INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CG						INDEX NUMBER				

BIOLOGY

9744/01

Paper 1 Multiple Choice

13 September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name, CG and index number in the spaces at the top of this page.
Write in soft pencil.
Write your name, CG and index number on the Answer Sheet in the spaces provided.

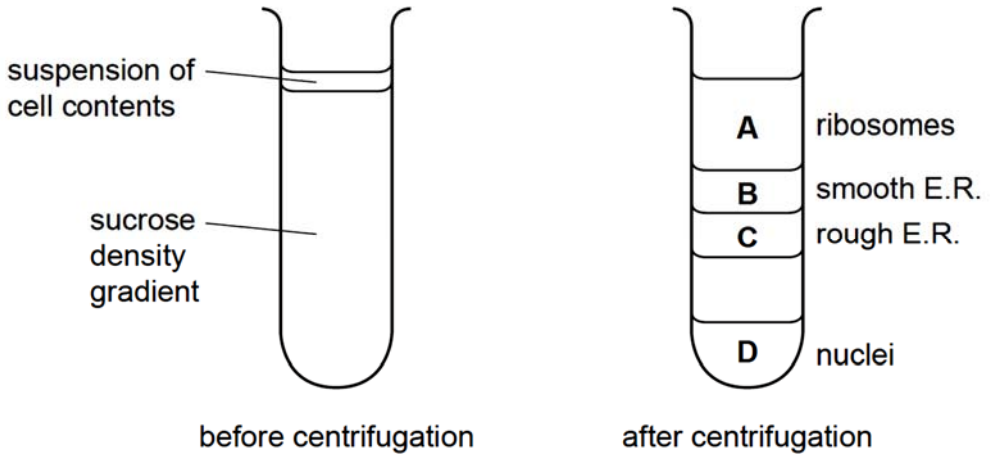
There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

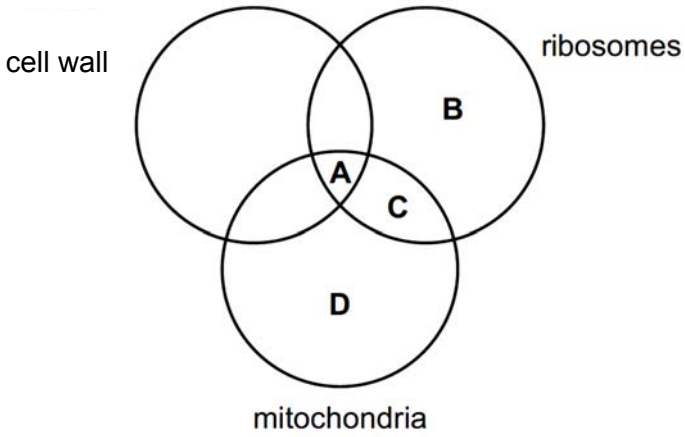
1 Sometimes scientists need to isolate organelles. This can be achieved by taking a number of cells and breaking their cell surface membranes to release the contents of the cells into a buffer solution.

In zonal centrifugation the suspension of cell contents is placed on top of a sucrose density gradient. The tube is then placed in a centrifuge and spun at high speed. The larger and denser particles will move towards the bottom of the tube faster than smaller and less dense particles as shown below.

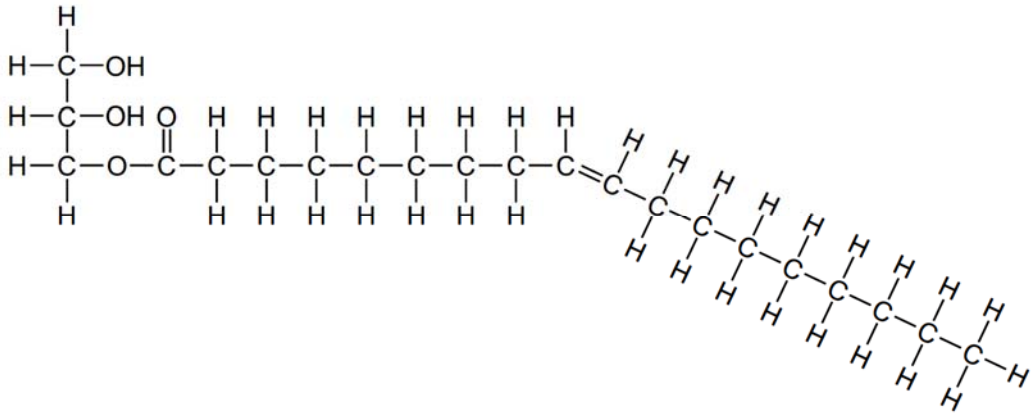


If a sample of intact prokaryotes had been added to a suspension of eukaryotic cell contents, where would you expect them to be found?

2 Which structures are present in a yeast cell?



3 The diagram shows a triglyceride molecule that has been partially hydrolysed.



What will be the products of the total hydrolysis of the molecule shown?

A a molecule of glycerol and a saturated fatty acid molecule only

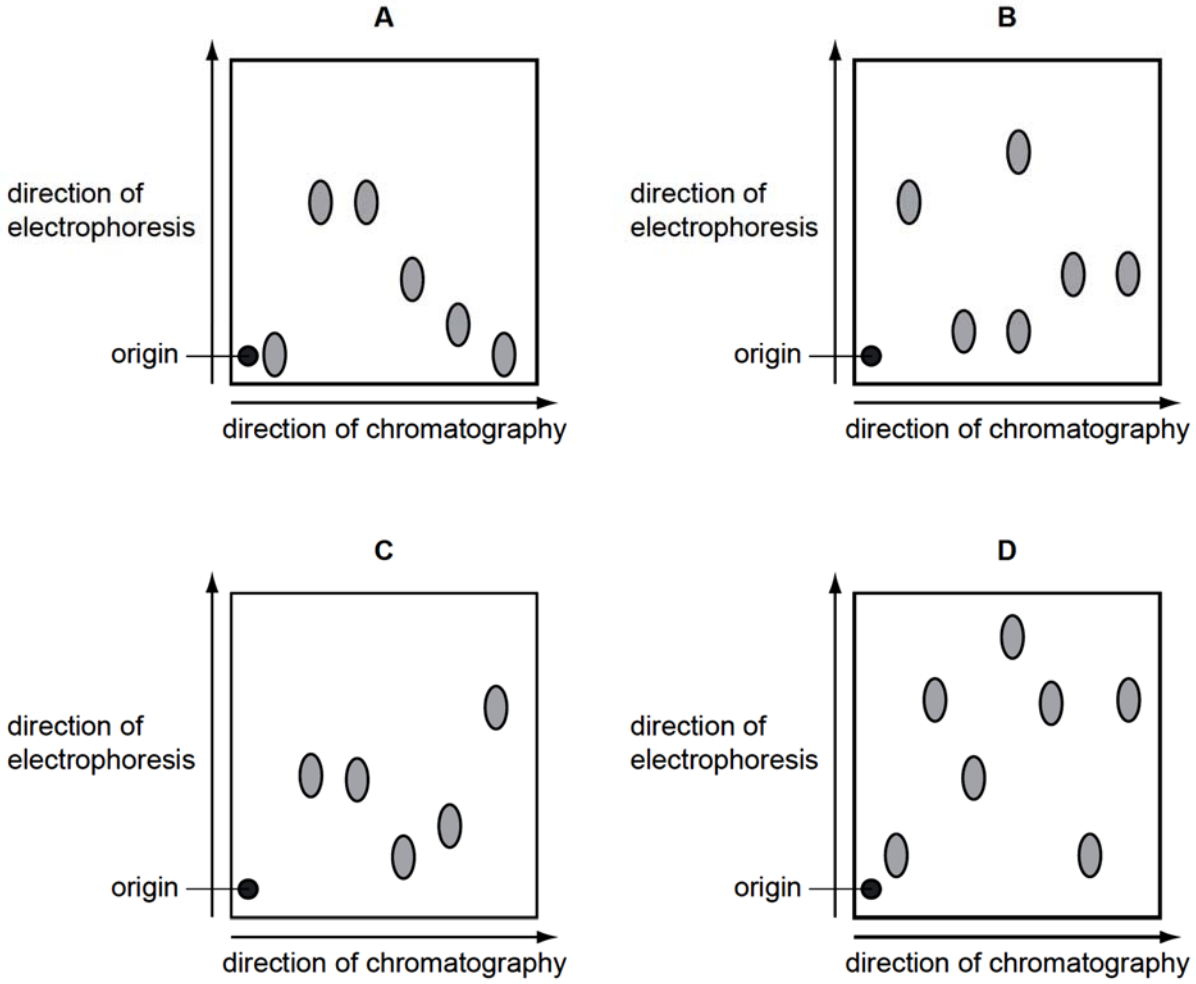
B a molecule of glycerol and an unsaturated fatty acid molecule only

C a molecule of glycerol and three fatty acid molecules

D a molecule of water, a molecule of glycerol and a fatty acid molecule

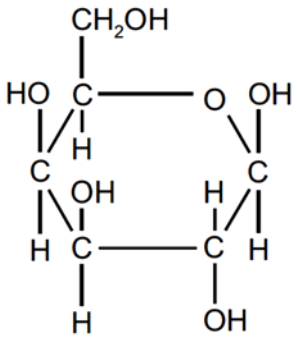
4 The diagrams show the results of an investigation into the composition of different mixtures of amino acids. Each mixture of amino acids was separated using chromatography. Each chromatogram was then turned through 90° and the amino acids separated again by electrophoresis.

Which diagram shows an amino acid mixture in which the solubility of some of the amino acids is the same but the charge on those particular amino acids is different?

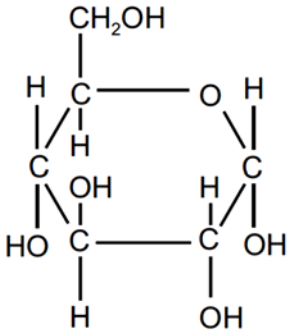


5 Which of the following shows a β-glucose?

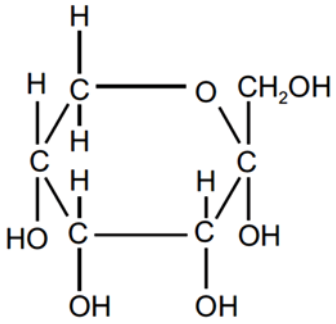
A



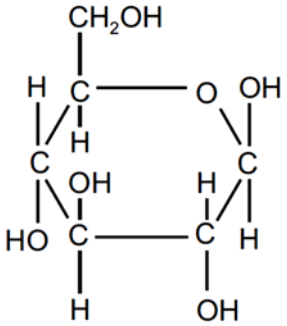
B



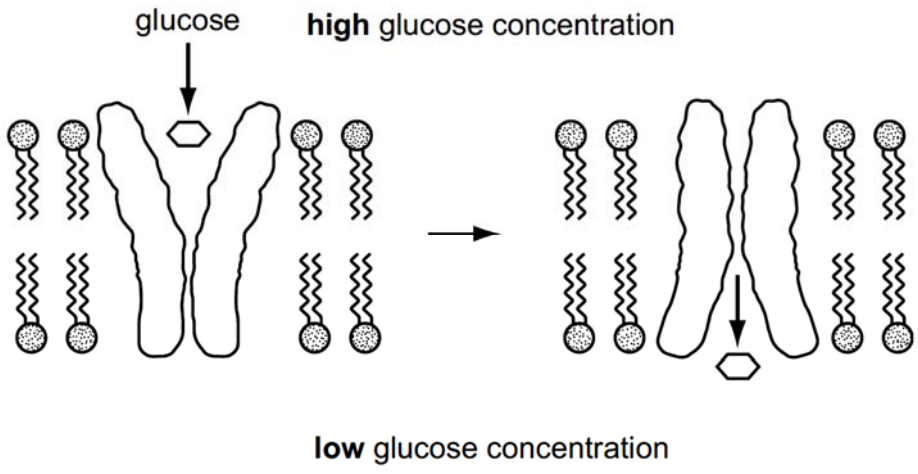
C



D



6 The diagram represents stages in glucose uptake through a cell surface membrane.



Which process is shown?

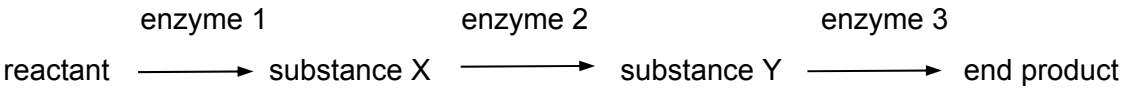
A active transport

B facilitated diffusion

C osmosis

D simple diffusion

7 A metabolic pathway is



What would be the effect of adding a small amount of a non-competitive inhibitor of enzyme 2?

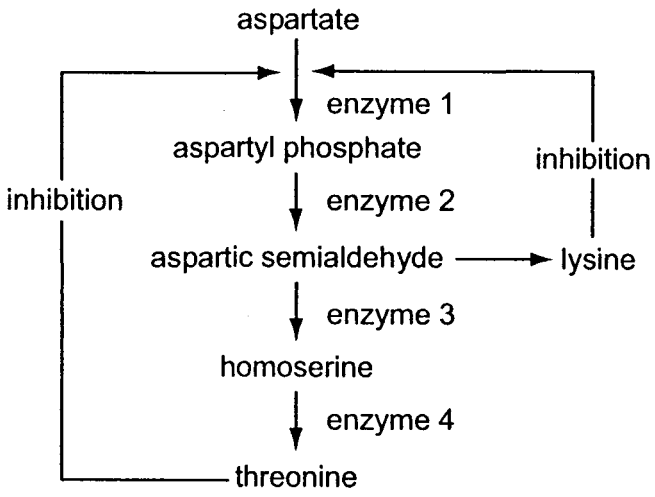
A Enzyme 2 would be partially denatured.

B Substance X would increase in concentration.

C Substance Y would no longer be formed.

D The initial reactant would no longer be metabolised.

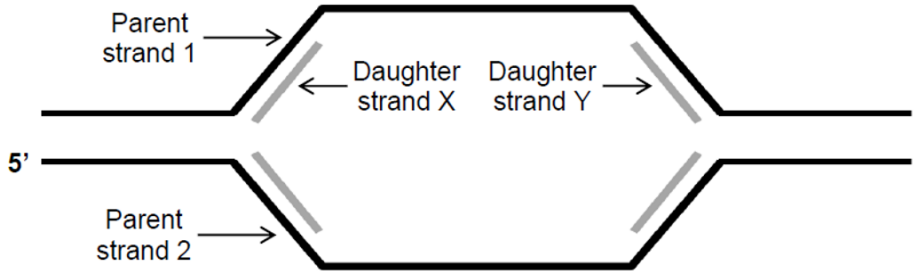
8 A culture of bacteria produces the food supplement lysine by the metabolic pathway shown.



Which change in enzyme activity will result in the greatest increase in lysine yield?

	enzyme	change in activity
A	1	decrease
B	2	increase
C	3	increase
D	4	decrease

9 A simplified representation of a replication bubble is shown in the figure below. Parental strands 1 and 2 and the growing daughter strands X and Y are indicated.



Which of the following statements about the syntheses of daughter strands X and Y is correct?

A Daughter strands X and Y are synthesised away from their respective replication forks.

B Daughter strand X is synthesised continuously while daughter strand Y is synthesised in the form of Okazaki fragments.

C Daughter strand X is synthesised in the 5' → 3' direction while daughter strand Y is synthesised in the 3' → 5' direction.

D DNA ligase will eventually catalyse the fusion of daughter strand X with daughter strand Y.

10 Which of the following statement(s) is/are **not** true of the translation process in all eukaryotes?

1 Polypeptides are only synthesised in the cytosol.

2 Amino acids are linked by the formation of peptide bonds catalysed by a ribozyme.

3 Ribosomes contain an amino-acyl tRNA site that is occupied by the initiator tRNA attached to methionine.

4 Amino-acyl tRNA synthetase attaches an amino acid to the 5' end of a tRNA molecule.

A 1, 3 and 4 only

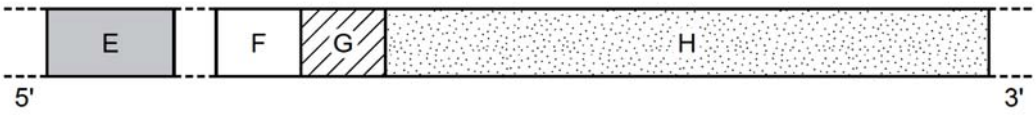
B 2, 3 and 4 only

C 2 and 4 only

D 1 only

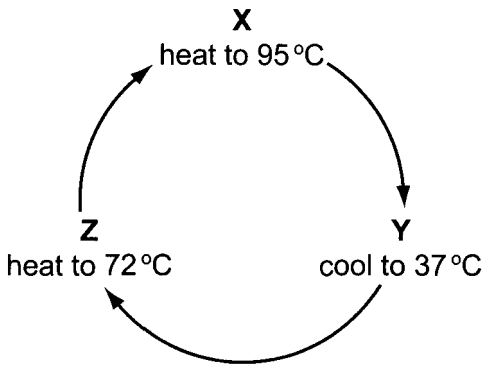
11 The diagram represents a length of DNA which forms a structure called an operon. Parts of the operon are labelled E, F, G and H. They have different functions.

What identifies the functions of parts E, F, G and H?



	E	F	G	H
A	operator	structural gene(s)	regulator/repressor	promoter
B	promoter	regulator/repressor	structural gene(s)	operator
C	regulator/repressor	promoter	operator	structural gene(s)
D	structural gene(s)	operator	promoter	regulator/repressor

12 The diagram shows the changes in temperature of the reaction mixture during the polymerase chain reaction (PCR).



The main events during one cycle of the reaction are listed.

1 binding of DNA primers
2 DNA synthesis
3 separation of DNA strands

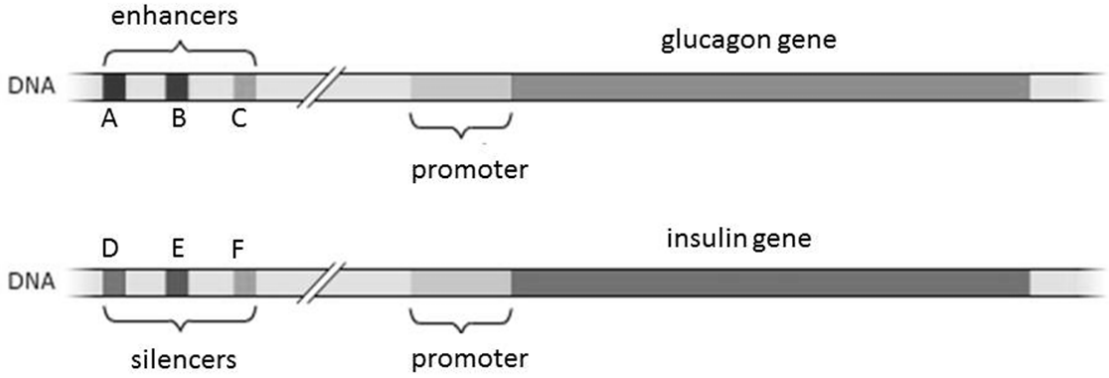
Which combination correctly matches each event with the temperature in the reaction mixture?

	X	**Y**	**Z**
A	1	2	3
B	2	3	1
C	3	1	2
D	3	2	1

13 Which combination correctly identifies the dengue virus?

	DNA	RNA	protein	phospholipid
A	✓	✓	✓	
B	✓		✓	✓
C		✓	✓	✓
D	✓		✓	

14 The diagram below shows the control elements and two genes found in the human genome.



Which of the following statement(s) about the above genes is/are true?

1 The glucagon gene is found only in the α-cells of the Islets of Langerhans while the insulin gene is found only in the β-cells of the Islets of Langerhans.

2 Binding of control elements, specific transcription factors and RNA polymerase at the promoter initiates transcription of glucagon.

3 The glucagon gene will be transcribed at a high level when transcription factors bind to control elements A, B, and C.

4 The expression of insulin can only be suppressed when transcription factors bind to control elements D, E and F.

A 3 only

B 2 and 3 only

C 1, 2 and 4 only

D 2, 3 and 4 only

15 Which of the following is an example of translational control of gene expression?

A The activation of proteins by association with other proteins

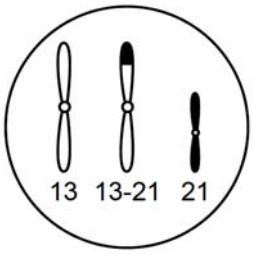
B The addition of chemical groups such as phosphates to free amino acids

C The binding of protein factors to mRNA to prevent the binding of the small ribosomal subunit

D The degradation of a protein by proteasome

16 Down's syndrome can be caused by a trisomy of chromosome 21, but can also result from translocation of chromosome 21 onto chromosome 13, forming a single chromosome 13-21.

The diagram shows chromosomes 13 and 21 in the nucleus of a diploid (2n) testis cell from a phenotypically normal male carrier of a 13-21 translocation. This cell has a chromosome number of 45.



Which is **not** a likely outcome of fertilisation of normal oocytes by sperm from this male?

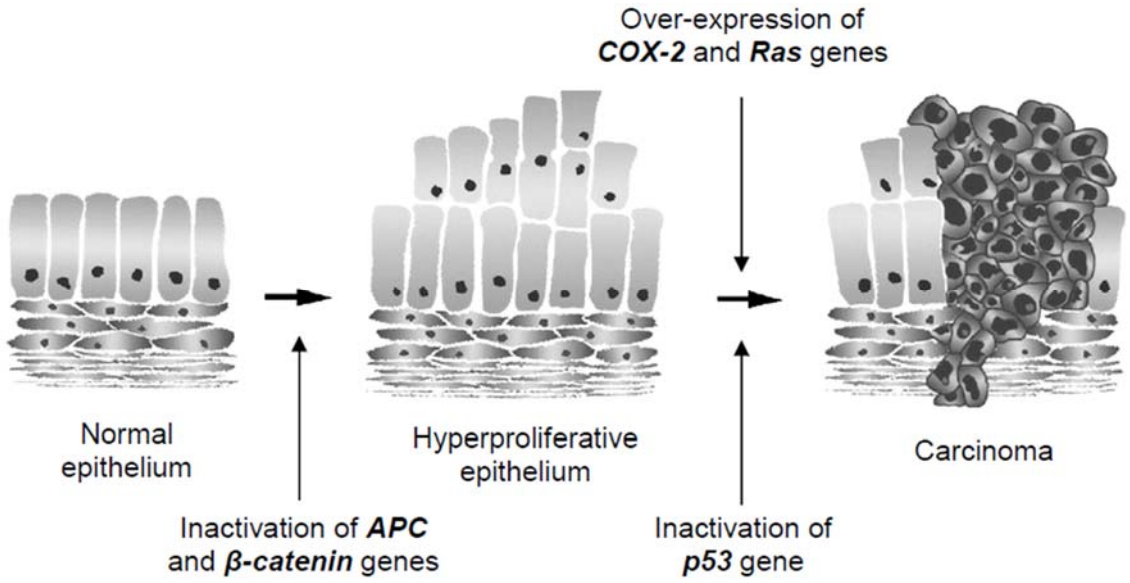
	chromosomes in sperm	embryo
A	13 and 21	2n = 46 normal phenotype
B	13-21	2n = 45 normal phenotype
C	13-21 and 21	2n = 46 Down's syndrome
D	13-21 and 21	2n = 47 Down's syndrome

17 The diagram shows the chromosomes of one cell which has been squashed during mitosis.

Which stage of mitosis is shown and what is the haploid chromosome number in this species?

	stage of mitosis	haploid chromosome number
A	anaphase	5
B	anaphase	10
C	metaphase	5
D	metaphase	10

18 The diagram below illustrates the development of colorectal cancer.



Which of these statements can be inferred from this multistep model of carcinogenesis?

1 Cells whose *APC* and *β-catenin* genes are inactivated have lost density dependent inhibition.

2 *APC* and *β-catenin* genes are most likely tumour suppressor genes.

3 High levels of *Ras* protein are produced only when both copies of *Ras* gene are mutated.

4 Two copies of normal *p53* alleles must be present to inhibit cell division.

5 Gain-of-function mutation in *COX-2* gene is one of the pre-requisites for the formation of carcinoma.

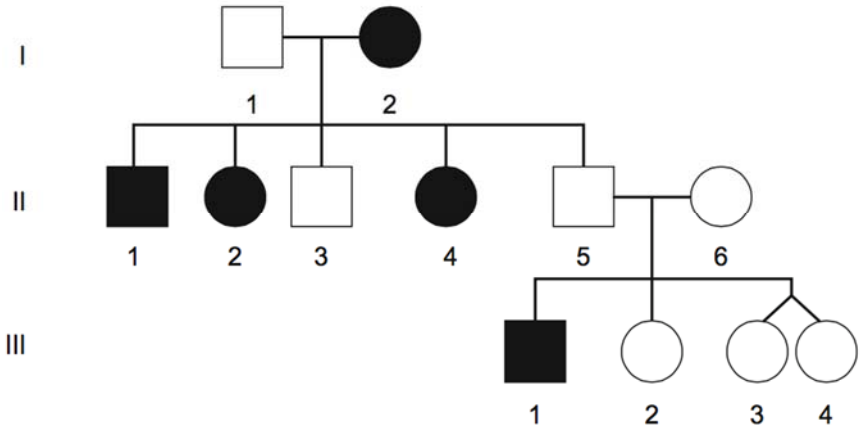
A 1, 2 and 3

B 1, 2 and 5

C 2, 3 and 4

D 2, 3 and 5

19 The pedigree below showed that the mode of inheritance of this disease is …… as supported by ……..



A autosomal dominant, individuals I-2 with offspring II-1, II-2 and II-4

B autosomal recessive, individuals I-1, I-2 with offspring II-3 and II-5

C autosomal recessive, individuals II-5, II-6 with offspring III-1

D sex-linked dominant, offspring II-2 and II-4

20 The phenotypes of 200 offspring of a dihybrid test cross were recorded. The cross involved petal colour and fertility of the anthers of sweet pea flowers. The table shows the observed and expected numbers of each phenotype.

phenotype	purple petals fertile anthers	purple petals sterile anthers	maroon petals fertile anthers	maroon petals sterile anthers
observed numbers	87	14	16	83
expected numbers	50	50	50	50

A chi-squared (χ^2) test was performed and the probability of the difference between the observed and expected results being due to chance was found to be <0.001.

Which conclusions may be drawn from this probability?

1 The difference is due to epistasis.

2 The difference is due to chance.

3 The difference is not due to chance.

4 The difference is due to some factor such as linkage of the genes concerned.

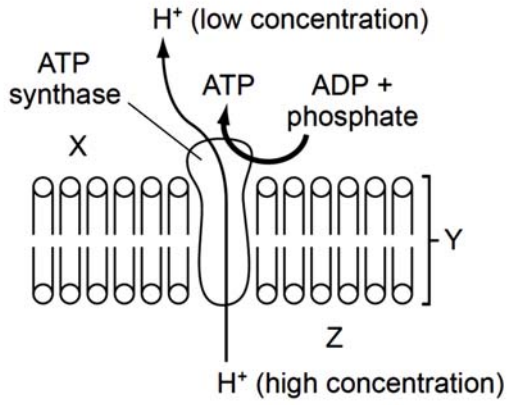
A 1 and 3 only

B 1 and 4 only

C 2 and 4 only

D 3 and 4 only

21 The diagram shows a membrane in a cell.



Which would be true of the diagram?

A X is the thylakoid space, Y is the thylakoid membrane and the diagram shows ATP synthesis in a chloroplast.

B X is the stroma, Y is the thylakoid membrane and the diagram shows ATP synthesis in a mitochondrion.

C Y is the thylakoid membrane, Z is the cytosol (cytoplasm) and the diagram shows ATP synthesis in a chloroplast.

D Z is the intermembranal space, X is the matrix and the diagram shows ATP synthesis in a mitochondrion.

22 During substrate-level phosphorylation, ATP is synthesised from ADP and inorganic phosphate.

What is the immediate source of energy for this reaction?

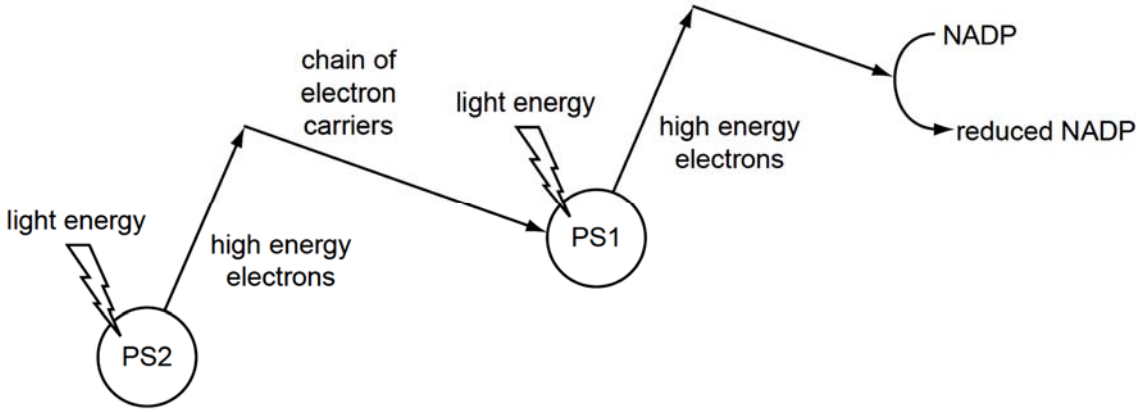
A chemical bond energy released during the light-independent stage of photosynthesis

B chemical bond energy released during glycolysis and the Krebs cycle

C kinetic energy of protons diffusing through mitochondrial membranes into the mitochondrial matrix

D kinetic energy of protons diffusing through thylakoid membranes in chloroplasts

23 The diagram shows some of the processes in the light-dependent stage of photosynthesis.



For the light-dependent stage to continue, photosystem two (PS2) must gain electrons.

Where do these electrons come from?

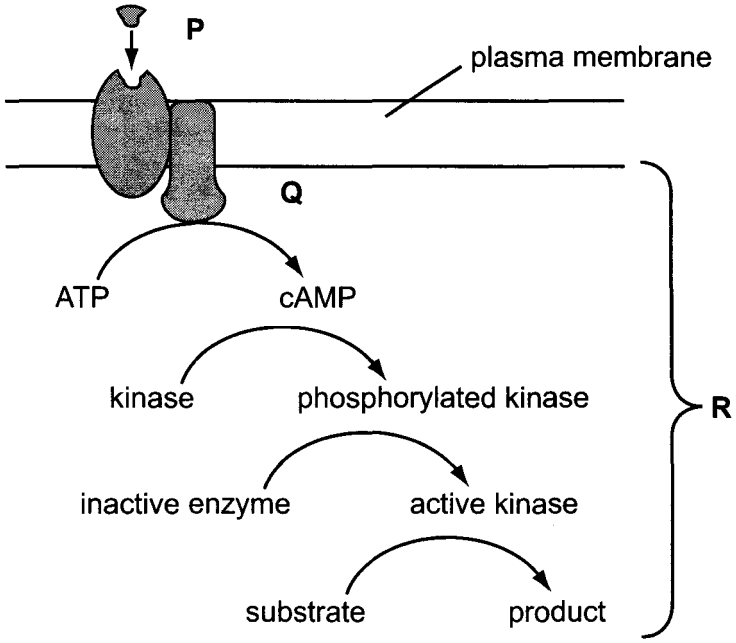
A electron carriers

B reduced NADP

C photolysis of water

D the formation of ATP

24 The diagram shows an example of cell signalling.



Which processes are shown on the diagram?

	P	Q	R
A	amplification	ligand-receptor interaction	phosphorylation
B	ligand-receptor interaction	amplification	phosphorylation
C	transduction	phosphorylation	amplification
D	ligand-receptor interaction	transduction	amplification

25 Which statements are true about Darwinian evolutionary theory?

1 Advantageous behaviour acquired during the lifetime of an individual is likely to be inherited.

2 In competition for survival, the more aggressive animals are more likely to survive.

3 Species perfectly adapted to a stable environment will continue to evolve.

4 Variation between individuals of a species is essential for evolutionary change.

A 1, 2 and 4 only

B 2 and 3 only

C 3 and 4 only

D 4 only

26 Darwin's view of the process of evolution to form new species (speciation) has been reinforced by more recent discoveries in genetics and cell biology.

In this view, which sequence of events is considered most likely to lead to speciation?

A	adaptation of population	→	competition and predation leading to natural selection	→	behavioural isolation	→ sympatric speciation
B	adaptation of population	→	competition and predation leading to natural selection	→	behavioural isolation	→ allopatric speciation
C	competition and predation leading to natural selection	→	geographical isolation	→	adaptation of isolated populations	→ sympatric speciation
D	competition and predation leading to natural selection	→	geographical isolation	→	adaptation of isolated populations	→ allopatric speciation

27 The huia, *Heteralocha acutirostris*, was found in New Zealand until 1907, when it became extinct. This bird had a ground-feeding habit and was particularly noted for large, attractive tail feathers. Males and females had very different beak forms, with the males having a short strong beak, whilst the females had a long curved beak to reach into otherwise inaccessible places.

What is the most likely reason for the extinction of the huia?

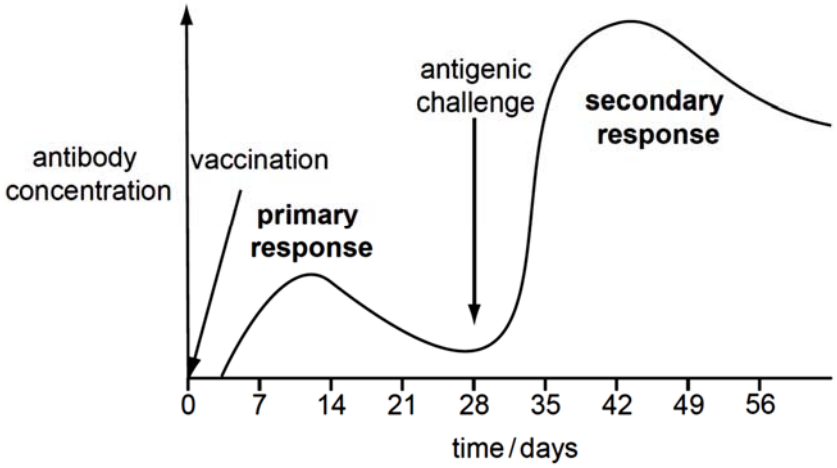
A Huia fed on species introduced by humans. When these declined, the huia population fell.

B In the face of a declining population the huia evolved into a tree-living species.

C Male and female huia were unable to breed successfully owing to strong sexual dimorphism.

D New competitors in New Zealand occupied part of the huia's niche.

28 The graph shows the level of antibody in serum following vaccination and a challenge with the same antigen 28 days later.



Which cells account for the difference in antibody concentration at the peaks of the primary and secondary responses?

A B-lymphocytes

B memory cells

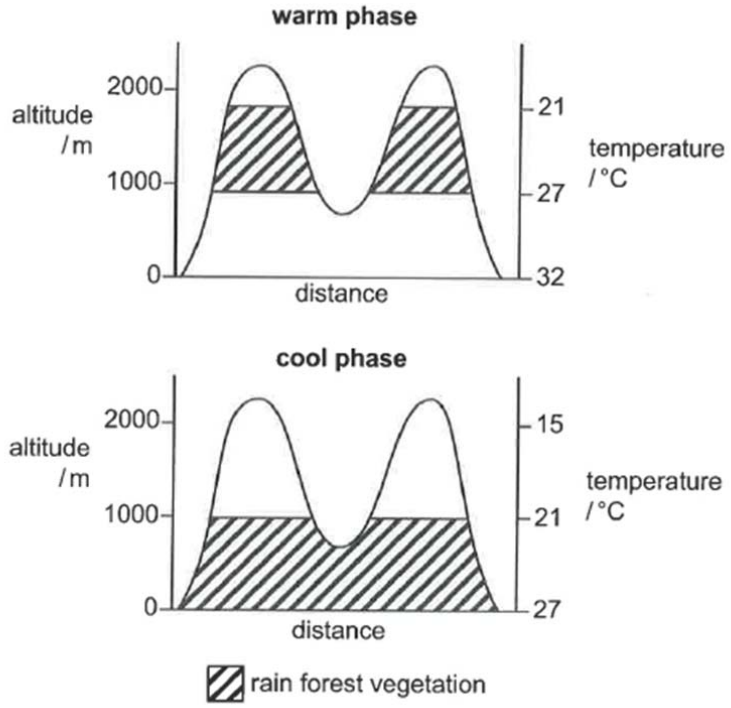
C phagocytes

D T-lymphocytes

29 What are the causative agents of AIDS, dengue and TB?

	AIDS	dengue	TB
A	human	bacterium	protozoan
B	bacterium	protozoan	virus
C	virus	mosquito	bacterium
D	virus	virus	bacterium

30 The diagram shows the topographical profile of two mountains in the tropics during natural warm and cool phases in the Earth's climate. The shape of the lines corresponds to a vertical section through the mountains to show their height and shape. The distribution of rain forest vegetation is also shown.



Which of the following statement is correct?

A The rain forest vegetation moves to stay in the suitable range of temperatures of 21 to 27^{o}C.

B The lower altitudes are too hot during the warm phase in the Earth's climate for the growth of the rain forest vegetation.

C Climate change causes the rain forest vegetation distribution to increase in altitude with different temperature range.

D The changing rain forest vegetation distribution decreases evolution as selection pressure remains the same.

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13 September 2018

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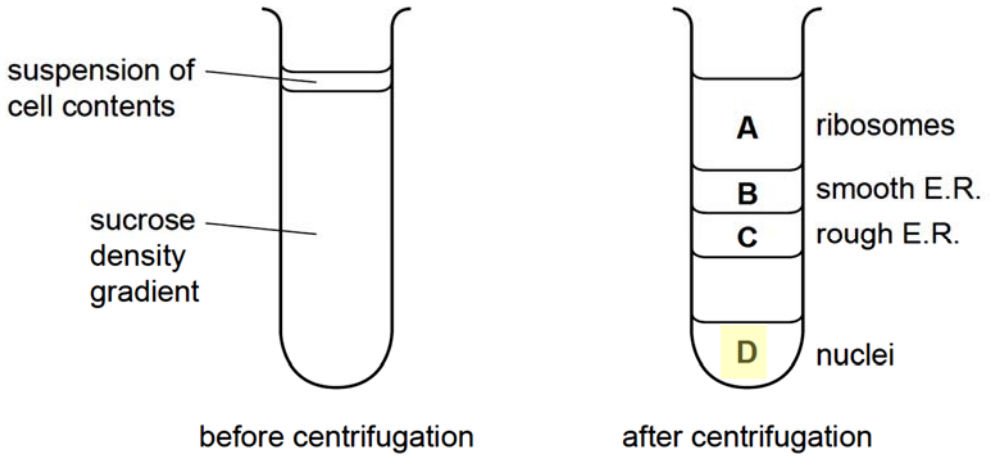
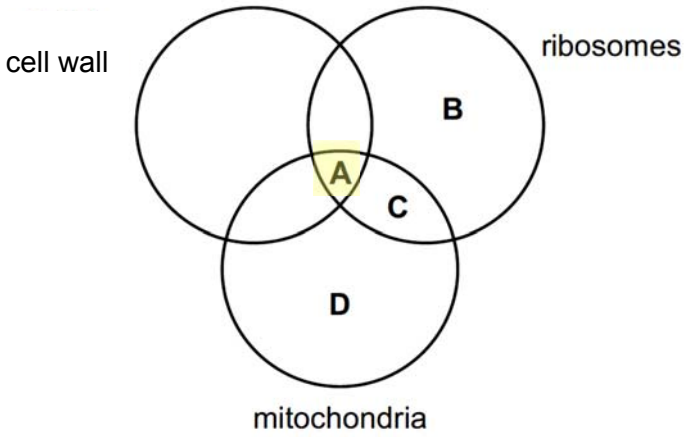
1 Sometimes scientists need to isolate organelles. This can be achieved by taking a number of cells and breaking their cell surface membranes to release the contents of the cells into a buffer solution.

In zonal centrifugation the suspension of cell contents is placed on top of a sucrose density gradient. The tube is then placed in a centrifuge and spun at high speed. The larger and denser particles will move towards the bottom of the tube faster than smaller and less dense particles as shown below.

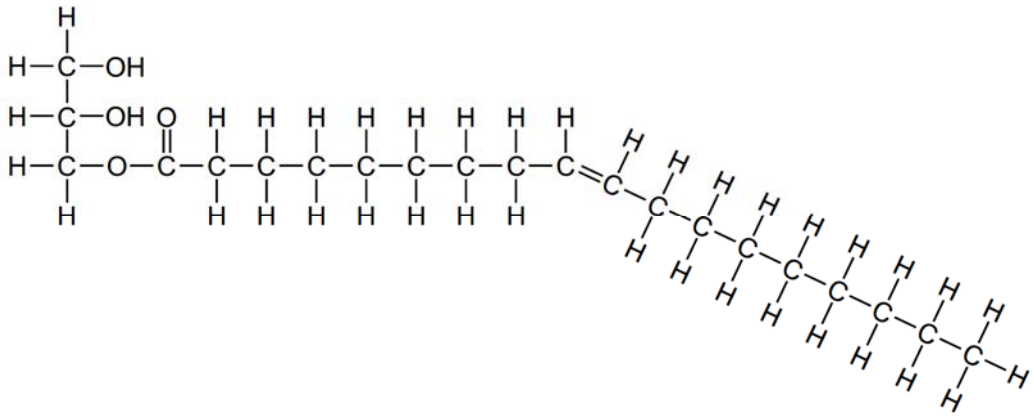


If a sample of intact prokaryotes had been added to a suspension of eukaryotic cell contents, where would you expect them to be found?

2 Which structures are present in a yeast cell?



3 The diagram shows a triglyceride molecule that has been partially hydrolysed.



What will be the products of the total hydrolysis of the molecule shown?

A a molecule of glycerol and a saturated fatty acid molecule only

B a molecule of glycerol and an unsaturated fatty acid molecule only

C a molecule of glycerol and three fatty acid molecules

D a molecule of water, a molecule of glycerol and a fatty acid molecule

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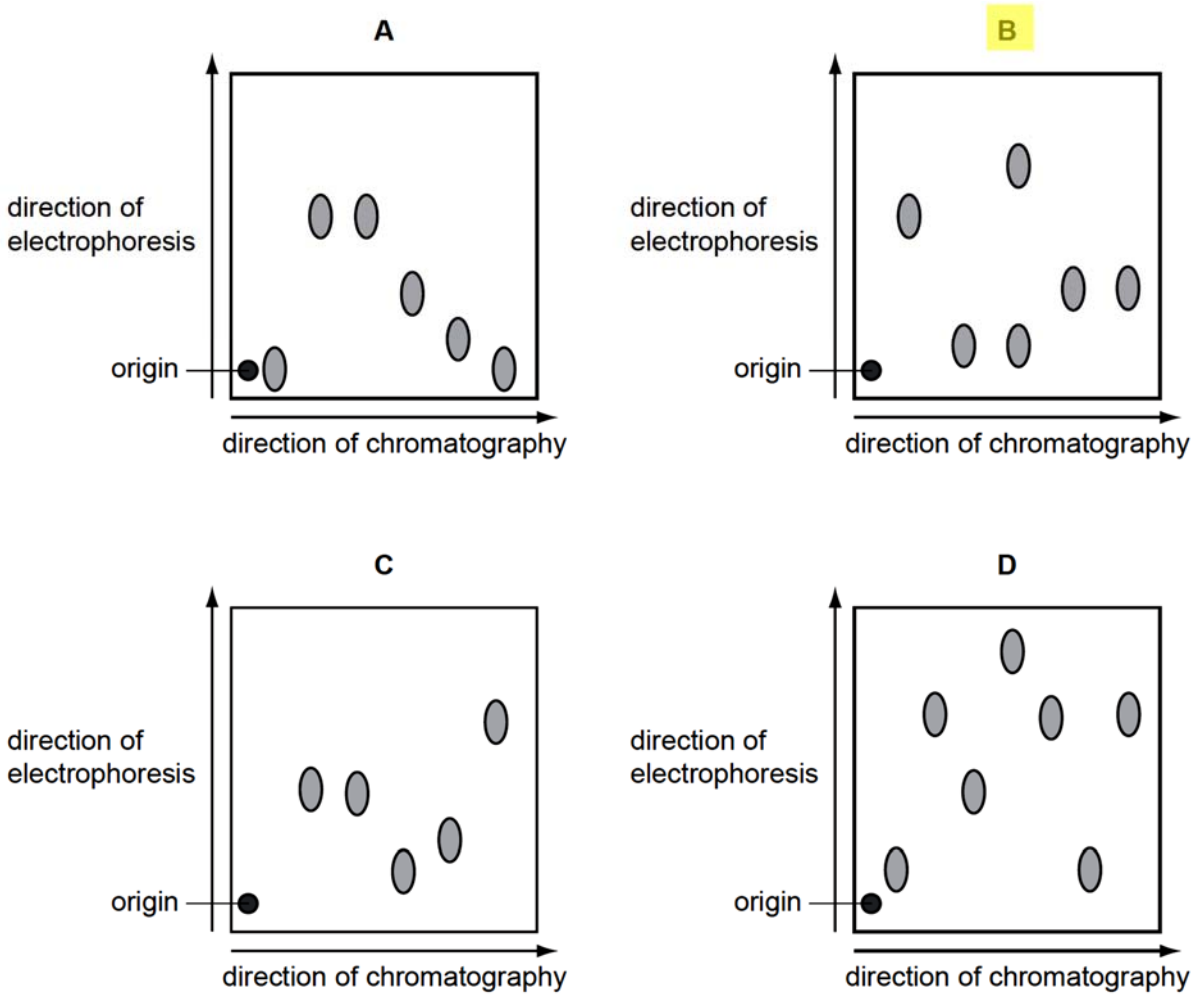
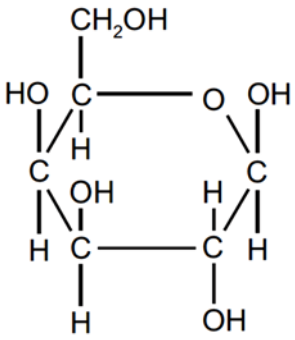
Which diagram shows an amino acid mixture in which the solubility of some of the amino acids is the same but the charge on those particular amino acids is different?

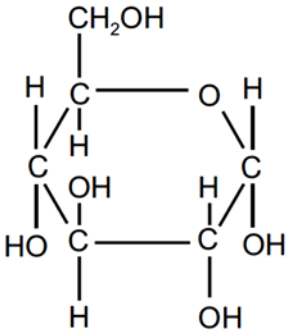


5 Which of the following shows a β-glucose?

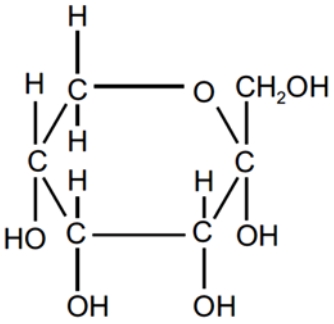
A



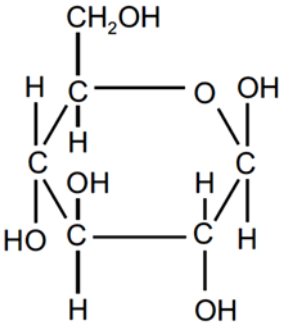
B



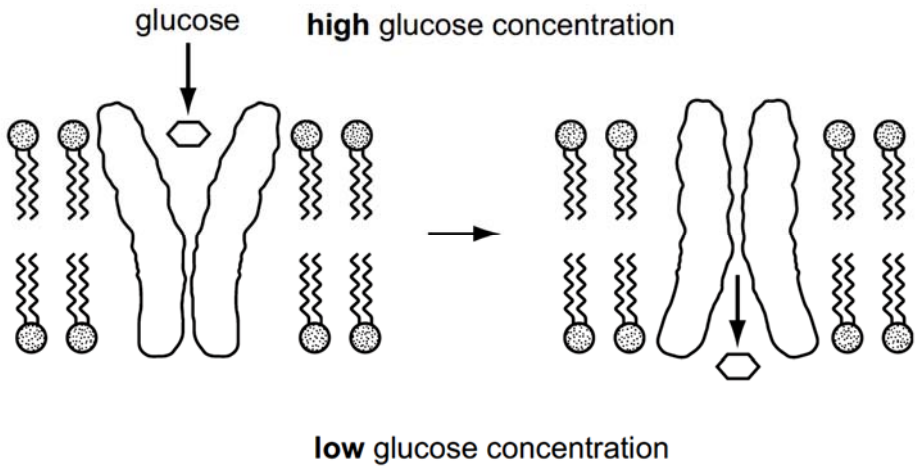
C



D



6 The diagram represents stages in glucose uptake through a cell surface membrane.



Which process is shown?

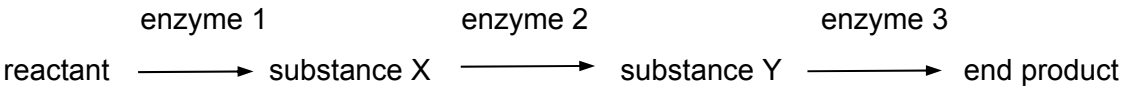
A active transport

B facilitated diffusion

C osmosis

D simple diffusion

7 A metabolic pathway is



What would be the effect of adding a small amount of a non-competitive inhibitor of enzyme 2?

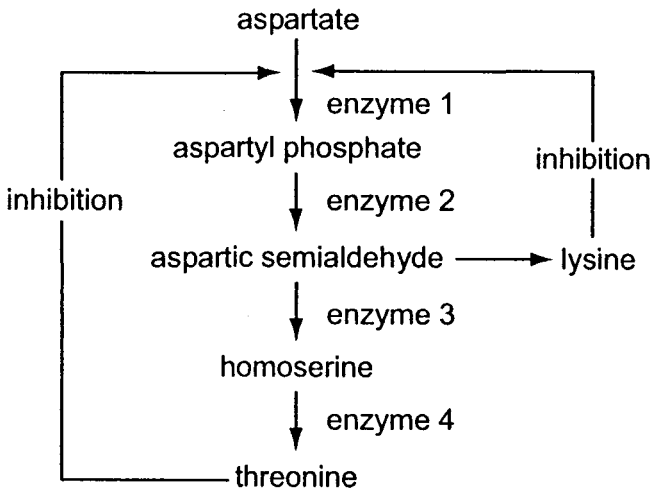
A Enzyme 2 would be partially denatured.

B Substance X would increase in concentration.

C Substance Y would no longer be formed.

D The initial reactant would no longer be metabolised.

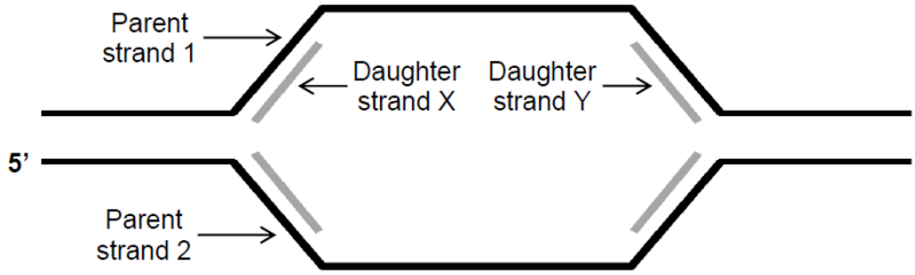
8 A culture of bacteria produces the food supplement lysine by the metabolic pathway shown.



Which change in enzyme activity will result in the greatest increase in lysine yield?

	enzyme	change in activity
A	1	decrease
B	2	increase
C	3	increase
D	4	decrease

9 A simplified representation of a replication bubble is shown in the figure below. Parental strands 1 and 2 and the growing daughter strands X and Y are indicated.



Which of the following statements about the syntheses of daughter strands X and Y is correct?

A Daughter strands X and Y are synthesised away from their respective replication forks.

B Daughter strand X is synthesised continuously while daughter strand Y is synthesised in the form of Okazaki fragments.

C Daughter strand X is synthesised in the 5' → 3' direction while daughter strand Y is synthesised in the 3' → 5' direction.

D DNA ligase will eventually catalyse the fusion of daughter strand X with daughter strand Y.

10 Which of the following statement(s) is/are **not** true of the translation process in all eukaryotes?

1 Polypeptides are only synthesised in the cytosol.

2 Amino acids are linked by the formation of peptide bonds catalysed by a ribozyme.

3 Ribosomes contain an amino-acyl tRNA site that is occupied by the initiator tRNA attached to methionine.

4 Amino-acyl tRNA synthetase attaches an amino acid to the 5' end of a tRNA molecule.

A 1, 3 and 4 only

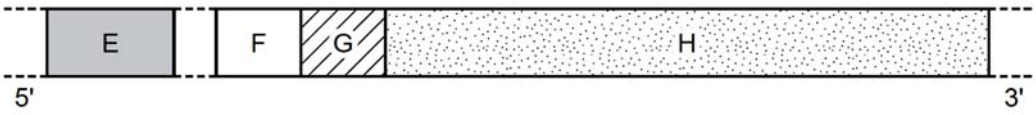
B 2, 3 and 4 only

C 2 and 4 only

D 1 only

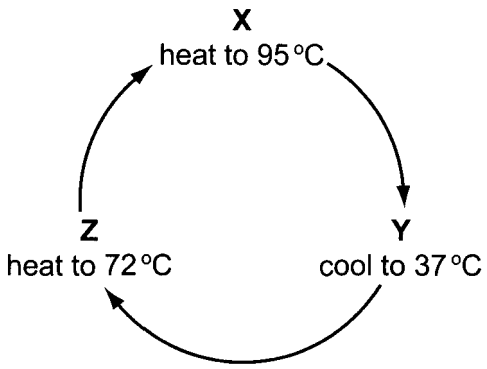
11 The diagram represents a length of DNA which forms a structure called an operon. Parts of the operon are labelled E, F, G and H. They have different functions.

What identifies the functions of parts E, F, G and H?



	E	F	G	H
A	operator	structural gene(s)	regulator/repressor	promoter
B	promoter	regulator/repressor	structural gene(s)	operator
C	regulator/repressor	promoter	operator	structural gene(s)
D	structural gene(s)	operator	promoter	regulator/repressor

12 The diagram shows the changes in temperature of the reaction mixture during the polymerase chain reaction (PCR).



The main events during one cycle of the reaction are listed.

1 binding of DNA primers
2 DNA synthesis
3 separation of DNA strands

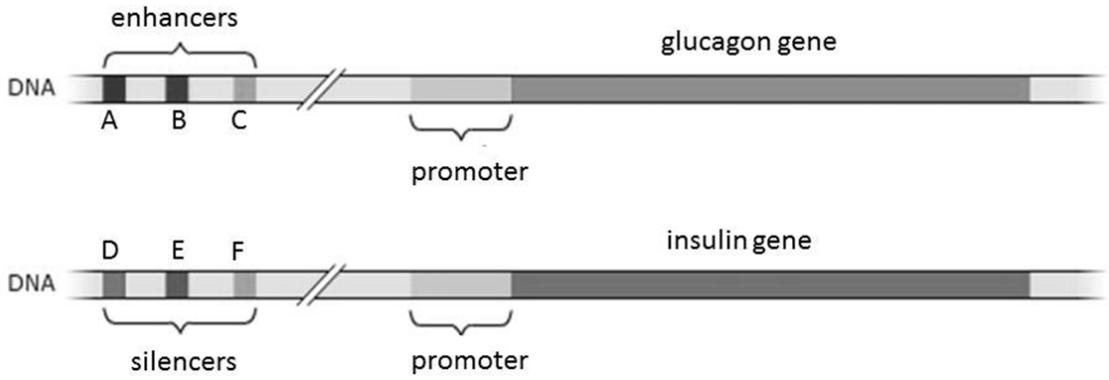
Which combination correctly matches each event with the temperature in the reaction mixture?

	X	Y	Z
A	1	2	3
B	2	3	1
C	3	1	2
D	3	2	1

13 Which combination correctly identifies the dengue virus?

	DNA	RNA	protein	phospholipid
A	✓	✓	✓	
B	✓		✓	✓
C		✓	✓	✓
D	✓		✓	

14 The diagram below shows the control elements and two genes found in the human genome.



Which of the following statement(s) about the above genes is/are true?

1 The glucagon gene is found only in the α-cells of the Islets of Langerhans while the insulin gene is found only in the β-cells of the Islets of Langerhans.

2 Binding of control elements, specific transcription factors and RNA polymerase at the promoter initiates transcription of glucagon.

3 The glucagon gene will be transcribed at a high level when transcription factors bind to control elements A, B, and C.

4 The expression of insulin can only be suppressed when transcription factors bind to control elements D, E and F.

A 3 only

B 2 and 3 only

C 1, 2 and 4 only

D 2, 3 and 4 only

15 Which of the following is an example of translational control of gene expression?

A The activation of proteins by association with other proteins

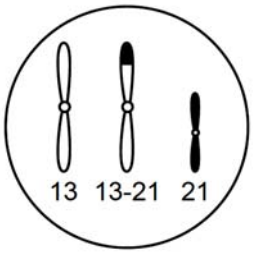
B The addition of chemical groups such as phosphates to free amino acids

C The binding of protein factors to mRNA to prevent the binding of the small ribosomal subunit

D The degradation of a protein by proteasome

16 Down's syndrome can be caused by a trisomy of chromosome 21, but can also result from translocation of chromosome 21 onto chromosome 13, forming a single chromosome 13-21.

The diagram shows chromosomes 13 and 21 in the nucleus of a diploid (2n) testis cell from a phenotypically normal male carrier of a 13-21 translocation. This cell has a chromosome number of 45.



Which is not a likely outcome of fertilisation of normal oocytes by sperm from this male?

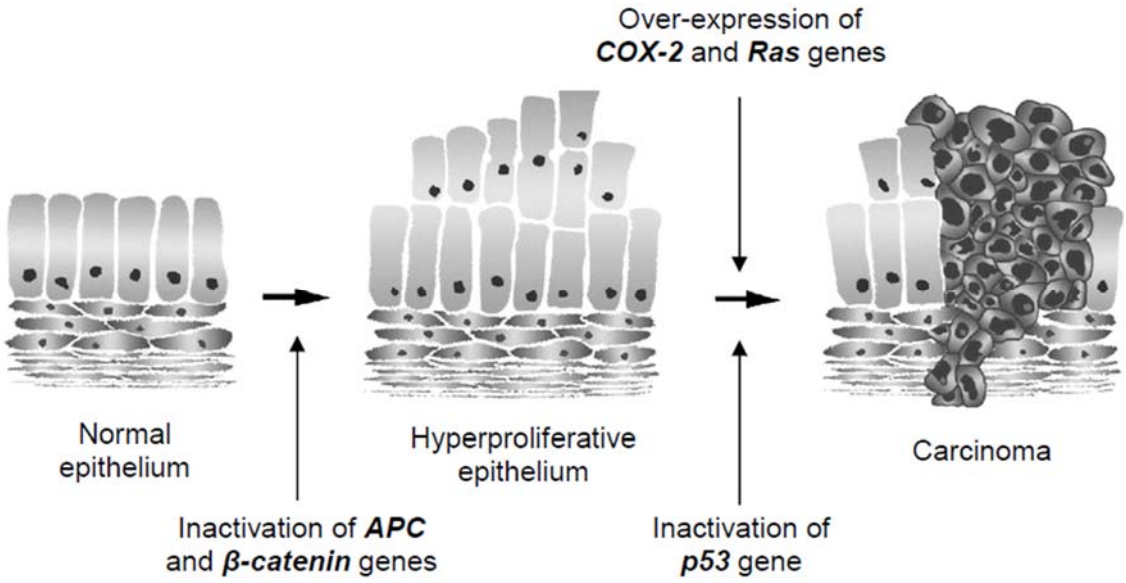
	chromosomes in sperm	embryo
A	13 and 21	2n = 46 normal phenotype
B	13-21	2n = 45 normal phenotype
C	13-21 and 21	2n = 46 Down's syndrome
D	13-21 and 21	2n = 47 Down's syndrome

17 The diagram shows the chromosomes of one cell which has been squashed during mitosis.

Which stage of mitosis is shown and what is the haploid chromosome number in this species?

	stage of mitosis	haploid chromosome number
A	anaphase	5
B	anaphase	10
C	metaphase	5
D	metaphase	10

18 The diagram below illustrates the development of colorectal cancer.



Which of these statements can be inferred from this multistep model of carcinogenesis?

1 Cells whose *APC* and *β-catenin* genes are inactivated have lost density dependent inhibition.

2 *APC* and *β-catenin* genes are most likely tumour suppressor genes.

3 High levels of *Ras* protein are produced only when both copies of *Ras* gene are mutated.

4 Two copies of normal *p53* alleles must be present to inhibit cell division.

5 Gain-of-function mutation in *COX-2* gene is one of the pre-requisites for the formation of carcinoma.

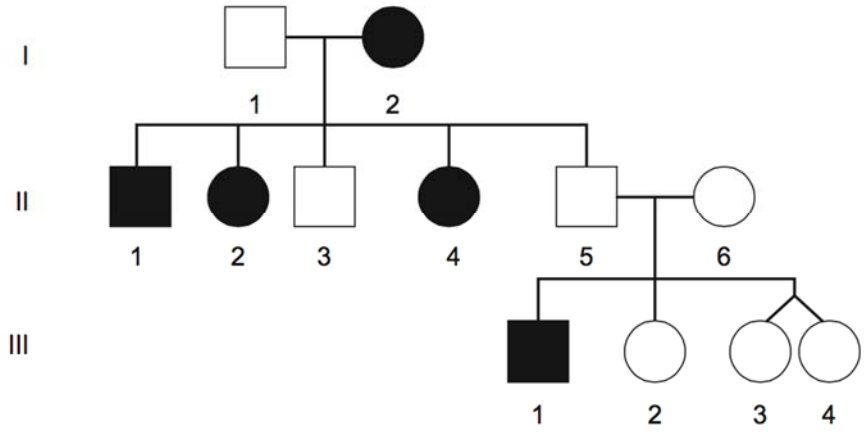
A 1, 2 and 3

B 1, 2 and 5

C 2, 3 and 4

D 2, 3 and 5

19 The pedigree below showed that the mode of inheritance of this disease is …… as supported by ……..



A autosomal dominant, individuals I-2 with offspring II-1, II-2 and II-4

B autosomal recessive, individuals I-1, I-2 with offspring II-3 and II-5

C autosomal recessive, individuals II-5, II-6 with offspring III-1

D sex-linked dominant, offspring II-2 and II-4

20 The phenotypes of 200 offspring of a dihybrid test cross were recorded. The cross involved petal colour and fertility of the anthers of sweet pea flowers. The table shows the observed and expected numbers of each phenotype.

phenotype	purple petals fertile anthers	purple petals sterile anthers	maroon petals fertile anthers	maroon petals sterile anthers
observed numbers	87	14	16	83
expected numbers	50	50	50	50

A chi-squared (χ^2) test was performed and the probability of the difference between the observed and expected results being due to chance was found to be <0.001.

Which conclusions may be drawn from this probability?

1 The difference is due to epistasis.

2 The difference is due to chance.

3 The difference is not due to chance.

4 The difference is due to some factor such as linkage of the genes concerned.

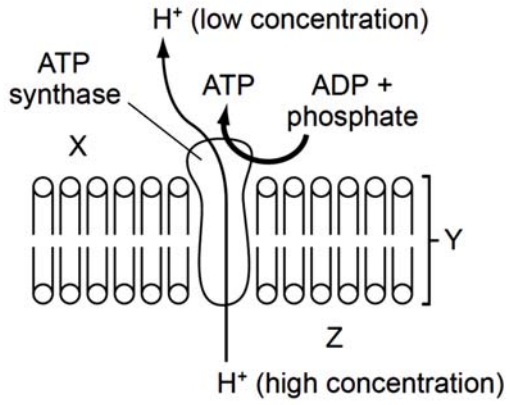
A 1 and 3 only

B 1 and 4 only

C 2 and 4 only

D 3 and 4 only

21 The diagram shows a membrane in a cell.



Which would be true of the diagram?

A X is the thylakoid space, Y is the thylakoid membrane and the diagram shows ATP synthesis in a chloroplast.

B X is the stroma, Y is the thylakoid membrane and the diagram shows ATP synthesis in a mitochondrion.

C Y is the thylakoid membrane, Z is the cytosol (cytoplasm) and the diagram shows ATP synthesis in a chloroplast.

D Z is the intermembranal space, X is the matrix and the diagram shows ATP synthesis in a mitochondrion.

22 During substrate-level phosphorylation, ATP is synthesised from ADP and inorganic phosphate.

What is the immediate source of energy for this reaction?

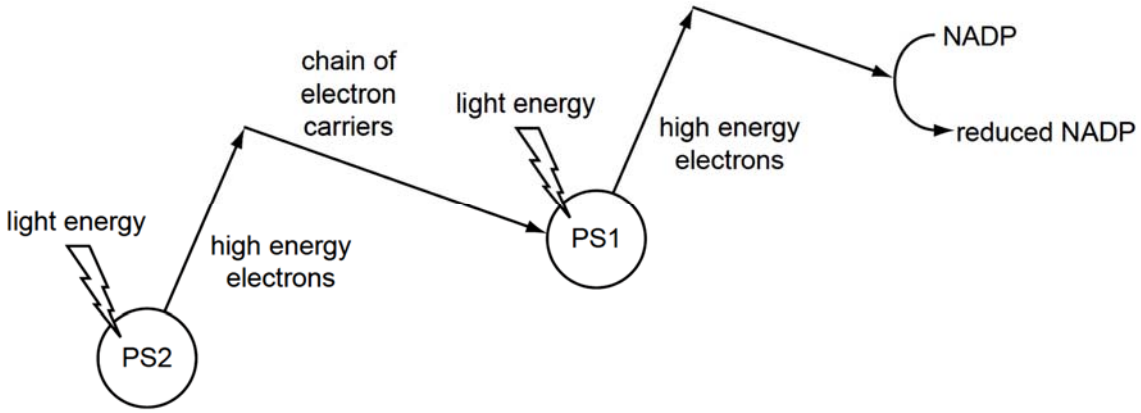
A chemical bond energy released during the light-independent stage of photosynthesis

B chemical bond energy released during glycolysis and the Krebs cycle

C kinetic energy of protons diffusing through mitochondrial membranes into the mitochondrial matrix

D kinetic energy of protons diffusing through thylakoid membranes in chloroplasts

23 The diagram shows some of the processes in the light-dependent stage of photosynthesis.



For the light-dependent stage to continue, photosystem two (PS2) must gain electrons.

Where do these electrons come from?

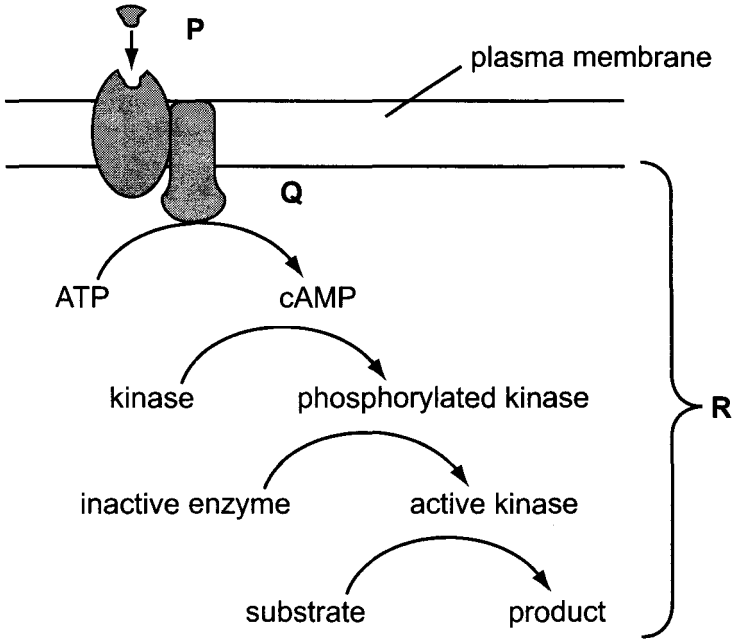
A electron carriers

B reduced NADP

C photolysis of water

D the formation of ATP

24 The diagram shows an example of cell signalling.



Which processes are shown on the diagram?

	P	Q	R
A	amplification	ligand-receptor interaction	phosphorylation
B	ligand-receptor interaction	amplification	phosphorylation
C	transduction	phosphorylation	amplification
D	ligand-receptor interaction	transduction	amplification

25 Which statements are true about Darwinian evolutionary theory?

1 Advantageous behaviour acquired during the lifetime of an individual is likely to be inherited.

2 In competition for survival, the more aggressive animals are more likely to survive.

3 Species perfectly adapted to a stable environment will continue to evolve.

4 Variation between individuals of a species is essential for evolutionary change.

A 1, 2 and 4 only

B 2 and 3 only

C 3 and 4 only

D 4 only

26 Darwin's view of the process of evolution to form new species (speciation) has been reinforced by more recent discoveries in genetics and cell biology.

In this view, which sequence of events is considered most likely to lead to speciation?

A	adaptation of population	→	competition and predation leading to natural selection	→	behavioural isolation	→	sympatric speciation
B	adaptation of population	→	competition and predation leading to natural selection	→	behavioural isolation	→	allopatric speciation
C	competition and predation leading to natural selection	→	geographical isolation	→	adaptation of isolated populations	→	sympatric speciation
D	competition and predation leading to natural selection	→	geographical isolation	→	adaptation of isolated populations	→	allopatric speciation

27 The huia, *Heteralocha acutirostris*, was found in New Zealand until 1907, when it became extinct. This bird had a ground-feeding habit and was particularly noted for large, attractive tail feathers. Males and females had very different beak forms, with the males having a short strong beak, whilst the females had a long curved beak to reach into otherwise inaccessible places.

What is the most likely reason for the extinction of the huia?

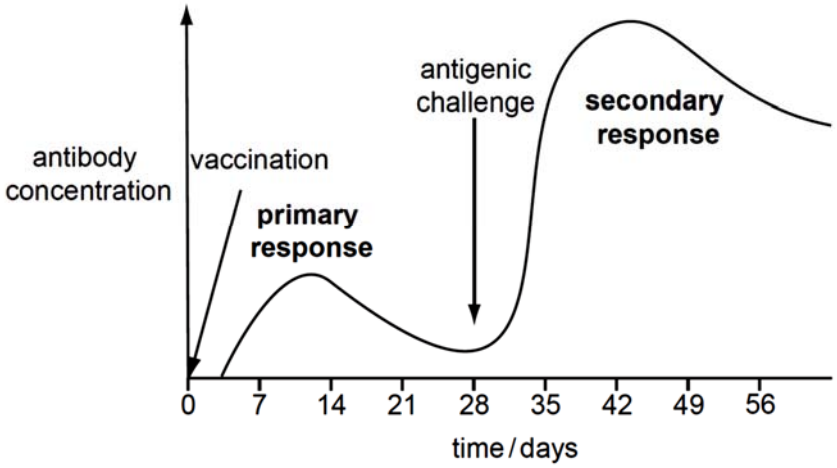
A Huia fed on species introduced by humans. When these declined, the huia population fell.

B In the face of a declining population the huia evolved into a tree-living species.

C Male and female huia were unable to breed successfully owing to strong sexual dimorphism.

D New competitors in New Zealand occupied part of the huia's niche.

28 The graph shows the level of antibody in serum following vaccination and a challenge with the same antigen 28 days later.



Which cells account for the difference in antibody concentration at the peaks of the primary and secondary responses?

A B-lymphocytes

B memory cells

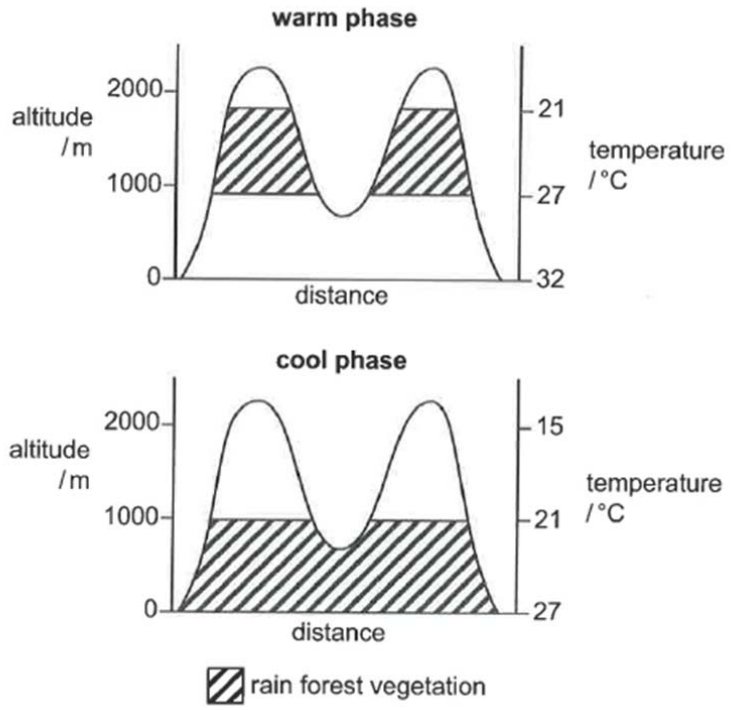
C phagocytes

D T-lymphocytes

29 What are the causative agents of AIDS, dengue and TB?

	AIDS	dengue	TB
A	human	bacterium	protozoan
B	bacterium	protozoan	virus
C	virus	mosquito	bacterium
D	virus	virus	bacterium

30 The diagram shows the topographical profile of two mountains in the tropics during natural warm and cool phases in the Earth's climate. The shape of the lines corresponds to a vertical section through the mountains to show their height and shape. The distribution of rain forest vegetation is also shown.



Which of the following statement is correct?

A The rain forest vegetation moves to stay in the suitable range of temperatures of 21 to 27°C.

B The lower altitudes are too hot during the warm phase in the Earth's climate for the growth of the rain forest vegetation.

C Climate change causes the rain forest vegetation distribution to increase in altitude with different temperature range.

D The changing rain forest vegetation distribution decreases evolution as selection pressure remains the same.

INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CG | | | | | |

INDEX NUMBER | | | | |

BIOLOGY

9744/02

Paper 2 Structured Questions

28 August 2018

Candidates answer on the Question Paper.

2 hours

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, CG and index number on page 1, 11 and 19 in the spaces provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

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.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/18
2	/10
3	/10
4	/10
5	/10
6	/11
7	/10
8	/8
9	/7
10	/6
Total	/100

This document consists of **27** printed pages and **1** blank page.

Answer **all** questions.

1 Fig. 1.1 shows an electron micrograph of a pancreatic cell that secretes large amounts of insulin that helps to regulate blood glucose level.

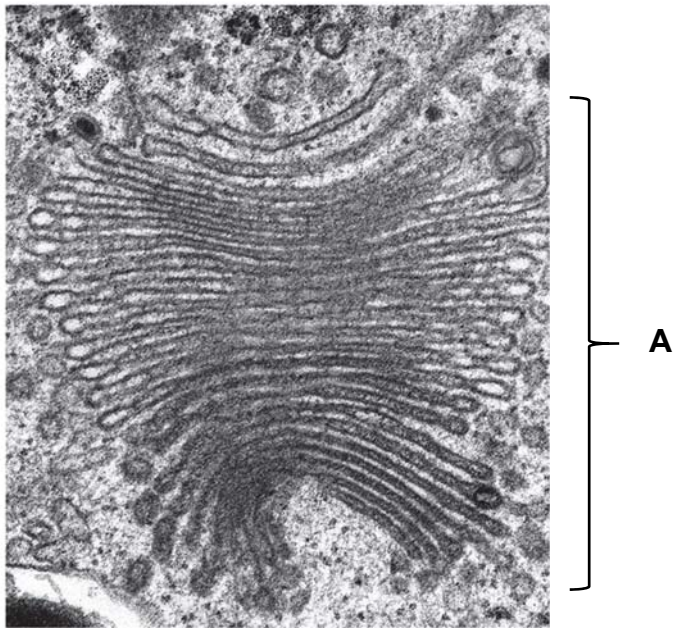


Fig. 1.1

(a) With reference to Fig. 1.1,

(i) identify organelle **A**;

.....[1]

(ii) describe **two** identifying features of organelle **A** that allows its identification in **(a)(i)**.

.....

.....

.....

.....[2]

Fig. 1.2 shows a diagram of the molecular structures of tristearin (a triglyceride) and phosphatidylcholine (a phospholipid).

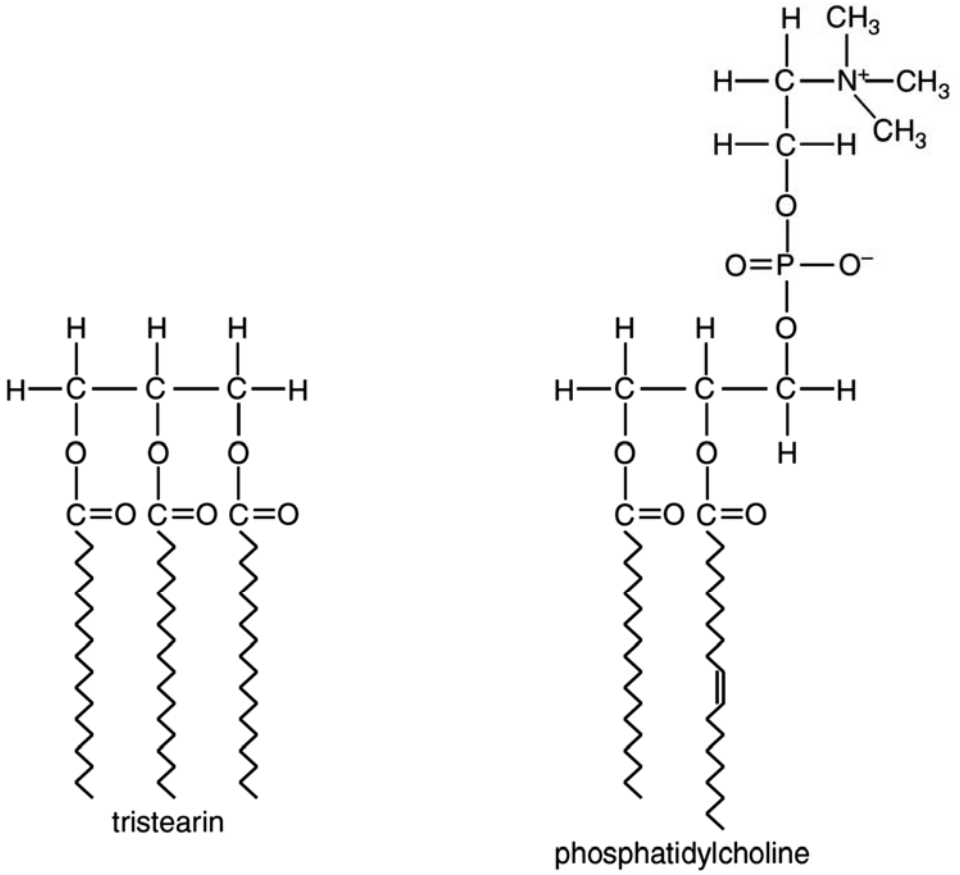


Fig. 1.2

(b) Table 1 shows a structural difference between the two molecules shown in Fig. 1.2.

Complete Table 1 with two further **structural** differences **other than** in numbers of different types of atoms.

Table 1

structural feature	tristearin	phosphotidylcholine
length of fatty acid chain	all same length	different lengths

[2]

(c) Triglyceride is used as energy storage while phospholipids are membrane components. Explain why phospholipids are suitable membrane components but not triglyceride.

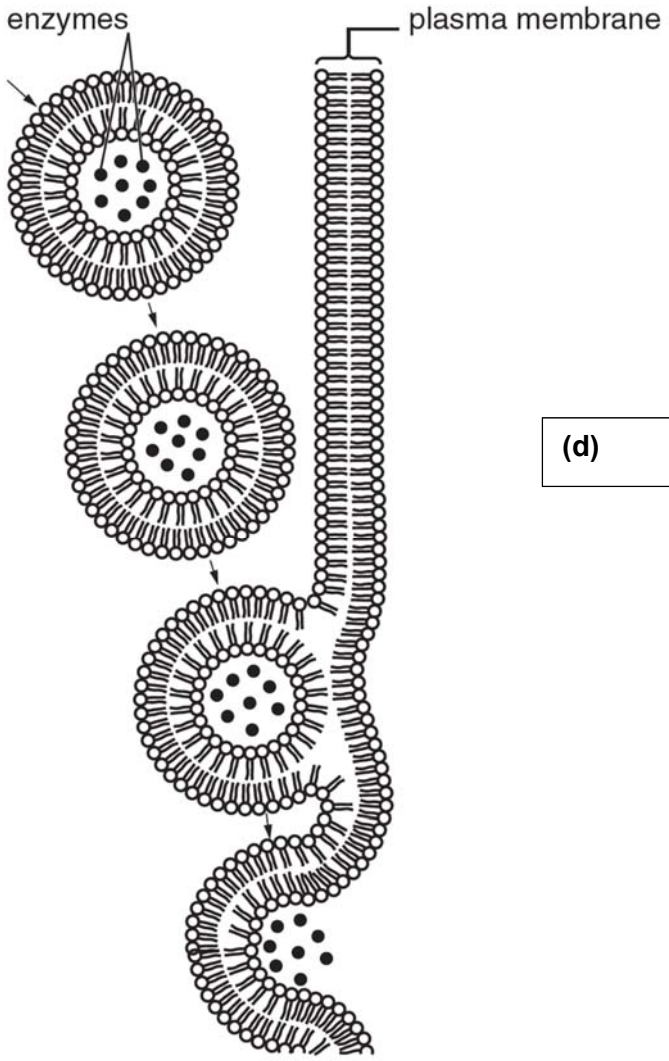
.....

.....

.....

..... [2]

Cells in the pancreas secrete enzymes, such as amylase and trypsin, into a duct. The enzymes are packaged in vesicles so that they can be exported from these cells as shown in Fig. 1.3.



(d)

(d)

Fig. 1.3

(d) On Fig. 1.3, label the cytoplasm of the cell as '**cytoplasm'** and extracellular fluid as '**extracellular'**. [1]

(e) With reference to Fig. 1.3,

(i) explain how enzymes that are secreted by cells in the pancreas are packaged into vesicles and exported, after their synthesis at the endoplasmic reticulum.

[6]

(ii) explain **one** property of the plasma membrane that allows vesicle formation.

[2]

(f) Describe **two** advantages of having plasma membranes **within** the cell.

[2]

[Total: 18]

2 Fig. 2.1 shows a bacterium cell.

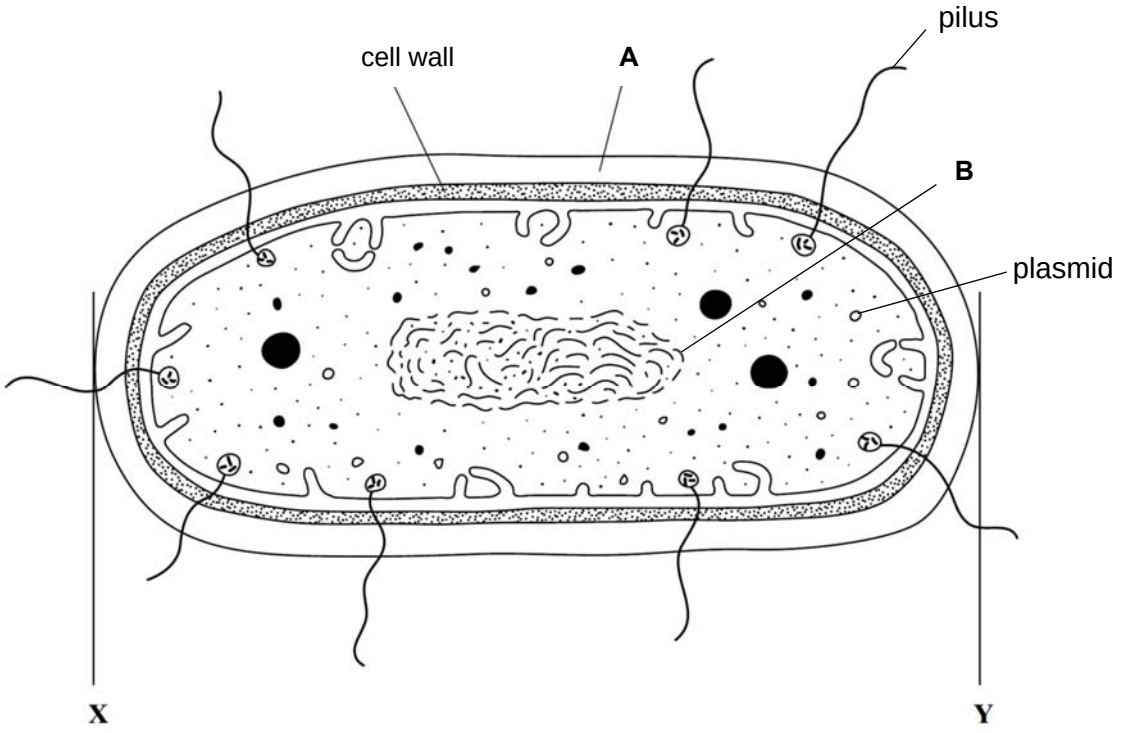


Fig. 2.1

(a) Identify structures **A** and **B**.

A .....

B ..... [2]

(b) Calculate the length of the bacterium cell from **X** to **Y** in **μm**. Show your working clearly.

[1]

Bacterial cells can acquire new alleles through genetic transfers between bacterial cells. One way is through plasmids called F plasmids in bacterial cells, another is through bacteriophages.

(c) Describe how a bacterium cell can acquire new alleles through F plasmids.

[3]

An investigation was conducted on a temperate phage that infects a new strain of bacteria, to find the prophage insertion site on the bacterial chromosome.

Fig. 2.2 shows the chromosome map of the bacterial strain. The chromosome map shows positions of the genes *ade*, *arg*, *cys*, *his*, *leu* and *pro*, which are each involved the synthesis of amino acids essential for bacterial growth.

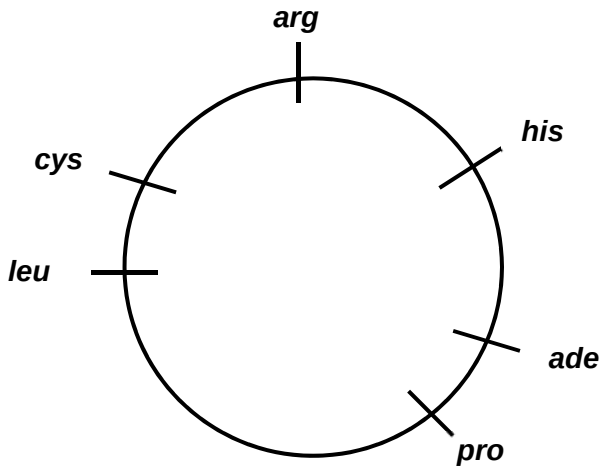


Fig. 2.2

The bacterial strain of genotype $ade^+ arg^+ cys^+ his^+ leu^+ pro^+$ (where '+' indicates functional wild-type allele) was used as a source of the phage. The phages were then added to a bacterial strain of genotype $ade^- arg^- cys^- his^- leu^- pro^-$ (where '-' indicates non-functional allele).

After a short incubation, samples of these bacteria were plated on six different media. The plates were then observed for growth of bacterial colonies. Table 2 shows the results of the experiment.

Table 2

medium	nutrient supplementation in medium						presence of colonies
	ade	arg	cys	his	leu	pro	
1	×	✓	✓	✓	✓	✓	N
2	✓	×	✓	✓	✓	✓	N
3	✓	✓	×	✓	✓	✓	C
4	✓	✓	✓	×	✓	✓	N
5	✓	✓	✓	✓	×	✓	C
6	✓	✓	✓	✓	✓	×	N

Key:
'✓' indicates presence of amino acid
'×' indicates absence of nutrient supplement
'C' indicates presence of colonies,
'N' indicates absence of colonies

(d) With reference to Table 2,

(i) indicate on Fig. 2.2, the position of prophage insertion. [1]

(ii) explain why colonies are able to grow on medium **3** and **5**.

--- [3]

[Total: 10]

3 Fig. 3.1 shows the structure of a mature tRNA that is involved in the production of a globular enzyme in a eukaryotic cell.

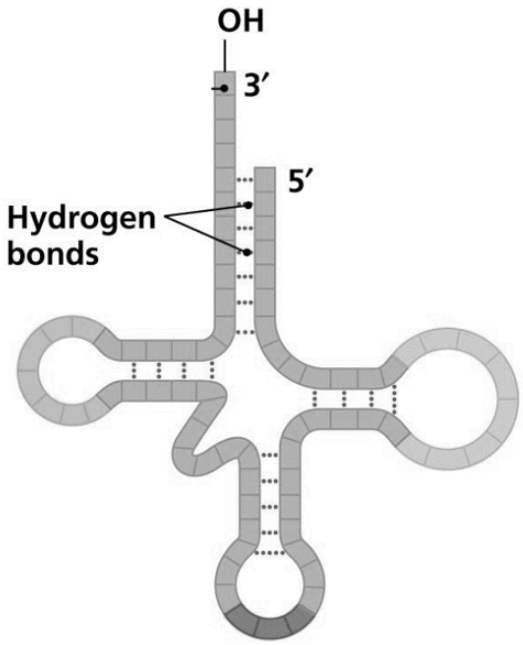


Fig. 3.1

(a) With reference to Fig. 3.1, explain the roles of hydrogen bonds in the proper functioning of tRNA.

[3]

(b) The length of the tRNA gene is longer than that of the mature tRNA.

Outline how a **mature** tRNA molecule is synthesised in eukaryotes.

[3]

Fig. 3.2 shows a pathway in the regulation of gene expression to synthesise enzymes in a eukaryotic cell can be achieved.

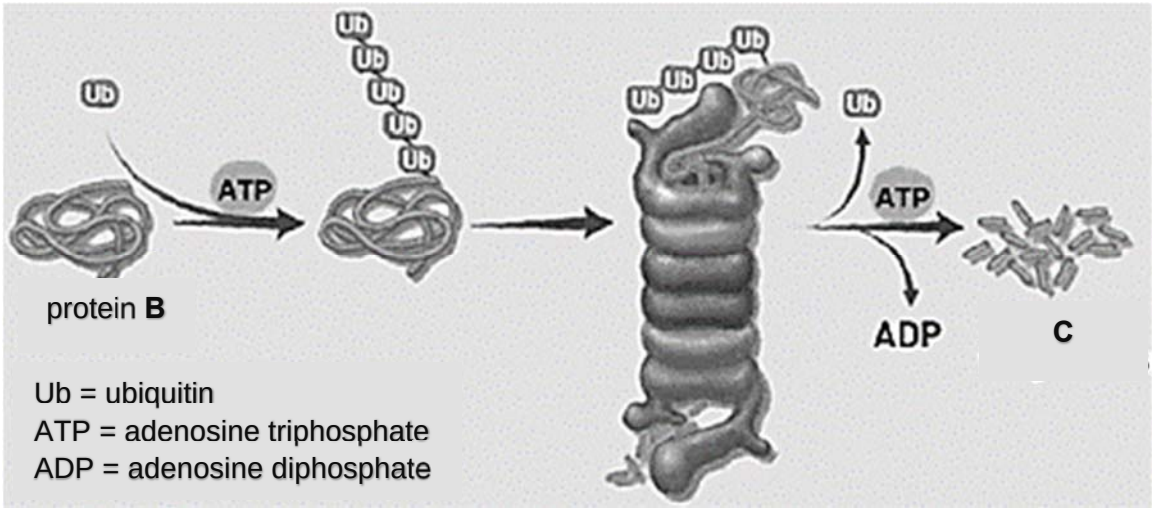


Fig. 3.2

(c) With reference to Fig. 3.2,

(i) name the process involved;

.....[1]

(ii) explain how product **C** is formed from protein **B**.

.....

.....

.....

.....

.....

.....[3]

[Total: 10]

Name: _____
Index No.: _____ CG: 17____

4 Crossing over between homologous chromosomes is an important process that gave rise to genetic variation.

Errors during crossing over can result in abnormal chromosomes that will affect the phenotype of an organism.

Fig. 4.1 show the result of an unequal crossing over event in prophase I.

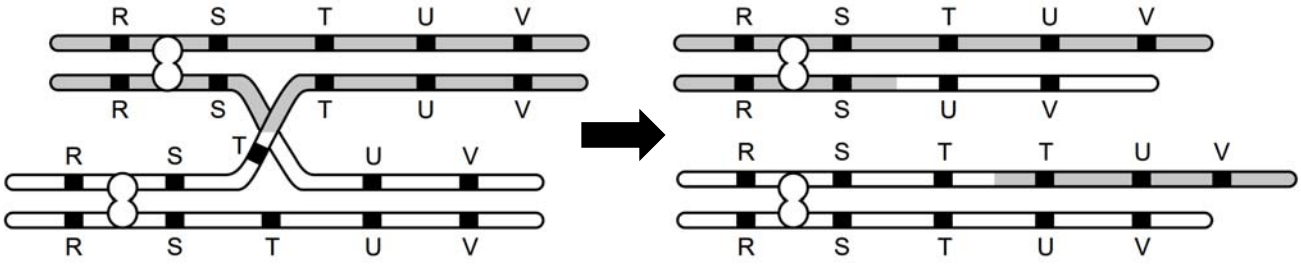


Fig. 4.1

(a) **(i)** State the type of mutation that has occurred in Fig. 4.1.

.....

[1]

(ii) Suggest the possible effects on the phenotype of the organism if protein T is a hormone involved in metabolism.

.....

.....

.....

.....

.....

.....

[2]

Fig. 4.2 shows the human karyotype of one of the most common chromosomal abnormalities. The affected embryos or foetuses with this condition ended up in miscarriages in the first trimester.

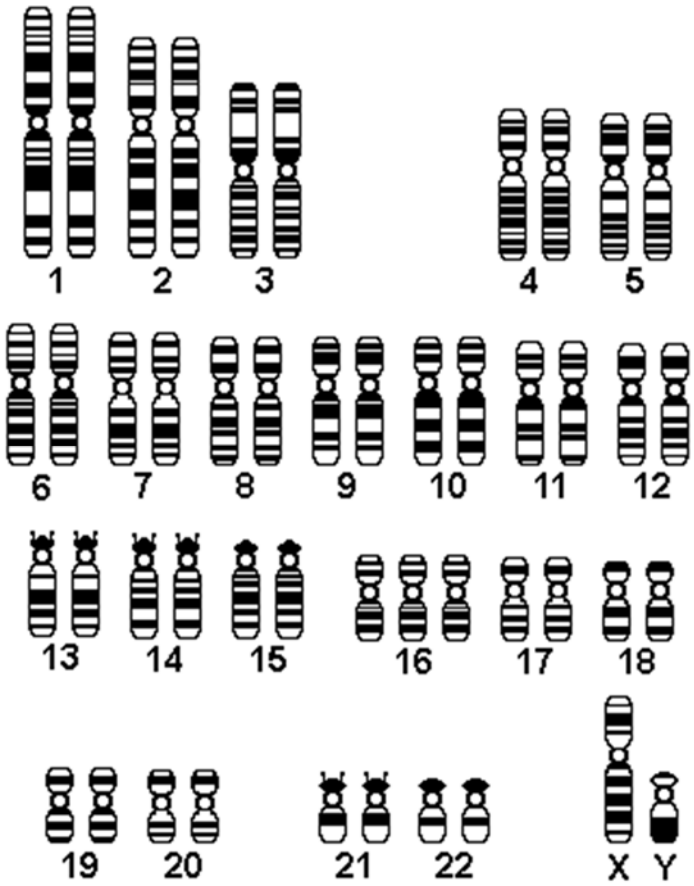


Fig. 4.2

(b) With reference to Fig. 4.2, explain how this condition arises.

[4]

(c) Fig. 4.1 and Fig 4.2 are examples of chromosome aberration.

Use examples other than the ones shown, outline what does *chromosome aberration* mean.

[3]

[Total: 10]

5 Two independently assorting genes coding for eye colour and the presence of wing crossveins in the *Drosophila* fruit fly were investigated in a few genetic crosses with different adults.

The outcomes of four crosses are shown below in Table 5.

Table 5

Cross	Parental phenotypes	Orange, crossveins present	Orange, crossveins absent	Red, crossveins present	Red, crossveins absent
1	orange, crossveins present, orange, crossveins present	83	26	0	0
2	red, crossveins present, red, crossveins absent	20	18	65	63
3	red, crossveins absent, red, crossveins present	0	0	71	81
4	red, crossveins present, red, crossveins present	28	11	93	34

(a) Using suitable symbols,

(i) deduce the genotypes of the adults in Cross 2.

Red, crossveins present .....

Red, crossveins absent ..... [2]

(ii) explain why Cross 1 and Cross 3 have zero offspring in some phenotypic categories.

.....

.....

.....

..... [2]

(b) In order to test the significance of differences between observed and expected results, a statistical test was carried out for Cross 4.

(i) Name the statistical test carried out.

..... [1]

(ii) State the expected offspring ratio.

..... [1]

(iii) Explain what does it mean when the results of the chi squared test has a probability of more than 0.05.

[2]

(c) Using a named example, describe how the environment may affect the phenotype of organisms.

[2]

[Total: 10]

6 Fig. 6.1 shows a section of a chloroplast.

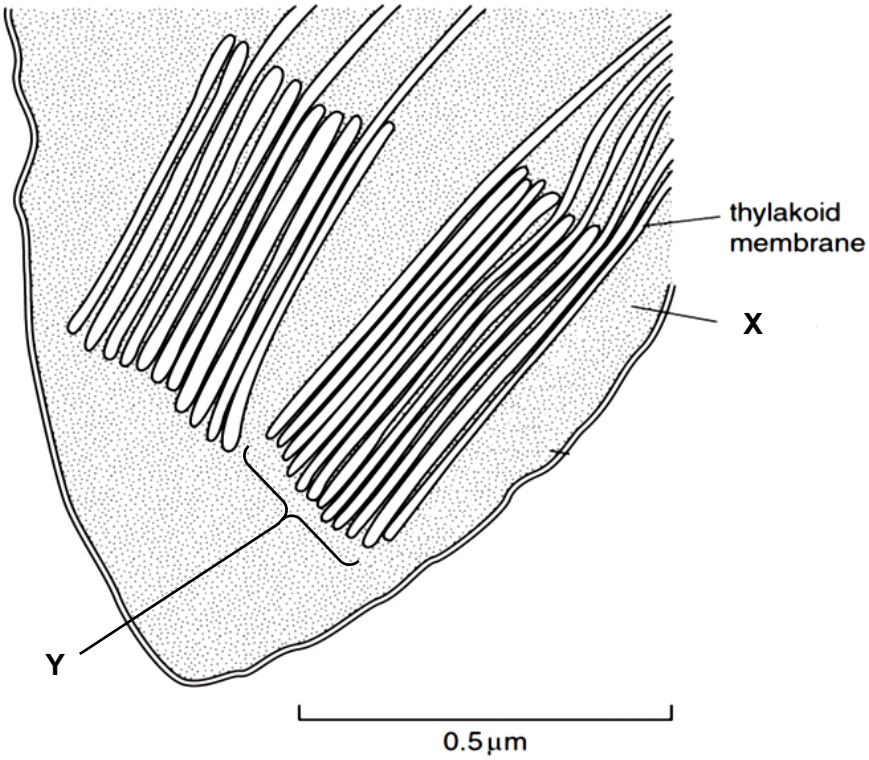


Fig. 6.1

(a) Identify structures **X** and **Y**.

X .....

Y ..... [2]

Fig. 6.2 shows ATP synthase embedded in the thylakoid membrane.

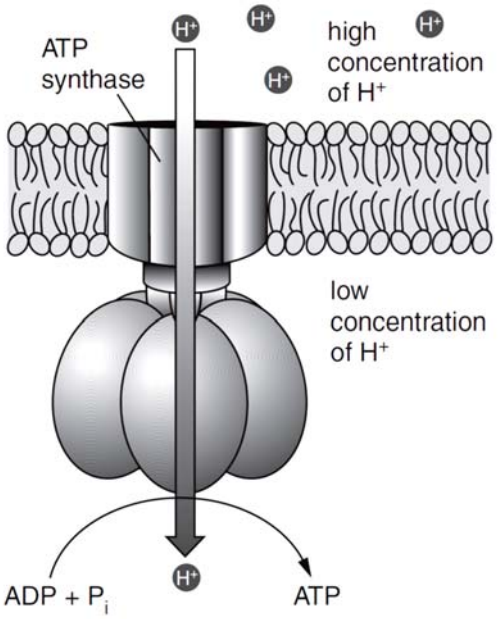


Fig. 6.2

(b) (i) Describe how the presence of light led to the synthesis of ATP.

[4]

(ii) Describe the fate of ATP produced in Fig. 6.2.

[2]

Fig. 6.3 shows the relationship between CO_2 assimilation rate and increasing light intensity in a plant.

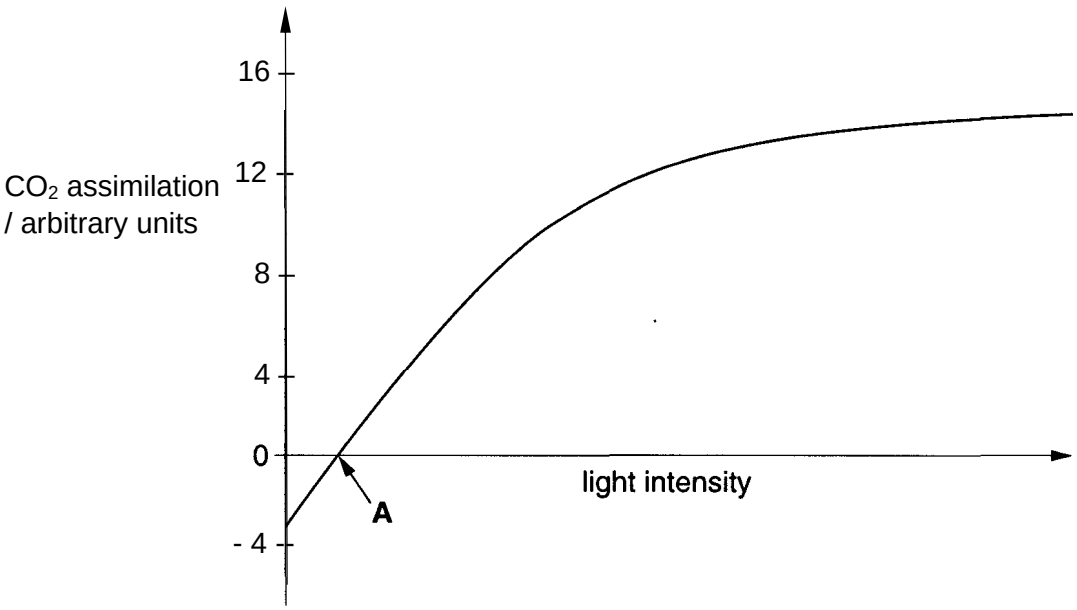


Fig. 6.3

(c) With reference to Fig. 6.3,

(i) State the total volume of CO_2 used by the plant for photosynthesis when light intensity is no longer the limiting factor.

[1]

(ii) Describe the significance of point **A** to the growth of the plant.

[2]

[Total: 11]

Name: _____

Index No.: _____ CG: 17____

7 Fig. 7.1 shows the structure of the hormone, insulin, which is responsible for the regulation of blood glucose level back to its normal set point.

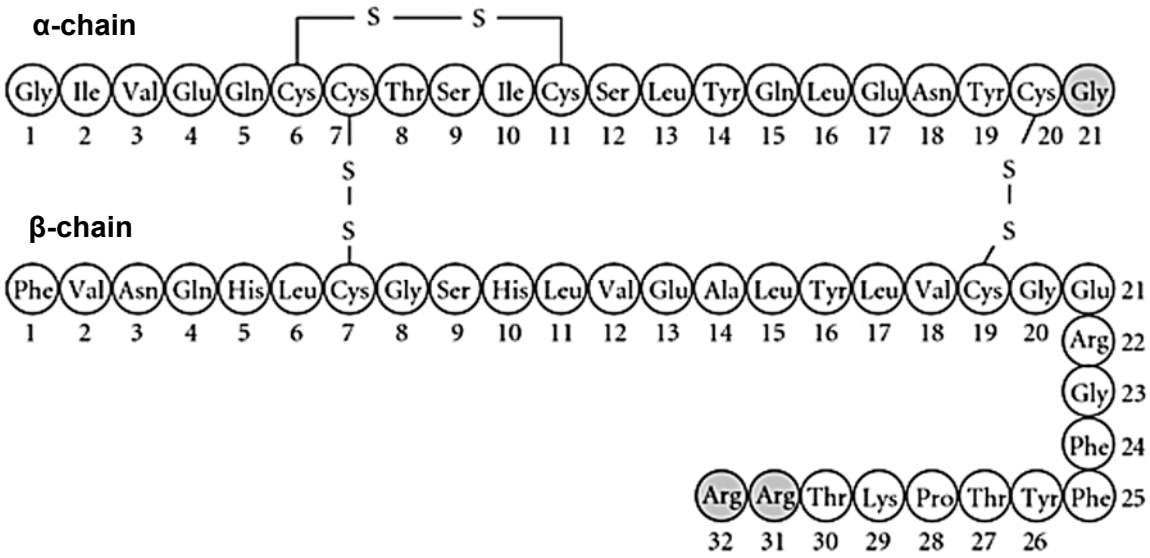


Fig. 7.1

(a) With reference to Fig. 7.1, describe the structure of insulin.

.....

.....

.....

.....

.....

..... [3]

Metformin is used as a drug to treat hyperglycaemic conditions in patients with Type II diabetes where the skeletal muscles are resistant to insulin stimulation. It is transported into the cell by specific protein carrier.

Fig. 7.2 illustrates how metformin influences the cellular activity involved in the signal transduction pathway. AMPK is a kinase that is involved in energy sensing and is activated by AMP (adenosine monophosphate) which is the one of the products of ATP hydrolysis.

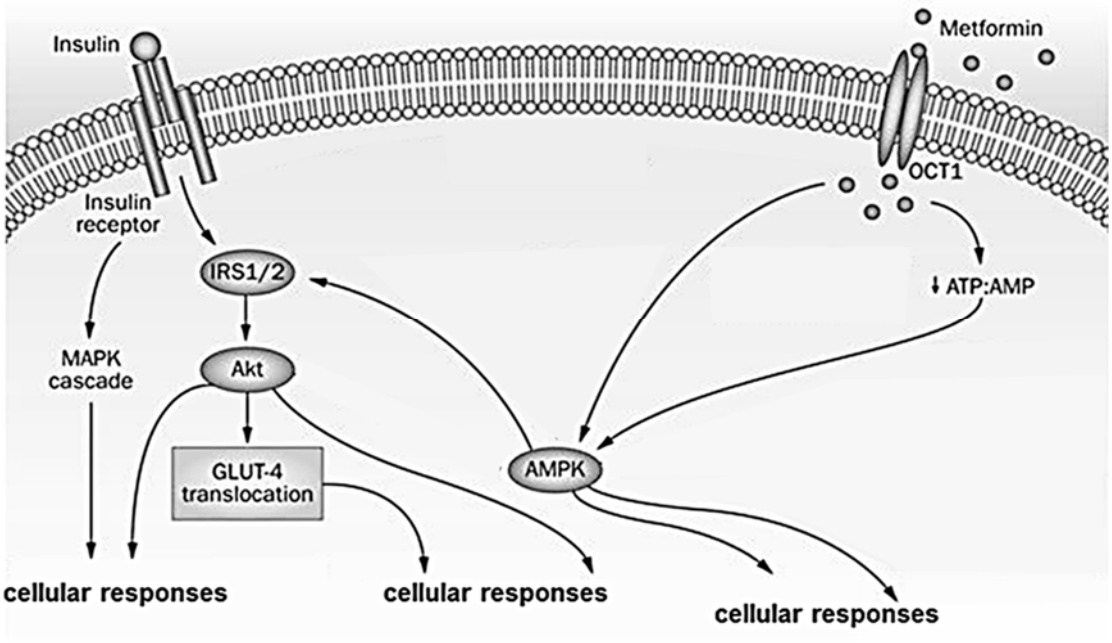


Fig. 7.2

(b) With reference to Fig. 7.2,

(i) explain how metformin can be used to decrease the blood glucose level in patients with Type II diabetes.

[4]

(ii) Akt is known to stimulate other cellular responses in the insulin signalling pathway.

Suggest how activation of Akt can lead to different cellular responses.

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

8 A mammoth can be any species belonging to the extinct genus *Mammuthus*, proboscideans commonly equipped with long, curved tusks. They were members of the family Elephantidae which contains, along with mammoths, the two genera of modern elephants and their ancestors.

About three million years ago, the ancestors of mammoths migrated from Africa into Europe and Asia. There, about 1.7 million years ago, the steppe mammoth evolved and became adapted to the cooler conditions. Then, about 700 000 years ago, as the climate changed and the Arctic became much colder, the woolly mammoth evolved.

Woolly mammoths showed a number of obvious adaptations to reduce heat loss, including thick fur, small ears and small tails.

(a) Explain how variation and natural selection may have brought about the evolution of the woolly mammoth from the steppe mammoth.

[4]

(b) The phylogenetic relationship of the woolly mammoth, Asian elephant (*Elephas maximus*) and African elephant (*Loxodonta africana*) was then investigated.

Fig. 8.1 shows the phylogenetic tree obtained.

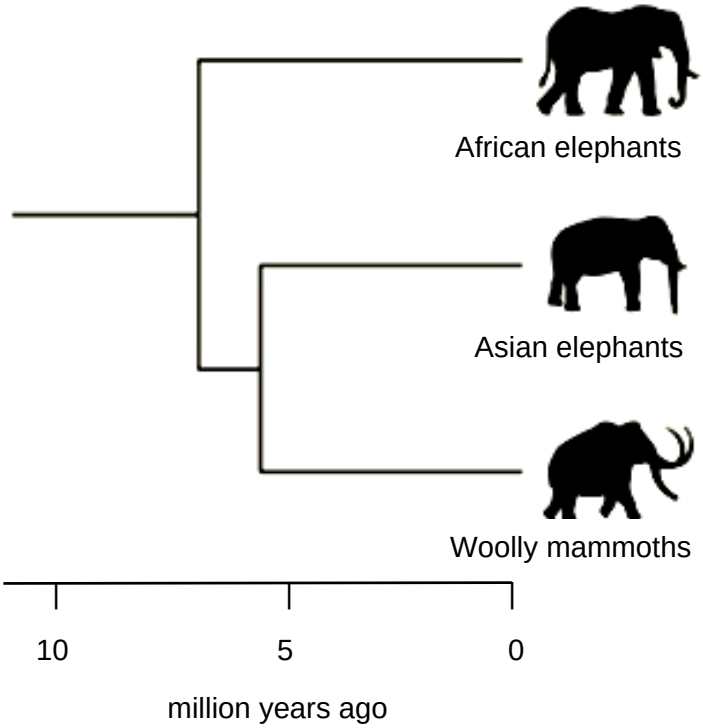


Fig. 8.1

With reference to Fig. 8.1, state

(ii) when the African elephant diverged;

.....[1]

(iii) when the Asian elephant diverged.

.....[1]

(c) Explain how molecular methods can be used to construct the phylogenetic tree in Fig. 10.1.

.....

.....

.....

.....[2]

[Total: 8]

9 Cholera is an infectious disease caused by the bacterium *Vibrio cholerae*. The bacteria are transmitted between humans through the fecal-oral route. Contaminated food or water can cause infection which symptoms can occur very quickly, from a few hours to a few days.

Table 9 shows

- the economic status of each of five countries
- the number of cases of cholera reported to the World Health Organization (WHO) over a five year period for each country
- the population in 2006 and in 2010 of each country.

Table 9

country	economic status	number of cholera cases reported			population / millions	
		2006	2008	2010	2006	2010
Zimbabwe	low	789	60055	951	12.5297	12.5715
Uganda	low	5194	3726	2341	29.3703	33.4247
Angola	middle	67257	10511	1484	17.0104	19.0819
Cameroon	middle	922	0	10759	17.9484	19.5989
Canada	high	2	1	2	32.6490	34.1088

(a) With reference to Table 9,

(i) suggest **two** reasons to explain the higher number of cholera cases reported in low economic status countries compared to high economic status country.

--- [2]

(ii) suggest if economic status of a country is likely to be the main reason for the high number of cases of cholera.

--- [2]

(b) Cholera can be treated with antibiotics like tetracycline.

(i) Suggest how tetracycline results in the death of the bacterium.

--- [2]

(ii) Explain why tetracycline does not cause death of human cells.

--- [1]

[Total: 7]

10 Dengue fever is a mosquito-borne viral disease and a regular epidemic in Thailand. The peak of the dengue epidemic period is around June to August during the rainy season. It is believed that climate is an important factor for dengue transmission.

Fig. 10.1 shows how changes in temperature affects the average monthly incidence rate of dengue cases in Chiang Rai, Thailand from 2004 – 2014.

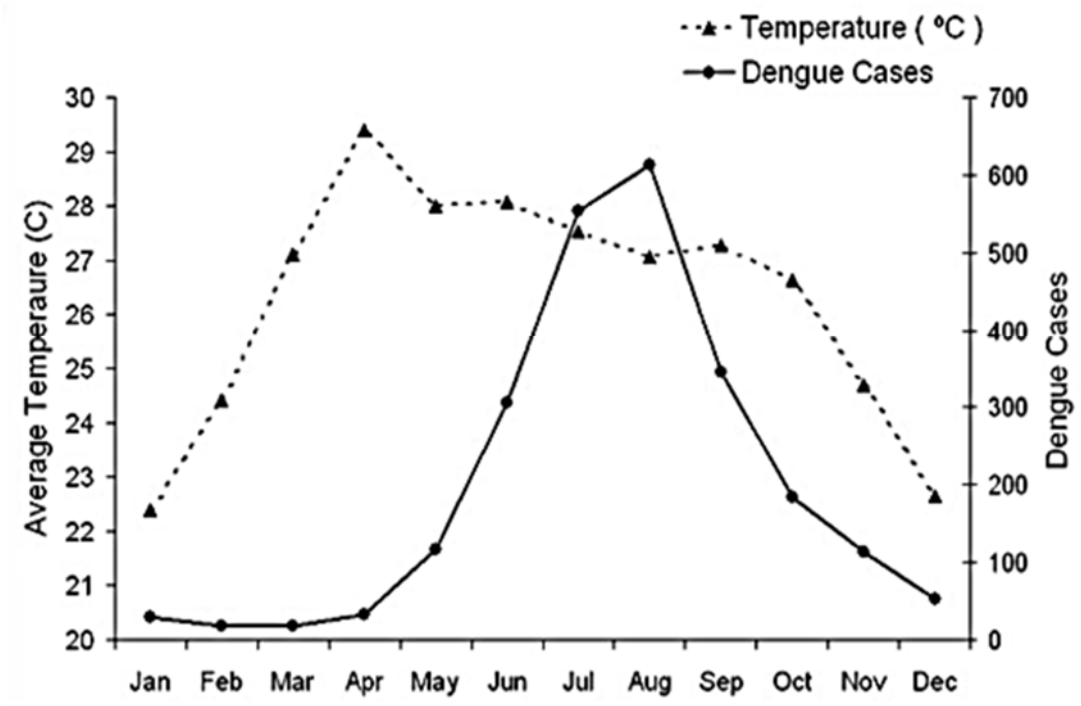


Fig. 10.1

(a) State how each data point in Fig. 10.1 is obtained.

.....

[1]

(b) With reference to Fig. 10.1,

(i) describe the trend of incidence of dengue cases with regard to changes in temperature;

.....

.....

.....

.....

[2]

(ii) explain the trend described in **(b)(i).**

[3]

[Total: 6]

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2018 JC2 H2 BIO P2 PRELIM EXAM ANSWER SCHEME

Answer **all** questions.

1 Fig. 1.1 shows an electron micrograph of a pancreatic cell that secretes large amounts of insulin that helps to regulate blood glucose level.

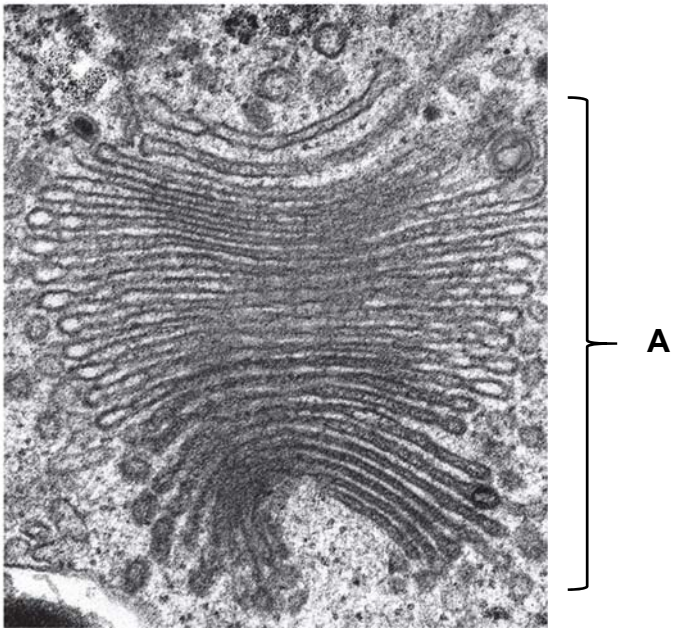


Fig. 1.1

(a) With reference to Fig. 1.1,

(i) identify organelle **A**;

Golgi apparatus/ body; [1]

(ii) describe **two** identifying features of organelle **A** that allows its identification in **(a)(i)**.

1. a stack of discrete, flattened, memb-bound sacs called cisternae;

2. distinct memb with 2 faces cis/ convex & trans/ concave);

3. vesicles pinching & joining from ends of each sac; ***(any 2)*** [2]

Fig. 1.2 shows a diagram of the molecular structures of tristearin (a triglyceride) and phosphatidylcholine (a phospholipid).

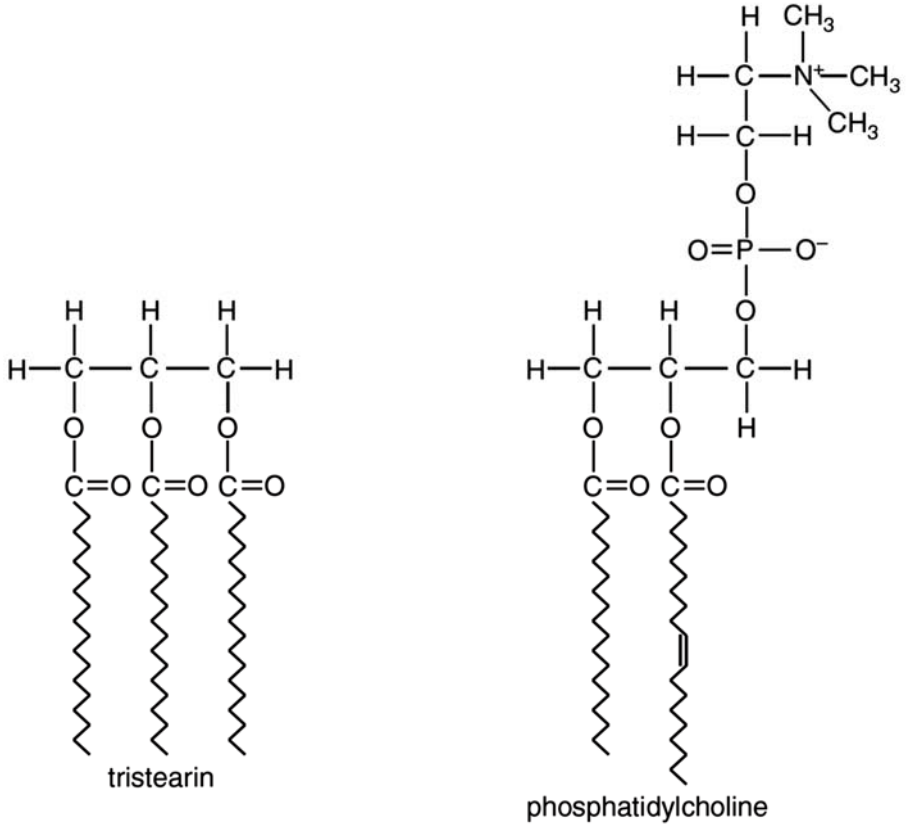


Fig. 1.2

(b) Table 1 shows a structural difference between the two molecules shown in Fig. 1.2.

Complete Table 1 with two further **structural** differences **other than** in numbers of different types of atoms.

Table 1

structural feature	tristearin	phosphotidylcholine
length of fatty acid chain	all same length	different lengths
degree of saturation	***all FA tails are saturated***	***1 FA tail is unsaturated / have C=C***
functional grp	***glycerol & carboxylic acid***	***glycerol, carboxylic acid & phosphate***
presence of phosphate group	***absent***	***present***
no. of FA	***3***	***3***

[2]

(c) Triglyceride is used as energy storage while phospholipids are membrane components. Explain why phospholipids are suitable membrane components but not triglyceride.

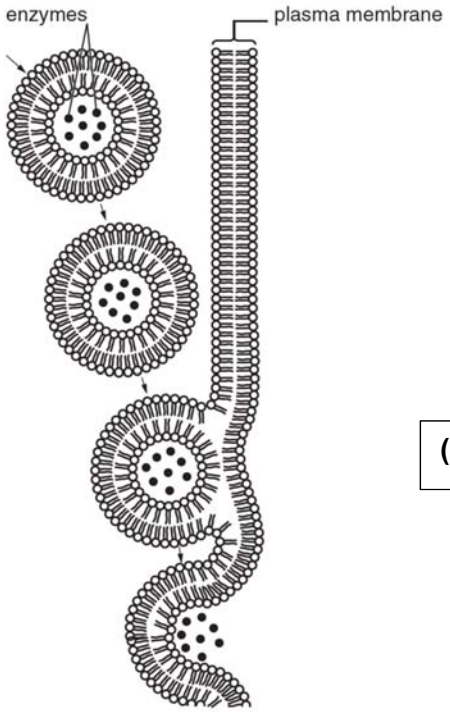
1. amphipathic

has hydrophilic head and hydrophobic tail;

2. able to form bilayer

w hydrophilic heads interxt w aq medium in/s & o/s cell (while forming a hydrophobic core that prevents free movement of hydrophilic subst); [2]

Cells in the pancreas secrete enzymes, such as amylase and trypsin, into a duct. The enzymes are packaged in vesicles so that they can be exported from these cells as shown in Fig. 1.3.



(d) ***cytoplasm***

(d) ***extracellular***

Fig. 1.3

(d) On Fig. 1.3, label the cytoplasm of the cell as '**cytoplasm'** and extracellular fluid as '**extracellular'**. [1]

(e) With reference to Fig. 1.3,

(i) explain how enzymes that are secreted by cells in the pancreas are packaged into vesicles and exported, after their synthesis at the endoplasmic reticulum.

1. enz packaged in tpt vesicles pinch off from surface of rER

pinch off from surface of rER;

2. tpt vesicles travel thru cytoplasm / or idea of transport

fuse with A/ Golgi apparatus at cis face;

3. protein modification occurs (adding phosphate grp/ adding, deleting, substituting sugar monomers)

modification results in molecular identification tag on enz;

4. vesicles containing enz pinch off

from trans face of A/ Golgi apparatus;

5. vesicles translocate towards CSM

via cytoskeleton (ATP req'd);

6. memb vesicle fuses with CSM

enz released out of cell via exocytosis; [6]

(ii) explain **one** property of the plasma membrane that allows vesicle formation.

1. memb is fluid

allows <u>evagination</u> of memb to form vesicles;

2. phospholipid molecules are held by weak hydrophobic interxns

thus capable of lateral movement (within the monolayer); [2]

(f) Describe **two** advantages of having plasma membranes **within** the cell.

1. allows compartmentalisation

to setup unique / optimum conditions for biochem rxns (e.g. acidic pH in lysosome);

2. regulates movement of subst in and out of cell / organelle

(by having prot trspters that only allows movement of specific subst); [2]

[Total: 18]

2 Fig. 2.1 shows a bacterium cell.

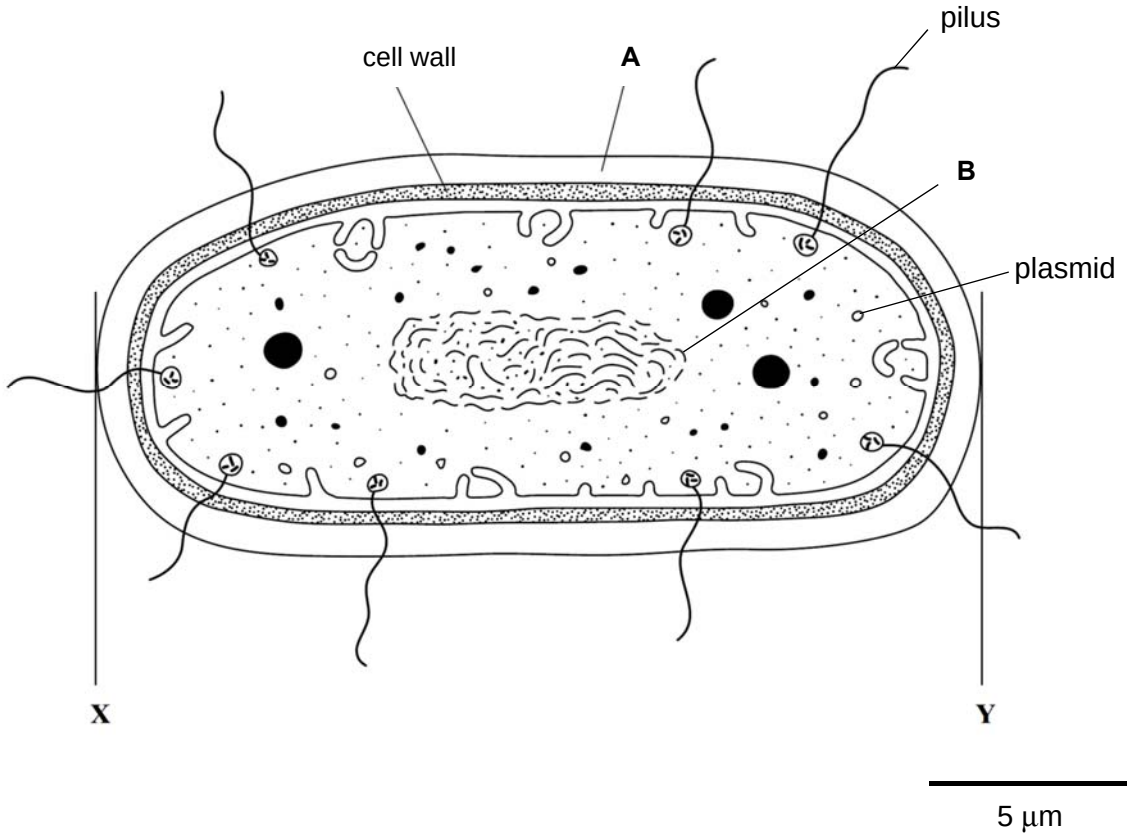


Fig. 2.1

(a) Identify structures **A** and **B**.

A ***capsule;***

B ***DNA / nucleoid / chromosome;*** [2]

(b) Calculate the length of the bacterium cell from **X** to **Y** in **μm**. Show your working clearly.

- ***Accept measurement of line between 2.5 – 2.7 cm***
- ***Accept measurement of XY between 11.5 – 11.7 cm***
- ***Accept answers with rounding off calculations***

[1]

Bacterial cells can acquire new alleles through genetic transfers between bacterial cells. One way is through plasmids called F plasmids in bacterial cells, another is through bacteriophages.

(c) Describe how a bacterium cell can acquire new alleles through F plasmids.

1. F plasmid in F+ cell syn sex pilus that binds to F- cell

retracts to form cytoplasmic bridge;

2. enz cleaves F plasmid at oriT

s/s transferred from F+ to F- cell;

3. F plasmid replicated by (rolling circle mechanism)

s/s F plasmid acts as template to syn 2nd F plasmid strand, F- cell becomes F+ with new alleles found on F plasmid; [3]

An investigation was conducted on a temperate phage that infects a new strain of bacteria, to find the prophage insertion site on the bacterial chromosome.

Fig. 2.2 shows the chromosome map of the bacterial strain. The chromosome map shows positions of the genes *ade*, *arg*, *cys*, *his*, *leu* and *pro*, which are each involved the synthesis of amino acids essential for bacterial growth.

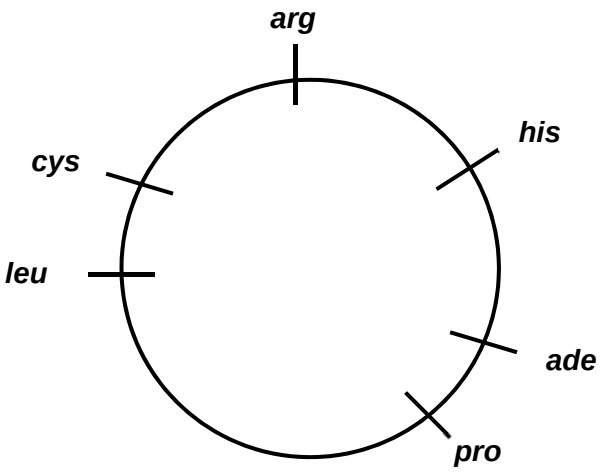


Fig. 2.2

The bacterial strain of genotype $ade^+ arg^+ cys^+ his^+ leu^+ pro^+$ (where '+' indicates functional wild-type allele) was used as a source of the phage. The phages were then added to a bacterial strain of genotype $ade^- arg^- cys^- his^- leu^- pro^-$ (where '-' indicates non-functional allele).

After a short incubation, samples of these bacteria were plated on six different media. The plates were then observed for growth of bacterial colonies. Table 2 shows the results of the experiment.

Table 2

medium	nutrient supplementation in medium						presence of colonies
	ade	arg	cys	his	leu	pro	
1	×	✓	✓	✓	✓	✓	N
2	✓	×	✓	✓	✓	✓	N
3	✓	✓	×	✓	✓	✓	C
4	✓	✓	✓	×	✓	✓	N
5	✓	✓	✓	✓	×	✓	C
6	✓	✓	✓	✓	✓	×	N

Key:
'✓' indicates presence of amino acid
'×' indicates absence of nutrient supplement
'C' indicates presence of colonies,
'N' indicates absence of colonies

(d) With reference to Table 2,

(i) indicate on Fig. 2.2, the position of prophage insertion. [1]

1. accept indication of insertion point between cys and leu;

(ii) explain why colonies are able to grow on medium **3** and **5**.

2. temperate phage infects donor bact cell

integrated prophage b/w cys+ and leu+ into bact chr;

3. cys+ and leu+ next to prophage accidentally excised & packaged

when temperate phage switch from lysogenic to lytic cycle;

4. phage infects recipient bact cell deficient in all enz

homologous recomb of cys & leu genes occurs resulting in recipient bact now with cys+ & leu+ alleles; [3]

[Total: 10]

3 Fig. 3.1 shows the structure of a mature tRNA that is involved in the production of a globular enzyme in a eukaryotic cell.

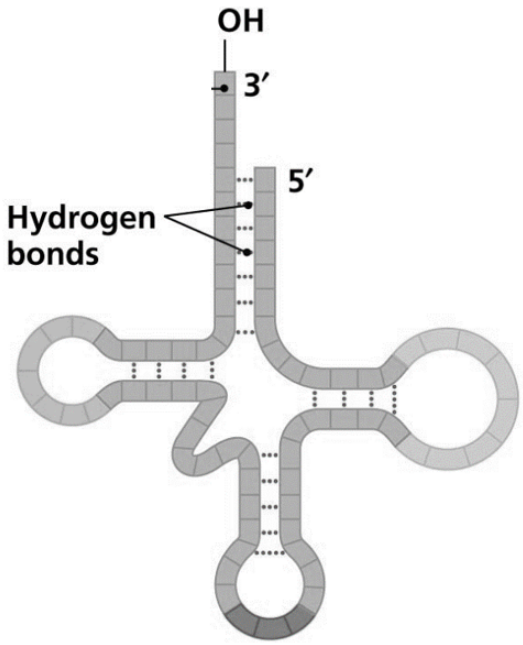


Fig. 3.1

(a) With reference to Fig. 3.1, explain the roles of hydrogen bonds in the proper functioning of tRNA.

1. H-bds are formed b/w compl bp allows folding of tRNA into (specific) 3D conformation / looped struc / clover-shape

for stability of tRNA (during activation & translation);

2. idea of folding, to fit into compl binding site of large ribosome subunit (P & A site);

3. idea of folding, to fit into active site of aminoacyl-tRNA synthase for tRNA activation;

4. H-bds formed b/w anticodons on tRNA with compl codons on mRNA; [3]

(b) The length of the tRNA gene is longer than that of the mature tRNA.

Outline how a **mature** tRNA molecule is synthesised in eukaryotes.

1. [initiation] RNA poly binds to promoter of tRNA gene to transcribe tRNA

together with basal TFs to form transcription initiation complex;

2. [elongation] adding of compl ribonucleotides from template to form pre-tRNA

modification of bases (addition of CCA stem) on pre-tRNA;

3. introns are excised & exons are spliced together

by spliceosomes to form mature tRNA; [3]

Fig. 3.2 shows a pathway in the regulation of gene expression to synthesise enzymes in a eukaryotic cell can be achieved.

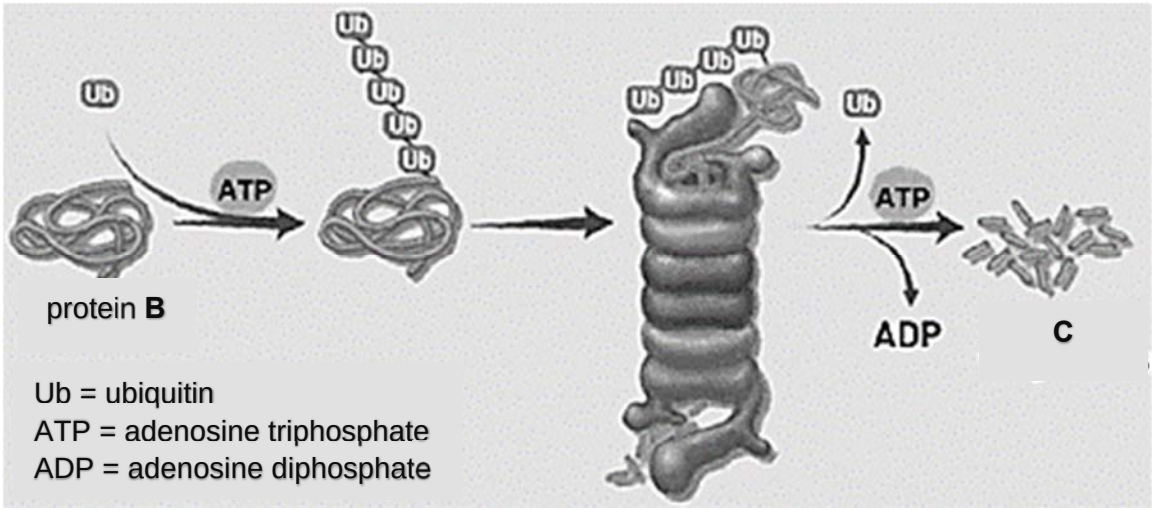


Fig. 3.2

(c) With reference to Fig. 3.2,

(i) name the process involved;

ubiquitination/ post translational modification/ proteolytic degradation; [1]

(ii) explain how product **C** is formed from protein **B**.

1. prot selected for degradation are tagged with/ bind to multiple ubiquitin mols

ATP is req'd in tagging process;

2. target prot tagged with ubiquitin enter proteasome

enz of proteasome hydrolyse peptide bonds;

3. into small peptide fragments

ubiquitin mols are released & re-used; [3]

[Total: 10]

4 Crossing over between homologous chromosomes is an important process that gave rise to genetic variation.

Errors during crossing over can result in abnormal chromosomes that will affect the phenotype of an organism.

Fig. 4.1 show the result of an unequal crossing over event in prophase I.

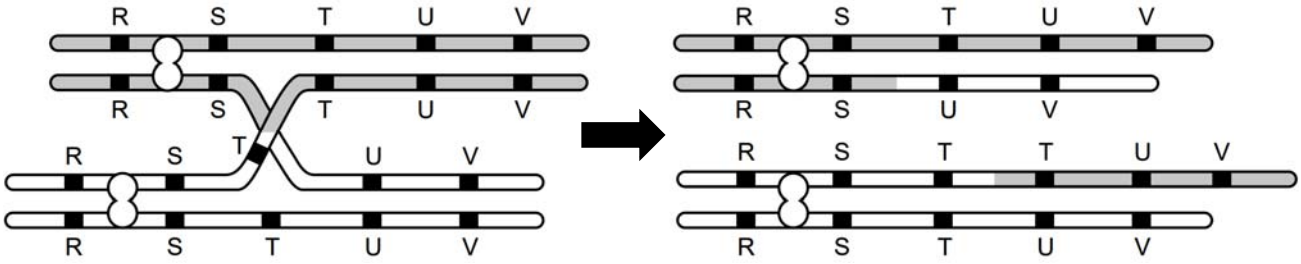


Fig. 4.1

(a) **(i)** State the type of mutation that has occurred in Fig. 4.1.

duplication of chr segment T / deletion of chr segment T; [1]

(ii) Suggest the possible effects on the phenotype of the organism if protein T is a hormone involved in metabolism.

duplication

1. more prot T pdc due to more mRNA transcribed from DNA template;

2. higher metabolism > normal; ***OR***

deletion

3. no prot T pdc due to no gene T transcribed;

4. lower metabolism < normal; [2]

gene T is a dominant allele, one copy is sufficient for expression into phenotype
(Any pair of answers)

Fig. 4.2 shows the human karyotype of one of the most common chromosomal abnormalities. The affected embryos or foetuses with this condition ended up in miscarriages in the first trimester.

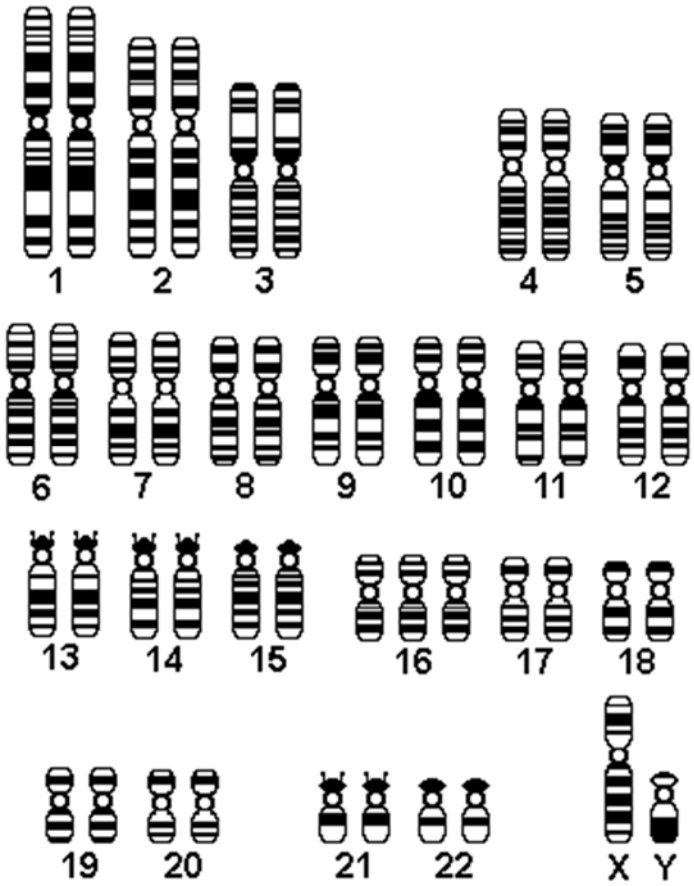


Fig. 4.2

(b) With reference to Fig. 4.2, explain how this condition arises.

1. trisomy 16 / w.t.e.;

2. aneuploidy

due to unequal separation of homolog chr (during anaphase I);

3. errors in spindle formation

resulted in one (haploid) gamete with 2 copies of chr 16;

4. fusion with a normal haploid gamete

restores diploid condition for all other chr pairs (except for chr 16); [4]

(c) Fig. 4.1 and Fig 4.2 are examples of chromosome aberration.

Use examples other than the ones shown, outline what does *chromosome aberration* mean.

1. changes to struc & nos of chr;

2. struc aberration can be due to translocation

exchange of chr segment b/w non-homolog chr; <u>OR</u>

3. struc aberration can be due to inversion

part of chr is cut out, reversed & reinserted back;

4. numerical aberration (of chr sets)

unequal separation of chr sets resulting in polyploidy; [3]

[Total: 10]

5 Two independently assorting genes coding for eye colour and the presence of wing crossveins in the *Drosophila* fruit fly were investigated in a few genetic crosses with different adults.

The outcomes of four crosses are shown below in Table 5.

Table 5

Cross	Parental phenotypes	Orange, crossveins present	Orange, crossveins absent	Red, crossveins present	Red, crossveins absent
1	orange, crossveins present, orange, crossveins present	83	26	0	0
2	red, crossveins present, red, crossveins absent	20	18	65	63
3	red, crossveins absent, red, crossveins present	0	0	71	81
4	red, crossveins present, red, crossveins present	28	11	93	34

(a) Using suitable symbols,

(i) deduce the genotypes of the adults in Cross 2.

Red, crossveins present ***RrPp;***

Red, crossveins absent ***Rrpp;*** [2]

(ii) explain why Cross 1 and Cross 3 have zero offspring in some phenotypic categories.

Cross 1

1. orange, recessive trait coded by rr

pure-breeding parents for eye colour;

Cross 3

2. red, dominant trait expressed with 1 allele copy

at least one parent has both copies of dominant alleles (RR) for eye colour; [2]

(b) In order to test the significance of differences between observed and expected results, a statistical test was carried out for Cross 4.

(i) Name the statistical test carried out.

Chi squared test;; [1]

(ii) State the expected offspring ratio.

9: 3: 3: 1;; [1]

(iii) Explain what does it mean when the results of the chi squared test has a probability of more than 0.05.

1. no sig diff b/w observed & expected results

genes assort independently & segregate randomly into gametes;

2. genes for eye colour & gene for presence of crossveins are not linked OR due to occurrence of chanced event (e.g. random fertilization, small sample size etc); [2]

(c) Using a named example, describe how the environment may affect the phenotype of organisms.

1. temp affecting coat colour of Himalayan rabbits;

black coat at temp <33^{o}C due to melanin pdtn by enzyme; (A) converse argument

2. prot content in diet affects devt of larvae in honey bees;

larvae fed with royal jelly continuously dev mature reproductive system & dev into the queen; (A) converse argument

3. AVP (state e.g.);

AVP (brief descriptions); [2]

[Total: 10]

6 Fig. 6.1 shows a section of a chloroplast.

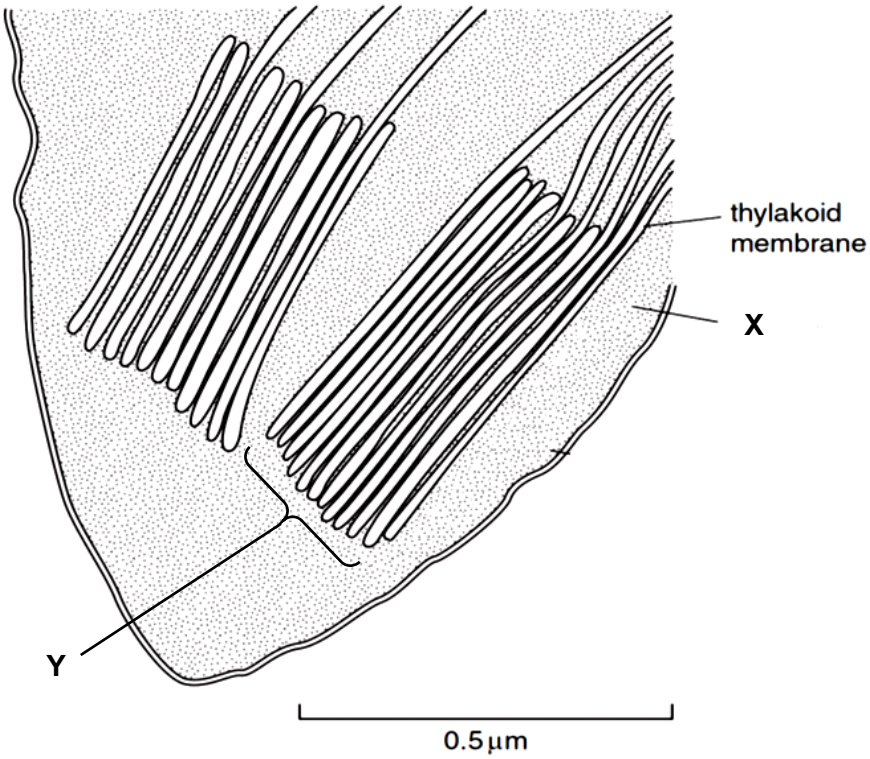


Fig. 6.1

(a) Identify structures **X** and **Y**.

X ***stroma;***

Y ***granum;*** [2]

Fig. 6.2 shows ATP synthase embedded in the thylakoid membrane.

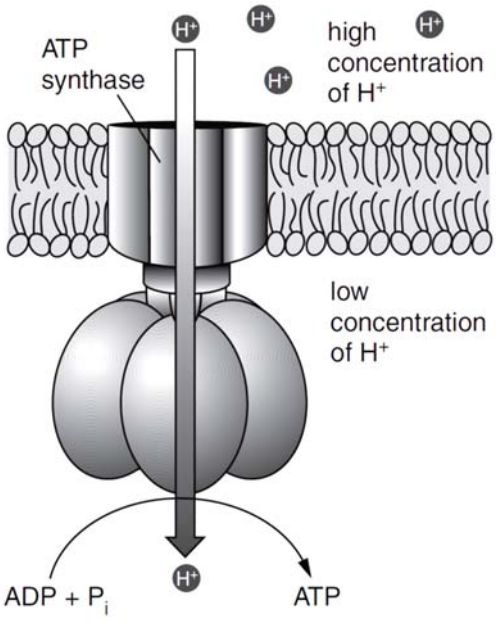


Fig. 6.2

(b) (i) Describe how the presence of light led to the synthesis of ATP.

1. photon of light accepted by PSII / chl a

cause photoactivation of chl a in rxn ctr / photoexcitation of e- in chl a;

2. e- is passed down on a series of e- carriers in ETC (to PSI)

of progressively lower energy level;

3. energy lost (during e- transfer) is used to pump/against conc grad H^+ ions from stroma to thylakoid lumen

accumulation of H^+ in thylakoid lumen creates a proton grad / motive force;

4. H^+ ions diffuse from thylakoid lumen back into stroma via (Fo of) ATP synthase

(F_1) catalyses phosphorylation of ADP → ATP, ATP synthesised via chemiosmosis; [4]

(ii) Describe the fate of ATP produced in Fig. 6.2.

1. provide en for Calvin cycle

reduction phase, GP → TP;

2. and phosphate grp

RuBP regeneration, TP → RuBP; [2]

Fig. 6.3 shows the relationship between CO_2 assimilation rate and increasing light intensity in a plant.

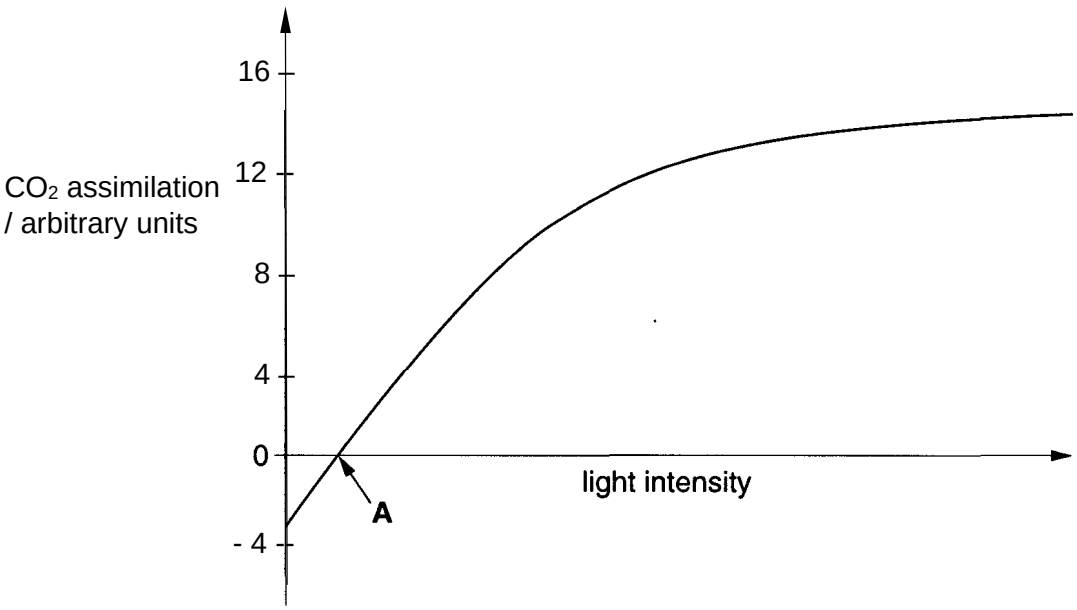


Fig. 6.3

(c) With reference to Fig. 6.3,

(i) State the total volume of CO_2 used by the plant for photosynthesis when light intensity is no longer the limiting factor.

14 + 3 = 17 arbitrary units; [1]

(ii) Describe the significance of point **A** to the growth of the plant.

1. A is the (light) compensation point

where PS rate = resp rate;

2. no net gain in dry mass thus no growth

as products of PS (glucose & O_2) are used up for resp and products of resp (H_2O & CO_2) are used up for PS; [2]

[Total: 11]

7 Fig. 7.1 shows the structure of the hormone, insulin, which is responsible for the regulation of blood glucose level back to its normal set point.

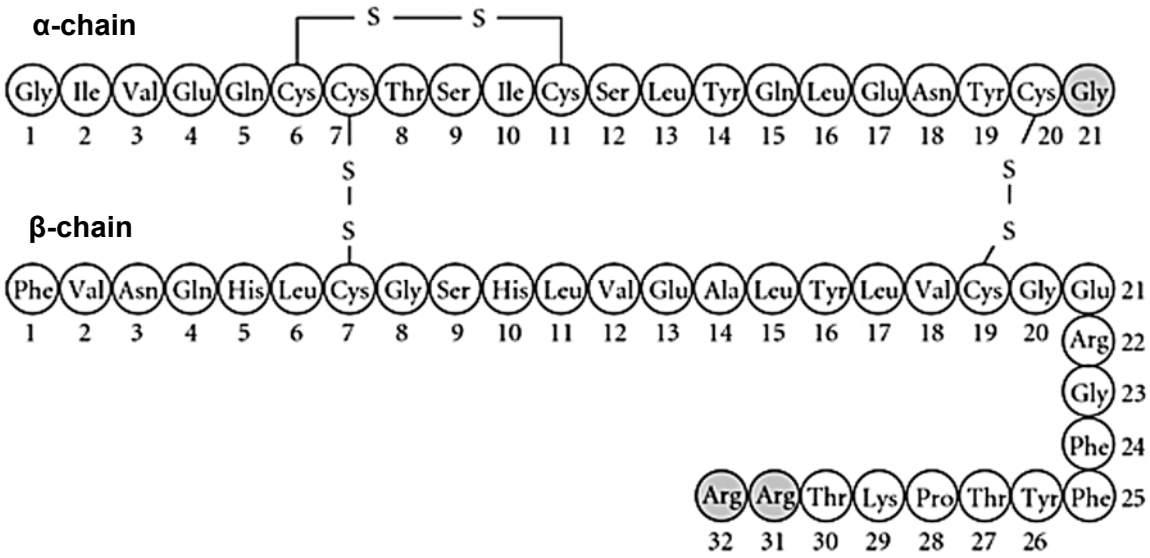


Fig. 7.1

(a) With reference to Fig. 7.1, describe the structure of insulin.

1. made up of 2 polypeptide chains

α chain with 21 aas and β chain with 32 aas / 53 aas in its pri prot struct

OR aas linked by peptide bonds;

2. presence of disulfide bridges

b/w (sulfhydryl grps) of cys residues;

3. (intrachain) within α-chain b/w cys at position 6 & 11;

4. (interchain) b/w chains at cys at position 7 in α-chain & position 7 in β-chain

OR cys at position 20 in α-chain & position 19 in β-chain; [3]

Metformin is used as a drug to treat hyperglycaemic conditions in patients with Type II diabetes where the skeletal muscles are resistant to insulin stimulation. It is transported into the cell by specific protein carrier.

Fig. 7.2 illustrates how metformin influences the cellular activity involved in the signal transduction pathway. AMPK is a kinase that is involved in energy sensing and is activated by AMP (adenosine monophosphate) which is the one of the products of ATP hydrolysis.

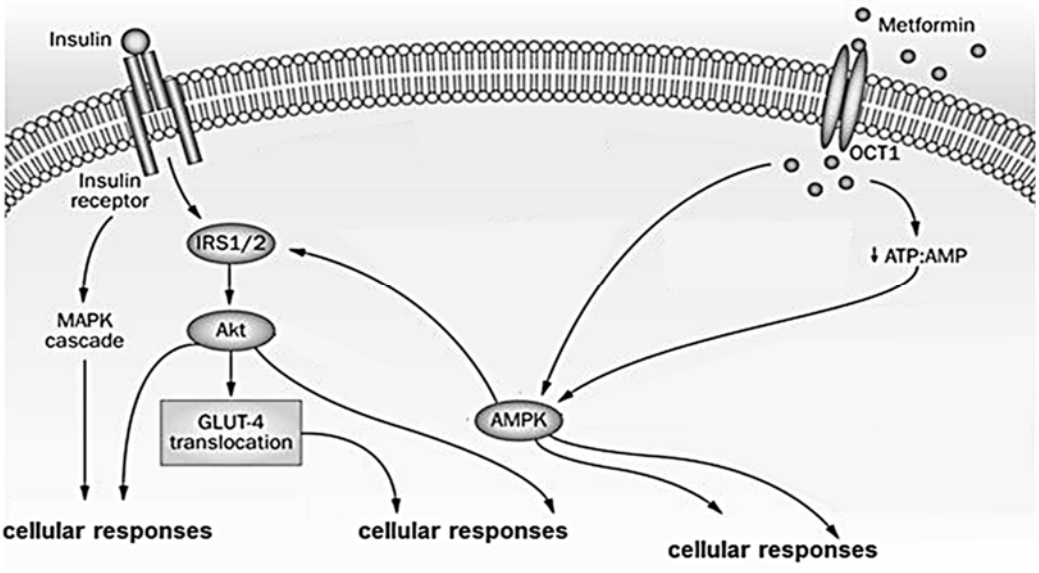


Fig. 7.2

(b) With reference to Fig. 7.2,

(i) explain how metformin can be used to decrease the blood glucose level in patients with Type II diabetes.

1. metformin enters cell via (prot channel / trspter) OCT1

by facilitated diffusion / which provides hydrophilic channel;

2. leads to ↓ ATP:AMP (by increasing ATP hydrolysis) / ↑ AMP

which activates AMPK;

3. AMPK phosphorylates & activates IRS1/2

which activates Akt;

4. activated Akt leads to ↑ GLUT-4 translocation to the CSM

leading to ↑ nos. of GLUT-4 on CSM ➡ ↑ glucose uptake into cell;

5. idea of activation of other cellular responses by Akt, AMPK

e.g. ⊕ glycogen synthase to ↑ glycogen synthesis
e.g. ⊘ glycogen phosphorylase to ↓ glycogen hydrolysis; [4]

(ii) Akt is known to stimulate other cellular responses in the insulin signalling pathway.

Suggest how activation of Akt can lead to different cellular responses.

1. ***acts as relay prot / 2nd messenger;***
2. ***that can bind to / activate diff relay prot / kinases (to cause phosphorylation cascade in other signalling pathways) ;***
3. ***leading to activation / inactivation of diff enz that can catalyse diff cellular rxns / cite e.g.;***
4. ***acts as TFs that can up / downregulate expression of diff genes;*** [3]

[Total: 10]

8 A mammoth can be any species belonging to the extinct genus *Mammuthus*, proboscideans commonly equipped with long, curved tusks. They were members of the family Elephantidae which contains, along with mammoths, the two genera of modern elephants and their ancestors.

About three million years ago, the ancestors of mammoths migrated from Africa into Europe and Asia. There, about 1.7 million years ago, the steppe mammoth evolved and became adapted to the cooler conditions. Then, about 700 000 years ago, as the climate changed and the Arctic became much colder, the woolly mammoth evolved.

Woolly mammoths showed a number of obvious adaptations to reduce heat loss, including thick fur, small ears and small tails.

(a) Explain how variation and natural selection may have brought about the evolution of the woolly mammoth from the steppe mammoth.

1. steppe mammoth w phenotypic variation (due to presence of diff alleles / genetic variation / mutation)

climate ⊿ (700 000 yr ago) colder temp act as selection pressure;

2. mammoth w favourable phenotype / adaptations to reduce heat loss selected for / have selective advantage

e.g. thick fur, small ears and small tails;

3. such mammoths experience ↑er survival rate & repro success

pass down alleles coding for favourable phenotype to offspring lead to ⊿ in allele frequency in gene pool;

4. accumulate mutations in gene pool over time

becomes genetically diverged from steppe mammoth ancestor ➡ evolve to become woolly mammoth; [4]

(b) The phylogenetic relationship of the woolly mammoth, Asian elephant (*Elephas maximus*) and African elephant (*Loxodonta africana*) was then investigated.

Fig. 8.1 shows the phylogenetic tree obtained.

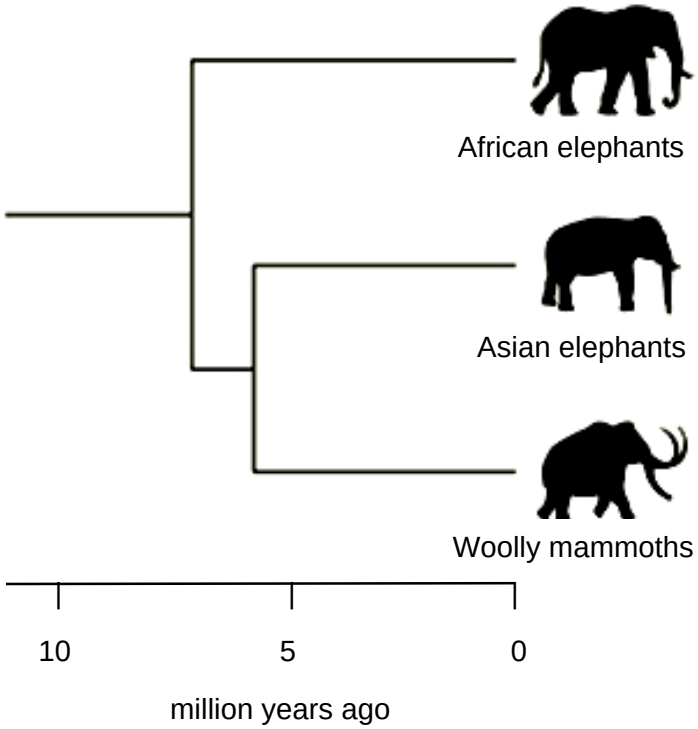


Fig. 8.1

With reference to Fig. 8.1, state

(ii) when the African elephant diverged;

7.5 million years ago; [1]

(iii) when the Asian elephant diverged.

6 million years ago; [1]

(c) Explain how molecular methods can be used to construct the phylogenetic tree in Fig. 10.1.

1. select a common gene / prot among the 3 species to compare the DNA / aa seq;

2. ↓er no. of differences → share more recent common ancestor ORA as they have less time to accumulate diff mutations / used to calculate length of time since divergence; [2]

[Total: 8]

9 Cholera is an infectious disease caused by the bacterium *Vibrio cholerae*. The bacteria are transmitted between humans through the fecal-oral route. Contaminated food or water can cause infection which symptoms can occur very quickly, from a few hours to a few days.

Table 9 shows
- the economic status of each of five countries
- the number of cases of cholera reported to the World Health Organization (WHO) over a five year period for each country
- the population in 2006 and in 2010 of each country.

Table 9

country	economic status	number of cholera cases reported			population / millions	
		2006	2008	2010	2006	2010
Zimbabwe	low	789	60055	951	12.5297	12.5715
Uganda	low	5194	3726	2341	29.3703	33.4247
Angola	middle	67257	10511	1484	17.0104	19.0819
Cameroon	middle	922	0	10759	17.9484	19.5989
Canada	high	2	1	2	32.6490	34.1088

(a) With reference to Table 9,

(i) suggest **two** reasons to explain the higher number of cholera cases reported in low economic status countries compared to high economic status country.

1. poor / inadequate sanitation / treatment of sewage;

2. no / poor water treatment → contaminated water;

3. poor access to healthcare

antibiotics / drugs / medication / vaccines not available;

4. less education about disease prevention / transmission or poor hygiene practices e.g. not washing hands; [2]

(Any 2 points)

(ii) suggest if economic status of a country is likely to be the main reason for the high number of cases of cholera.

1. no

quote any country with middle economic status e.g. Angola (67257 in 2006) having higher no. of cases than country with low status e.g. Uganda (5194 in 2006);

2. other reasons like war / famine etc.; [2]

(b) Cholera can be treated with antibiotics like tetracycline.

(i) Suggest how tetracycline results in the death of the bacterium.

1. inhibits prot synthesis OR
<u>cell wall synthesis in bact</u>
lack of essential metabolic enz causing bact cell death; OR
<u>bact cell undergoes (osmotic) lysis due to weakened cell wall;</u>

2. by binding to ribo subunit OR
<u>transpeptidase</u>
preventing formation of translation initiation cplx / translation OR
<u>prevents cross linking of peptidoglycan in cell wall;</u> [2]

(ii) Explain why tetracycline does not cause death of human cells.

1. humans have 80S ribo instead of 70S in bact with diff 3D config that tetracycline cannot bind; OR

<u>human cells do not synthesize cell wall;</u> [1]

[Total: 7]

10 Dengue fever is a mosquito-borne viral disease and a regular epidemic in Thailand. The peak of the dengue epidemic period is around June to August during the rainy season. It is believed that climate is an important factor for dengue transmission.

Fig. 10.1 shows how changes in temperature affects the average monthly incidence rate of dengue cases in Chiang Rai, Thailand from 2004 – 2014.

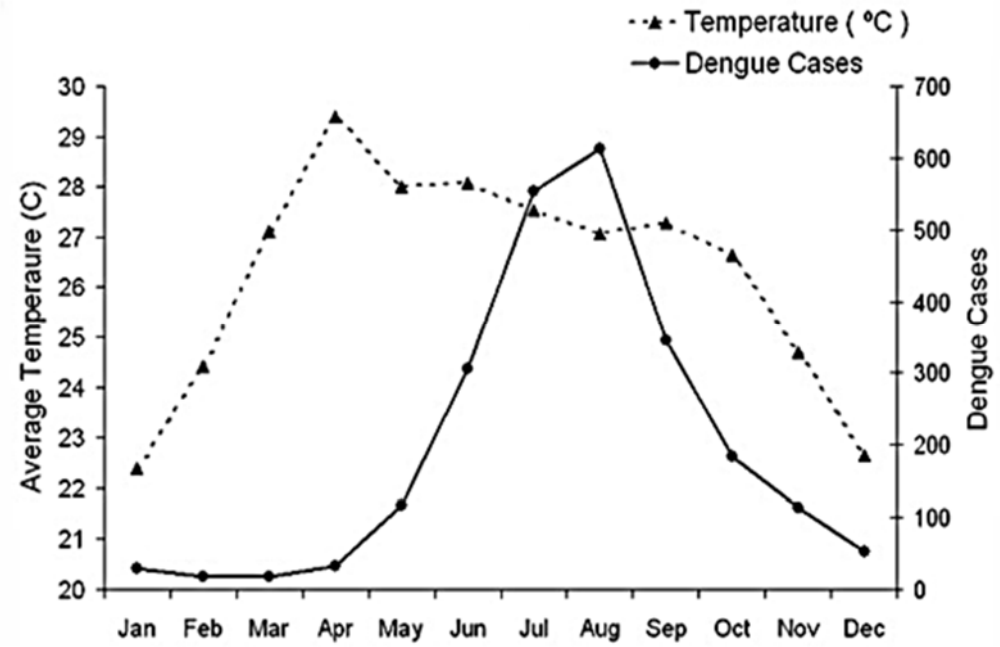


Fig. 10.1

(a) State how each data point in Fig. 10.1 is obtained.

average calculation of all temp in same month from 2004 – 2014; [1]

(b) With reference to Fig. 10.1,

(i) describe the trend of incidence of dengue cases with regard to changes in temperature;

1. temp ↑ sharply from 22 – 29.5 ºC from Jan to Apr

almost constant no. of dengue cases at 20 cases;

2. temp ↓ from 29.5 – 23 ºC from Apr to Dec

steep ↑ in dengue cases from 20 – 620 from Apr to Aug

steep ↓ in dengue cases from Aug to Dec from 620 – 50; [2]

(ii) explain the trend described in **(b)(i).**

1. ↑ in ave temp ↑ metabolic activity in mosquitoes

↑ in freq of effective collisions b/w E & S ➡ more ES cplx formed;

2. faster growth rate ➡ faster maturation rate

shorter time needed to complete life cycle;

3. more adult mosquitoes available to become vectors for dengue virus to infect more human host leading to ↑ no. dengue cases observed in <u>subsequent months</u> after ↑ in temp due to time needed for mosquito to grow and mature; [3]

[Total: 6]

INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CG | | | | | | INDEX NUMBER | | | | |

BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

12 September 2018

Candidates answer on the Question Paper.

2 hours

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, CG and index number on page 1, 5, 9 and 13 in the spaces provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, 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.

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.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/15
2	/20
3	/15
4 or 5	/25
Total	/75

This document consists of **18** printed pages.

Section A

Answer **all** the questions in this section.

1 Red blood cells are formed from cells called reticulocytes. Stem cells in the bone marrow produce reticulocytes which differentiate into red blood cells. Red blood cells have an average life span of 120 days, after which they are destroyed in the liver.

(a) Describe how stem cells in the bone marrow produce red blood cells.

.....

.....

.....

..... [2]

New red blood cells are constantly produced in the bone marrow as stem cells, unlike other somatic cells, can divide throughout the lifespan of the individual. Somatic cells undergo a limited number of cell divisions as the DNA daughter strand is shortened with every replication.

Fig. 1.1 shows the shortened daughter strand with its parent template after a replication.

Fig. 1.1

(b) **(i)** Explain why the daughter DNA strand is shortened after each replication.

.....

.....

.....

..... [2]

(ii) Explain why stem cells are able to divide throughout the lifespan of the individual.

.....

.....

.....

..... [2]

During differentiation, haemoglobin is produced. Fig. 1.2 shows the structure of a section of the haemoglobin gene and its corresponding messenger RNA (mRNA) in the nucleus of a reticulocyte during transcription.

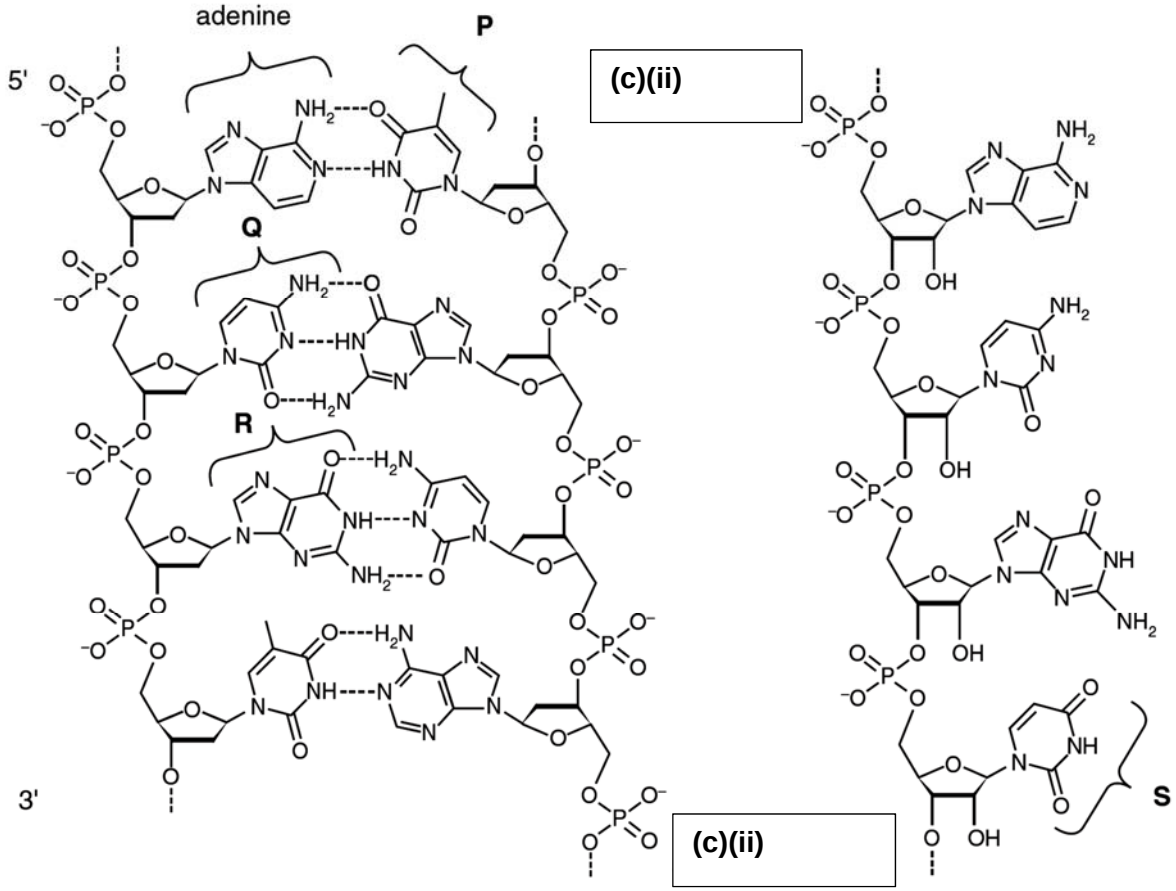


Fig. 1.2

(c) **(i)** Identify structures **P – S**.

P .....

Q .....

R .....

S ..... [2]

(ii) On Fig. 1.2, label the 5' and 3' end of the mRNA molecule. [1]

(iii) Briefly describe the fate of the mRNA molecule after transcription before its export out of the nucleus.

[3]

(d) Describe **two** differences between transcription and DNA replication.

[2]

(e) Suggest **one** additional change, besides production of haemoglobin that occurs to produce reticulocytes during their differentiation into red blood cells.

[1]

[Total: 15]

Name: _____
Index No.: _____ CG: 17____

2 Lactate dehydrogenase (LDH) is an enzyme found in many organisms. Within the same organism, it can be found in different forms, called isoenzymes. The isoenzymes are structurally different but they all catalyse the same reaction.

Fig. 2.1 shows a reaction catalysed by lactate dehydrogenase that occurs during anaerobic respiration in muscle tissue.

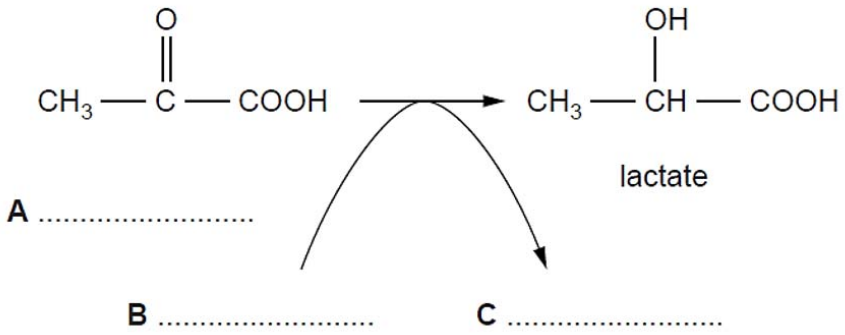


Fig. 2.1

(a) With reference to Fig. 2.1,

(i) identify compounds **A**, **B** and **C**.

A .....

B .....

C ..... [2]

(ii) state the location in the cell where this reaction takes place.

..... [1]

(iii) explain the significance of this reaction in mammalian muscle tissue.

.....

.....

.....

.....

.....

..... [3]

Lactate dehydrogenase isoenzymes are globular proteins, each consisting of four polypeptides.

(b) Explain how the structure of an enzyme, such as lactate dehydrogenase is suited to its role.

[4]

Lactate dehydrogenase isoenzymes are made up of two types of polypeptide: polypeptide M, which is coded for by the *LDH-A* gene and polypeptide H, which is coded for by the *LDH-B* gene.

Table 2.1 shows the composition of different human lactate dehydrogenase isoenzymes and examples of tissues and organs where each can be found.

Table 2.1

isoenzyme	polypeptide composition of enzyme	example of isoenzyme location
LDH-1	HHHH	heart red blood cells
LDH-2	HHHM	heart red blood cells
LDH-3	HHMM	brain lungs
LDH-4	HMMM	kidneys placenta
LDH-5	MMMM	liver skeletal muscles

(c) With reference to Table 2.1, suggest how red blood cells of the same individual can produce different isoenzymes.

[2]

Besides lactate dehydrogenase, another extensively studied protein which is also involved in respiration is cytochrome c. Cytochrome c plays an important role in oxidative phosphorylation as an electron carrier of the electron transport chain.

Table 2.2 shows the amino acid sequence of a section of the cytochrome c polypeptide chain retrieved from 1 individual from each of the species below. The dashes shown in the figure indicates that the amino acid present at the position is identical to that of the human species.

Table 2.2

		1					6				10				14			17	18		20		
Human		Gly	Asp	Val	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Ile	Met	Lys	Cys	Ser	Gln	Cys	His	Thr	Val	Glu	Lys
Pig		-	-	-	-	-	-	-	-	-	-	Val	Gln	-	-	Ala	-	-	-	-	-	-	-
Chicken		-	-	Ile	-	-	-	-	-	-	-	Val	Gln	-	-	-	-	-	-	-	-	-	-
Dogfish		-	-	-	-	-	-	-	-	Val	-	Val	Gln	-	-	Ala	-	-	-	-	-	-	Asn
Drosophila	<<<	-	-	-	-	-	-	-	-	Leu		Val	Gln	Arg		Ala	-	-	-	-	-	-	Ala
Wheat	<<<	-	Asn	Pro	Asp	Ala	-	Ala	-	-	-	Lys	Thr	-	-	Ala	-	-	-	-	-	Asp	Ala
Yeast	<<<	-	Ser	Ala	Lys	-	-	Ala	Thr	Leu	-	Lys	Thr	Arg	-	Glu	Leu	-	-	-	-	-	-

(d) With reference to Table 2.2,

(i) suggest what information indicates about the evolutionary relationships between humans and the other species;

.....

.....

.....

..... [3]

(ii) explain why the stated conclusion in **(d)(i)** needs to be treated with caution.

.....

.....

.....

..... [2]

(e) Suggest how the differences in the amino acid sequences shown in Table 2.2 may have arisen.

.....

.....

.....

..... [2]

(f) Suggest why the cytochrome c protein was chosen to compare amino acid sequences across the different species.

.....

..... [1]

[Total: 20]

Name: _____
Index No.: _____ CG: 17____

3 A student cut thin sections of a root tip of *Allium cepa* (*A. cepa*) and stained them to show chromosomes. A photomicrograph of part of one of these sections is shown in Fig. 3.1.

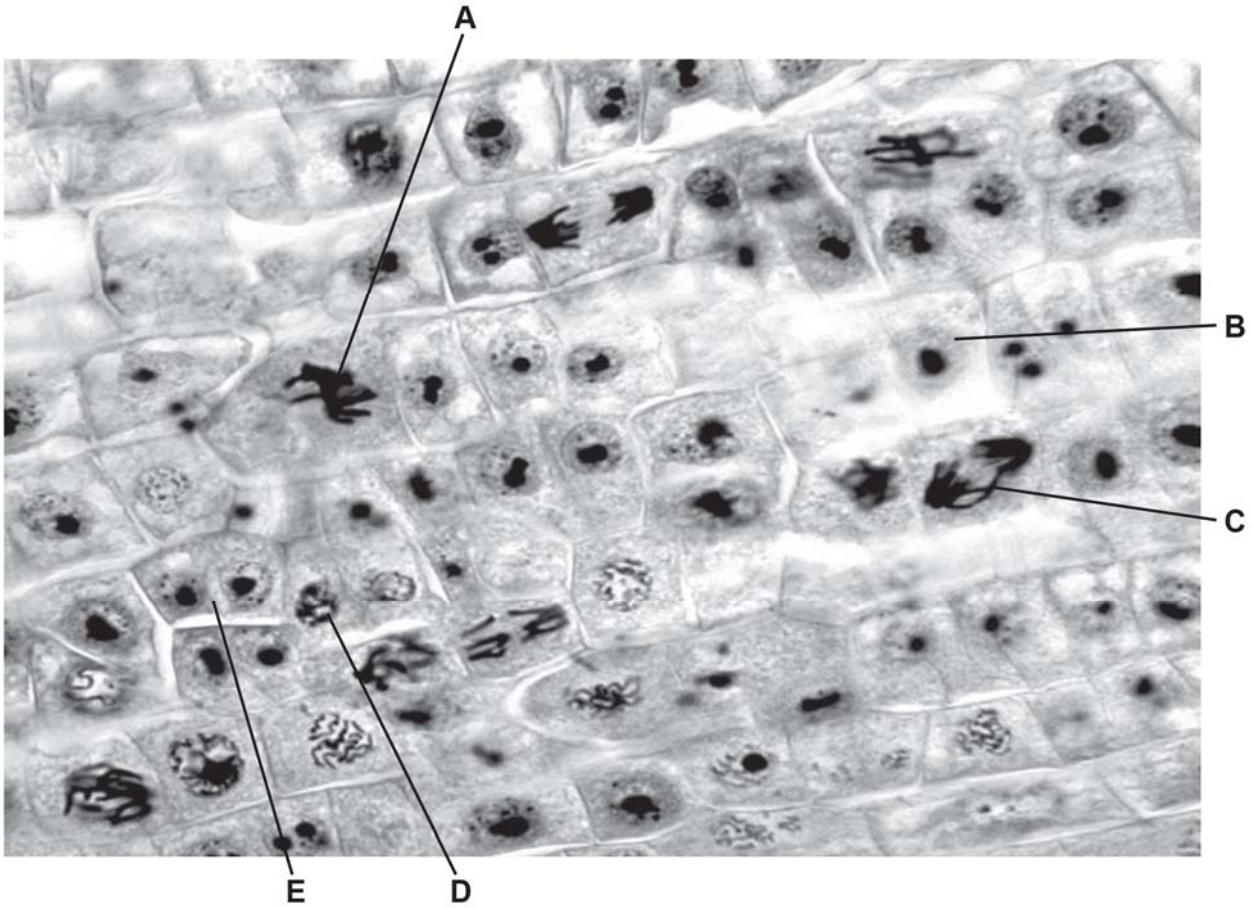


Fig. 3.1

(a) Table 3.1 shows the behaviour of chromosomes and the changes that occur to the nuclear envelope during a mitotic cell cycle in the root tip of *A. cepa*.

Complete Table 3.1.

Table 3.1

name of stage	letter of cell	behaviour of chromosomes	nuclear envelope
	B	uncondensed, may be replicating	
prophase			intact, eventually breaks down
metaphase			Not present
anaphase			Not present
telophase		uncoil/ to become thin chromatin threads	

[5]

(b) Explain why the growth of roots, such as those of *A. cepa*, involves mitosis and not meiosis.

[3]

(c) Some bacteria infect the plant to result in tumour formation at the infected tissues as shown in Fig. 3.2.

Research on the tumour formation processes revealed that there was an unusual excessive production of auxin, an important plant growth hormone. Auxin has been found to regulate gene expression resulting in cell division, expansion, differentiation and specialisation.

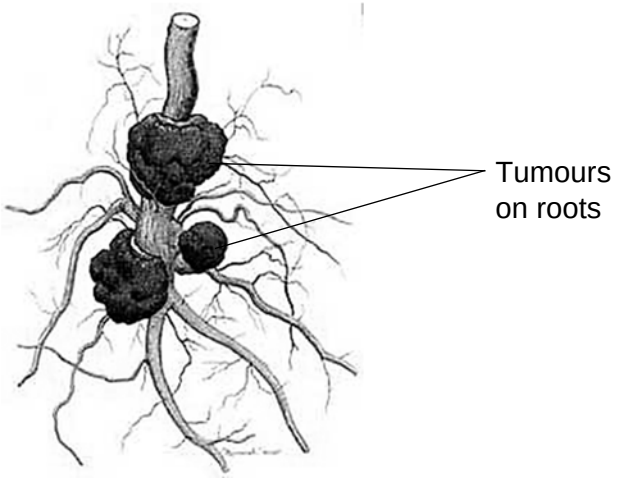


Fig. 3.2

Suggest how the bacteria infection resulted in tumour formation.

[3]

(d) A protein, mitosis promoting factor (MPF), has been identified in cells and has a role in initiating prophase.

MPF is made up of cyclin B1 coupled with cyclin-dependent kinase 1 (CDK1) and normally begins to break down and stops functioning during anaphase.

An overexpression of cyclin B1 has been reported in various human tumours, and is related to aneuploidy and high growth rate for cancerous growths in the breast.

(i) Suggest reasons for the overexpression of cyclin B1.

[3]

(ii) State what does *aneuploidy* mean.

[1]

[Total: 15]

Question 4 and 5 starts on Page 13

Name: _____

Index No.: _____ CG: 17____

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 parts **(a)** and **(b)**, as indicated in the question.

4 **(a)** ATP is known as the universal currency of energy in living organisms. It can be utilised and regenerated in various chemical and physical reactions that occur in living systems.

With reference to named examples, outline the roles of ATP in living organisms. [13]

(b) Plasma membranes exist on the surface of cells and in the endomembrane systems within the cells. They play critical roles in the regular functioning of a cell.

Discuss the functions of various components in plasma membrane and explain why there is a different composition of these components in membranes of different cells and organelles. [12]

[Total: 25]

5 The immune system responds to foreign antigens by producing specific immune responses to remove the antigen.

(a) Outline the processes involved in the generation of antibody diversity which allowed the humoral immunity to be effective in both the primary and secondary response. [12]

(b) The human immunodeficiency virus (HIV) is a retrovirus that causes AIDS. The infected person has a weakened immune system and is susceptible to opportunistic infections which can lead to their death.

Describe the HIV reproductive cycle and explain how these opportunistic infections may arise. [13]

[Total: 25]

INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME **ANSWERS**

CG | | | | | | INDEX NUMBER | | | | |

BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

12 September 2018

Candidates answer on the Question Paper.

2 hours

No Additional Materials are required.

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Section B
Answer any **one** question in the spaces provided on the Question Paper.

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.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/15
2	/20
3	/15
4 or 5	/25
Total	/75

This document consists of **18** printed pages.

Section A

Answer **all** the questions in this section.

1 Red blood cells are formed from cells called reticulocytes. Stem cells in the bone marrow produce reticulocytes which differentiate into red blood cells. Red blood cells have an average life span of 120 days, after which they are destroyed in the liver.

(a) Describe how stem cells in the bone marrow produce red blood cells.

1. asymmetrical division

1 remain SC, the other becomes (myeloid) progenitor cell ;

2. which further divides to give rise to erythroid lineage

which produces reticulocytes that differentiates into RBCs ; [2]

New red blood cells are constantly produced in the bone marrow as stem cells, unlike other somatic cells, can divide throughout the lifespan of the individual. Somatic cells undergo a limited number of cell divisions as the DNA daughter strand is shortened with every replication.

Fig. 1.1 shows the shortened daughter strand with its parent template after a replication.

Fig. 1.1

(b) **(i)** Explain why the daughter DNA strand is shortened after each replication.

1. end replication problem

DNA pol can only elongate a pre-existing strand w a free 3'OH end ;

2. no preceding strand exist after removal of the last / terminal primer at the 5' end of the daughter strand

thus a gap occurs in the daughter strand, with a 3' overhang in the parent strand ; [2]

(ii) Explain why stem cells are able to divide throughout the lifespan of the individual.

1. due to presence of active telomerase

that lengthens parent strand (by several tandem repeats) ;

2. to (act as template for) primase to synthesize another primer further upstream

for DNA pol (III) to synthesize daughter strand that is as long as the initial parent strand ; [2]

During differentiation, haemoglobin is produced. Fig. 1.2 shows the structure of a section of the haemoglobin gene and its corresponding messenger RNA (mRNA) in the nucleus of a reticulocyte during transcription.

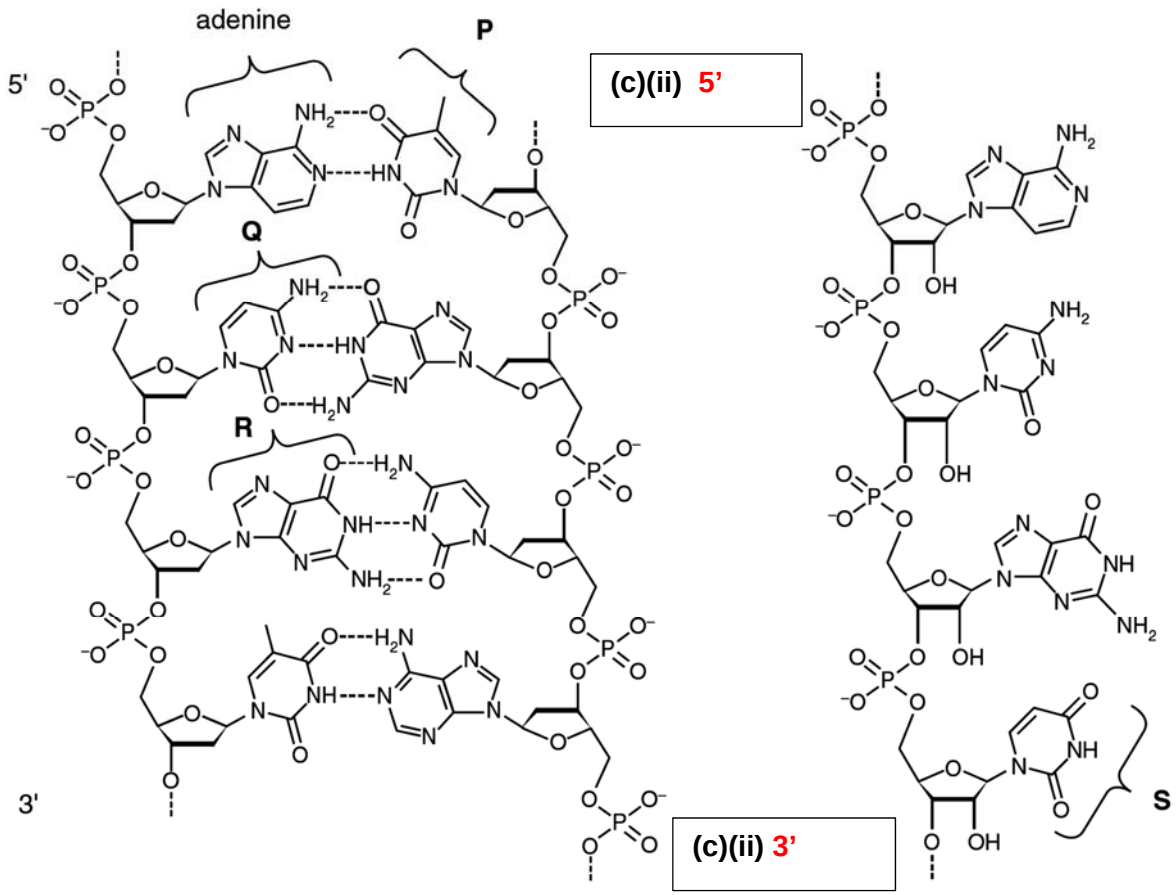

Fig. 1.2

(c) **(i)** Identify structures **P – S**.

P ***thymine***

Q ***cytosine***

R ***guanine***

S ***uracil*** [2]

(ii) On Fig. 1.2, label the 5' and 3' end of the mRNA molecule. [1]

(iii) Briefly describe the fate of the mRNA molecule after transcription before its export out of the nucleus.

1. 5' capping

addition of methylated guanine (residue) at 5' end ;

2. 3' polyadenylation

addition of <u>multiple</u> adenine residues/nucleotides at 3' end (after polyadenylation signal) ;

3. splicing

removal of introns, joining of exons (by splicesome) ; [3]

(d) Describe **two** differences between transcription and DNA replication.

1. template

2 DNA parent strand vs 1 DNA template / nonsense strand ;

2. product

(two) DNA molecules (each consisting of 1 parent coiled w 1 daughter strand) vs RNA / uses deoxyribonucleotides vs ribonucleotides ;

® thymine vs uracil ® rRNA vs 1 daughter strand / 2 daughter strand (implies 2 daughter strands coiled together)

3. enz

DNA pol vs RNA pol ; [2]

® primase / helicase / topoisomerase vs none

(e) Suggest **one** additional change, besides production of haemoglobin that occurs to produce reticulocytes during their differentiation into red blood cells.

1. degradation of nucleus

(by hydrolytic enz in lysosome / fusion w lysosome / autophagy) ; [1]

[Total: 15]

2 Lactate dehydrogenase (LDH) is an enzyme found in many organisms. Within the same organism, it can be found in different forms, called isoenzymes. The isoenzymes are structurally different but they all catalyse the same reaction.

Fig. 2.1 shows a reaction catalysed by lactate dehydrogenase that occurs during anaerobic respiration in muscle tissue.

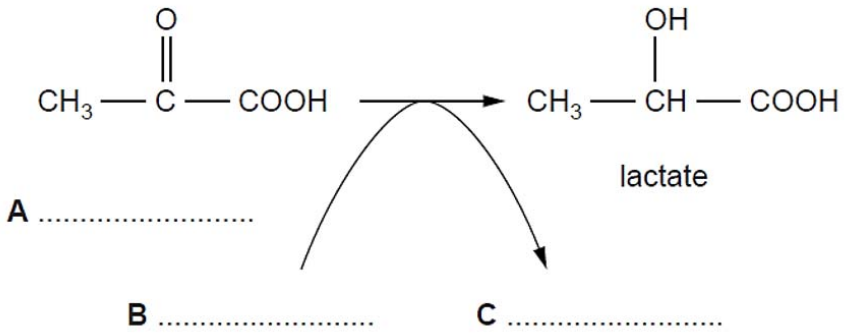

Fig. 2.1

(a) With reference to Fig. 2.1,

(i) identify compounds **A**, **B** and **C**.

A ***pyruvate;***

B ***reduced NAD/ NADH + H^+;***

C ***oxidised NAD/ NAD+;*** [2]

(ii) state the location in the cell where this reaction takes place.

cytosol; [1]

(iii) explain the significance of this reaction in mammalian muscle tissue.

1. pyruvate reduced to lactate

In absence of O_2 in anaerobic respiration;

2. where NADH is oxidised to NAD

allows NAD regeneration for glycolysis to continue;

3. allows ATP pdtn for glycolysis to continue for muscle contraction

Lactate converted back into pyruvate & glucose in liver; [3]

Lactate dehydrogenase isoenzymes are globular proteins, each consisting of four polypeptides.

(b) Explain how the structure of an enzyme, such as lactate dehydrogenase is suited to its role.

1. has 4º prot struc (4 polypeptides)

each polypeptide has 3º struc held in place by bds/ interxns b/w R grps of aas;

2. bonds/ interxns (e.g. H bds, hydrophobic interxns) b/w polypeptides

forms specific 3D config with active site compl to substrate;

3. active site is compl (shape, size, charged, orientation)

brings catalytic residues nearer each other in active site;

4. ES complex formation lowers E_a for catalysis

bond angle (stress bonds)/ favourable microenv/ stabilize transition state;

5. globular prot with hydrophilic aas on exterior allowing prot to be soluble

rxns in aqueous medium/ ref to tpt of enz; [4]

Lactate dehydrogenase isoenzymes are made up of two types of polypeptide: polypeptide M, which is coded for by the *LDH-A* gene and polypeptide H, which is coded for by the *LDH-B* gene.

Table 2.1 shows the composition of different human lactate dehydrogenase isoenzymes and examples of tissues and organs where each can be found.

Table 2.1

isoenzyme	polypeptide composition of enzyme	example of isoenzyme location
LDH-1	HHHH	heart red blood cells
LDH-2	HHHM	heart red blood cells
LDH-3	HHMM	brain lungs
LDH-4	HMMM	kidneys placenta
LDH-5	MMMM	liver skeletal muscles

(c) With reference to Table 2.1, suggest how red blood cells of the same individual can produce different isoenzymes.

1. genome of rbc progenitor cells contains both genes that code for LDH-A & LDH-B polypeptides;

2. diff expression of genes at diff times & locations of cell pdc diff isoenzymes (QV frm Table 2.1); OR

3. ctrl of assembly of polypeptides to pdc diff prots/ diff polypeptide chains make up diff prots;

4. ***diff R grp interxns b/w diff polypeptide chains, resulting diff 4° struc/ specific 3D config (QV frm Table 2.1);*** [2]

Besides lactate dehydrogenase, another extensively studied protein which is also involved in respiration is cytochrome c. Cytochrome c plays an important role in oxidative phosphorylation as an electron carrier of the electron transport chain.

Table 2.2 shows the amino acid sequence of a section of the cytochrome c polypeptide chain retrieved from 1 individual from each of the species below. The dashes shown in the figure indicates that the amino acid present at the position is identical to that of the human species.

Table 2.2

		1					6				10				14			17	18		20		
Human		Gly	Asp	Val	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Ile	Met	Lys	Cys	Ser	Gln	Cys	His	Thr	Val	Glu	Lys
Pig		-	-	-	-	-	-	-	-	-	-	Val	Gln	-	-	Ala	-	-	-	-	-	-	-
Chicken		-	-	Ile	-	-	-	-	-	-	-	Val	Gln	-	-	-	-	-	-	-	-	-	-
Dogfish		-	-	-	-	-	-	-	-	Val	-	Val	Gln	-	-	Ala	-	-	-	-	-	-	Asn
Drosophila	<<<	-	-	-	-	-	-	-	-	Leu		Val	Gln	Arg		Ala	-	-	-	-	-	-	Ala
Wheat	<<<	-	Asn	Pro	Asp	Ala	-	Ala	-	-	-	Lys	Thr	-	-	Ala	-	-	-	-	-	Asp	Ala
Yeast	<<<	-	Ser	Ala	Lys	-	-	Ala	Thr	Leu	-	Lys	Thr	Arg	-	Glu	Leu	-	-	-	-	-	-

(d) With reference to Table 2.2,

(i) suggest what information indicates about the evolutionary relationships between humans and the other species;

1. ***all spp share a common ancestor/ prot is highly conserved;***
2. ***smaller the no. of diff^{ce} more closely related/more recently divergence occurred/ lesser time to accumulate diff mutations;***
3. ***pigs & chickens are phylogenetically closest to humans with only 3 no. of aas diff from humans***

yeast is most distantly related to humans with 11 aas diff from humans; [3]

(ii) explain why the stated conclusion in **(d)(i)** needs to be treated with caution.

1. ***c.f. aa seq (22 aas) is only coded by a small fraction of whole genome;***
2. ***cyt c is likely to be a larger polypeptide/ prot, hence not good representation; OR***
3. ***aa seq in Table 2.2 comes from 1 indiv of each spp, should be variation within each spp;***
4. ***small sample size/ use of aa seq does not allow detection of silent mutations due to degeneracy of genetic code; OR***
5. ***aa seq only reflects coding region of DNA seq;***
6. ***changes in non-coding regions are not detected as these spp are eukaryotic, hence larger non-coding regions;*** [2]

(e) Suggest how the differences in the amino acid sequences shown in Table 2.2 may have arisen.

1. ***point/ missense mutation in nucleotide seq causing change in single base via substitution; OR***

mis-pairing of compl bases (e.g. pyrimidine dimers) during DNA replication;

2. ***by mutagens e.g. UV, X-rays, ionising radiation;*** [2]

(f) Suggest why the cytochrome c protein was chosen to compare amino acid sequences across the different species.

1. cyt c prot is ubiquitous/ present in all org as all org need to respire hence serves as a good comparison b/w org; OR

cyt c gene is an essential gene that changes very slowly, useful for estimating time of divergence that occurred long time ago; [1]

[Total: 20]

3 A student cut thin sections of a root tip of *Allium cepa* (*A. cepa*) and stained them to show chromosomes. A photomicrograph of part of one of these sections is shown in Fig. 3.1.

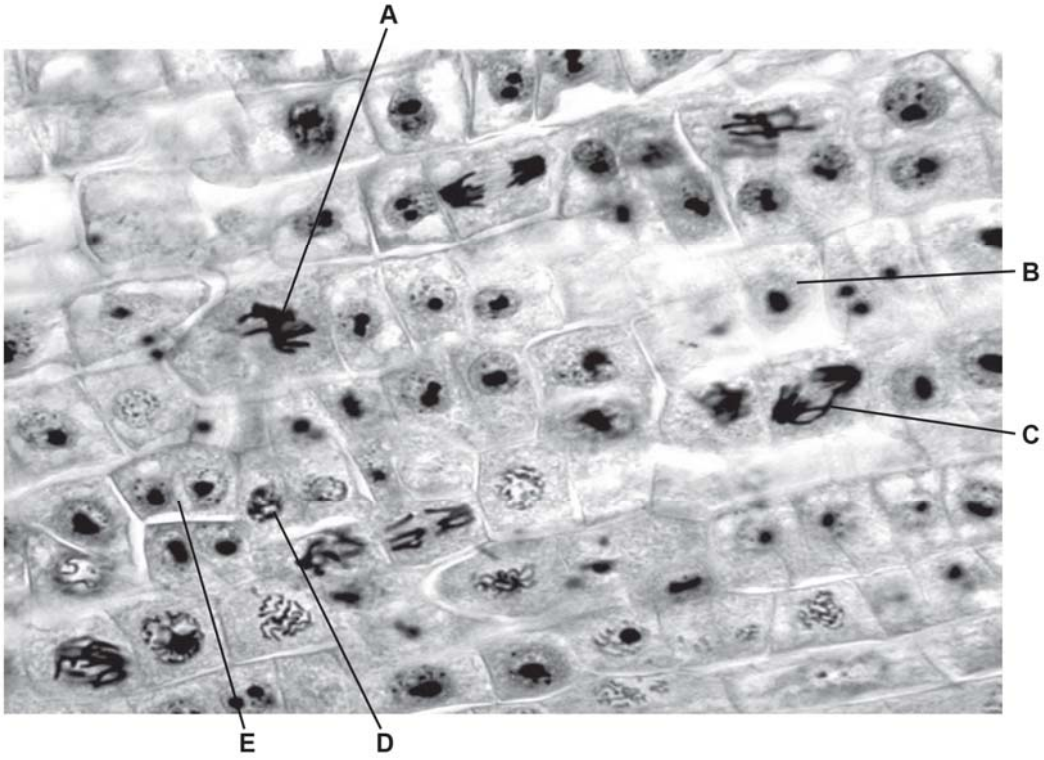

Fig. 3.1

(a) Table 3.1 shows the behaviour of chromosomes and the changes that occur to the nuclear envelope during a mitotic cell cycle in the root tip of *A. cepa*.

Complete Table 3.1.

Table 3.1

name of stage	letter of cell	behaviour of chromosomes	nuclear envelope
interphase	B	uncondensed, may be replicating	***present / intact***
prophase	***D***	***condensed, visible as chromosome / 2 sis chromatids held at centromere***	intact, eventually breaks down
metaphase	***A***	***aligned (in a single row) at equatorial / metaphase plate ® equator alone, mddle of cell***	Not present
anaphase	***C***	***move to oppo / spindle poles of cell ® oppo ends of cell***	Not present
telophase	***E***	uncoil / to become thin chromatin threads	***reforming / present / intact***

(b) Explain why the growth of roots, such as those of *A. cepa*, involves mitosis and not meiosis.

1. mitosis produces genetically identical

diploid daughter cells / maintain genetic stability ;

2. meiosis produces genetically varied / non-identical

haploid daughter cells ; (l) produce gametes

3. growth of roots requires similar cells (to be grouped together)

to form tissue / organ / perform same fn / replace damaged cells ;
® repair damaged cells [3]

(c) Some bacteria infect the plant to result in tumour formation at the infected tissues as shown in Fig. 3.2.

Research on the tumour formation processes revealed that there was an unusual excessive production of auxin, an important plant growth hormone. Auxin has been found to regulate gene expression resulting in cell division, expansion, differentiation and specialisation.

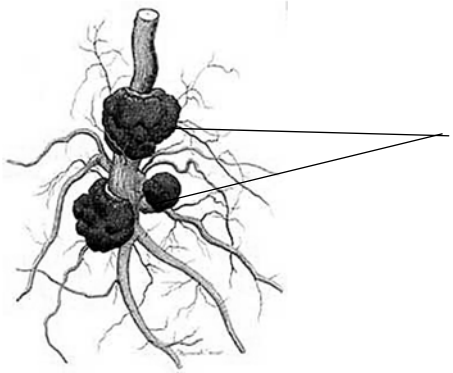

Fig. 3.2

Suggest how the bacteria infection resulted in tumour formation.

1. bacteria triggers infected plant cell to produce excessive auxin

➡ uncontrolled cell proliferation / dysregulation of cell cycle / G1 chkpt

2. auxin upregulates / ↑ expression / transcription

of POG / genes coding for production of CDKs / cyclins / prot that ⊕ cell division ;

3. auxin activates telomerase gene ➡ active telomerase

allowing plant cells to divide indefinitely / unlimited replicative potential ;

4. auxin downregulates / ↓ expression / transcription

of TSG / genes coding for prot involved in apoptosis / cell cycle arrest ; [3]

(d) A protein, mitosis promoting factor (MPF), has been identified in cells and has a role in initiating prophase.

MPF is made up of cyclin B1 coupled with cyclin-dependent kinase 1 (CDK1) and normally begins to break down and stops functioning during anaphase.

An overexpression of cyclin B1 has been reported in various human tumours, and is related to aneuploidy and high growth rate for cancerous growths in the breast.

(i) Suggest reasons for the overexpression of cyclin B1.

1. state at least 1 cause of mutation

e.g. DNA replication errors / named mutagen / category of mutagens

2. cause chromosome aberration ➡ cyclin B1 gene is amplified / duplicated

expression of multiple copies of cyclin B1 gene ➡ ↑ cyclin B1 production ;

3. cause gene mutation / △ in DNA seq of cyclin B1 gene

➡ △ in 3D config. of cyclin B1 ➡ not degraded by degradative enz ;

4. cause gene mutation / △ in DNA seq in gene regulating cyclin B1 gene expression / core promoter / enhancer

➡ ↑ transcription of cyclin B1 gene ; [3]

(ii) State what does *aneuploidy* mean.

abnormal / extra / reduction /△ in no. of chr ; [1]

® abnormal no. of sets of chromosome e.g. 3n / 4n etc.
® ref. to human ploidy e.g. has 45 / 47 chromosomes

[Total: 15]

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 parts **(a)** and **(b)**, as indicated in the question.

4 (a) ATP is known as the universal currency of energy in living organisms. It can be utilised and regenerated in various chemical and physical reactions that occur in living systems.

With reference to named examples, outline the roles of ATP in living organisms. [13]

General

1. ***small, easily transported, water soluble***
   energy currency for cellular processes ;
2. ***high energy bonds between phosphate groups***
   when broken releases energy / exothermic reaction ;

Transport & Arrangement

3. ***reestablishment of ion concentration gradient in neurones***
   NA+/K+ pump to move ions against concentration gradient;
4. ***movement of vesicles along cytoskeleton***
   provide e.g. between organelles / to CSM (secretion of insulin from pancreatic cells/antibodies from plasma cells);
5. ***deformation of membrane for bulk transport***
   endocytosis/exocytosis/receptor mediated endocytosis/phagocytosis ;
6. ***assembly of microtubules in spindle fibres***
   arrangement of chromosomes during cell division;

Cell Signalling

7. ***substrate for adenyl cyclase***
   convert to cAMP → 2nd messenger for cell signalling e.g. G-protein signalling cascade/ lac operon in bacteria
8. ***activation of RTK through autophosphorylation***
   docking ports for relay proteins ;

Energetics

9. *involved in glycolysis*
   transfer of phosphate from ATP to activate glucose (or give e.g.);
10. *concentration of ATP regulates glycolysis*
    allosteric inhibitor to PFK ;
11. *used in PGA reduction reactions in Calvin Cycle*
    transfer of phosphate from ATP to 3-PGA ➔ 1,3- Bisphosphoglycerate
12. *used in regeneration reactions in Calvin Cycle*
    G3P ➔ RUBP

Other cellular processes

13. *tRNA activation by amino-acyl tRNA synthase*
    aa binding to active site of enzyme
14. *synthesis of macromoelcules*
    aa synthesis/polysacc/lipid synthesis ;
15. *substrate for RNA synthesis by RNA polymerase*
    tRNA, rRNA, mRNA ;

Additional e.g.

16. *Additional e.g. for categories mentioned above (e.g. phosphorylation of relay proteins with e.g.)*
17. *Additional e.g. for categories mentioned above (e.g. active transport of materials against concentration gradient with e.g.)*
18. *Additional e.g. for categories mentioned above*
19. *AVP*

- *QWC (1m): points communicated clearly without ambiguity & with relevant e.g.*

(b) Plasma membranes exist on the surface of cells and in the endomembrane systems within the cells. They play critical roles in the regular functioning of a cell.

Discuss the functions of various components in plasma membrane and explain why there is a different composition of these components in membranes of different cells and organelles. [12]

Components of membrane and their functions:

Phospholipids

1. ***Phospholipids, amphipathic***
   forms bilayer ;
2. ***acts as barrier***
   hydrophilic/ water-soluble substances ;
3. ***held by weak hydrophobic interactions***
   provides fluidity to memb ;

Cholesterol

4. ***cholesterol regulates fluidity***
   and permeability of membrane
5. ***keeps phospholipids together at high temperature***
   to prevent membrane breakage ;
6. ***prevents phospholipids from packing at low temperature***
   prevents membrane solidification ;
7. ***function as a plug***
   regulate movement of molecules aX membrane ;

Proteins

8. ***transport proteins***
   allow hydrophilic molecules to be tpted in & out of cell / aX membrane
9. ***enzymes***
   catalyse chemical rxns on memb
10. ***receptor***
    allows for specific binding of ligand/ 1st messenger in cell signalling pathways
11. ***structural support***
    prots attached to cytoskeleton to provide framework for cell ;
12. ***energy transducers***
    harness energy from proton flow to phosphorylate ADP e.g. ATP synthase ;

Carbohydrates (@glycoproteins or glycolipids)

13. ***form H bonds with water***
    & stabilizes memb
14. ***on proteins and lipids forming glycoproteins and glycolipids***
    cell-cell recognition / cell communication / cell-cell adhesion

Significance of different components:

<u>In different organelles (relate to its functions)</u>

Transport proteins

15. ***function as electron transporters on ETC to facilitate electron transfer along***
    e.g. OP in mitochondrion & light-dependent rxns in chloroplast ;
16. ***proteins function as hydrogen ion transporter / pump***
    harness energy lost from e^- transfer to move H^+ against conc gradient
17. ***proteins function as nuclear pores***
    regulate the movement of molecules in and out of nucleus
18. ***Proteins function as channel proteins***
    On rER for newly translated proteins to enter lumen ;
19. ***Proteins act as proton pumps***
    Maintain acidic internal env in lysosomes ;

Others

20. ***Proteins complex with pigments in light harvesting complex***
    Maximise efficiency of light dependent reactions ;
21. ***Proteins function as enzyme***
    ATP synthase to transport H^+ from IMS to matrix / thylakoid lumen to stroma

Phospholipids

22. ***phospholipids in internal membranes of organelles (e.g. IMM / thylakoid membrane) allows the setting of a proton gradient***
    for chemiosmosis to take place as H+ flows down proton grad to produce ATP ;

<u>In different cells (relate to its functions)</u>

Cell Signalling

23. ***diff cell types contains diff amt & types of glycoproteins & glycolipids***
    similar cell types can adhere together to form tissues
24. ***cells receiving signalling ligand / specific e.g. of effector cells etc***
    req specific prot receptors to be present on cell memb
25. ***immune cells e.g. B cell/macrophage/ T helper cell etc***
    contain specific receptor e.g. BCR with specific antigen binding sites to bind to antigen ;

Transport

26. ***Channel/carrier proteins for movement of molecules from ECF into cell for storage/processing***
    Give e.g. GLUT on liver/muscle cells

Others

27. ***higher amount of cholesterol / higher % of saturated fatty acids in phospholipids***

    in membranes of cells in organisms living in areas of higher temp for greater stability of the memb

28. ***AVP (cell Signalling e.g. recognition of self vs non-self)***
29. ***AVP (Transport)***
30. ***AVP (compartmentalisation of processes)***
31. ***AVP (fluidity of membrane ➔ fluidity and vesicle formation)***

- ***QWC (1m): points communicated clearly without ambiguity &with relevant***

[Total: 25]

5 The immune system responds to foreign antigens by producing specific immune responses to remove the antigen.

(a) Outline the processes involved in the generation of antibody diversity which allowed the humoral immunity to be effective in both the primary and secondary response. [12]

1. ***Antibodies are made up on 4 polypeptides***

   Arranged in a Y structure ;
2. ***Each polypeptide is coded for by more than 1 gene segment***

   Coding for the variable and constant regions of each polypeptide ;
3. ***Variable regions of the light chains and the heavy chains***

   Forms the antigen binding site which is complementary to the antigen epitope
4. ***(in naïve B cells) DNA segments coding for the variable regions***

   undergoes genetic recombination ;
5. ***Different coding sequences after genetic recombination***

   ➔ different polypeptides ➔ different antigen binding site ;
6. ***There are 2 types of light chains (κ and λ)***

   1 type of heavy chain ;
7. ***Any combination of L and H chain can occur***

   With both light chains identical ;
8. ***Inheritance of large number of gene segments for both L and H chains***

   Coding for VJ (L chain) and VDJ (H chain) segments ;
9. ***Any combination of V(D)J gene segments can occur***

   combinatorial diversification resulting in specific aa sequence for each combination for the antigen binding site ;
10. ***Imprecise joining between gene segments of V to J (L chain) and V to (D)J (H chain)***

    Results in junctional diversity in the hypervariable regions in the antigen binding site ;

11. ***Upon antigen presentation (in germinal centres), hypermutation of the genes coding for the variable segment and class switching occurs ;***
12. ***Changes nucleotide sequence coding for the hypervariable regions Altering antigen binding sites of antibodies ;***
13. ***B cells with high affinity antibodies selected Continue clonal expansion to produce antibodies specific for antigenic epitopes for effective immune response during secondary exposure ;***
14. ***Class switching occurs Gene rearrangements of the constant regions while retaining the genes of the variable regions ;***

- ***QWC (1m): points communicated clearly without ambiguity &with relevant***

(b) The human immunodeficiency virus (HIV) is a retrovirus that causes AIDS. The infected person has a weakened immune system and is susceptible to opportunistic infections which can lead to their death.

Describe the HIV reproductive cycle and explain how these opportunistic infections may arise. [13]

1. ***Adsorption involving gp120 Binding to CD4 receptor and co-receptor on cell surface of host cell ;***
2. ***Penetration due to membrane fusion exposed fusion domain due to conformation changes in gp41 ;***
3. ***Nucleocapsid released into cytoplasm Capsid degradation results in release of viral enzymes and RNA ;***
4. ***Reverse Transcription by reverse transcriptase dsDNA formed from ssRNA ;***
5. ***dsDNA enters nucleus through nuclear pore integrated into host DNA by integrase ;***
6. ***Provirus state Persist for a long time in the latent state with viral genome replicated along with host's chromosomes ;***
7. ***Upon activation, viral gene expression occurs Using cell's protein synthesis mechanisms ;***
8. ***mRNA synthesized functions as a template for translation and genome replication ;***
9. ***viral ENV polyproteins synthesized cleaved by cellular protease forms gp120 and gp41 which are inserted into the CSM ;***
10. ***viral polyproteins (GAG-POL) polyproteins are cleaved by viral protease forms viral enzymes (integrase, RT, protease) and structural proteins respectively ;***
11. ***mature virons leave the cell via budding***

CSM taken from host cell becomes the envelope ;

12. lost of CSM results in destruction of CD4 cells

population of CD4 T/ T helper cells dy/dx into TH ↓ ;

13. B cells are not activated to dy/dx into plasma cells by TH

No antibodies secreted (no humoral immunity) against pathogens ;

14. CD8 cells not activated to dy/dx into Tc

Pathogen infected cells are not destroyed (lack cytotoxic mechanisms) ;

15. Compromised immunity results in opportunistic infections

By pathogens which usually do not cause serious illnesses in people with functional immune system ;

- ***QWC (1m): points communicated clearly without ambiguity &with relevant***

[Total: 25]