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



- A J, K, L and 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 overwinter (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.

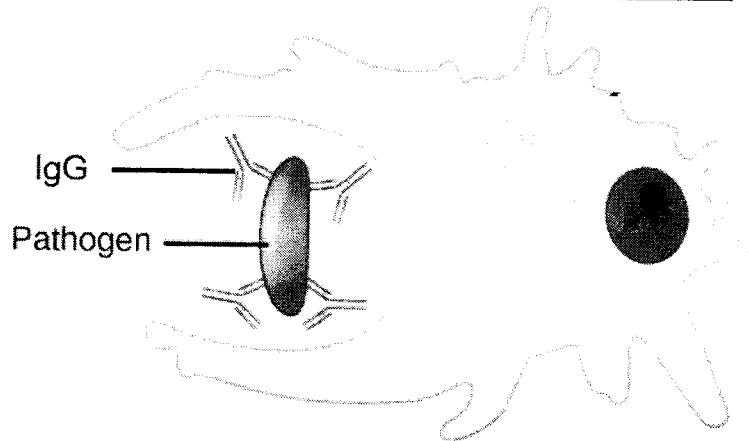
27 Which of these statements explaining about biogeography could be correct?

- 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

★ Mosquitoes gut is where ¹⁵ virus multiply not the salivary gland
 The transmission of dengue disease virus from an infected to an uninfected person can be described in four steps. Note that viral replication only occurs within

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

step 2

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

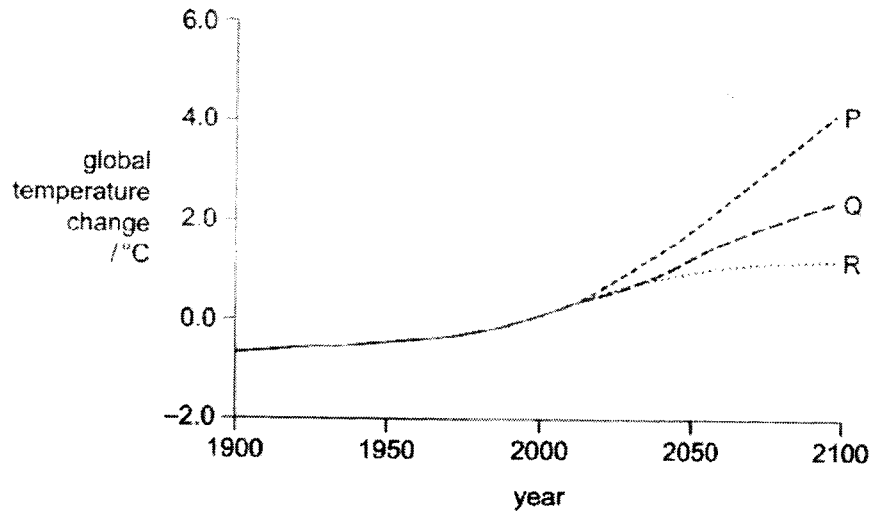
step 4 The mosquito bites an uninfected person and viruses pass into the person's blood with the mosquito's saliva. when saliva of mosquito is ejected into human host

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. virus replicates in the gut of mosquito then move to salivary gland.
- B Viruses taken in with the blood meal move from the mosquito's gut into the salivary duct and multiply there. X
- C Viruses taken in with the blood meal multiply in the cavity of the mosquito's gut. cells not cavity.
- D Viruses taken in with the blood meal pass between the cells of the mosquito's gut wall and multiply in the blood stream. X

- 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.

H2ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2**2022 JC2 PRELIMINARY EXAMINATIONS**CANDIDATE
NAME

CLASS

INDEX NUMBER

BIOLOGY**9744/02****PAPER 2**
SHORT STRUCTURED QUESTIONS**13 SEPTEMBER 2022**
TUESDAYCandidates answer on the Question Paper.
No Additional Materials are required.**2 HOURS****READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph
Do not use paper clips, highlighters, glue or correction fluid.

Answer all questions.

The use of an approved scientific calculator is expected,
where appropriate.
You may lose marks if you do not show your working or if you
do not use appropriate units.

At the end of the examination, fasten all your work securely
together.
The number of marks is given in brackets [] at the end of each
question or part question.

For Examiner's Use	
1	/ 10
2	/ 11
3	/ 9
4	/ 10
5	/ 10
6	/ 10
7	/ 10
8	/ 10
9	/ 10
10	/ 5
11	/ 5
Total	/100

This document consists of **29** printed pages and **3** blank pages.

Answer all the questions.

- 1 Chitin, the second most abundant organic polymer after cellulose on Earth, is found in the cell walls of fungi and the exoskeleton of insects. Both chitin and cellulose serve as structural polysaccharides.

The chitin polysaccharide consists of N-acetylglucosamine. Fig. 1.1 shows the structure of chitin.

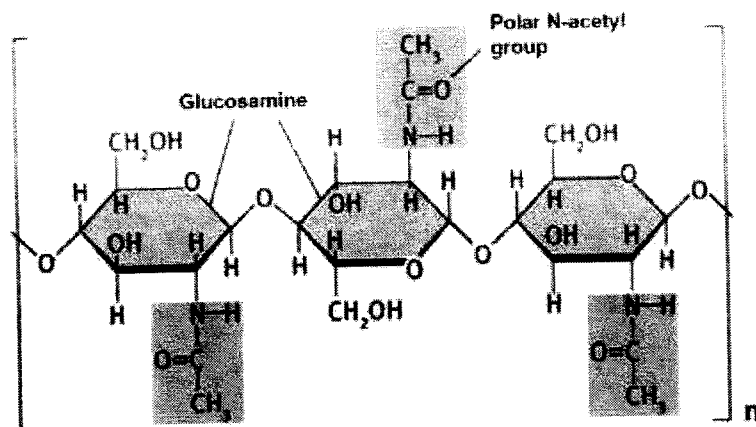


Fig. 1.1

(a) With reference to Fig. 1.1,

- (i) name the covalent bond between two monomers in a chitin molecule and describe how this bond is formed.

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[3]

(ii) explain how the structure and property of chitin are related to its role as a structural polysaccharide in fungi and insects.

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[4]

(c) Chitinase is an enzyme found in plants. It degrades chitin in fungal cell walls and exoskeletons of insects, protecting the plants against a range of pathogens.

Describe the mode of action of chitinase.

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[3]

[Total: 10]

- 2 Fig. 2.1 is an electronmicrograph of a human cell during mitosis.

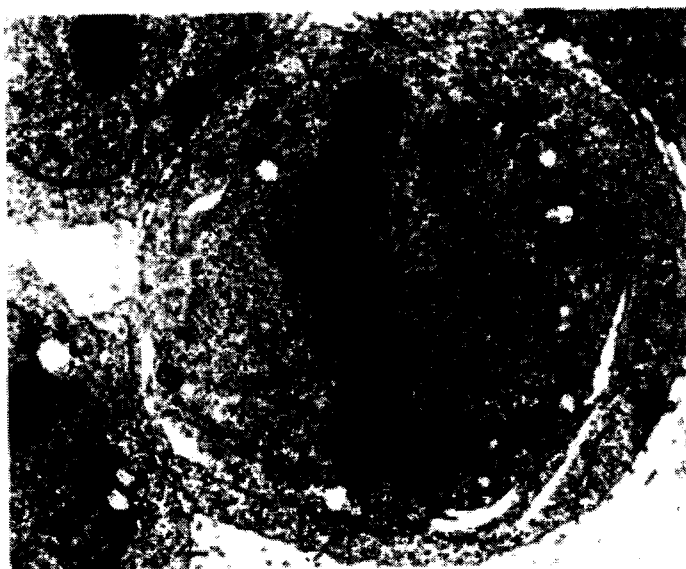


Fig. 2.1

- (a) Describe the events that take place in the stage of mitosis **before** that seen in Fig. 2.1.

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[3]

- (b) The normal diploid number of chromosomes for a human cell, such as that shown in Fig. 2.1, is 46.

The cell in Fig. 2.1 has 92 DNA molecules.

Explain the presence of 92 DNA molecules in this cell and why it is important to have this number.

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[4]

(c) Fig. 2.2 shows DNA replication occurring in a human cell (A) and in an *Escherichia coli* (B). Diagrams are not shown to scale.

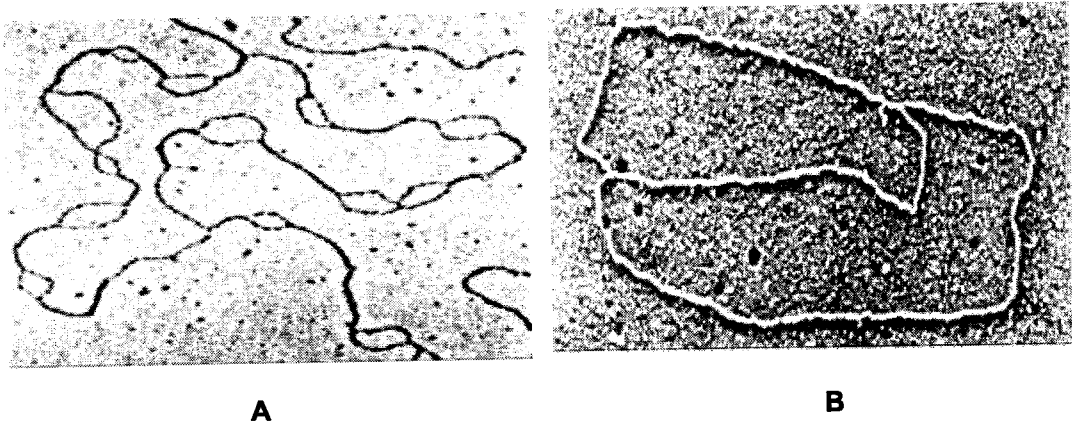


Fig. 2.2

(i) State one visible difference in the structure of these two DNA molecules during DNA replication and account for this difference.

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[2]

(ii) Explain why there is both continuous and discontinuous synthesis of daughter strands during DNA replication.

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[2]

[Total: 11]

Question 3 starts on page 8

3 Fig. 3.1 shows a diagram of protein synthesis.

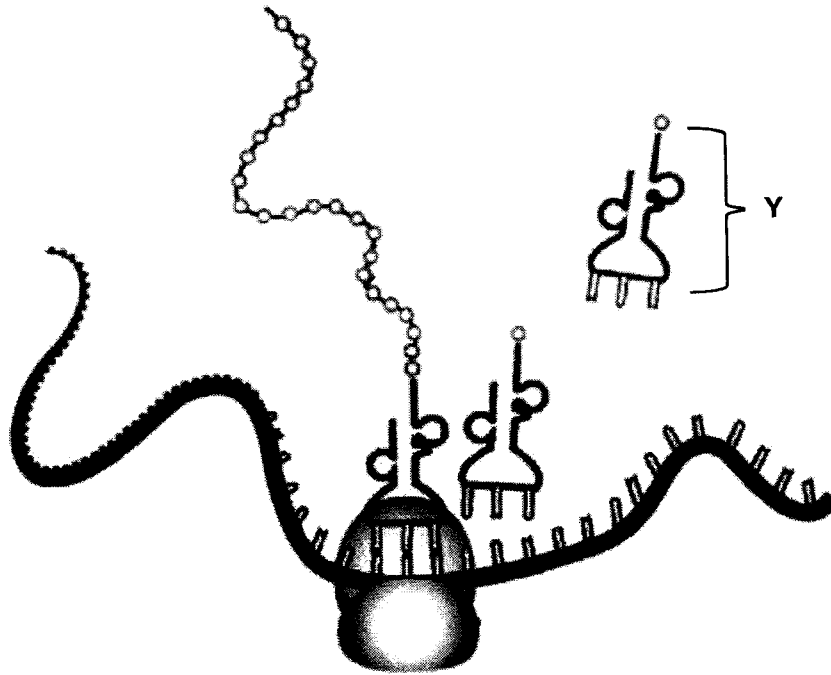


Fig. 3.1

(a) With reference to Fig. 3.1, outline the synthesis of the polypeptide chain from its mRNA.

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[4]

(b) During protein synthesis in cells of an embryo, all molecules Y in Fig. 3.1 are observed to be attached to the arginine amino acid instead of lysine.

(i) Suggest how the attachment of the wrong amino acid, arginine, to molecule Y may arise.

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[2]

(ii) Suggest and explain the effect of attachment of the wrong amino acid, arginine, to molecule Y on the embryo.

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[3]

[Total: 9]

- 4 The building blocks of anterior (head) – posterior (tail) axis patterning in *Drosophila* embryo (fertilised egg) are laid out during egg cell formation. Four genes (*hunchback*, *caudal*, *bicoid*, *nanos*) are responsible for the polarity of the egg cell and then of the subsequent embryo. mRNA molecules of these four genes were found to be distributed along the anterior-posterior axis of the developing egg cell as shown in Fig. 4.1.

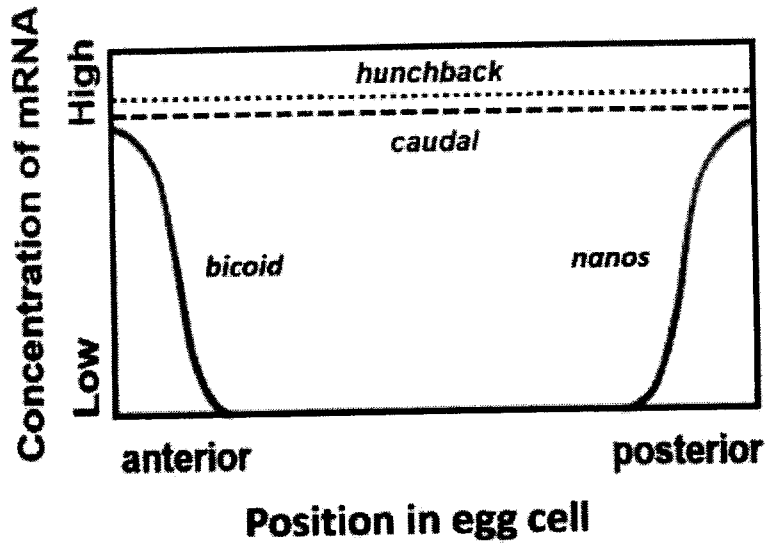


Fig. 4.1

- (a) With reference to Fig 4.1,
 - (i) explain the types of chromatin modifications that may be carried out on the *hunchback* and *caudal* genes.

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[4]

- (ii) The length of *hunchback* and *caudal* mRNA in the cytoplasm is shorter than the *hunchback* and *caudal* primary mRNA in the nucleus.

Describe what happens to the *hunchback* and *caudal* mRNA in the nucleus before they enter the cytoplasm.

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[3]

- (iii) mRNAs in cells are very unstable, having short half-lives of not more than 30 minutes. Explain how the *hunchback* and *caudal* mRNA levels are maintained within the cell.

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[2]

- (b) The corresponding protein concentrations of the four genes were measured in the early stages of development of the *Drosophila* embryo as shown in Fig. 4.2.

It was found that bicoid and nanos proteins act as repressors to block the translation of *caudal* and *hunchback* mRNA respectively.

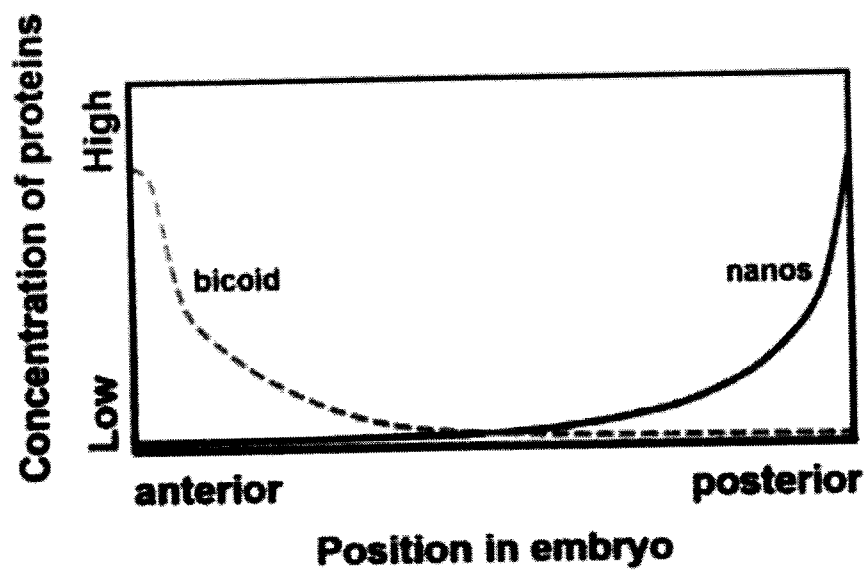


Fig. 4.2

Sketch one graph on Fig. 4.2, to represent the concentration of hunchback protein. [1]

[Total: 10]

5 Fig. 5.1 shows the main structural features of the influenza virus.

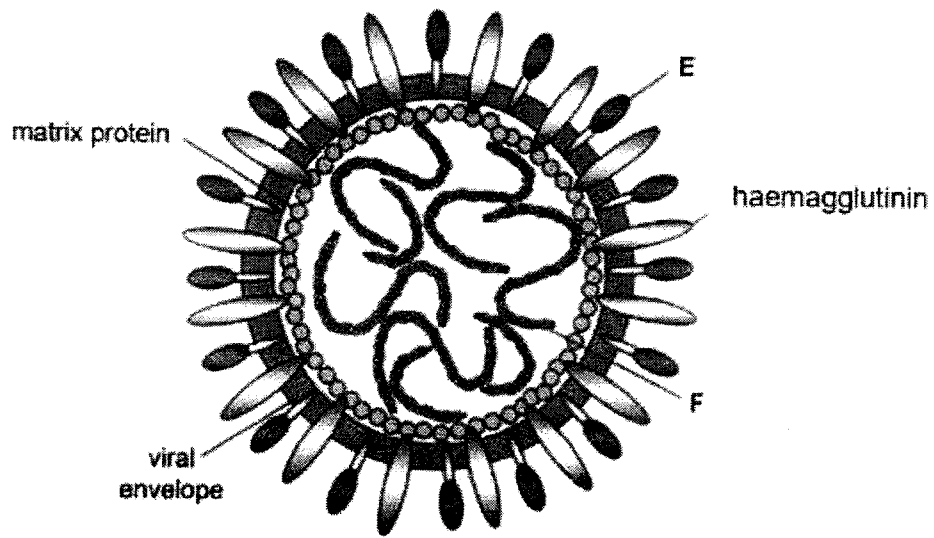


Fig. 5.1

(a) Explain the role of E and F in the influenza virus.

E

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F

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[4]

The sub-types of the influenza A virus that infect birds, human and pigs in one area of the world in recent times are shown in Table 5.1 below.

Table 5.1

time period	influenza A virus sub-types present		
	birds	humans	pigs
1918 – 1957	show any one of the H1 – H16 antigens combined with any one of the N1 – N9 antigens	H1N1	H1N1
1958 – 1970		H2N2	
1971 to present day		H3N2 H1N1	H3N2 H2N3

(b) Using the data in Table 5.1, two students, each has different claims that described how influenza A is a danger to human health in this area of the world.

- (i) Student X claimed that "Antigenic drift of influenza human virus such as H3N2 would lead to vaccines that target hemagglutinin glycoprotein being less effective."

Put a tick (✓) in one box to indicate whether or not this statement is true.

Give a reason for your answer.

true

false

Reason

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.....

[3]

- (ii) Student Y claimed that "Antigenic shift of influenza virus is happening within humans, by combining H2N2 from older people with H1N1 or H3N2."

Put a tick (✓) in one box to indicate whether or not this statement is true.

Give a reason for your answer.

true false

Reason

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[3]

[Total: 10]

- 6 Wing pattern in the butterfly species *Heliconius melpomene* is controlled by genes on autosomal chromosomes.

The gene for banding pattern on the upper wing has two alleles:

- a dominant allele coding for a full band
- a recessive allele coding for a broken band.

The gene for ray pattern on the lower wing has two alleles:

- a dominant allele coding for rays
- a recessive allele coding for no rays.

Scientists crossed a butterfly that was homozygous dominant for both genes with a butterfly that was homozygous recessive for both genes. The scientists wanted to check whether the phenotypic ratio for offspring in the F₂ generation agreed with the expected phenotypic ratio of 9 : 3 : 3 : 1.

The results of these genetic crosses are shown in Fig. 6.1.

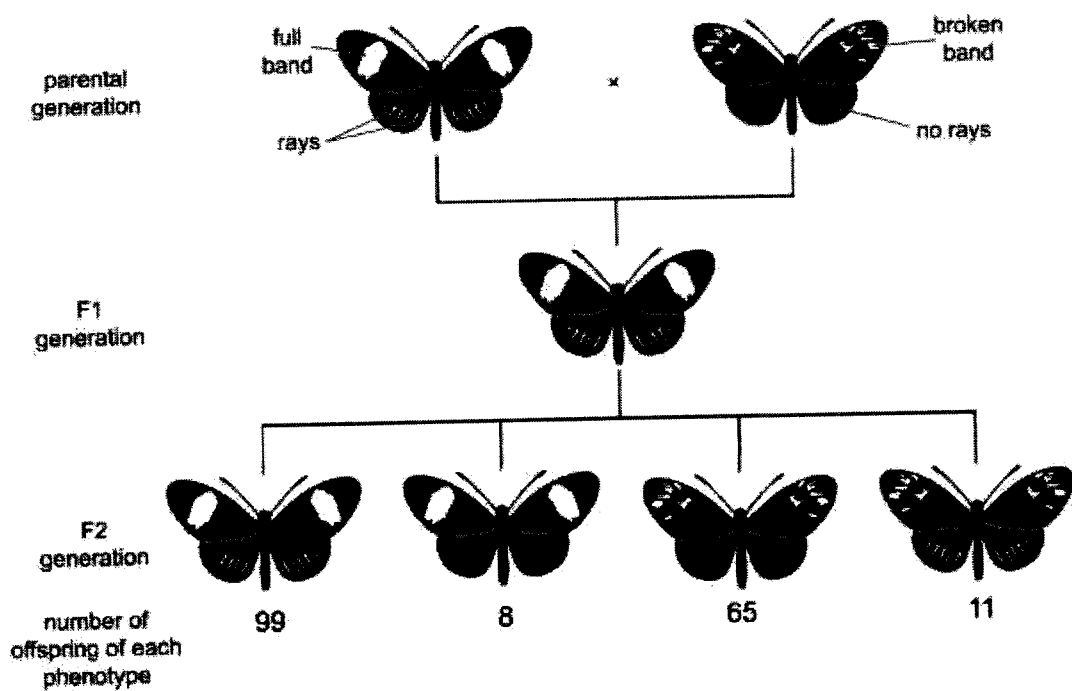


Fig. 6.1

(a) Draw a genetic diagram to explain the results of the genetic crosses.

[5]

(b) Two varieties of *Heliconius* butterflies, both pure-breeding for white wings, were crossed. All the F1 generation progeny produced orange wings.

The F1 butterflies were then crossed. In the F2 generation, 145 butterflies had orange wings and 111 butterflies had white wings. The control of wing colour is an example of epistasis resulting in a ratio that is close to 9:7.

Explain the term epistasis in this context.

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[3]

(c) The genus *Heliconius* contains more than 40 species of brightly patterned butterflies.

Researchers have investigated in the laboratory how one species, *Heliconius heurippa*, could have developed as a separate species. The phenotype of *H. heurippa* is intermediate between that of two other species, *H. cydno* and *H. melpomene* as it contains DNA from these two parent species as a result of hybridisation.

Laboratory breeding experiments showed that:

- matings between *H. cydno* and *H. melpomene* (parent species) produce fertile hybrid offspring
- controlled matings of the hybrids produces individuals identical in appearance to *H. heurippa* within three generations
- hybrid butterflies prefer to mate with each other, rather than with individuals of either of the parent species to produce fertile offspring.

In the wild,

- the genus *Heliconius* butterflies taste unpleasant to predators such as birds.
- the bright colours on the wings of the butterflies act as warnings so that birds avoid eating them. Therefore, this pattern provides a selective advantage.
- *Heliconius* hybrids occur in small numbers and have patterns that do not resemble the established warning pattern of either parent species. These hybrids have a selective disadvantage.

The researchers thought that, because the hybrid butterflies preferred to mate with each other, this could make speciation more likely to occur.

Suggest why *H. heurippa* is still **not** regarded as a separate species in the wild.

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[2]

[Total: 10]

7 Pancreatic cancer is an almost universally lethal disease.

Many genes are involved in the development of pancreatic cancer. Table 7.1 shows four of these genes.

Table 7.1

genes	genetic changes observed
P	homozygous deletion
Q	hypermethylation of the gene promoter
R	substitution in codon 56
S	amplification of gene

(a) Using the data in Table 7.1, identify an oncogene and a mutated tumour suppressor gene. Explain your answer.

(i) oncogene

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[2]

(ii) mutated tumour suppressor gene

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[2]

(b) Fig. 7.1 shows where the restriction enzyme *EcoRI* cuts within the two different alleles of gene R, the sizes of the fragments produced and the regions that bind to two probes, Y and Z.

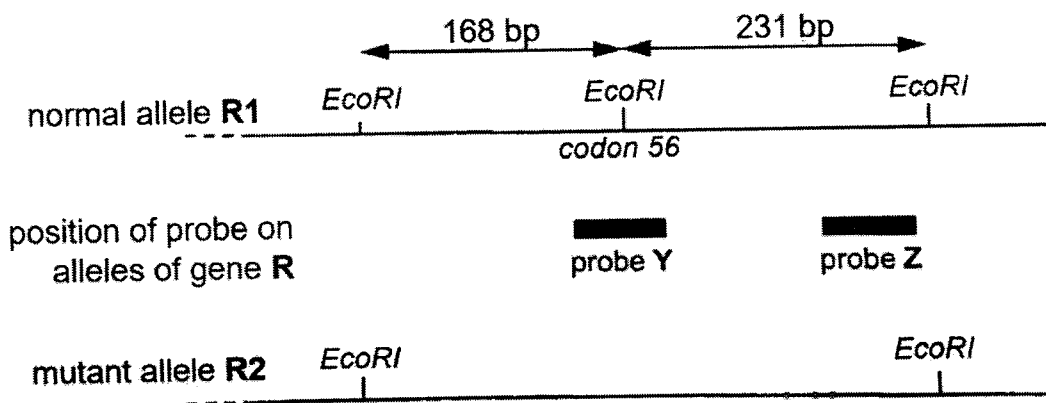


Fig. 7.1

(i) With reference to Fig. 7.1, explain how the two alleles of gene R can be distinguished using gel electrophoresis and detected by probe Y.

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- (ii) On Fig. 7.2 below, draw the position(s) and label the size(s) of the DNA fragment(s) of a heterozygous individual if probe Z were to be used instead.

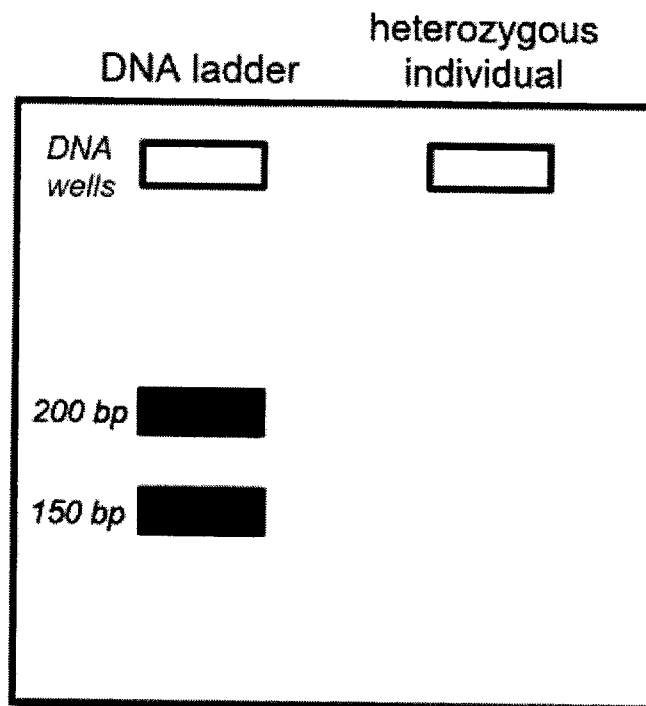


Fig. 7.2

[2]

[Total: 10]

8 Red algae are multicellular photosynthetic eukaryotes that contain phycoerythrin. Phycoerythrin is a photosynthetic pigment.

Fig. 8.1 shows:

- the absorption spectrum of phycoerythrin.
- the action spectrum of red algae.

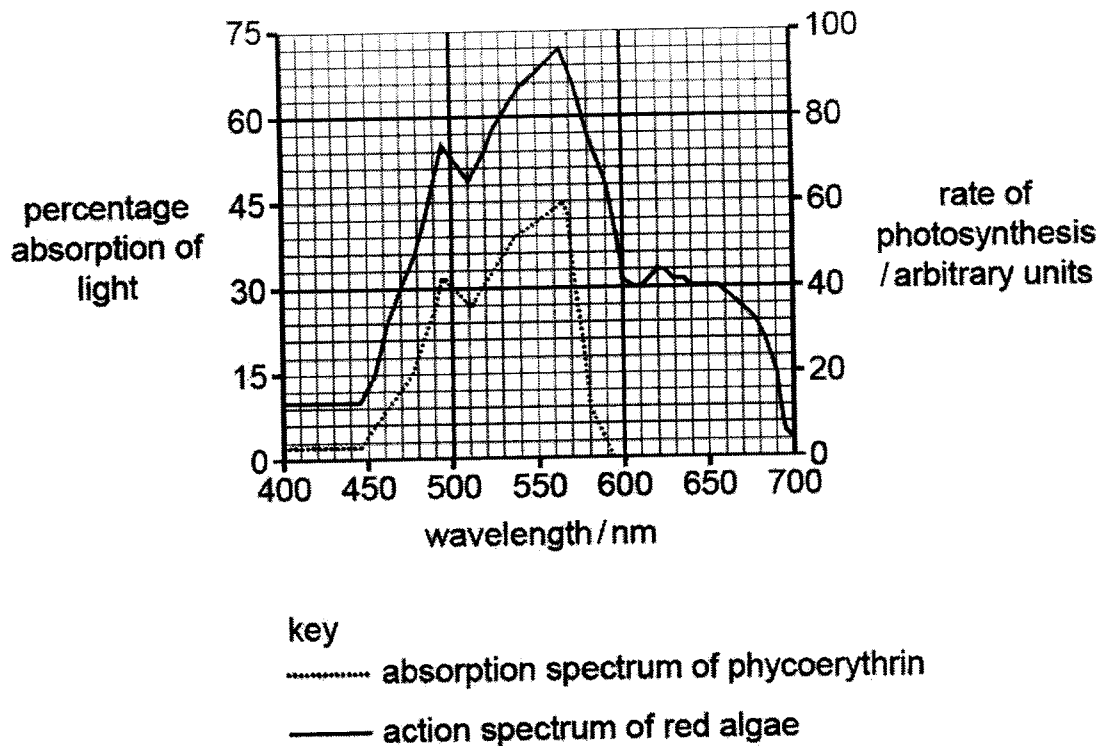


Fig. 8.1

(a) (i) With reference to Fig. 8.1, state the wavelength of peak absorption by phycoerythrin.

..... [1]

(ii) Explain how the data in Fig. 8.1 show that phycoerythrin is **not** the only photosynthetic pigment in red algae.

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[2]

- (iii) Phycoerythrin is **not** the primary pigment (pigment in reaction centre) for photosynthesis in red algae.

Suggest the role of phycoerythrin in photosynthesis in red algae.

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[2]

- (b) The rate of photosynthesis is affected by factors other than wavelength of light. These factors may act as limiting factors. A student investigated the effect of limiting factors on rate of photosynthesis by measuring the volume of oxygen released from a plant.

- (i) Explain what is meant by the term limiting factor and state an example of a limiting factor in photosynthesis.

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- (ii) Explain why the volume of oxygen released from a plant does **not** give a true rate of photosynthesis.

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[Total: 10]

9 Fig 9.1 shows the arrangement of bones in the pentadactyl forelimbs of four vertebrates. This is used by many people to provide evidence for evolution.

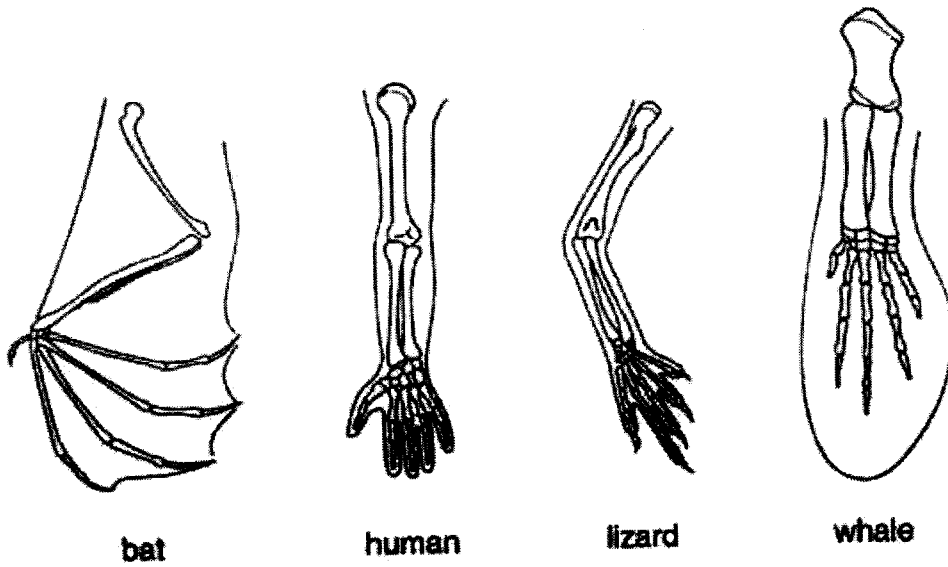


Fig. 9.1

(a) (i) State the term used to describe the relationship between structures such as those in Fig. 9.1.

..... [1]

(ii) Explain how the relationship between the structures in Fig. 9.1 provides evidence to support the theory of evolution.

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- (b) There are many different species of lizards. Three of these species, *Liolaemus fabiani*, *L. molinai* and *L. multicolor*, are thought to be closely related.

Samples of these three species were collected from the Andes range in Western South America. The base sequences of four regions of DNA of each species were sequenced.

The percentage difference in the base sequences in *L. molinai* and *L. multicolor*, compared to the sequences in *L. fabiani*, was calculated. The results are shown in Table 9.1.

Table 9.1

DNA region	Lizard species	Percentage difference in base sequence from that of <i>L. fabiani</i> / %
Non-coding region 1	<i>L. molinai</i>	4.8
	<i>L. multicolor</i>	4.4
Non-coding region 2	<i>L. molinai</i>	8.1
	<i>L. multicolor</i>	7.3
Coding region 1	<i>L. molinai</i>	2.1
	<i>L. multicolor</i>	2.0
Coding region 2	<i>L. molinai</i>	1.9
	<i>L. multicolor</i>	1.7

- (i) Using the evidence from the non-coding regions in Table 9.1, explain why *L. fabiani* may be more closely related to *L. multicolor* than to *L. molinai*.

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[2]

- (ii) The coding regions 1 and 2 in Table 9.1 were measured by analysing the *cytochrome c* gene.

Suggest why the *cytochrome c* gene is used to measure changes in DNA sequences in closely related species.

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[2]

- (c) Explain the importance of variation in the coding regions for evolution to occur.

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[Total: 10]

- 10 Fig 10.1 shows an antigen presenting cell (APC) presenting an antigen from a pathogen such as a virus, to a cytotoxic T cell.

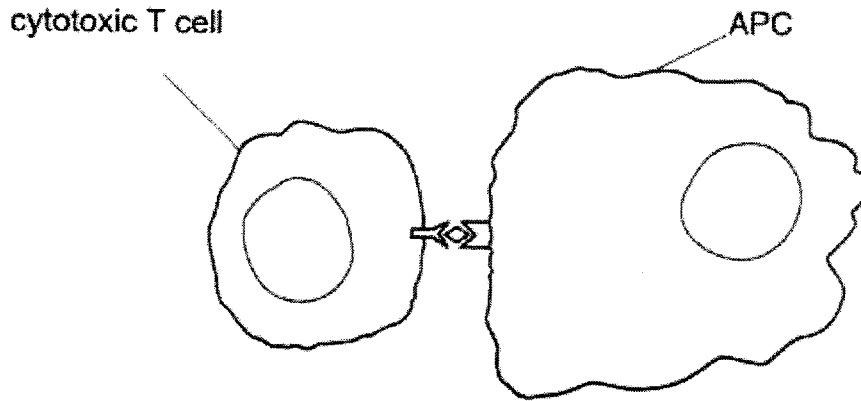


Fig. 10.1

- (a) Using Fig. 10.1, describe how presentation of an antigen by APC will lead to the elimination of the pathogen.

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[3]

- (b) State **two** differences between artificial active immunity and natural passive immunity.

Difference between artificial and natural immunity

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Difference between active and passive immunity

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[2]

[Total: 5]

- 11 Plant biodiversity varies throughout the world and is dependent on many factors, particularly climate.

Fig. 11.1 shows the relationship between the number of plant genera and the mean annual rainfall in seven countries.

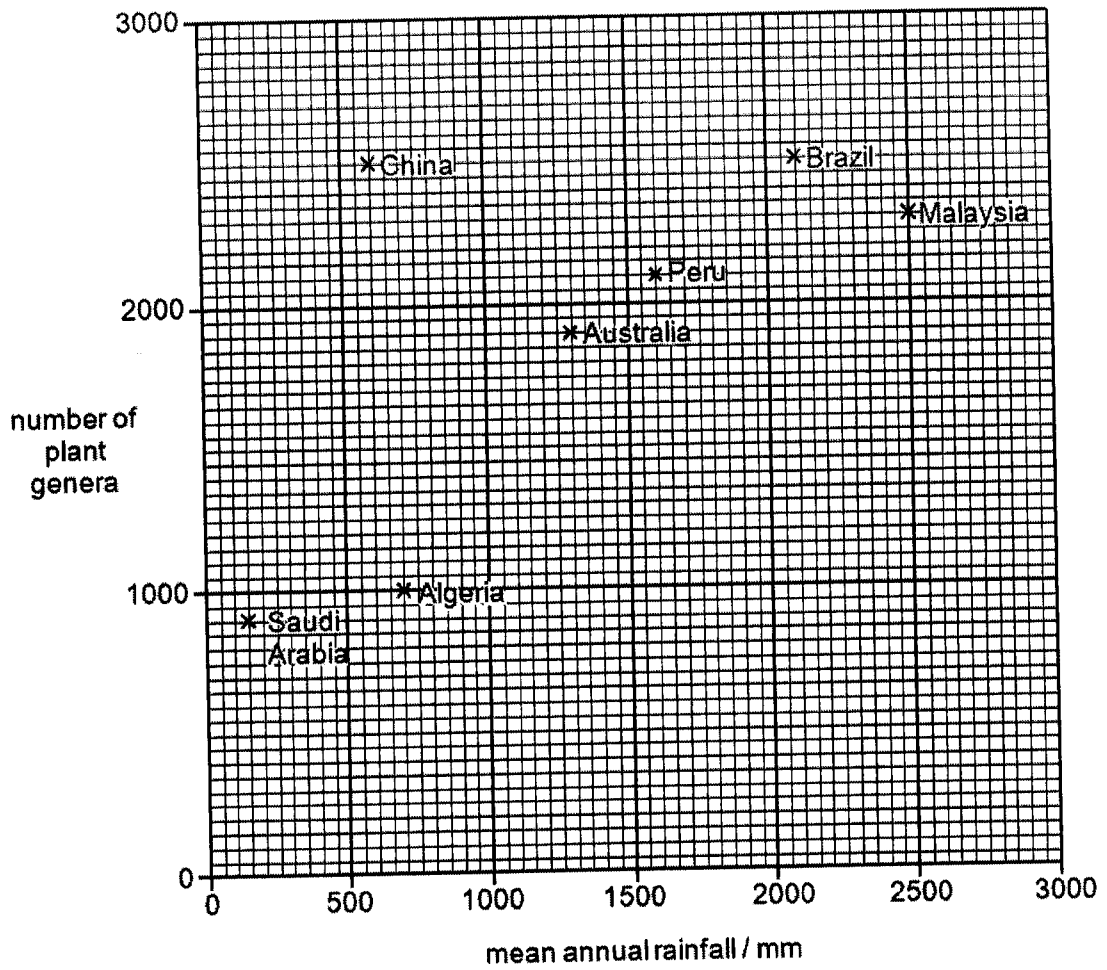


Fig. 11.1

- (a) (i) Describe the relationship between the number of plant genera and the mean annual rainfall in these seven countries.

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[2]

(ii) Global warming has led to changes in rainfall in many parts of the world.

Explain how changes in rainfall can decrease plant biodiversity.

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[2]

(b) The Millennium Seed Bank is located in the United Kingdom. So far it has successfully stored seeds from 10% of the world's wild plant species.

Suggest **one** benefit to humans of conserving plant species.

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[1]

[Total: 5]

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H2ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2**2022 JC2 PRELIMINARY EXAMINATION**CANDIDATE
NAME

CLASS

INDEX NUMBER

BIOLOGY**9744/03****PAPER 3
LONG STRUCTURED AND FREE RESPONSE
QUESTIONS****15 SEPTEMBER 2022
THURSDAY**Candidates answer on the Question Paper.
No Additional Materials are required.**2 HOURS****READ THESE INSTRUCTIONS FIRST**Write your name and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph
Do not use paper clips, highlighters, glue or correction fluid.**Section A**Answer **all** questions in the spaces provided on the Question Paper.**Section B**Answer **any one** question in the spaces provided on the Question Paper.

For Examiner's Use	
1	/ 30
2	/ 10
3	/ 10
4 / 5	/ 25
Total	/ 75

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.This document consists of **23** printed pages and **1** blank page.

Section A

Answer all the questions in this section.

- 1 Lactose is a disaccharide found in milk. Lactase, an enzyme found in mammals and some fungi, catalyse the breakdown of lactose.

The lactase enzyme is made up of 4 identical polypeptide chains. In humans, molecules of lactase are embedded in the cell surface membrane of epithelial cells lining the small intestine. As the lactose molecules float by in the lumen, they are broken down.

- (a) Explain how the polypeptide chains in lactase are held together and how they interact with the cell surface membrane.

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[3]

Question 1 continues on page 4

The products of lactose digestion, glucose and galactose, are actively absorbed by intestinal epithelial cells. This absorption is carried out by the sodium-glucose linked transporter (SGLT).

SGLT is a secondary active transporter that works together with sodium-potassium ($\text{Na}^+\text{-K}^+$) pump. SGLT transports glucose and galactose concurrently with entry of sodium ions (Na^+) into the intestinal epithelial cells. This transport of glucose and galactose uses the driving force generated by the sodium ion gradient created by the $\text{Na}^+\text{-K}^+$ pump.

Fig. 1.1 illustrates the transport process.

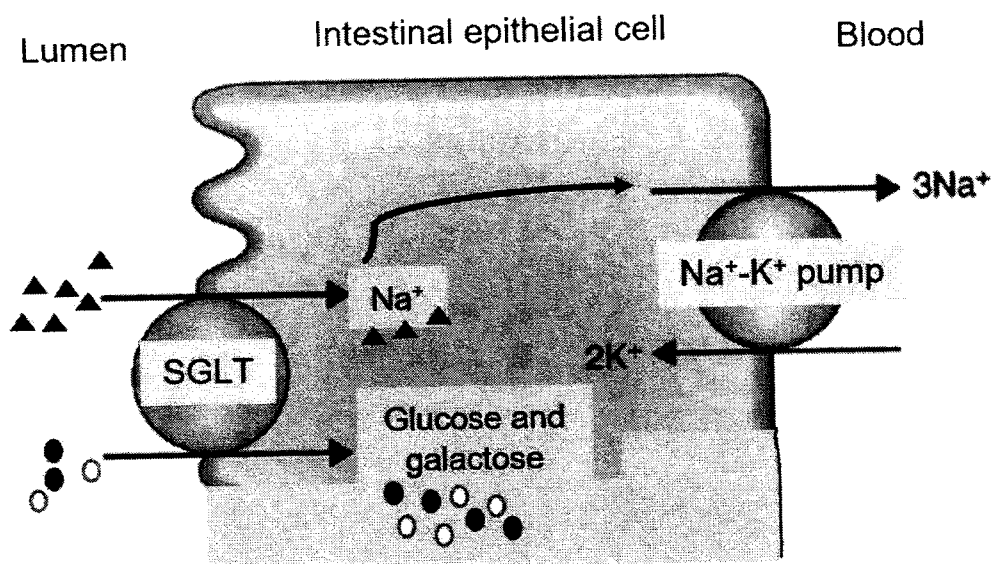


Fig. 1.1

Cyanide is a poison that binds with cytochrome oxidase, one of the electron carriers in the mitochondrial membrane.

It has been observed that the absorption of glucose and galactose from the lumen of the small intestine is reduced when the intestinal epithelial cells are treated with cyanide.

- (b) Using Fig. 1.1 and all the information provided, explain why absorption of glucose and galactose from the lumen of the small intestine is reduced when the intestinal epithelial cells are treated with cyanide.

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[4]

- (c) Many human adults do not produce lactase and are lactose intolerant. This means they cannot digest lactose. Lactose intolerance leads to side-effects such as abdominal pain after eating food containing lactose.

Scientists have investigated ways to produce low-lactose cow's milk from normal cow's milk for people who are lactose intolerant. One method involved extracting lactase from fungi and mixing the extracted lactase with normal cow's milk. This method is, however, ineffective because one of the products of lactose digestion, galactose, is an inhibitor of lactase.

- (i) Explain the effect of galactose on lactase activity.

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[2]

- (ii) Explain why product inhibition is useful when lactase is acting as an intracellular enzyme in fungi cells but can be a disadvantage when extracted lactase is used free in solution for the production of low-lactose cow's milk.

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[2]

Another method of producing low-lactose cow's milk involved immobilising extracted lactase within alginate beads and putting in high-lactose cow's milk. As the high-lactose cow's milk comes into contact with the alginate beads, the immobilised lactase hydrolyses the lactose.

Fig. 1.2 shows the set-up.

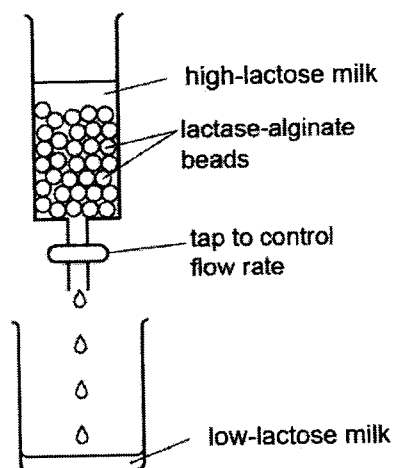


Fig. 1.2

- (iii) Suggest how using immobilised lactase for the production of low-lactose cow's milk helps to reduce the problem of product inhibition.

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[1]

A company producing low-lactose cow's milk carried out an investigation to study the effect of drinking normal high-lactose cow's milk and the company's own processed low-lactose cow's milk.

Fig. 1.3 shows the results of the investigation which compares:

- the effects on 50 lactose-intolerant volunteers of drinking normal cow's milk
- the effects on the same 50 lactose-intolerant volunteers of drinking low-lactose cow's milk
- the effects on a control group of 15 volunteers, who were not lactose intolerant, of drinking normal cow's milk.

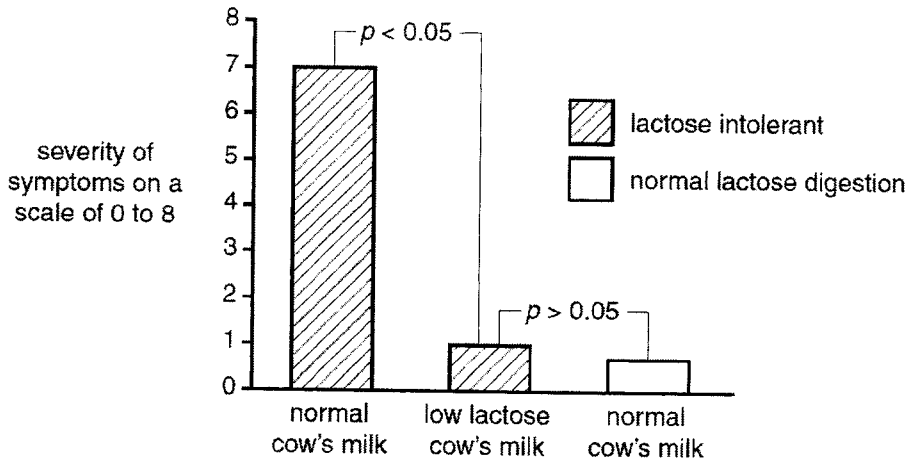


Fig. 1.3

(d) The company claimed that their processed low-lactose cow's milk is suitable for consumption by lactose-intolerant individuals.

With reference to the probability (*p*) values shown in Fig. 1.3, comment on the validity of the claim.

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[5]

(e) Scientists have found evidence of natural selection in humans.

- Originally, in human populations it was only babies and children that needed to digest lactose. The gene coding for the enzyme lactase (*LCT* gene) was switched off before adulthood.
- However, today, in many populations, only some adult individuals have lactose intolerance.
- A mutation has been identified that keeps the *LCT* gene switched on. An adult who has this mutation is able to digest lactose. This is called lactase persistence (which means lactose tolerance) .
- Lactase persistence increased in populations in Europe several thousand years ago. The increase in lactase persistence in Europe coincided with an increase in farming of cows for milk.

(i) Natural selection has caused an increase in lactase persistence in human populations.

State the type of selection that has caused this increase.

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(ii) Explain why there was selection for lactase persistence in humans several thousand years ago.

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The conclusion that lactase persistence is evidence of recent human evolution is further supported by a study. This study correlates lactase persistence allele frequency with fresh milk consumption and reliance on livestock (pastoral and non-pastoral populations) in Europe.

The result of this correlation study is represented in Fig. 1.4.

- Squares (■) and triangles (▲) represent pastoral populations with high (> 0.6) and low (< 0.4) lactase persistence frequency respectively.
- Non-pastoral populations are represented by diamonds (◆).
- Pastoral populations raised livestock such as cattle and goats for food while non-pastoral populations grow crops for food.
- Allele frequency is calculated by dividing the number of times the allele of interest is observed in a population by the total number of copies of all the alleles at that particular genetic locus in the population.

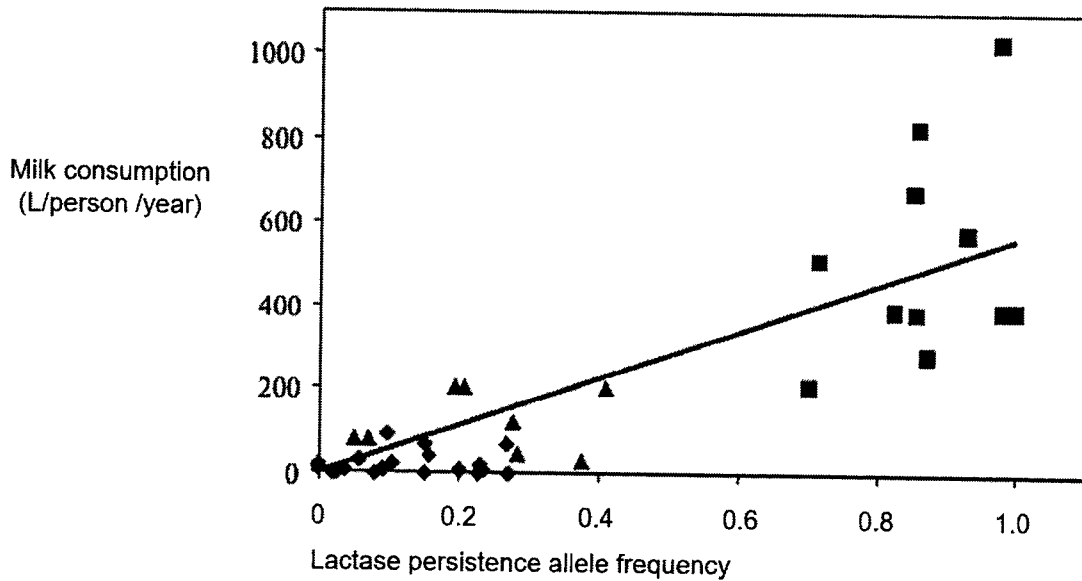


Fig. 1.4

- (iii) The study concluded that direct fresh milk consumption has a stronger correlation with lactase persistence than reliance on livestock.

Use information from Fig. 1.4 to justify this conclusion.

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(iv) The mutation causing lactase persistence does **not** occur in the *LCT* gene.

Suggest and explain where the mutation that causes lactase persistence may occur.

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[2]

(f) In bacteria, the enzyme β -galactosidase breaks down lactose. β -galactosidase is an inducible enzyme but lactase is not.

(i) Explain what is meant by an inducible enzyme.

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[2]

(ii) Describe **two other** differences between the transcriptional control of the β -galactosidase gene in bacteria cells and the *LCT* gene in human cells.

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[2]

[Total: 30]

2 (a) Name the pathogen that causes tuberculosis (TB).

..... [1]

(b) Antibiotics are drugs which are very important in the treatment and cure of some diseases, including TB.

(i) Describe the modes of action of antibiotics.

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(ii) Antibiotic treatment of active TB is done with a combination of several antibiotics that are taken over a period of about nine months.

Suggest why the antibiotics used to treat TB are taken in combination over a long period of time.

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..... [2]

(c) Fig. 2.1 shows the number of deaths from TB and the number of new cases of TB from 1925 to 2000 in Canada.

Antibiotics, such as streptomycin, were introduced in Canada from 1940.

Vaccine for TB was introduced in Canada for use from 1948.

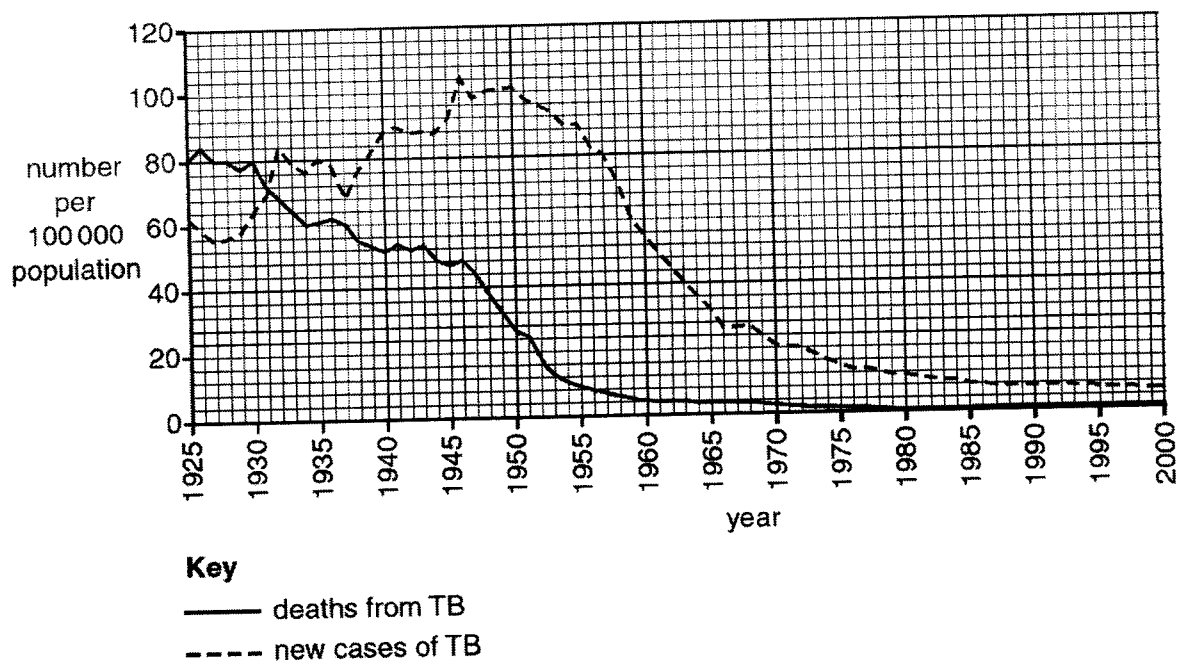


Fig. 2.1

(i) Use data from Fig. 2.1 to evaluate the effectiveness of the introduction of the antibiotics and vaccine and on the number of new cases and deaths from TB.

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[4]

(ii) Suggest why the numbers of new cases or deaths **per 100 000 population** were calculated instead of stating the numbers of new cases or deaths alone.

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..... [1]

[Total: 10]

Question 3 starts on page 15.

- 3 Mangroves are plants that are able to live in harsh coastal conditions through various adaptations. One such adaptation is the ability to grow in low oxygen concentrations in waterlogged mud. Mangroves have lateral roots known as pneumatophores that grow upward out of the mud and water to absorb gases directly from the atmosphere as shown in Fig. 3.1.

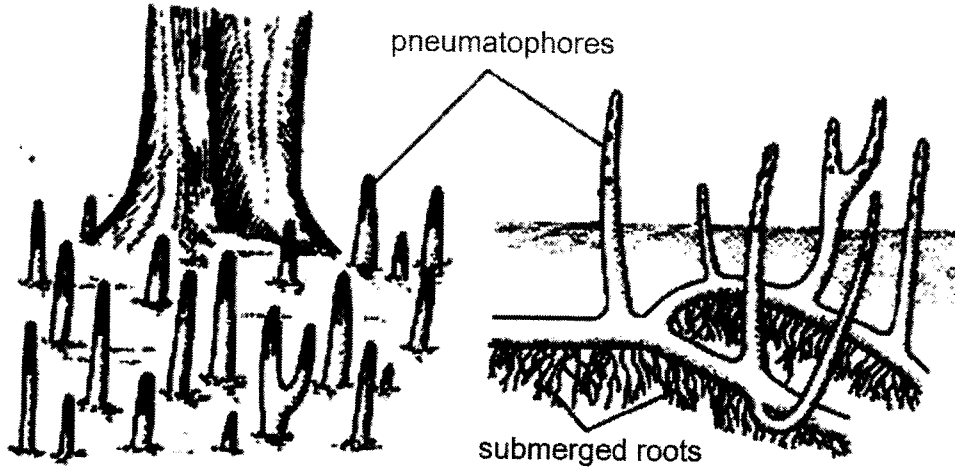


Fig. 3.1

- (a) Explain how mangrove plants with more pneumatophores are able to yield more ATP.

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[2]

One effect of climate change is rising sea levels, often resulting in severe storm surge and coastal flooding.

(b) Explain how climate change can lead to rising sea levels.

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[3]

(c) In many tropical and subtropical regions, mangroves as shown in Fig. 3.2 reduce waves and storm surges, and serve as a first line of defense against flooding and erosion.

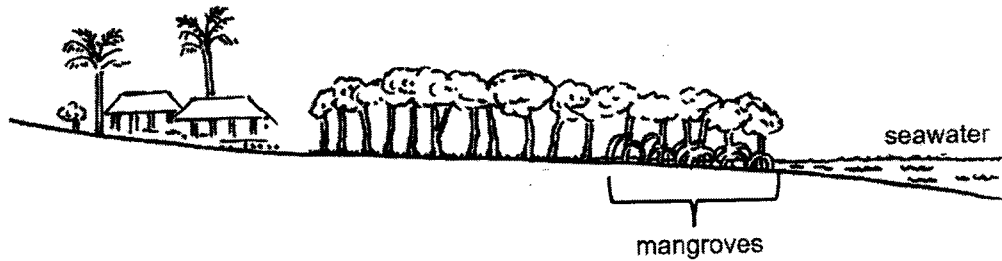


Fig. 3.2

One study quantifies global mangrove benefits by estimating the difference in flood damages between two scenarios: one "with mangroves" (current global extent of mangroves) and another "without mangroves".

Table 3.1 shows the land flooded, people and property damaged with and without mangroves across 700,000 km of mangrove coastlines globally. The difference between scenarios is the benefits provided by current mangroves.

Table 3.1

global benefit of mangroves in terms of	annual expected		
	with mangroves	without mangroves	benefit
land flooded (x1000 km ²)	122	157	35
people affected (million)	53	68	
property loss (\$US billion)	732	797	

(i) Calculate the annual expected benefit of mangroves in terms of people affected and property loss and fill in your answers in Table 3.1.

[1]

(ii) With reference to Table 3.1, explain how **one** human activity could **directly** damage mangroves leading to greater climate change impact on humans.

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[4]

[Total: 10]

Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate

Your answers must be set out in sections **(a)**, **(b)**, as indicated in the question.

4 (a) Describe how membrane fluidity is regulated in cells and explain the significance of membrane fluidity to the functions of vesicles. [13]

(b) Describe the structure of an antibody and explain how the vast diversity of antibodies is generated in B lymphocytes. [12]

[Total: 25]

5 (a) There are many examples of concentration gradients in a cell, for example, the proton gradient in mitochondria plays an important role in aerobic respiration.

Describe how the proton gradient is established in mitochondria and explain the importance of all concentration gradients in aerobic respiration. [13]

(b) Describe the life cycle of *Aedes aegypti* and discuss the possible impacts of global warming on geographical patterns of dengue disease. [12]

[Total: 25]

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