2017

JC2 H1 Biology

1.	Anderson Junior College	
2.	Anglo Chinese Junior College	
3.	Dunman High School	
4.	Innova Junior College	
5.	Jurong Junior College	
6.	Meridian Junior College	
7.	Millennia Institute	
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11.	Serangoon Junior College	
12.	St. Andrew's Junior College	
13.	Temasek Junior College	
14.	Victoria Junior College	

H1

ANDERSON JUNIOR COLLEGE
HIGHER 1

BIOLOGY 8875/01

Paper 1 Multiple Choice

19 September 2017
Tuesday

1 hour
30 marks

Additional Materials: Multiple Choice Answer Paper

READ THESE INSTRUCTIONS FIRST

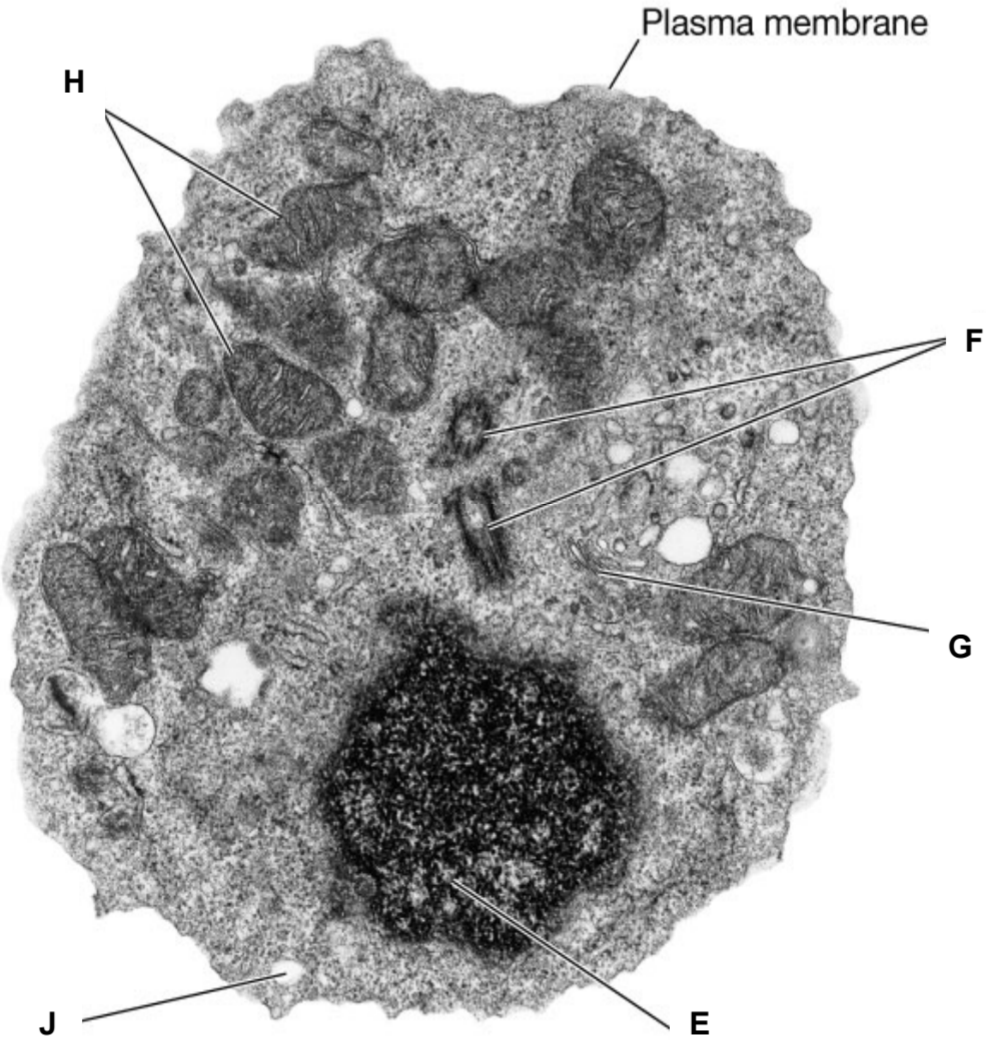
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, PDG and identification number on the Answer Sheet.

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

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

Calculators may be used.

1 An electron micrograph of a cell is shown below.



Match the organelles **E**, **F**, **G**, **H** and **J** associated with the cellular processes listed.

	E	F	G	H	J
A	DNA replication	Digestion of materials	Organises the spindle fibre	Oxidative phosphorylation	Packaging of secretory products
B	Oxidative phosphorylation	Organises the spindle fibre	Digestion of materials	DNA replication	Packaging of secretory products
C	Organises the spindle fibre	Digestion of materials	Oxidative phosphorylation	Packaging of secretory products	DNA replication
D	DNA replication	Organises the spindle fibre	Packaging of secretory products	Oxidative phosphorylation	Digestion of materials

2 Which of the following are the most likely consequences for a cell lacking functional Golgi bodies?

1. The cell dies because it is unable to make glycoproteins to detect stimuli from its environment.
2. The cell dies from a lack of enzymes to digest food taken in by endocytosis.
3. The cell dies from the accumulation of worn-out organelles within itself.
4. The cell is unable to reproduce itself.
5. The cell is unable to export its enzymes or peptide hormones.

A 1 and 5

B 2 and 3

C 1, 2 , 3 and 4

D 1, 2 , 3 and 5

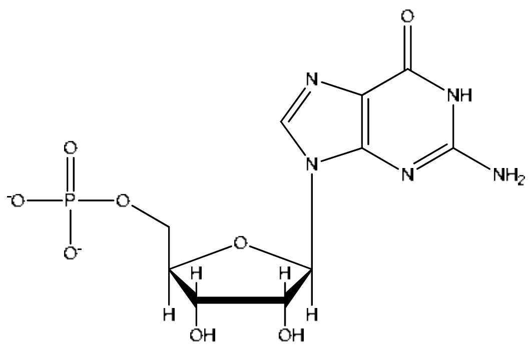
3 Three pure substances are analyzed. The table shows the elements that each contains.

	C	H	O	N	P	S
X	+	+	+	+	-	-
Y	+	+	+	-	-	-
Z	+	+	+	+	-	+

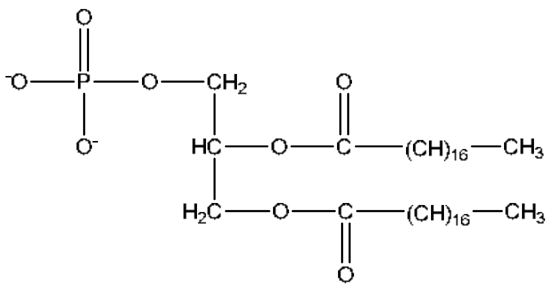
Which of the following combination best describes **X**, **Y** and **Z**?

	X	Y	Z
A	adenine	carbohydrate	fat
B	adenine	fat	an amino acid
C	an amino acid	fat	carbohydrate
D	fat	carbohydrate	an amino acid

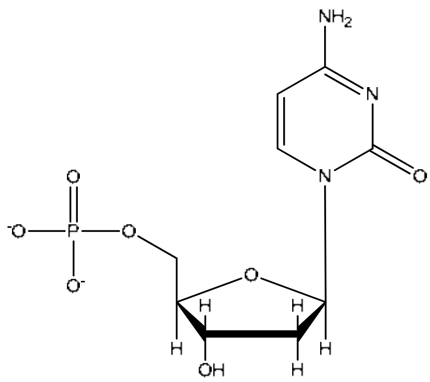
4 A student uses centrifugation to separate the various subcellular structures of human epithelial cells by size and density. Which of the following molecule(s) would you expect to find in the pellet containing the cell membrane?



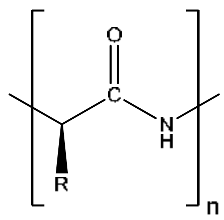
I



II



III



IV

A II only

B III only

C II and IV only

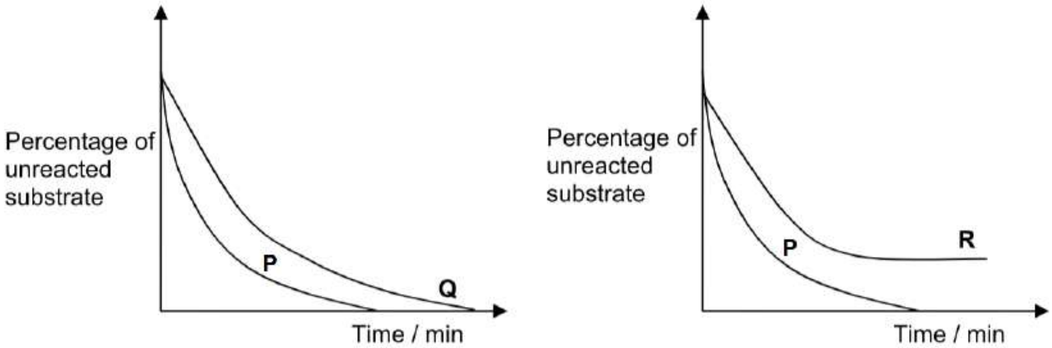
D I, III and IV only

5 Curve P represents the course of an enzyme-catalyzed reaction under optimum conditions. Curves Q and R show the action of the same enzyme on the same substrate but with the addition of a competitive and a non-competitive inhibitor respectively. Assume that the starting amount of enzyme and substrate is the same for all three curves.

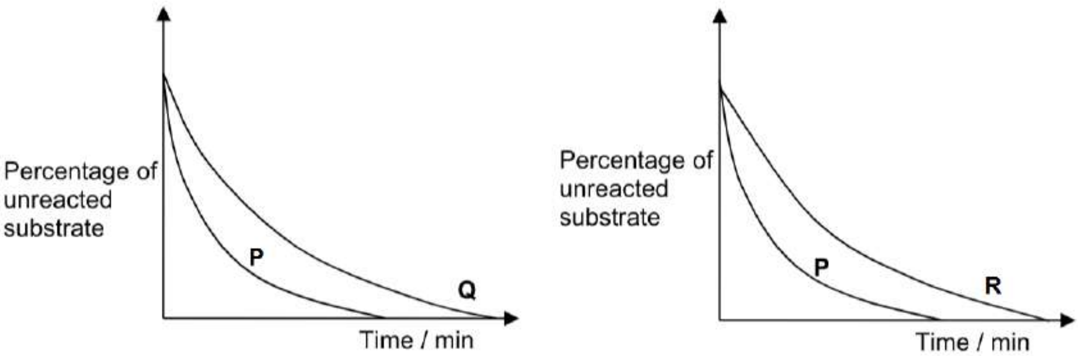
Which of the following pairs of graphs correctly shows the effects of competitive and non-competitive inhibitors on the reaction?

Competitive inhibitor | **Non-competitive inhibitor**

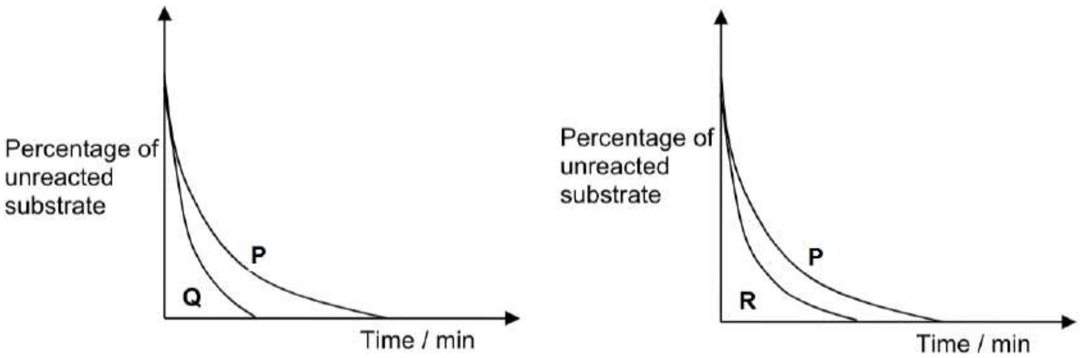
A



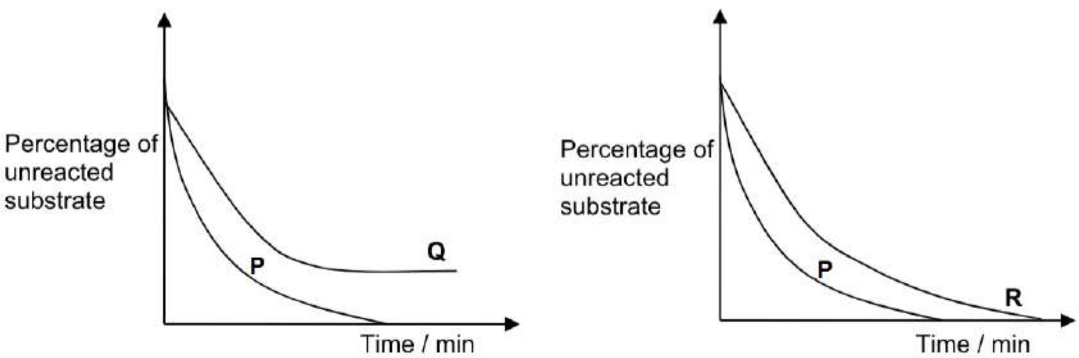
B



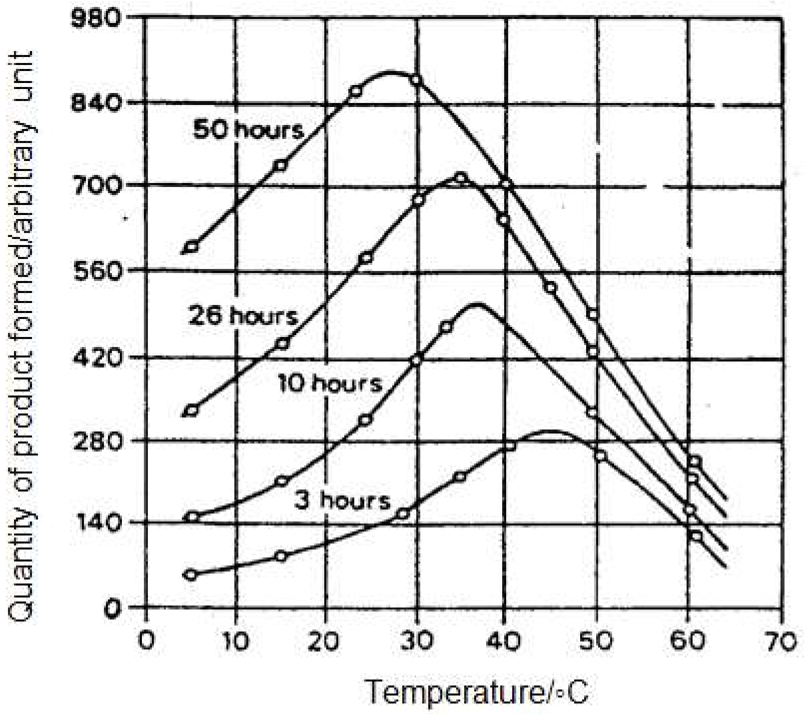
C



D



6 The graph below shows the quantity of the product formed when samples containing the same concentration of enzyme and substrate were kept at different temperature for four different durations.



Which statement best explains why the optimum temperature is lowered if the duration of incubation is increased?

A There is an increase in the denaturation of enzymes at high temperature.

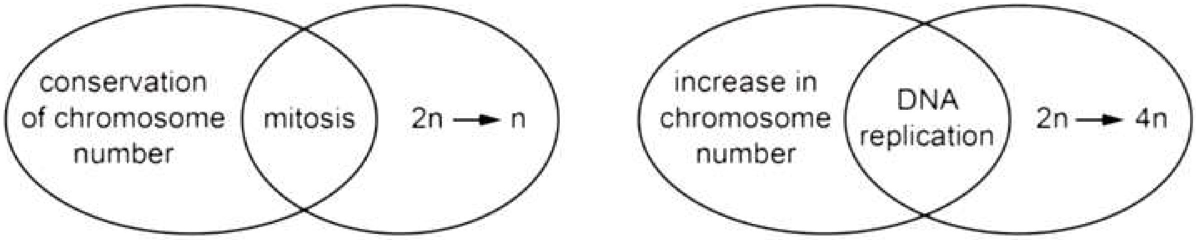
B The activation energy of the reaction is lowered at high temperature.

C The product formed as an allosteric activator to enhance enzyme activity.

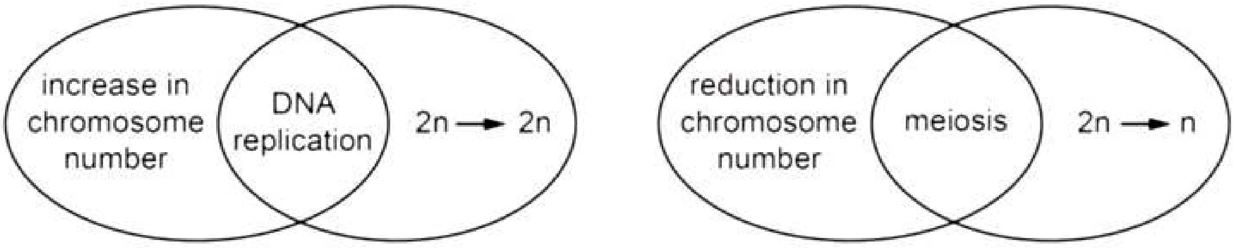
D More substrates are converted into products for longer durations of incubation.

7 Which diagrams show the correct relationships?

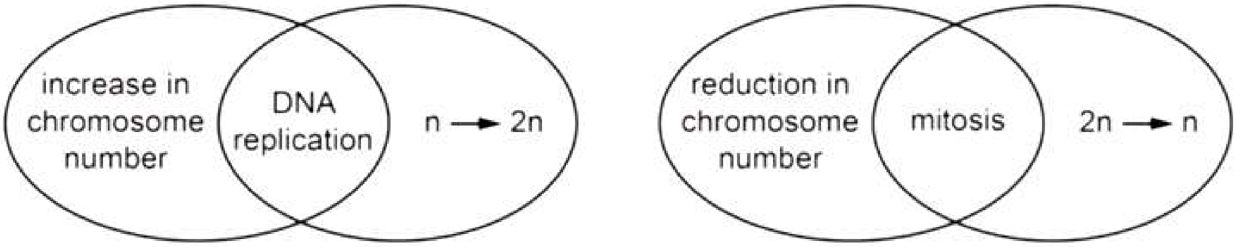
A



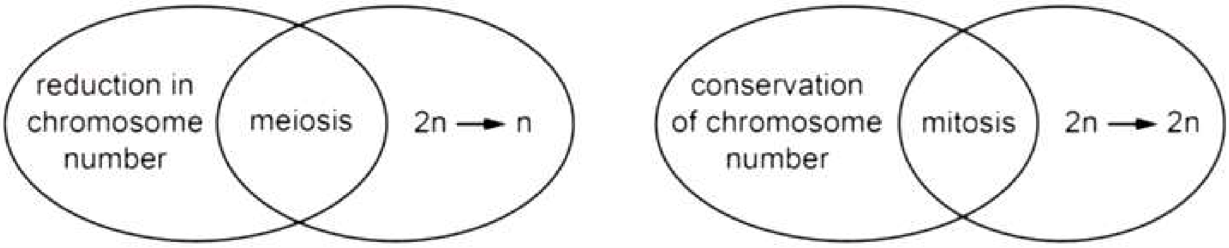
B



C



D



8 The amount of DNA in a mammalian cell in early prophase I of meiosis is **X**. What is the amount of DNA in the same cell at G1 of interphase ?

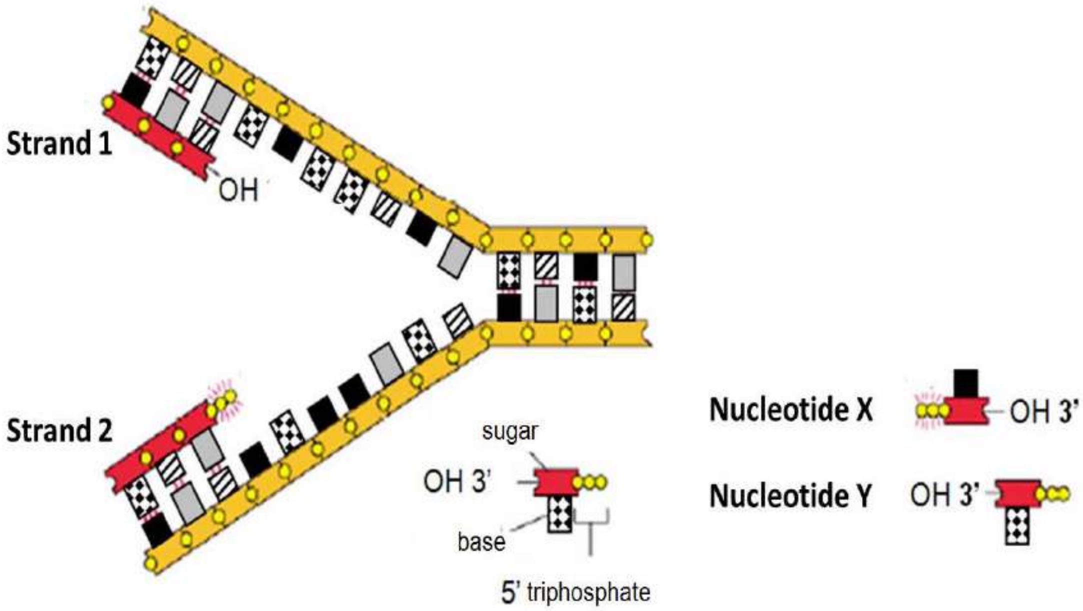
A 0.25X

B 0.5X

C X

D 2X

9 DNA replication is illustrated in the following figure.



Which of the following correctly describes the addition of the next nucleotide in the DNA strands undergoing replication?

A Nucleotide **X** will be added to the leading strand, which is strand 1.

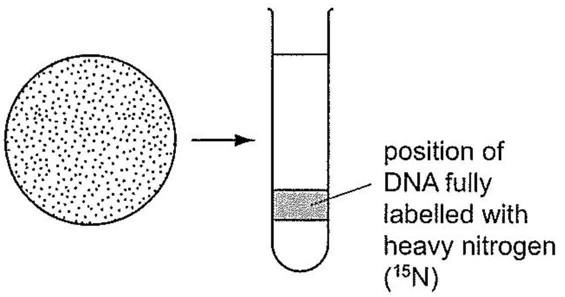
B Nucleotide **Y** will be added to the leading strand, which is strand 1.

C Nucleotide **X** will be added to the lagging strand, which is strand 1.

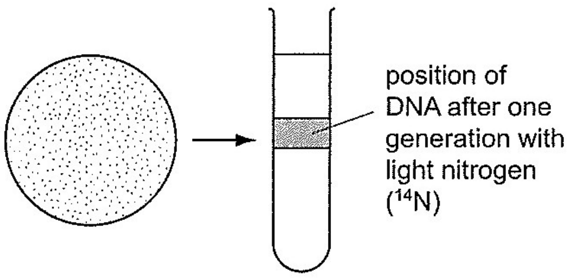
D Nucleotide **Y** will be added to the leading strand, which is strand 2.

10 The diagrams show an investigation into semi-conservative replication of DNA.

Bacteria were grown on a medium containing heavy nitrogen(^{15}N) until all the DNA was labelled. A sample of the DNA was extracted and separated by centrifugation. A dye added to the DNA shows its position in the centrifuge tube.

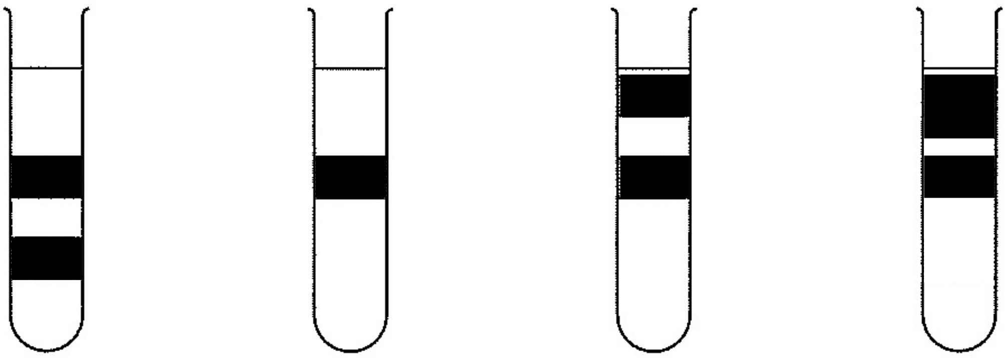


The bacteria were then transferred to a medium containing light nitrogen(^{14}N) and allowed to replicate for two generations.

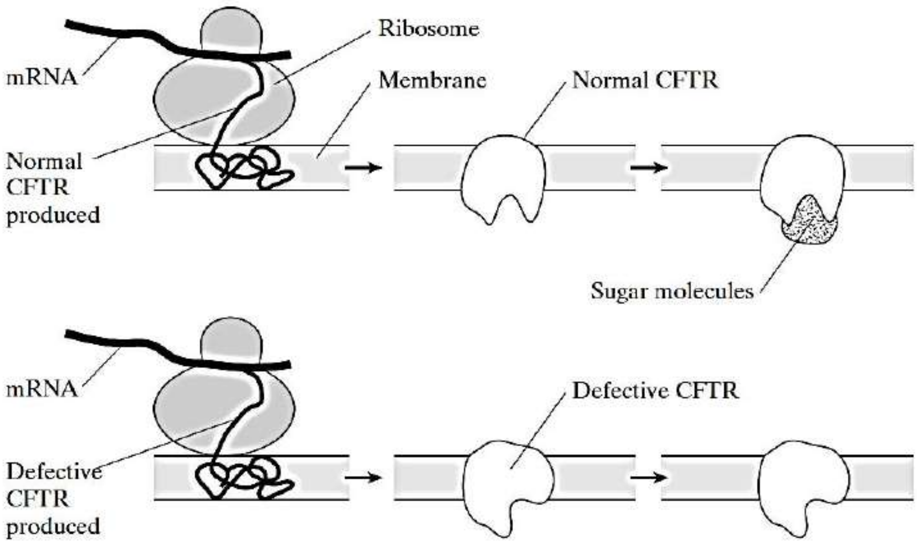


Which tube shows the position of the DNA after two generations of semi-conservative replication in light nitrogen (^{14}N)?

A **B** **C** **D**



11 CFTR is a transmembrane regulator protein. It is made up of 1480 amino acids. People with cystic fibrosis produce a defective CFTR protein which is missing one amino acid from its structure. The diagram shows the synthesis of a normal and a defective CFTR in a cell. A normal CFTR protein molecule has sugar molecules attached to it which make it functional.



Which of the following statements are true?

1. 4440 is the number of bases on the template DNA which code for the amino acid sequence of a normal CFTR protein.

2. Cystic fibrosis is due to a chromosomal mutation known as a deletion.

3. The functional CFTR is a protein that undergone glycosylation.

4. The defective CFTR is not functional as the mutation in the DNA resulted in changes in its tertiary structure.

A 1 and 4 only

B 1 and 3 only

C 1, 3 and 4 only

D 2, 3 and 4 only

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

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

What step in protein synthesis does edeine inhibit?

A It blocks translocation of the ribosome along the mRNA.

B It interferes with chain termination and release of peptide.

C It prevents formation of the translation initiation complex.

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

13 Seeds from a pure breeding plant were planted in identical pots of compost and watered regularly. Sets of ten pots were placed in different light conditions and left until the first leaves had developed.

The table shows the mean height for the young stems, mean length of first leaf and the colour of the leaves.

	no light	dim light	bright light
mean height / cm	8	6	4
mean leaf length / cm	1.5	1.4	1.4
colour of leaves	pale yellow	pale green	dark green

Which explains the effect of light on the phenotype of the young plants?

A The activity of genes involved in chlorophyll synthesis and stem growth varies with light intensity.

B The activity of genes involved in stem and leaf growth is decreased by light

C The genes involved in chlorophyll synthesis and stem growth are activated by light.

D The genes involved in chlorophyll synthesis and stem growth are inactivated by light.

14 Fruit flies (*Drosophila*), homozygous for long wings, were crossed with fruit flies homozygous for vestigial wings. The F_1 and F_2 generations were raised at three different temperatures.

At each temperature, the F_1 generation all had long wings.

The table shows the results in the F_2 generation.

temperature / °C	result
21	¾ long wings, ¼ vestigial wings
26	¾ long wings, ¼ intermediate wing length
31	all long wings

Which statement explains these results?

A Heterozygous flies have vestigial wings only at 21°C or below but have long wings at 31°C or above.

B Long wing and vestigial wing illustrate codominance at 26°C.

C Long wing is dominant at higher temperatures but vestigial wing is dominant at lower temperatures.

D Vestigial wing is recessive but causes a vestigial wing phenotype only at lower temperatures.

15 In rabbit, there are two alleles for fur colour, grey and white, and two alleles for fur length, short and long. Two pure-breeding rabbits were mated, and the F_1 offspring all had grey and long hair. When the F_1 offspring were selfed, they produced the following numbers of F_2 offspring:

grey and long haired:	92
grey and short haired:	32
white and long haired:	28
white and short haired:	13

Which of the following are true?

1. The genes for fur colour and fur length assort independently.
2. The probability of producing pure-bred offspring is 1 in 16.
3. The original pure-breeding parents must be only grey and long haired, and white and short haired.
4. The two traits show sex-linked inheritance.

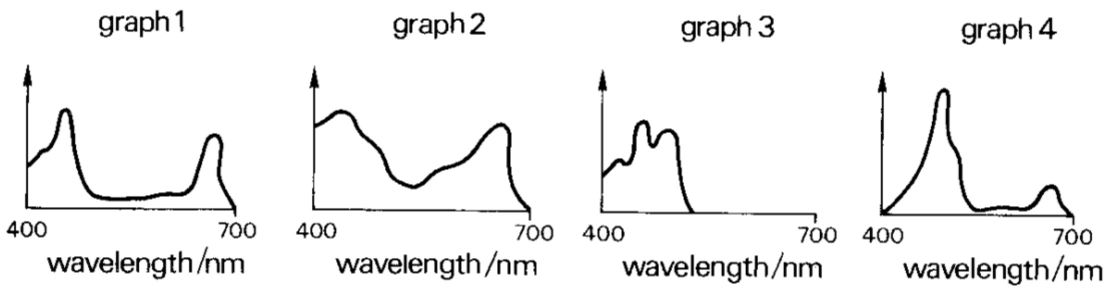
A 1 only.

B 2 and 3

C 1 and 3

D 2, 3 and 4

16 Three of the graphs below show the absorption spectra of photosynthetic pigments. One graph shows the action spectrum of photosynthesis for a plant containing the pigments.



All the x axes show wavelength. Three of the y axes show light absorption. One y axis shows the rate of photosynthesis.

Which of the following identifies the four graphs?

	Absorption spectra			
	Chlorophyll a	**Chlorophyll b**	**Carotenoids**	**Action spectrum**
A	1	4	3	2
B	2	1	3	4
C	3	2	4	1
D	4	2	1	3

17 The blue dye DCPIP can be converted to colourless DCPIP as shown below:

DCPIP (blue) → reduced DCPIP (colourless)

A suspension of chloroplasts was made by grinding fresh leaves in buffer solution and centrifuging the mixture. Tubes were then prepared and treated in the following ways.

Tube	Contents	Treatment	Colour	
			At start	After 20 minutes
1	1 cm^3 chloroplast suspension + 5 cm^3 DCPIP	Illuminated strongly	Blue green	Green
2	1 cm^3 buffer solution + 5 cm^3 DCPIP	Illuminated strongly	Blue	Blue
3	1 cm^3 chloroplast suspension + 5 cm^3 DCPIP	Left in the dark	Blue green	Blue green

Which one of the following statements is a possible conclusion for the observation above?

A Photolysis of water produces oxygen which oxidizes DCPIP.

B Respiration consumes oxygen from the suspension, hence DCPIP is partially reduced.

C Light reaction which occurs in the chloroplasts yield free electrons which reduce DCPIP.

D Either strong illumination or the buffer solution used in the extraction of chloroplasts could oxidize DCPIP.

18 Below are some statements about anaerobic respiration in yeasts and animal cells.

1. Pyruvate acts as the alternative hydrogen acceptor.
2. Carbon dioxide is produced.
3. Oxidation of reduced coenzyme occurs
4. ATP is synthesized.

Which statements apply to animal cells and yeast cells?

	Animal cells	**Yeast**
A	1, 2 and 3	3 and 4
B	1, 3 and 4	2, 3 and 4
C	2, 3 and 4	1, 2, 3 and 4
D	1, 2 and 3	2 and 3

19 Two test tubes containing the following contents are shown below:

Tube 1:
Radioactive glucose solution + yeast cells suspension + oxygen + antimycin

Tube 2:
Radioactive glucose solution + yeast cells suspension + oxygen

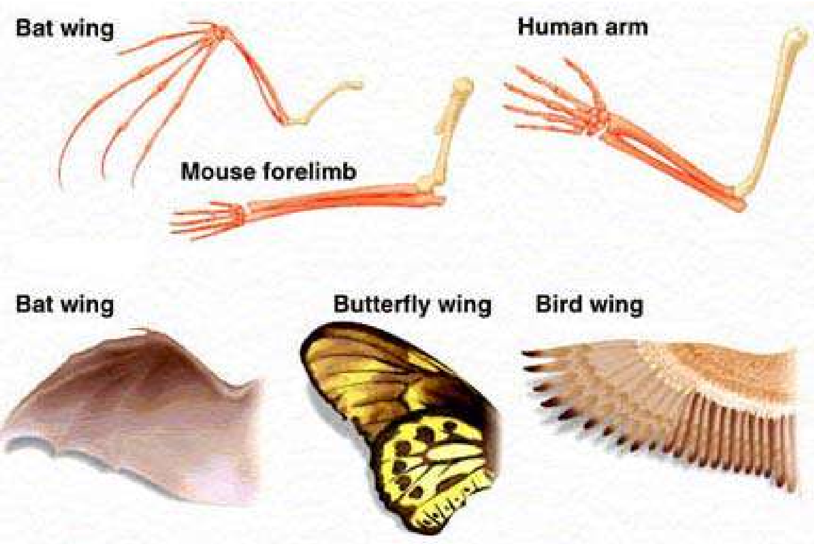
Radioactive glucose has all its six carbons made of radioactive ^{14}C. The initial radioactivity measured for the glucose in each test tube is 60 arbitrary units.

Antimycin is an electron transport chain inhibitor.

If the gaseous product and the aqueous products are tested using a radioactive meter after all the glucose has been metabolized, what would be the final observed readings?

	Tube 1 (radioactivity measured/ arbitrary units)		Tube 2 (radioactivity measured/ arbitrary units)	
	aqueous products	gaseous products	aqueous products	gaseous products
A	0	60	40	20
B	20	40	0	60
C	40	20	0	60
D	40	20	60	0

20 The diagram below shows the bone structures of the human arm, mouse forelimb and bat wings as well as the morphology of the wings of bat, butterfly and birds.



Which of the following are correct conclusions made from the diagram provided?

1. Bat, mouse and human share a common ancestor as their bone structure exhibit anatomical homology.
2. Variations in the bone morphology of bats, mouse and human are due to natural selection.
3. Bat, butterfly and bird share a recent common ancestor as shown by their common wing morphology.
4. Bat, butterfly and bird exhibit analogous structures.

A 1 and 2

B 2 and 3

C 1 and 4

D 1, 2 and 4

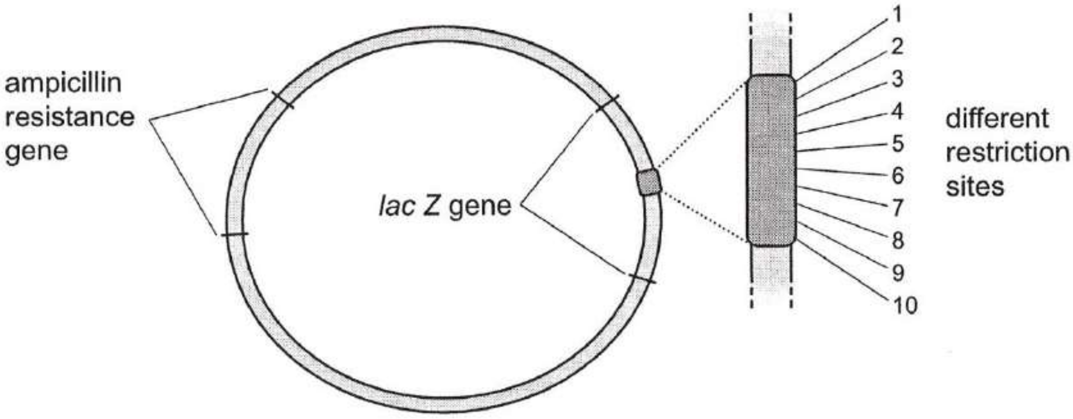
21 A large population of a certain species of freshwater fish lives in a South America lake. If there are no mutations and all immigration into the population is prevented, which one of the following statements best expresses the probable future of the population?

- **A** All evolution will promptly cease because without mutation, there will be no raw material for evolution.
- **B** The population will begin to decrease in size after three to four generations because of excessive inbreeding that will result from the absence of immigration.
- **C** The population will continue to evolve as selection acts on the different allelic combinations formed during meiosis.
- **D** The population will cease to evolve and it may survive for a long time as there is no selection.

22 What explains why genetic variation is important in selection?

- **A** An increase in genetic variation in a population improves the chance of successful breeding
- **B** It allows those organisms with the best genotype to survive.
- **C** It gives alternative alleles that increase the gene pool of a species.
- **D** It results in different phenotypes that allow adaptation to occur.

23 The diagram shows the plasmid pUC18. Bacteria containing this plasmid produce blue colonies when grown in the presence of *X-gal*. Bacteria containing a genetically engineered recombinant pUC18 plasmid produce white colonies.



Some of the features of this plasmid are:

1. It is small and replicates to form about 500 copies per host cell.
2. It contains restriction sites for 10 different restriction enzymes.
3. It contains a gene giving resistance to the antibiotic ampicillin.
4. It contains the *lac Z* gene which allows the metabolism of *X-gal* to produce a blue colour.

A gene of interest was inserted into one of the restriction sites to form a recombinant plasmid. Bacteria were transformed with this recombinant plasmid and identified using a selective agar medium.

Which selective growth medium would identify the bacteria containing the recombinant plasmids?

A A medium containing agar.

B A medium containing ampicillin.

C A medium containing ampicillin and *X-gal*.

D A medium containing *X-gal*.

24 The *F8* gene is over 185 000 base pairs long and codes for Factor VIII, which is used during blood clotting.

People with a mutation of the *F8* gene have the condition haemophilia and are treated using a recombinant Factor VIII, synthesised by mammalian cells.

Escherichia coli cells cannot be used to synthesise the recombinant Factor VIII as they cannot add carbohydrate to protein.

What can be deduced using only this information?

A Different mutations of the *F8* gene will lead to different severities of haemophilia.

B Human factor VIII is a glycoprotein.

C Human factor VIII is composed of 61 667 amino acids.

D The F8 gene is located on the X chromosome.

25 If a researcher began with a PCR on a sample that contained three copies of double stranded DNA, and each step in PCR takes 1 minute, how many copies would be present after 1 hour 21 minutes?

A 2^{27}

B 4^{27}

C 2^{3x27}

D 3×2^{27}

26 Some of the steps involved in DNA analysis are listed below:

1 transfer segments of DNA to nitrocellulose membrane
2 extraction of DNA
3 gel electrophoresis
4 treating DNA with restriction enzymes
5 autoradiography
6 hybridise with probe

The correct sequence is

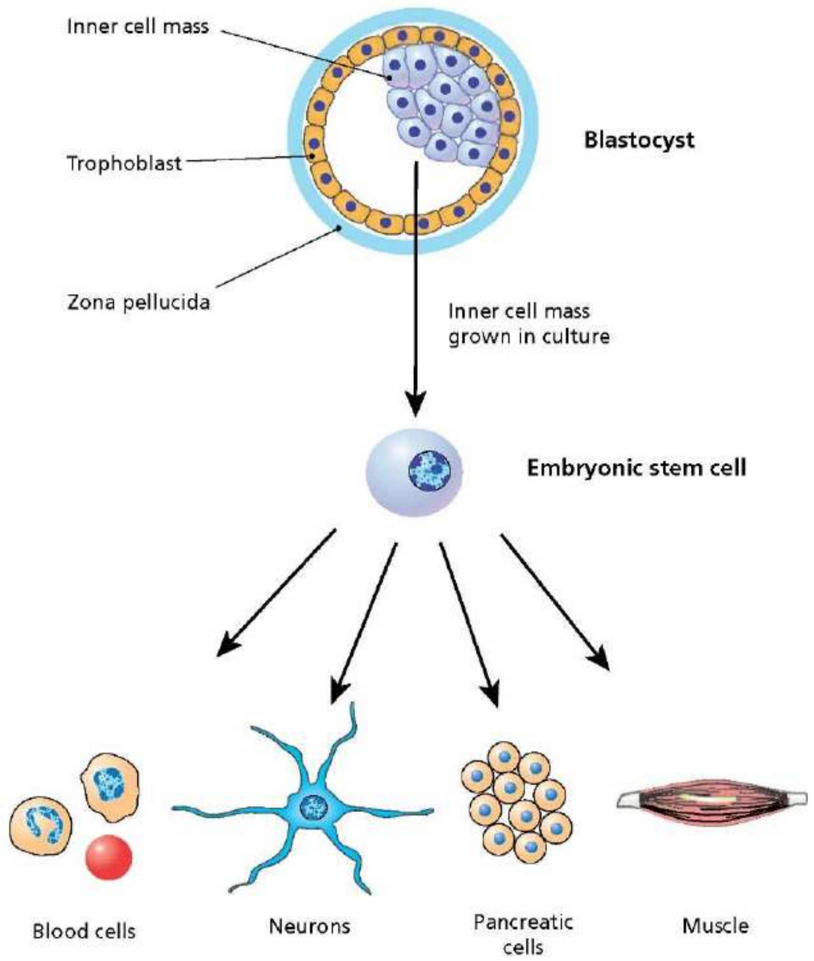
A 2 → 4 → 3 → 1 → 6 → 5

B 4 → 2 → 3 → 1 → 6 → 5

C 4 → 2 → 1 → 3 → 6 → 5

D 2 → 4 → 3 → 1 → 5 → 6

27 Which of the following features of the embryonic stem cells and specialized cells shown in the diagram are true?



	Embryonic stem cells	Specialized cells
A	Embryonic stem cells display greater plasticity when grown in culture than when in blastocyst.	The blood cells are genetically different from the embryonic stem cells but have shorter telomeres.
B	Embryonic stem cells are pluripotent and are capable of transdifferentiating (convert one cell type to another) into many different cell types.	The pancreatic cells are genetically identical to the embryonic stem cells but with a different set of genes expressed.
C	Embryonic stem cells are multipotent and are capable of differentiating into limited range of cell types.	The blood cells are genetically different from the embryonic stem cells because different genes are expressed.
D	Embryonic stem cells are pluripotent and are capable of differentiating into many different cell types.	The pancreatic cells are genetically identical to the embryonic stem cells but have shorter telomeres.

28 In bone marrow, multipotent stem cells can be distinguished from precursors of blood cells which are synthesising proteins by the chromatin and organelles that they contain.
What are the features seen in cells that are synthesizing large quantities of protein?

	Chromatin	Ribosomes	Golgi size
A	clumped	few	large
B	clumped	many	small
C	dispersed	few	small
D	dispersed	many	large

29 Which uses of information from the human genome project are generally considered to be unethical?

1 an insurance company only giving cheap rates to people with genetic predispositions to fewer diseases

2 genetic archaeologists identifying the earliest forms of genes to show evolutionary relationships

3 cytologists developing tests for only some defective genes

4 doctors only giving specific drugs to block the actions of faulty genes to carriers of those genes

5 genetic counsellors giving specific lifestyle information only to people genetically predisposed to risks

6 parents choosing embryos for implantation only after prenatal tests for acceptable genes

A 1 and 3

B 1 and 6

C 2 and 5

D 3 and 4

30 *Bt* gene from *Bacillus thuringiensis* may be inserted into cotton plant cells to produce *Bt* cotton plants. Insecticide use and yield in India were compared for *Bt* cotton hybrid (X*Bt*), the same hybrid X but without the *Bt* gene (X_), and another hybrid widely grown in that particular locality (Y). This process was repeated at more than 150 locations. The table below shows the results:

hybrid	**X*Bt***	**X_**	**Y**
mean number of sprays against insects that eat the cotton	0.6	3.7	3.6
mean number of sprays against sap sucking insects	3.6	3.5	3.5
yield / $kg\ ha^{-1}$	1500.0	830.0	800.0

The following are the conclusions that are drawn from the data:

1. All insect pests are killed when they consume the *Bt* crop.
2. *Bt* cotton reduces the amount of pesticide used.
3. Both yield and quality of cotton from X*Bt* crop improved.
4. *Bt* cotton increases cost effectiveness.
5. Both X_ and Y hybrids contain susceptible genes to the pest.
6. *Bt* toxin is not found in the plant sap.

Which of the conclusions stated are **correct**?

A 1, 2 and 3

B 2, 3 and 5

C 4, 5 and 6

D 2, 4 and 6

H1 Bio P1 2017 Answers

1	D	**16**	B
2	D	**17**	C
3	B	**18**	B
4	C	**19**	C
5	A	**20**	D
6	A	**21**	C
7	D	**22**	D
8	B	**23**	C
9	A	**24**	B
10	C	**25**	D
11	C	**26**	A
12	C	**27**	D
13	A	**28**	D
14	D	**29**	B
15	A	**30**	D

H1 ANDERSON JUNIOR COLLEGE
HIGHER 1

NAME

PDG | | | | | INDEX NUMBER | | |

BIOLOGY
8875/02
Paper 2 Core Paper

12 September 2017
Tuesday
2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **either Question 4 or Question 5.**

All working for numerical answers must be shown.

At the end of the examination, fasten all your work securely together.

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

Calculators may be used

For Examiner's Use	
PAPER 1	
1-30	
	30 marks
PAPER 2	
Section A	*40 marks*
1	
2	
3	
Section B	*20 marks*
4 or 5	
PAPER 2	
	60 marks
TOTAL	
	90 marks

Section A

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

1 Fig 1.1 shows an outline of the first three stages of aerobic respiration.

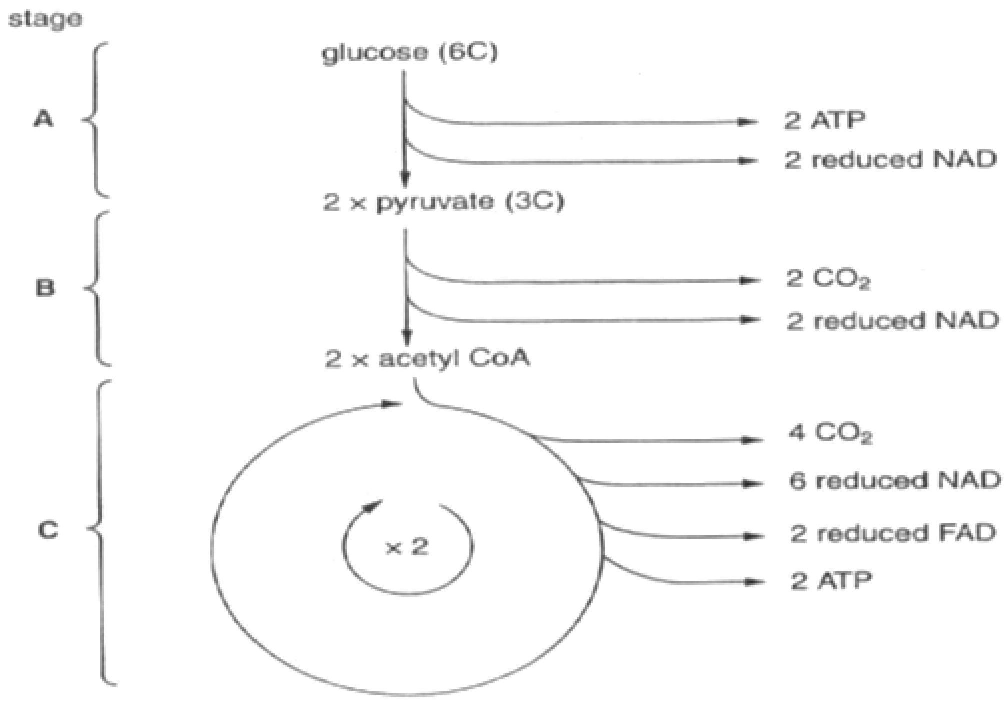


Fig. 1.1

(a) For each glucose molecule, state the total number of molecules of ATP formed as a result of stages A to B, including any ATP produced through oxidative phosphorylation of the products. Assume that 1 reduced NAD synthesizes 2.5 ATP and 1 reduced FAD synthesizes 1.5 ATP. **Show your working**.

A: ....

....

B: ....

....

C: ....

.... [3]

(b) Many enzymes are involved in Krebs cycle. An experiment was carried out to investigate the effect of temperature on respiration. Isolated liver mitochondria were placed in five reaction tubes, with contents and temperature of reaction tube as shown in Table 1 below. The corresponding rates of oxygen uptake were measured. Results are shown in Table 1.

Table 1

Tubes	Temperature/ °C	Volume of solution added/ cm^3		Rate of oxygen uptake / a.u
		Buffered isolated liver mitochondria	2% pyruvate solution	
1	35	Boiled and cooled	0.01	1.1
2	25	2.00	0.01	7.2
3	35	2.00	0.01	15.1
4	45	2.00	0.01	13.2
5	55	2.00	0.01	1.1

(i) Enzymes are essential in helping to speed up the rate of metabolic reactions such as those in the Krebs cycle. Explain how enzymes help to speed up rate of reaction.

[4]

(ii) Pyruvate has to be used as a substrate for this experiment instead of glucose. Explain why.

[2]

(iii) With reference to Tubes 2 – 4 from Table 1, account for the effect of temperature on rate of oxygen uptake.

[4]

(iv) With reference to Table 1, briefly explain the results to Tube 5.

[2]

[Total: 15 m]

2 Fig. 2.1 shows a part of a pancreatic cell. The pancreas is important in regulating the level of blood glucose in the body by secreting insulin at high blood glucose level.

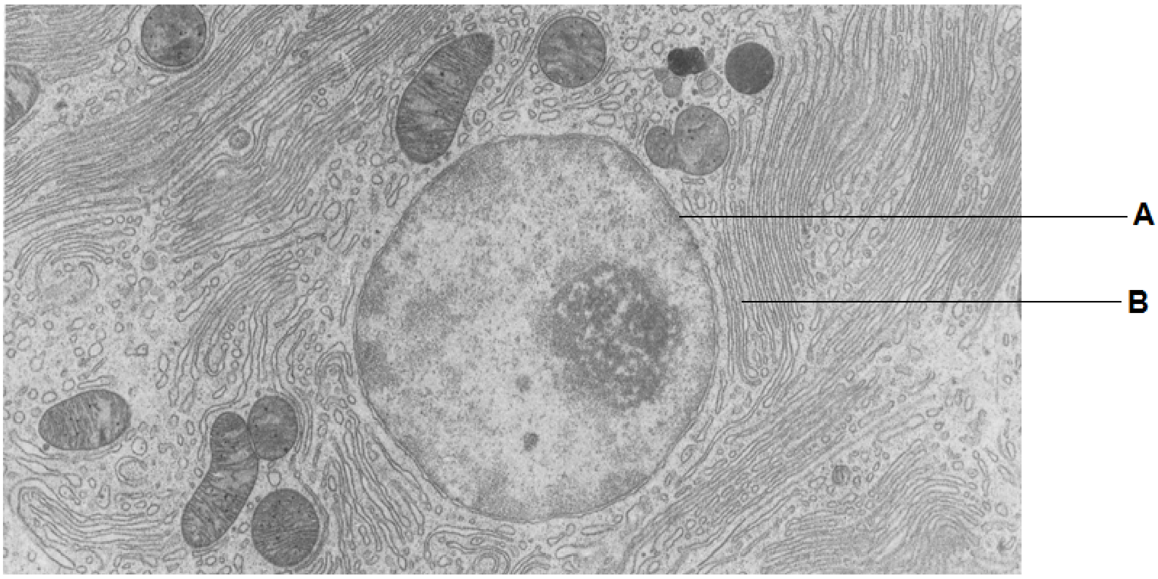


Fig 2.1

(a) **(i)** State organelle A and B and describe the relationship between the two organelles in a pancreatic cell.

[3]

(ii) State one other organelle you can observe in Fig. 2.1 and how it is important to the function of a pancreatic cell.

[1]

(b) Fig. 2.2 shows a diagrammatic depiction of the process that occurs at organelle B.

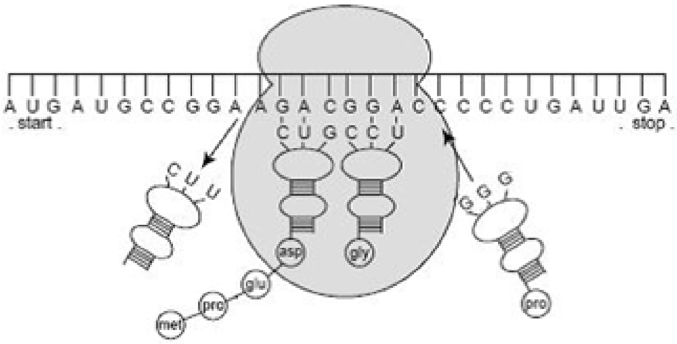


Fig. 2.2

Starting from the position of the ribosome as shown in Fig. 2.2, outline the steps that occur to produce the complete polypeptide.

____

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____

____ [4]

(c) Fig. 2.3A shows a DNA base sequence. It also shows the effect of two mutations on this base sequence. Fig. 2.3B shows DNA triplets that code for different amino acids.

Original DNA base sequence	A	T	T	G	G	C	G	T	G	T	C	T
Mutation 1 DNA base sequence	A	T	T	G	G	A	G	T	G	T	C	T
Mutation 2 DNA base sequence	A	T	T	G	G	C	C	T	G	T	C	T

Fig. 2.3A

DNA triplets	**Amino acid**
GGT, GGC, GGA, GGG	Gly
GGT, GTA, GTG, GTC	Val
ATC, ATT, ATA	Ile
TCC, TCT, TCA, TCG	Ser
CTC, CTT, CTA, CTG	Leu

Fig. 2.3B

Some mutations affect the amino acid sequences while others do not. Using the information in Fig. 2.2A and Fig. 2.2B and a **feature of the genetic code**, explain

(ii) why mutation 1 has no effect on the protein structure

[3]

(ii) why mutation 2 could lead to the formation of a non-functional enzyme.

[3]

[Total: 14 m]

3 **(a)** State the structural features of DNA that make it a stable molecule.

....

....

.... [2]

DNA polymerase is an enzyme involved in the replication of DNA.

One of the substrates required by DNA polymerase is ATP.

ara-ATP is a chemical that affects DNA polymerase activity.

In an investigation, the effect of different concentrations of ATP on the rate of DNA synthesis was determined:

- with no ara-ATP
- with a low concentration of ara-ATP
- with a high concentration of ara-ATP.

The results of the investigation are shown in Fig. 3.1.

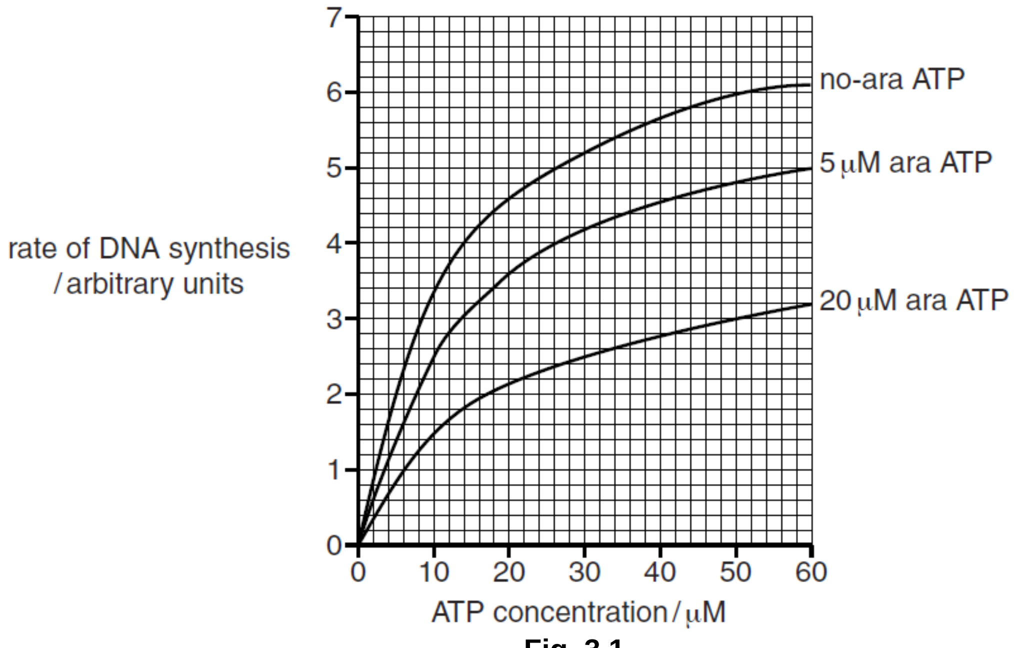


Fig. 3.1

(b) Explain the results of the investigation shown in Fig. 3.1 in terms of mode of action of enzymes.

....

....

....

....

....

....

....

.... [4]

Colour blindness is a genetic condition characterised by the inability of the brain to perceive certain colours accurately.

- The most common form is termed red-green colour blindness (RGC).
- RGC results from a recessive allele.
- 0.6% of females worldwide have RGC.
- 8.0% of males worldwide have RGC.

The results of the investigation are shown in Fig. 3.2.

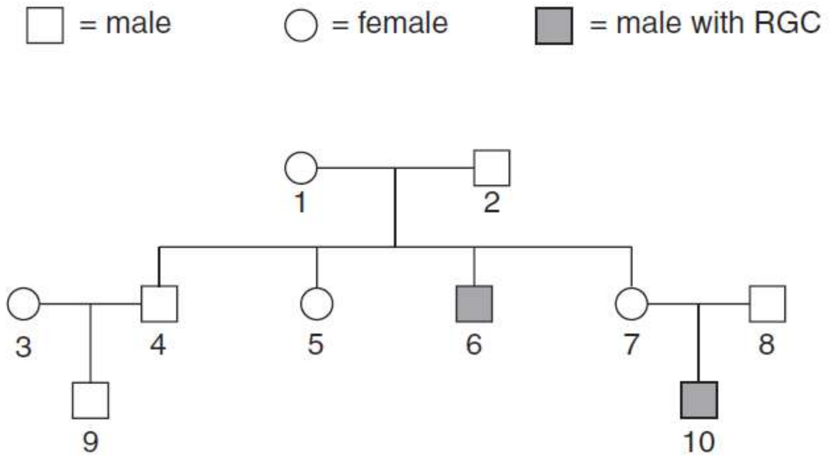


Fig. 3.2

(c) Define the term *recessive*.

....

.... [1]

(d) Explain why females are less likely than males to have RGC.

[2]

(e) With reference to Fig. 3.2, and using the symbols **R** for the dominant allele and **r** for the recessive allele, state the genotypes of the individuals **1** and **6**.

1 ____________________

6 ____________________ [2]

[Total: 11 m]

Section B
Answer EITHER 4 OR 5.

Write your answers on the separate answer paper provided.
Your answer 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 section (a), (b) etc., as indicated in the question.

4 **(a)** Describe how gel electrophoresis separates DNA, and explain why it is useful in genetic fingerprinting analysis. [10]

(b) Describe the features of zygotic stem cells and embryonic stem cells that distinguish them from each other. [3]

(c) Discuss the social and ethical implications of genetically modifying plants. [7]

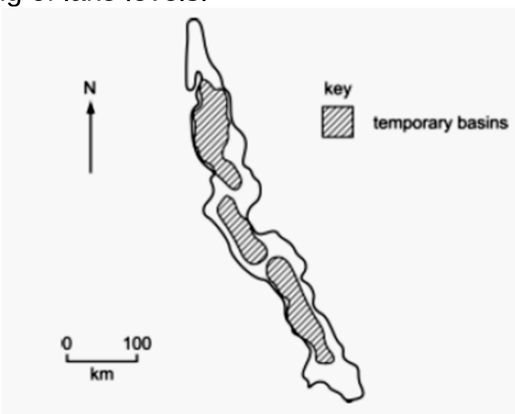
OR

5 **(a)** In Lake Tanganyika in Africa, there are six species of fish of the genus Tropheus and a much larger number of distinctly coloured subspecies of each of the six species. Tropheus species are small fish that are confined to isolated rocky habitats around the shores of Lake Tanganyika.

The six species evolved during the primary radiation phase when the lake was first filled, about 1.25 million years ago. They arose from river dwelling ancestors and then filled all available niches in the lake.

Secondary radiations into the many subspecies occurred during the last 200 000 years. Sometime during this period, the water level in the lake fell, resulting in the formation of three separate lake basins. These basins persisted for many thousands of years before the water level rose again.

Figure below shows an outline map of the lake and the location of the three temporary basins caused by lowering of lake levels.



Using Darwin's theory of natural selection, explain how did the six species and subspecies of each species arise on Lake Tanganyika. [10]

(b) Discuss advantages of using molecular data in determining evolutionary relationships. [3]

(c) Describe how mitosis ensures genetic stability. [7]

[Total: 20 m]

H1 ANDERSON JUNIOR COLLEGE
HIGHER 1

NAME

PDG

INDEX NUMBER

BIOLOGY
8875/02
Paper 2 Core Paper

13 September 2017
Tuesday
2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **all** questions

All working for numerical answers must be shown.

At the end of the examination, fasten all your work securely together.

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

Calculators may be used

For Examiner's Use	
PAPER 1	
1-30	
	30 marks
PAPER 2	
Section A	*40 marks*
1	
2	
3	
Section B	*20 marks*
5 or 6	
PAPER 2	
	60 marks
TOTAL	
	90 marks

Section A

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

1 Fig 1.1 shows an outline of the first three stages of aerobic respiration.

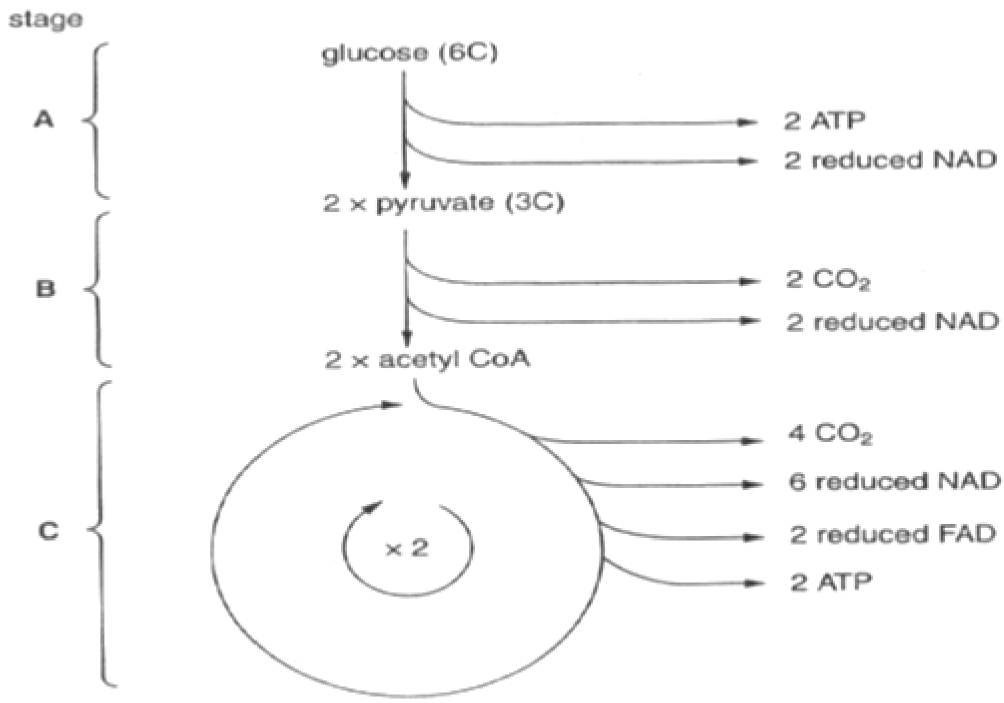


Fig. 1.1

(a) For each glucose molecule, state the total number of molecules of ATP formed as a result of stages A to B, including any ATP produced through oxidative phosphorylation of the products. Assume that 1 NADP synthesizes 2.5 ATP and 1 $FADH_2$ synthesizes 1.5 ATP. **Show your working**.

A:

B:

C:

[3]

A: 2 + 2(2.5) = 7 ATP;
B: 2(2.5) = 5 ATP;
C: 2 + 6(2.5) + 2 (1.5) = 20 ATP;
Must show working to get 1 m for each stage

(b) Many enzymes are involved in Krebs cycle. An experiment was carried out to investigate the effect of temperature on respiration. Isolated liver mitochondria were placed in five reaction tubes, with contents and temperature of reaction tube as shown in Table 1 below. The corresponding rates of oxygen uptake were measured. Results are shown in Table 1.

Table 1

Tubes	Temperature/ °C	Volume of solution added/ cm^3		Rate of oxygen uptake / a.u
		Buffered isolated liver mitochondria	2% pyruvate solution	
1	35	Boiled and cooled	0.01	1.1
2	25	2.00	0.01	7.2
3	35	2.00	0.01	15.1
4	45	2.00	0.01	13.2
5	55	2.00	0.01	1.1

(i) Enzymes are essential in helping to speed up the rate of metabolic reactions such as those in the Krebs cycle. Explain how enzymes help to speed up rate of reaction.

- Lowers activation energy;
- Shape of active site is complementary to substrate;
- Ref. to catalytic and contact residues;
- Holding substrates in precise orientation;
- Causing physical stress in the bonds, making easier for bond breakage/formation;
- Provides favourable microenvironment for reaction to take place;

(ii) Pyruvate has to be used as a substrate for this experiment instead of glucose. Explain why.

- Pyruvate can enter mitochondrion while glucose cannot;
- Ref. to pyruvate carrier proteins embedded in mitochondrial membrane but not glucose carrier proteins
- Enzymes for glycolysis is not present in mitochondrial only tubes;
- glucose cannot be converted to pyruvate for aerobic respiration to occur.

Any 2, 2 m

(iii) With reference to Tubes 2 – 4 from Table 1, account for the effect of temperature on rate of oxygen uptake.

- Ref. to increasing rate of oxygen uptake with temperature + quotation of data with appropriate units;
- As temperature increases, increase in kinetic energy of enzyme and substrate;
- More effective collision between enzyme and substrate molecules, more enzyme-substrate complexes formed per unit time;
- More NADH (and FADH2) molecules formed per unit time;
- More oxygen used as final electron acceptor per unit time;

(iv) With reference to Table 1, briefly explain the results to Tube 5.

- Ref. to rate of oxygen uptake similar to tube 1 + quotation of data;
- Enzymes are denatured, active site configuration is lost and no longer complementary to substrates;

			[Total: 15 m]	

2	Fig. 2.1 shows a part of a pancreatic cell. The pancreas is important in regulating the level of blood glucose in the body by secreting insulin at high blood glucose level.		

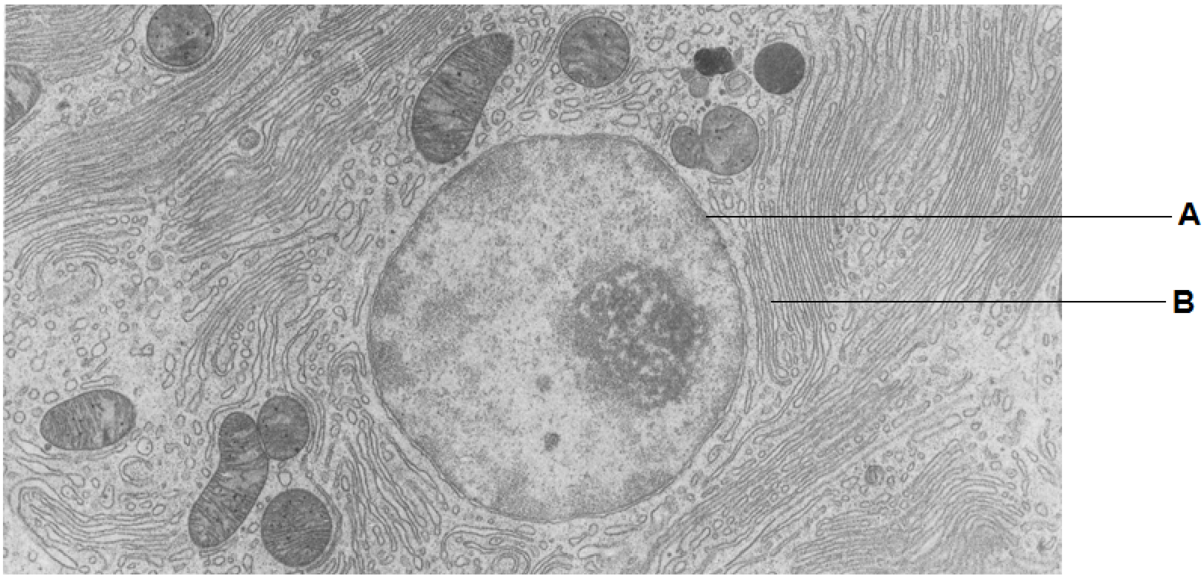


Fig 2.1

(a)	**(i)**	State organelle A and B and describe the relationship between the two organelles in a pancreatic cell.	
		• A: nucleus; B: rough ER; • Ref. to nucleus containing insulin gene that will be transcribed to insulin mRNA; • Ref. to nucleus containing nucleolus that transcribes rRNA genes to form ribosomal subunits; • Ref. to ribosomes embedded on rER; • Ref. to mRNA from nucleus exported via nuclear pore to cytoplasm; • Ref. to insulin mRNA being transcribed at ribosomes embedded on rER;	
	(ii)	State one other organelle you can observe in Fig. 2.1 and how it is important to the function of a pancreatic cell.	
		• Mitochondria; • Synthesizes ATP from aerobic respiration for protein synthesis/ AVP; Or • sER; • synthesize lipids to replace endomembranal systems such as rER/ GA;	
(b)	Fig. 2.2 shows a diagrammatic depiction of the process that occurs at organelle B.		

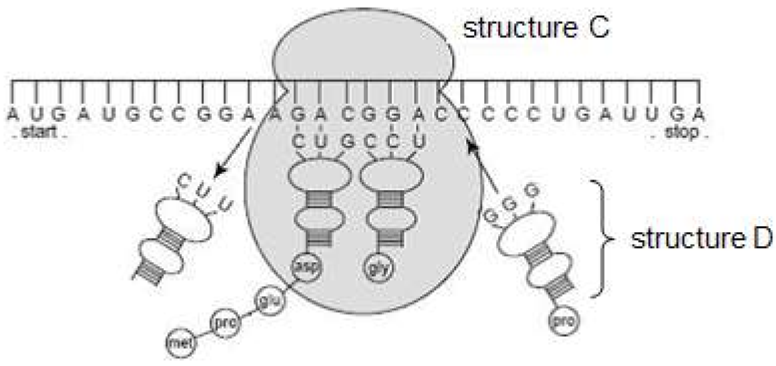


Fig. 2.2

Starting from the position of the ribosome as shown in Fig. 2.2, outline the steps that occur to produce the complete polypeptide.

- Peptidyl transferase catalyses formation of peptide bond between amino acids;
- Ribosome moves along mRNA in 5' to 3' direction / downstream;

- Ref. to amino acids are carried by specific tRNAs to ribosomes / aminoacyl tRNA recruited to ribosome and anticodons complementary base pairs to codon of mRNA;

- Until stop codon reached, release factor binds at A site;
- Covalent ester bond between amino acid and terminal acyl-tRNA hydrolysed, polypeptide released;

(c) **Fig. 2.3A** shows a DNA base sequence. It also shows the effect of two mutations on this base sequence. **Fig. 2.3B** shows DNA triplets that code for different amino acids.

Original DNA base sequence	A	T	T	G	G	C	G	T	G	T	C	T
Mutation 1 DNA base sequence	A	T	T	G	G	A	G	T	G	T	C	T
Mutation 2 DNA base sequence	A	T	T	G	G	C	C	T	G	T	C	T

Fig. 2.3A

DNA triplets	**Amino acid**
GGT, GGC, GGA, GGG	Gly
GGT, GTA, GTG, GTC	Val
ATC, ATT, ATA	Ile
TCC, TCT, TCA, TCG	Ser
CTC, CTT, CTA, CTG	Leu

Fig. 2.3B

Some mutations affect the amino acid sequences while others do not. Using the information in **Fig. 2.2A and Fig. 2.2B and a feature of the genetic code**, explain

		(ii)	why mutation 1 has no effect on the protein structure	
			• genetic code is degenerate; • base substitution on the last codon from GGC to GGA encodes for the same amino acid, gly; • no change in amino acid sequence, no change in R group interactions, no change in protein folding;	
		(ii)	why mutation 2 could lead to the formation of a non-functional enzyme.	
		• genetic code is unambiguous; • mutation from GTC to CTC changes the amino acid encoded for from val to leu; • change in R group interactions, change in protein folding, change in active site configuration;		
				[Total: 14 m]

3	**(a)**	State the structural features of DNA that make it a stable molecule.	[2]
		[Any 2] 1. complementary bases / base pairing, hold(s) strands together 2. (because of) many hydrogen bonds 3. sugar-phosphate backbone / AW, with covalent / phosphodiester, bonds	

DNA polymerase is an enzyme involved in the replication of DNA.

One of the substrates required by DNA polymerase is ATP.

ara-ATP is a chemical that affects DNA polymerase activity.

In an investigation, the effect of different concentrations of ATP on the rate of DNA synthesis was determined:

- with no ara-ATP
- with a low concentration of ara-ATP
- with a high concentration of ara-ATP.

The results of the investigation are shown in Fig. 3.1.

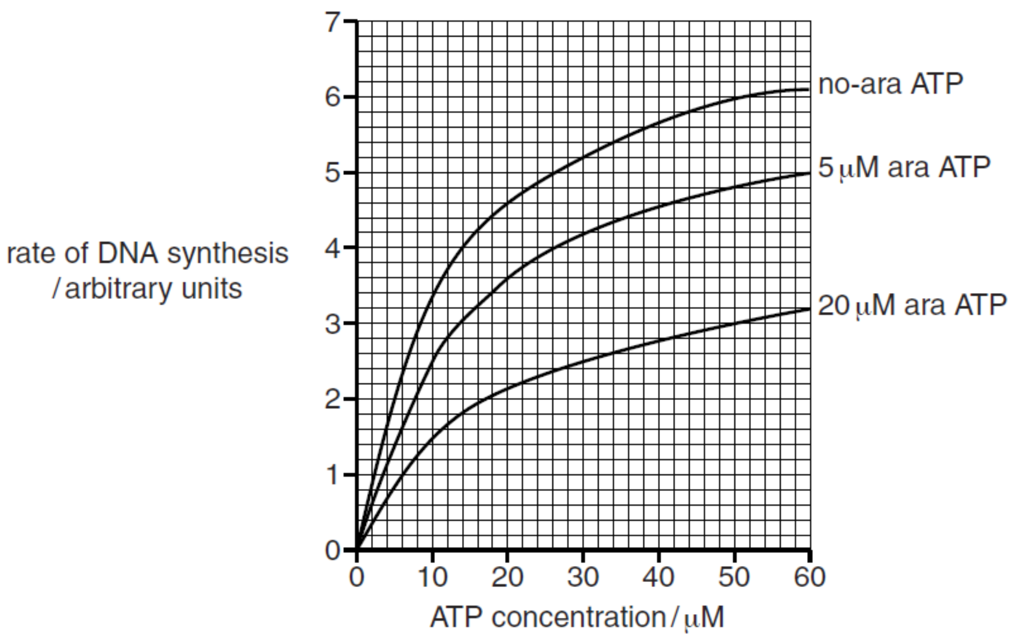


Fig. 3.1

(b) Explain, in terms of mode of action of enzymes, the results of the investigation shown in Fig. 3.1. [4]

1. increasing concentration of ara-ATP (can be comparison between 0 and 5 / 20 or between 5 and 20) decreases enzyme activity, ref. to rate of DNA synthesis for enzyme activity
2. ara-ATP acting as an inhibitor
3. substrate unable to bind with active site / fewer enzyme-substrate complexes (formed)
4. further detail

for either *competitive* inhibition e.g. competes with substrate for (binding to) the active site / similar, structure / shape, as substrate or complementary shape to active site

OR

for *non-competitive inhibition* e.g. binds to site other than active site / changes shape of active site

Colour blindness is a genetic condition characterised by the inability of the brain to perceive certain colours accurately.

- The most common form is termed red-green colour blindness (RGC).
- RGC results from a recessive allele.
- 0.6% of females worldwide have RGC.
- 8.0% of males worldwide have RGC.

The results of the investigation are shown in Fig. 3.2.

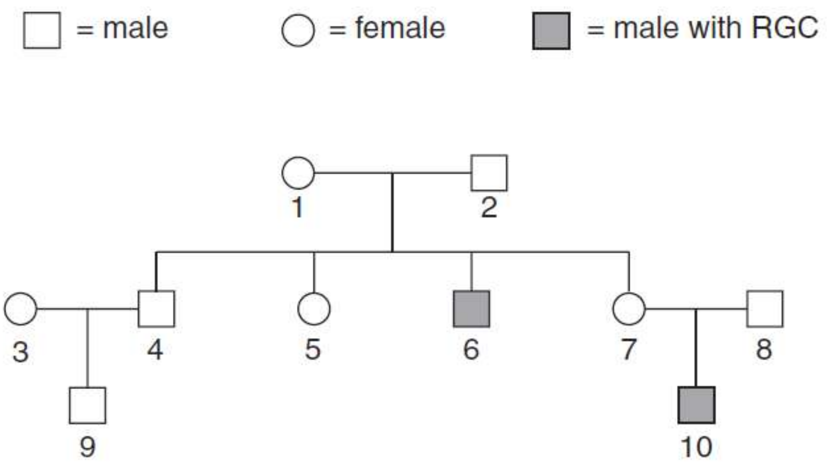


Fig. 3.2

(c)	Define the term *recessive*.	[1]
	allele which does not have its effect in heterozygote	
(d)	Explain why females are less likely than males to have RGC.	[2]
	1. gene / allele, on X chromosome / sex linkage 2. female, needs 2 RGC alleles / homozygous recessive / can be heterozygous 3. male needs only 1 RGC allele to be affected	
(e)	With reference to Fig. 3.2, and using the symbols **R** for the dominant allele and **r** for the recessive allele, state the genotypes of the individuals **1** and **6**.	[2]
	1 X^RX^r **6** X^rY	
	[Total: 11 m]	

Section B
Answer EITHER 4 OR 5.

Write your answers on the separate answer paper provided.
Your answer 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 section (a), (b) etc., as indicated in the question.

4 **(a)** Describe how gel electrophoresis separates DNA, and explain why it is useful in genetic fingerprint. [10]

Principles

- DNA and loading dye are added into the wells at the cathode/ negative electrode end.
- A direct current is switched on.
- DNA is negatively charged due to the phosphate group.
- Hence it migrates twards the anode/ positive electrode
- Separation is by size as agarose gel acts as molecular sieve;
- The larger the mass, the slower it would travel/ found closer to cathode (or vice versa);
- Buffer solution in which the gel is placed in conducts electricity;

(Compulsory 5 marks from above) Any 5 below:

Usefulness

- Allows comparison of genetic fingerprints in a **named** case;
- E.g. criminal case, detection of genetic disease, paternity testing
- Each individual has a unique genetic fingerprint;
- As each individual has alleles that give rise to the bands/ reference to bands obtained after DNA is cut with restriction enzyme;
- Similarity between genetic fingerprint implies inheritance of genes/ genetic similarity/ genetically related;
- Reference to DNA ladder to allow estimation of band size.
- Award 1 mark for an annotated diagram to illustrate;

(b) Describe the features of zygotic stem cells and embryonic stem cells that distinguish them from each other. [3]

Feature	Zygotic Stem Cell	Embryonic Stem Cell
Potential to give rise to cell types	**Totipotent**-have the capacity to give rise to all cell type of the body and to form an entire organism	**Pluripotent**- capable of generating all cell types of the body except extra-embryonic tissues e.g. the amnion, chorion, and other components of the placenta.
Normal Function	divide by mitosis to form a compact ball of cells known as morula, which further divides to form a blastocyst. The blastocyst eventually develops into a growing foetus.	differentiate into cells of different cell types, tissues and organs in a **developing foetus**. Specifically, it first gives rise to cells that form the three embryonic **germ layers** – endoderm, mesoderm and ectoderm.
Formation process	Formed by union of **sperm** and **egg**	Formed from differentiation of zygotic stem cell
Location	Found within zygote	Found within embryo/ **blastocyst**
Therapeutic use	None (Ethical concerns)	Embryonic stem cells induced to differentiate to specialised cells such as nerve cells for Parkinsons or heart muscle

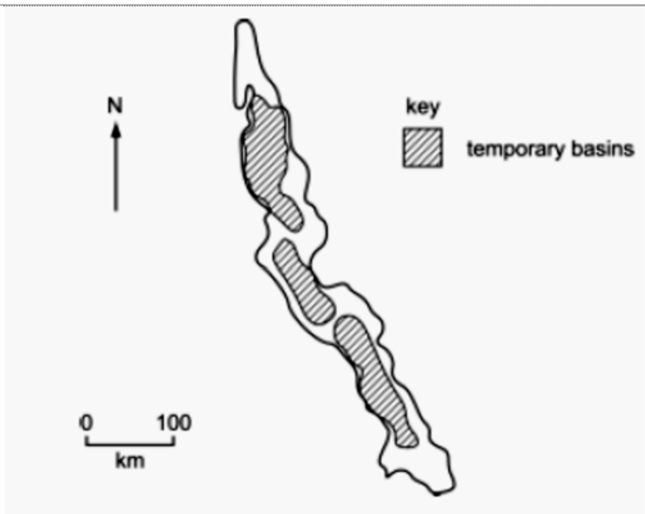
		cells for heart disease. Also ethical concerns. Possible solution – iPSC and cybrids.

	(c)	Discuss the ethical implications of genetically modifying plants.	[7]

- Bt corn, Golden Rice and GM Salmon have the capability of producing more yield with a given number of resources, as compared to traditional methods. Allow for more people to be fed with a given amount of resources.
- Bt corn, Golden Rice and GM Salmon have the capability of producing more yield with a given number of resources, as compared to traditional methods. Helps to cut down cost of production.
- Bt corn has the capability of producing better quality crops as the crystallized protein has an insecticidal effect.
- Mixing genes among species may be argued to be creating a new 'species' through artificial means.
- There is a risk of the genetically modified organism escaping and its effect on the environment and biodiversity is unknown.
- The effects of GM products on human health are still not fully known The effects may only be known after a long period of exposure.
- There is no law making it mandatory for GM food to be labelled.
  Allergic reactions may occur if people unknowingly consume products containing introduced genes.

OR

5	**(a)**	In Lake Tanganyika in Africa, there are six species of fish of the genus *Tropheus* and a much larger number of distinctly coloured subspecies of each of the six species. *Tropheus* species are small fish that are confined to isolated rocky habitats around the shores of Lake Tanganyika. The six species evolved during the primary radiation phase when the lake was first filled, about 1.25 million years ago. They arose from river dwelling ancestors and then filled all available niches in the lake. Secondary radiations into the many subspecies occurred during the last 200 000 years. Sometime during this period, the water level in the lake fell, resulting in the formation of three separate lake basins. These basins persisted for many thousands of years before the water level rose again. **Fig. 5.1** shows an outline map of the lake and the location of the three temporary basins caused by lowering of lake levels.	[10]



Using Darwin's theory of natural selection, explain how did the six species and subspecies of each species arise on Lake Tanganyika.

- Mutations/ different alleles in the genetic sequence of population of fish;
- Genetic variation leads to phenotypic variation in the population of fish;
- Different parts of the shore/rocky habitat exerts different selection pressure;
- Phenotypes that have selective advantage are selected for, go on to survive, reproduce and pass down favourable alleles/ converse argument;;
- Overtime, allele frequency of population changes;
- Fish with advantageous traits increase in population;
- Genetic drift event occurs independently in different parts of the shores;
- Gene pool between population of fish diverges;
- Population of fish becomes reproductively isolated;
- Because of habitat differentiation/ behavioural isolation/ avp;
- No gene flow;
- Do not interbreed to produce viable and fertile offsprings, forming six species of fish;
- Formation of 3 temporary basins resulted in geographical isolation;
- Ref. to different environment and selection pressure in the 3 basins;
- No gene flow between species of fish in the 3 basins, many subspecies arise;

(b) Discuss advantages of using molecular data in determining evolutionary relationships. [3]

- Analysis of molecular data is objective since differences in DNA/RNA/ proteins can be objectively compared by analyzing nucleotide and amino acid sequences.
- Data obtained from sequence comparisons are quantitative and can be used to measure degree of relatedness between different organisms based on calibrated molecular clocks, the number of nucleotide/amino acid
- differences can be used to estimate the time of divergence between two closely related species
- Molecular methods are able to differentiate two organisms with similar morphologies/ convergent evolution based on molecular differences.
- Molecular methods are also useful for studying evolutionary relationships between groups of organisms that have very little common ground for morphological comparison e.g. mammals and bacteria
- All known life forms can be compared since all organisms possess nucleic acids as the genetic material.

- Scientists are able to use both living and dead specimen material in classification of organisms.
- Molecular methods also reveal that some major phenotypic differences may actually be due to small genetic differences

Any 3

(c) Describe how mitosis ensures genetic stability. [7]

- Definition of genetic stability: Genetical stability means daughter cells have the same number of chromosomes and same genes as the parent cells.

(Compulsory one mark for first point) Any 6 below:

- At prophase, each chromosome comprises of genetically identical sister chromatids joined at centromere.
- No crossing-over at prophase ensures that the chromatids are genetically identical.
- Due to semi-conservative replication of DNA during S phase of interphase earlier before mitosis.
- At metaphase, chromosomes align singly along equator.
- Correct attachment of spindle fibres during metaphase ensure no non-disjunction later.
- At anaphase, centromere of each chromosome divides.

To consider following marking points?

- Genetically identical sister chromatids separate to form genetically identical chromsomes.
- Spindle fibres pull equal number of chromosomes to each pole.
- Cytokinesis (separation of cytoplasm) during telophase ensures two genetically identical daughter cells.

- Mitosis forms 2 nuclei/ cells with **same number of chromosomes** as the parent cells/ has **complete set of genome**;
- During prophase, chromatin fibres (fully) condense into discrete chromosomes to ensure that **even distribution** of the genetic material is **manageable**;
- Chromosomes appear as double arm structures with **genetically identical** sister chromatids join at the centromeres;
- The sister chromatids are genetically identical with **same base sequences, same alleles of genes**;
- The sister chromatids are products of **semi-conservative** DNA replication that took place in **S phase of interphase** before mitosis begin;
- During prophase, the nuclear envelope disintegrates/ break down to allow for the attachment of kinetochore microtubules to the centromeres of the chromosomes;
- During prophase, **homologous chromosomes do not pair up** and thus **no crossing over** occurs, that allow sister chromatids to remain genetically identical throughout mitosis;
- All the chromosomes lined up singly at the metaphase plate during metaphase; they do not pair up and orientation of each chromosome does not affect the gene sequence each daughter cell receives because the sister chromatids are genetically identical/ each pole will receive one DNA molecule of each chromosome;
- Microtubules attached to a particular chromatid all comes from one pole of spindle and those attached to its other sister chromatids come from the opposite pole ensures each pole will receive one DNA molecule of each chromosome/ Centrioles migrate to opposite poles of the cells and organises spindle fibers that attach to each chromosomes at the centromere via kinetochores to ensure one complete set of genetic material is pulled to opposite poles;
- During telophase, chromosomes decondense to form chromatin and nuclear envelope reforms around each set of chromosomes at opposite poles of the cell, forming 2 nucleus containing identical genetic information;
- During cytokinesis, cell membrane undergoes cleavage to form 2 genetically identical daughter cells

ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

BIOLOGY	**8875/01**
HIGHER 1	**25 August 2017**
Paper 1 Multiple Choice	**1 hour**

Additional Material: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, pencil clips, highlighters, glue or correction fluid.
Write your name, centre number and index number on the Answer Sheet provided.

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

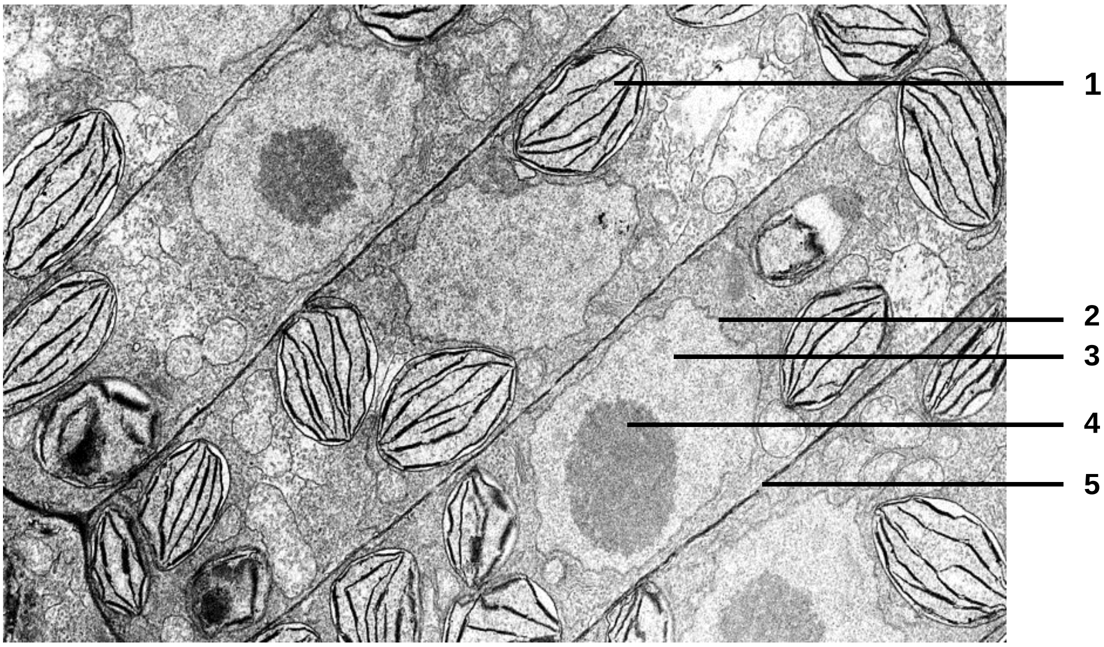
Read the instructions on the Answer Sheet very carefully.

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.

Calculators may be used.

This question paper consists of **21** printed pages.

1 The electron micrograph shows root cells from the duckweed plant.



Which of the following options about structures 1 to 5 is correct?

	Contain ribosomal subunits	Contain tRNA	Contain phospholipids
A	1, 2, 3	3 only	1, 4
B	1, 3, 4	1, 3	2, 5
C	1, 3, 5	1, 2, 4	2, 4, 5
D	2, 4, 5	2, 4, 5	1, 3, 4, 5

2 Studies have shown that the formation of stable multi-layered flattened stacks appears to be essential for the proper functioning of the Golgi body. This structure is maintained by an intact microtubule network and a group of peripheral and integral proteins found on the cytoplasmic surface of Golgi membranes.

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

Normal Golgi body   Fragmented Golgi body

Which of the following are possible inferences from the information?

1 Fragmented Golgi bodies may result in the disorganisation of glycosyltransferases, leading to abnormal glycosylation of proteins linked to cancer.
2 Fragmented Golgi bodies are a consequence of mutated Golgi membrane proteins, resulting in the loss of attachment sites for cisternae to stack.
3 Fragmented Golgi bodies may result in the loss of attachment sites for transport vesicles from the rough endoplasmic reticulum, leading to unmodified proteins which are non-functional.
4 Fragmented Golgi bodies may result in reduction of sorting and processing of proteins for the maintenance of nerve cells, leading to their degeneration.

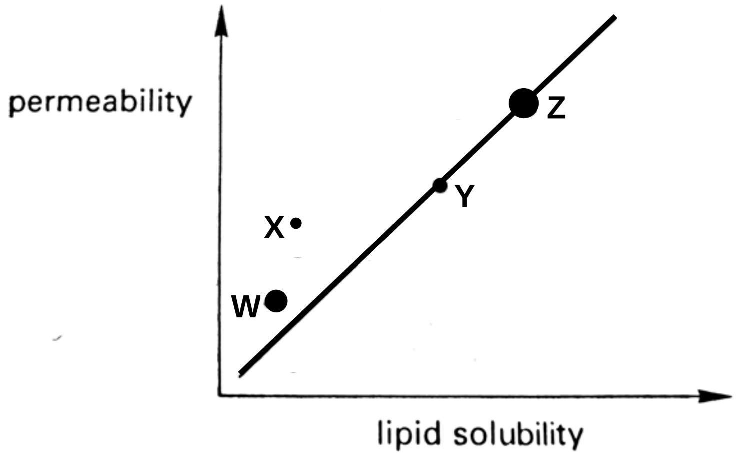
A 1, 2, 3 and 4

B 2, 3 and 4 only

C 1 and 2 only

D 4 only

3 The diagram shows the relationship between the size, lipid solubility and ability of molecules to cross the mammalian cell surface membrane. The diameter of the black circles in the diagram is proportional to the size of the molecules.



Which of the following could molecules W to Z represent?

	W	X	Y	Z
A	calcium chloride	methane	cholesterol	glucose
B	glucose	water	carbon dioxide	cholesterol
C	calcium chloride	water	glucose	cholesterol
D	glucose	methane	carbon dioxide	calcium chloride

4 Plants are able to regulate their thylakoid membrane fluidity at different seasons of the year. In an investigation on thylakoid membrane fluidity in spinach leaves, three variables which influence membrane fluidity were measured at winter and summer.

Variable	Season X	Season Y
Percentage of saturated fatty acids	15.5	13.9
Average number of double carbon bonds per lipid	4.71	4.76
Lipid to chlorophyll ratio	2.9	2.1

Which of the following correctly identifies season X, with the most possible explanation?

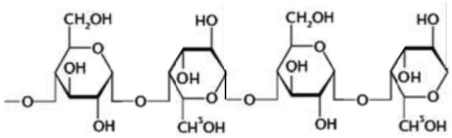
A Winter; a higher lipid to chlorophyll ratio increases proportion of weak hydrophobic interactions resulting in a more fluid membrane at lower temperatures

B Summer; a higher proportion of saturated fatty acids prevents phospholipids from moving too far apart at higher temperatures

C Winter; a higher proportion of saturated fatty acids prevents phospholipids from packing too closely at lower temperatures

D Summer; a higher number of kinks per lipid allows phospholipids to pack closely together at higher temperatures

5 Dextrins are a group of carbohydrates with low molecular weight, and are produced by hydrolysing starch or glycogen. Which of the following is/are **not** likely to be a segment from a dextrin molecule?

1


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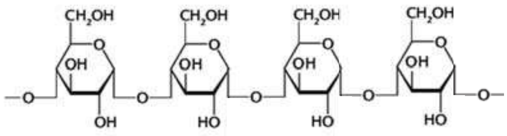

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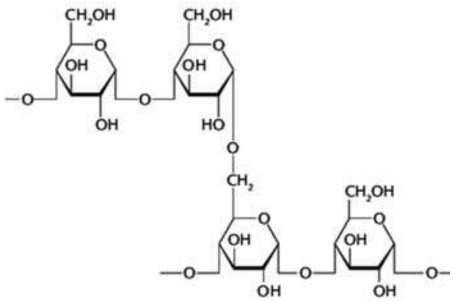
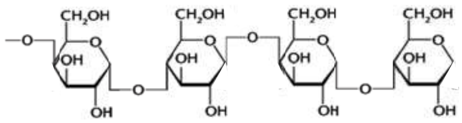


4


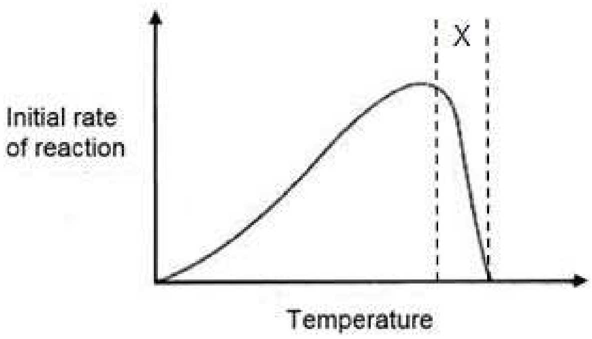
A 1, 3 and 4 only

B 1 and 4 only

C 2 and 3 only

D 4 only

6 The diagram below shows the initial rate of reaction at different temperatures, using constant substrate and enzyme concentrations.



Which of the following is/are possible reason(s) for the decline shown in region X?

1 End product inhibition occurs to inhibit enzyme activity
2 Depletion of substrate at the end of the enzyme catalysed reaction
3 Disruption of intramolecular bonds in the enzyme
4 Change in ionic charges at the active site of the enzyme

A 1, 2, 3 and 4

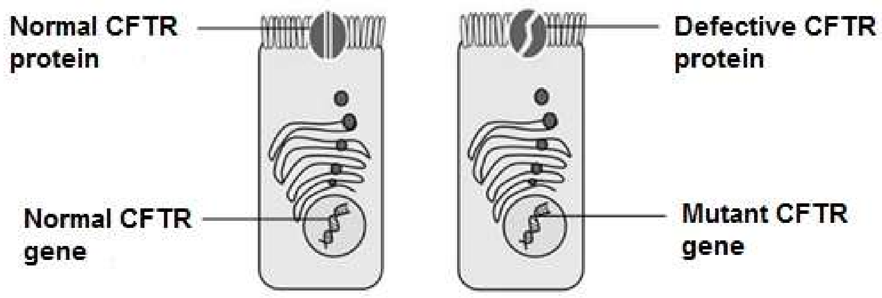
B 1 and 2 only

C 3 and 4 only

D 3 only

7 Cystic fibrosis is a genetic disease caused by the synthesis of a defective form of the cystic fibrosis transmembrane conductance regulator (CFTR) protein found in epithelial cells that line the lungs, digestive tract, sweat glands, and genitourinary system. The CFTR protein is a transmembrane protein that transports chloride ions across the cell surface membrane.

The diagram shows the difference between a normal CFTR protein and a type of defective CFTR protein.



Which of the following is the most likely explanation for the defective CFTR protein?

A The mutation did not change the primary structure, but the bonds between the R-groups were altered, causing the tertiary structure to change.

B The mutation resulted in a change in the primary structure of the protein, causing a loss of α-helices and the dislodging of the protein from the cell membrane.

C The mutation resulted in a shorter polypeptide, altering the bonds between the R-groups, causing the tertiary structure to change.

D The mutation resulted in a replacement of an amino acid in the primary structure, causing the channel in the protein to become more hydrophilic.

8 Which of the following correctly describes the cellular events that occur between anaphase and telophase in mitosis?

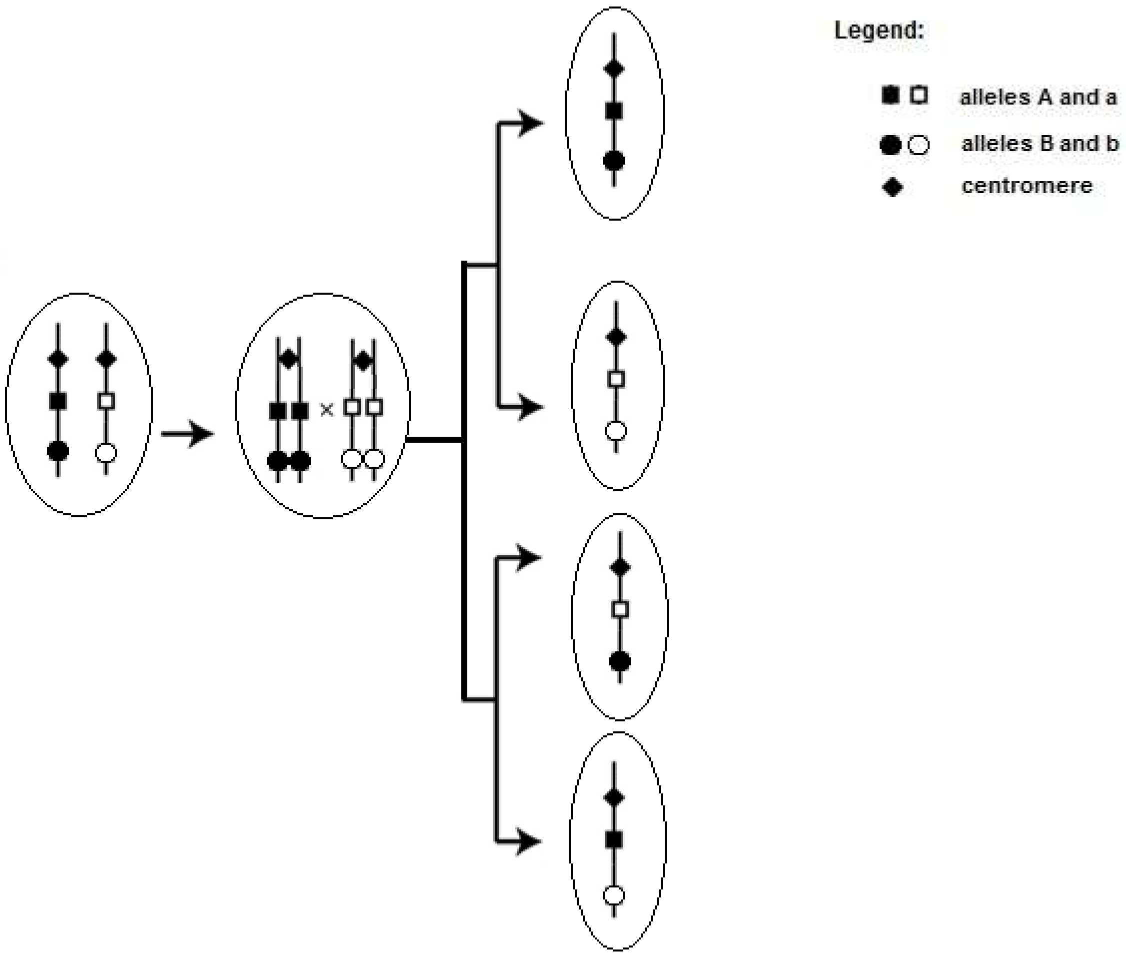
A There is a decrease in protein synthesis to shorten the spindle fibres during anaphase to pull the chromosomes to opposite poles of the cell.

B Homologous chromosomes undergo independent assortment during anaphase to ensure equal division of the genetic material.

C Chromosomes become more compact to prevent entanglement between two nucleoli as they reform at telophase.

D The number of vesicles within the cytoplasm decreases during telophase as fragments of the nuclear membrane fuse to reform the nuclear envelope.

9 The diagram illustrates the daughter cells formed at the end of a meiotic cell cycle. Alleles A and a are represented by black and white boxes respectively. Alleles B and b are represented by black and white circles respectively. The centromere on the chromosome is represented by the diamond.



Which of the following statements about genetic variation can be concluded from the diagram?

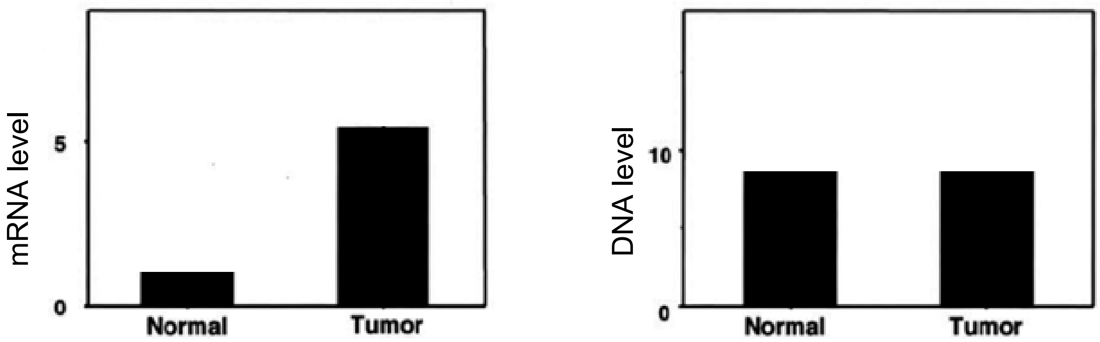
A Random assortment and segregation of homologous chromosomes result in different combinations of paternal and maternal chromosomes in the gametes.

B Random assortment and segregation of homologous chromosomes in the presence of crossing over increases the allele frequency of a population.

C Crossing over between non-sister chromatids of homologous chromosomes can result in new combinations of alleles on the chromosomes of the gametes.

D Crossing over between non-sister chromatids of homologous chromosomes result in new alleles on the chromosomes of the gametes.

10 Gene expression profiling has identified a new risk locus in influencing susceptibility to human colorectal cancer. The diagram below shows the comparison of mRNA and DNA levels between tumours and adjacent normal tissues.



Which of the following are possible products of this gene?

1 Proteins involved in cell adhesion
2 Proteins involved in cell cycle progression
3 Protein involved in apoptosis
4 Proteins involved in DNA repair

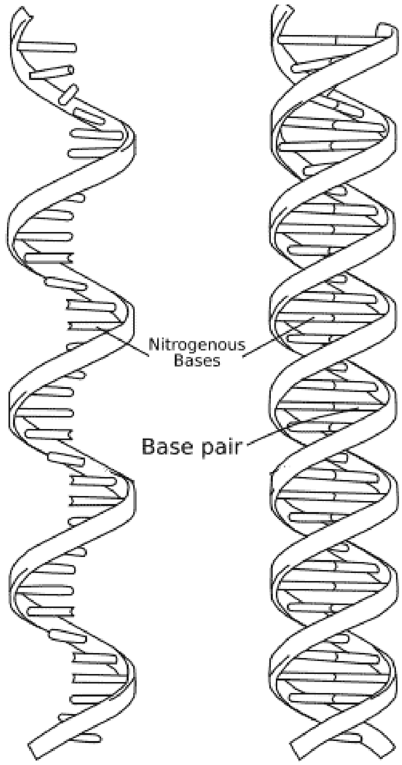
A 1, 3 and 4 only

B 1 and 4 only

C 2 and 3 only

D 2 only

11 The structures of two molecules are shown.



Which option best describes the structures and functions of these two molecules?

A Both molecules have phosphodiester, hydrogen bonds and hydrophobic interactions, allowing them to be stable molecules so that genetic information can be passed from one cellular generation to the next.

B Both molecules have nucleotides that allow for complementary base pairing with nucleotides in other molecules, hence allowing for genetic information to be passed from one cellular generation to the next.

C Both molecules have nucleotides that allow for complementary base pairing. However, complementary base pairing in one ensures accuracy during replication while in the other, it enables gene expression.

D Both molecules have covalent phosphodiester bonds between nucleotides. This ensures both molecules have increased stability and are not easily degraded by exonucleases.

12 The list shows the stages in the cellular replication of DNA.

1 Formation of phosphodiester bonds between Okazaki fragments
2 Dissociation of DNA from histone proteins
3 Synthesis of RNA primers
4 Addition of deoxyribonucleotides
5 Separation of DNA double helix

Which is the correct sequence?

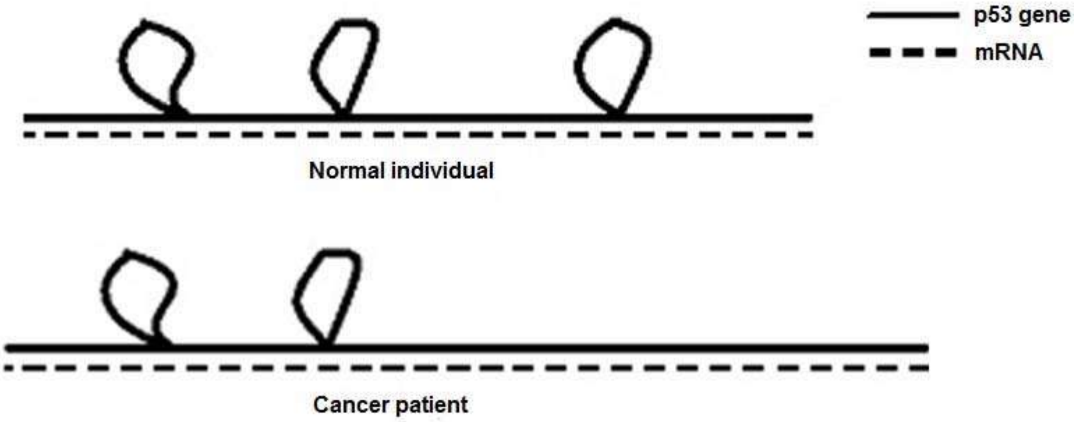
A 5 → 4 → 3 → 1 → 2

B 2 → 5 → 4 → 3 → 1

C 5 → 2 → 3 → 1 → 4

D 2 → 5 → 3 → 4 → 1

13 mRNA was isolated from a normal individual and a patient suffering from cancer. The mRNA was allowed to hybridise with the *p53* gene. The schematic diagram shows the results of the hybridisation process under the electron microscope.



Which of the following could be a possible explanation why the patient is suffering from cancer?

A A point mutation had occurred in the intron leading to the failure to excise one intron, hence leading to a longer dysfunctional protein being translated.

B A point mutation had occurred in the intron leading to an exon being excised, hence leading to a shorter dysfunctional protein being translated.

C A point mutation had occurred leading to the failure of spliceosome to recognise splice sites leading to the excision of the wrong intron, leading to a dysfunctional protein being translated.

D Gene amplification had occurred leading to the multiple copies of a trinucleotide repeat in an intron, hence causing splice site to be misread due to frameshift mutation, leading to a longer dysfunctional protein being translated.

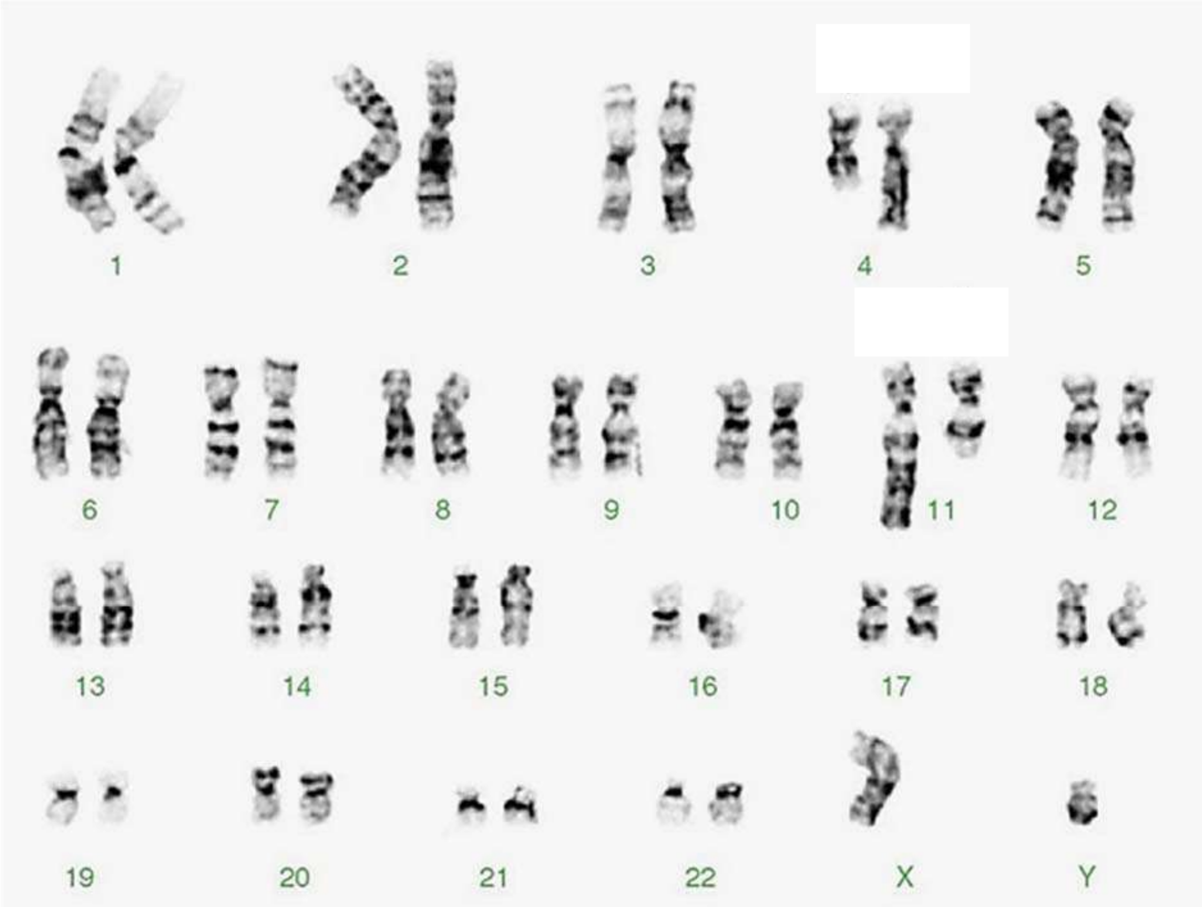
14 Many of the most effective antibiotics used in modern medicine are compounds made by fungi that inhibit bacterial protein synthesis. Among the most commonly used drugs are Chloramphenicol, Cycloheximide and Rifampicin. The results of the exposure to eukaryotic and prokaryotic cells to the above three drugs are shown.

Anti-microbial drug	Chloramphenicol	Cycloheximide	Rifampicin
Eukaryotic animal cell	Truncated polypeptides were found in mitochondria only	Truncated polypeptides were found in cytosol	No protein synthesized
Prokaryotic cell	Truncated polypeptides were found in the cytosol	Truncated polypeptides were found in the cytosol	No protein synthesized

Which of the following shows the correct combination of the possible drug mechanisms of the above drugs?

	Chloramphenicol	Cycloheximide	Rifampicin
A	Inhibits the peptidyl transferase activity of the 70S ribosomes	Inhibits elongation by binding the E site of the ribosome hence preventing the release of tRNA	Inhibits the transcription of DNA by blocking the movement of RNA polymerase on DNA
B	Inhibits the peptidyl transferase activity of the 80S ribosomes	Inhibits elongation by binding the E site of the ribosome hence preventing the release of tRNA	Inhibits the transcription of DNA by blocking the movement of RNA polymerase on DNA
C	Inhibits elongation by binding the P site of the ribosome hence preventing the formation of peptidyl tRNA	Inhibits elongation by binding the A site of the ribosome hence preventing the release of tRNA	Inhibits translation by binding to the small ribosomal subunit
D	Inhibits elongation by binding to mRNA and preventing ribosomal translocation	Inhibits elongation by binding the P site of the ribosome hence preventing the release of polypeptide	Inhibits translation by binding to the binding site of large ribosomal subunit

15 The diagram shows a human karyotype.



The person who has this karyotype is a male with

A aneuploidy

B polyploidy

C chromosomal translocation

D chromosomal amplification

16 Which of the following would cause phenotypic variation among organisms of the same genotype?

A Crossing over

B Independent assortment

C Exposure to different environments

D Different varieties of the same species

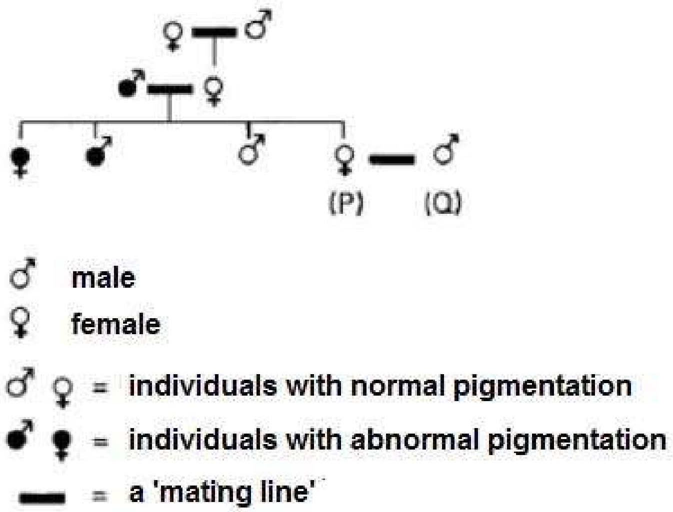
17 In a cross between red haired cattle and white haired cattle, the offspring produced are always a colour called roan (light red). If the roan cattle are interbred, they produce white, roan and red offspring.

In rabbits, several different coat colours are observed – agouti, chinchilla, himalayan and albino.

Based on the above observations, how many alleles are possibly controlling the coat colour in cattle and rabbits?

	Cattle	Rabbits
A	2	2 or 3
B	2	3 or 4
C	3	2 or 3
D	3	3 or 4

18 In a species where the female is homogametic, a sex-linked allelic pair controls pigmentation. The following results were obtained during the course of a breeding experiment.



Which one of the following ratios of offspring will be produced when P and Q are bred together?

A 2 females (both normal): 2 males (both abnormal)

B 2 females (both carriers): 2 males (both normal)

C 2 females (1 carrier, 1 abnormal): 2 males (1 normal, 1 abnormal)

D 2 females (1 carrier, 1 normal): 2 males (1 normal, 1 abnormal)

19 Which of the following is the final pathway followed by all carbon atoms derived from the oxidation of carbohydrates, lipids and proteins in the presence of oxygen?

A Calvin cycle

B Electron transport system

C Krebs cycle

D Oxidative phosphorylation

20 Glucose, made from six radioactively-labelled carbon atoms, is fed to yeast cells in the absence of oxygen. How many molecules of radioactive alcohol are formed from each molecule of the glucose?

A 1 **B** 2 **C** 3 **D** 6

21 Dinitrophenol is a metabolic poison that can lodge within the thylakoid membranes of chloroplasts. It then provides an alternative route for H^+ ions to diffuse across the thylakoid membranes. In what way will the Calvin cycle be affected in chloroplasts poisoned by dinitrophenol?

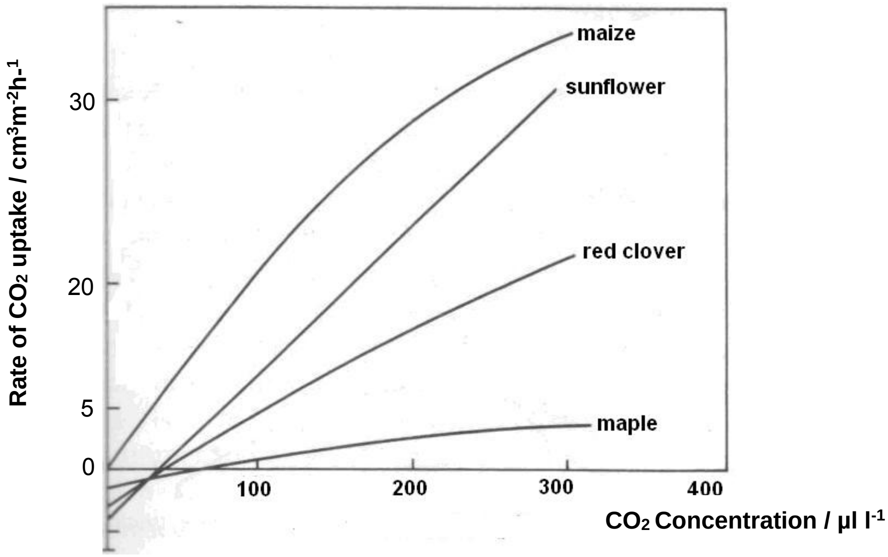
A No change in rate as Calvin cycle occurs in the stroma and not at thylakoid membranes.

B The rate of Calvin cycle will increase as pH in the stroma will decrease towards the optimum for enzymes involved in the cycle.

C The rate of Calvin cycle will decrease with the accumulation of glycerate-3-phosphate.

D The rate of Calvin cycle will decrease with the accumulation of glyceraldehyde-3-phosphate.

22 The diagram below shows the rate of photosynthesis of four different plants at different concentrations of carbon dioxide.



Which of the following conclusions can be made?

1 At CO_2 concentrations below 150 μl l^{-1}, CO_2 concentration is the main limiting factor for all the plants.
2 CO_2 compensation point is around 40 μl l^{-1} for sunflower and red clover, and it measures the light intensity when the rate of CO_2 uptake equals to the rate of CO_2 given off.
3 Rate of CO_2 uptake was zero for maize at CO_2 concentration of 0 μl l^{-1} as the amount of CO_2 released from respiration is used for photosynthesis.
4 Of the four plants, maple has the lowest amount of organic compound produced at CO_2 concentration of 200 μl l^{-1}.

A 1, 2 and 3 only

B 1, 3 and 4 only

C 1 and 2 only

D 3 and 4 only

23 Vancomycin is an antibiotic which inhibits the growth of bacteria by interfering with the action of bacterial transpeptidase, thus preventing the proper synthesis of the bacterial cell wall. Bacteria with a weakened cell wall lyses under osmotic pressure.

In response to increased bacterial resistance to vancomycin, scientists modified the chemical structure of vancomycin to confer it with two additional antibacterial mechanisms. The modified antibiotic can also inhibit bacterial transglycosylase, another enzyme involved in cell wall synthesis. The modifications also allow the antibiotic to bind to bacterial plasma membrane and disrupt it, hence increasing membrane permeability.

Medical institutions reserve the use of such new antibiotics to last-resort cases where other antibiotics are unable to treat the infection.

Which of the following statements explain why it is difficult for bacterial resistance against the modified vancomycin to evolve?

1 Most strains of bacteria would be susceptible to one of the three mechanisms of the modified vancomycin.
2 The proportion of alleles conferring resistance in the gene pool of a bacterial population would only increase slowly due to a short replicative cycle.
3 A bacterium cell would require mutations in at least three different genes to gain resistance to the modified vancomycin.
4 Due to controlled usage in the medical setting, selection pressure for resistant strains is likely to be weak.

A 1, 2 and 3 only

B 1, 3 and 4 only

C 2 and 3 only

D 3 and 4 only

24 The greater prairie chicken (*Tympanuchus cupido*) used to be an abundant species in North America. With the conversion of tallgrass prairies to agriculture cropland, the loss of their native habitat have led to rapid population decline in the greater prairie chicken.

The following table shows the change in population size of greater prairie chickens in the state of Illinois (USA) over three decades. Analyses of the average number of alleles per gene locus, as well as the success rates of egg hatching, are also shown in the table.

Year	Population size / n	Average number of alleles per gene locus	Success rate of egg hatching / %
1962	2,000	5.2	91
1994	46	3.7	38

Scientists were concerned with the population decline in greater prairie chickens. Which of the following explains why it is a cause for concern?

A When the average number of alleles per gene locus decreases from 5.2 to 3.7, the population is no longer able to evolve by natural selection.

B When the average number of alleles per gene locus decreases, changes in environmental conditions may easily lead to extinction of the population.

C The population size is inversely related to the level of genetic diversity in the population of greater prairie chickens as a result of inbreeding.

D The level of genetic diversity in the population is inversely related to the success rate of egg hatching of greater prairie chickens, which further affects the population size.

25 The phylogenetic relationship of four different species – human, whale, pigeon and the house lizard – was investigated. Part of the amino acid sequence for the cytochrome c protein found in the different species was analysed and is shown in the following table (the letters denote different amino acids).

Species	Amino acid sequence of cytochrome c
Human	I F V G I K K K E E R A D L I A Y L K K A T N E
Whale	I F A G I K K K G E R A D L I A Y L K K A T N E
Pigeon	I F A G I K K K A E R A D L I A Y L K Q A T A K
House Lizard	I F A G I K K K A E R A D L I A Y L K D A T S K

Which of the following statements regarding the evolutionary relationships of these four species is true?

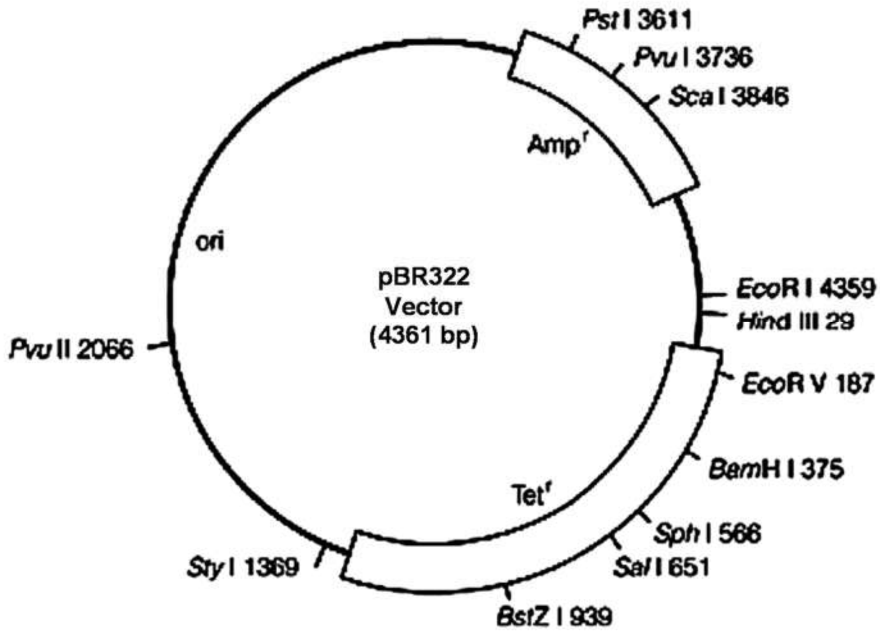
A Pigeons are unrelated to all the other three species due to differences in forelimb anatomy.

B House lizards and humans are the most closely related due to similarities in forelimb anatomy.

C Humans are more closely related to whales than to pigeons based on molecular homology seen in cytochrome c.

D Whales are more closely related to pigeons than house lizards based on molecular homology seen in cytochrome c.

26 The pBR322 vector is used to clone a eukaryotic gene, which has been digested by the restriction endonuclease *BamHI*.



Following transformation, bacterial cells were grown in four different media, as shown below:

1 Nutrient broth containing ampicillin
2 Nutrient broth containing tetracycline
3 Nutrient broth containing ampicillin and tetracycline
4 Nutrient broth without ampicillin and tetracycline

Which of the following media would bacterial cells containing the recombinant plasmids grow in?

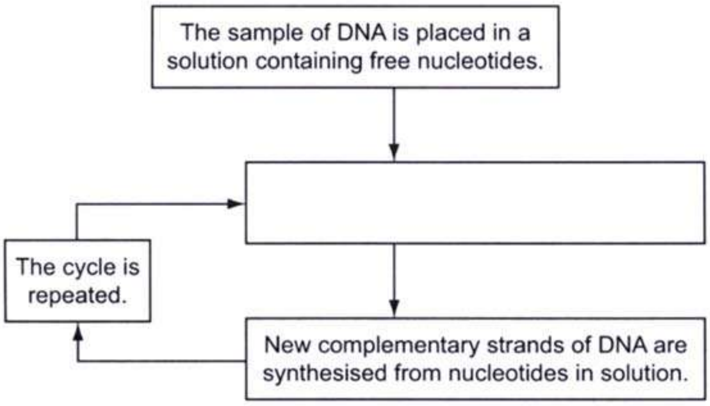
A 1 and 2 only

B 1 and 4 only

C 2 and 3 only

D 4 only

27 The polymerase chain reaction is summarised in the flowchart below.



Which statement completes the flow chart?

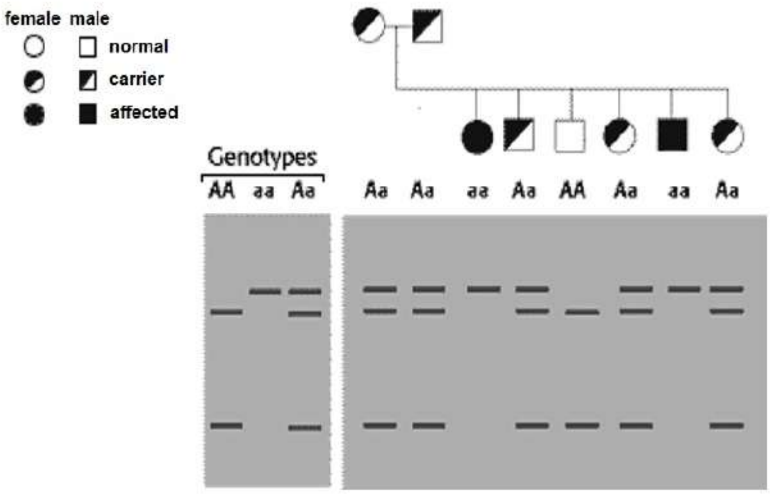
A Complementary strands of DNA are separated.

B Free nucleotides are added to the ends of parental DNA strands.

C Small sections of DNA are formed.

D Strands of DNA bind to RNA primers.

28 Sickle-cell anaemia is an autosomal, recessive human disease. A hypothetical pedigree for parents, each heterozygous for the sickle-cell allele, is shown in the figure below.



Based on the above analysis, which of the following statements is true?

A The sickle-cell anaemia is caused by a mutation resulting in a gain of a new restriction site.

B The sickle-cell anaemia is caused by a mutation resulting in a loss of an existing restriction site.

C The sickle-cell anaemia is caused by a mutation where 3 bases are inserted in between the restriction sites.

D The fragments generated from the normal allele is a result of cutting at more than three restriction sites.

29 Which of the following is a correct statement about obtaining human embryonic stem cells for research?

A Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.

B The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.

C The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.

D The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

30 Which of the following genetic modifications would **not** decrease the quantity of chemicals sprayed onto crop plants by farmers?

A Fungal resistance

B Herbicide resistance

C Insect resistance

D Viral resistance

ACJC Prelim 2017
H1 Biology Paper 1 (8875/01) Answers

Question	Answer	Question	Answer
1	**B**	16	**C**
2	**A**	17	**B**
3	**B**	18	**D**
4	**B**	19	**C**
5	**B**	20	**B**
6	**D**	21	**C**
7	**C**	22	**B**
8	**D**	23	**B**
9	**C**	24	**B**
10	**D**	25	**C**
11	**C**	26	**B**
12	**D**	27	**A**
13	**A**	28	**B**
14	**A**	29	**B**
15	**C**	30	**B**

Name	Subject Class	Class	Candidate Number
	2BIX01		

ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

BIOLOGY — **8875/02**

17 AUGUST 2017

HIGHER 1 — **2 hours**

Paper 2

Additional Material: Writing Paper

READ THESE INSTRUCTIONS FIRST
Write your name, index number and class on this answer booklet.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

At the end of the examination, circle the number of the Section B question you have answered in the grid opposite.
Fasten all your work securely together.

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

For Examiner's Use	
Section A	
1	
2	
3	
Section B	
4 or 5	
Total	**60**

This question paper consists of **10** printed pages.

For examiner's use

SECTION A
Answer all questions.

1 Fig. 1.1 shows part of a cell.

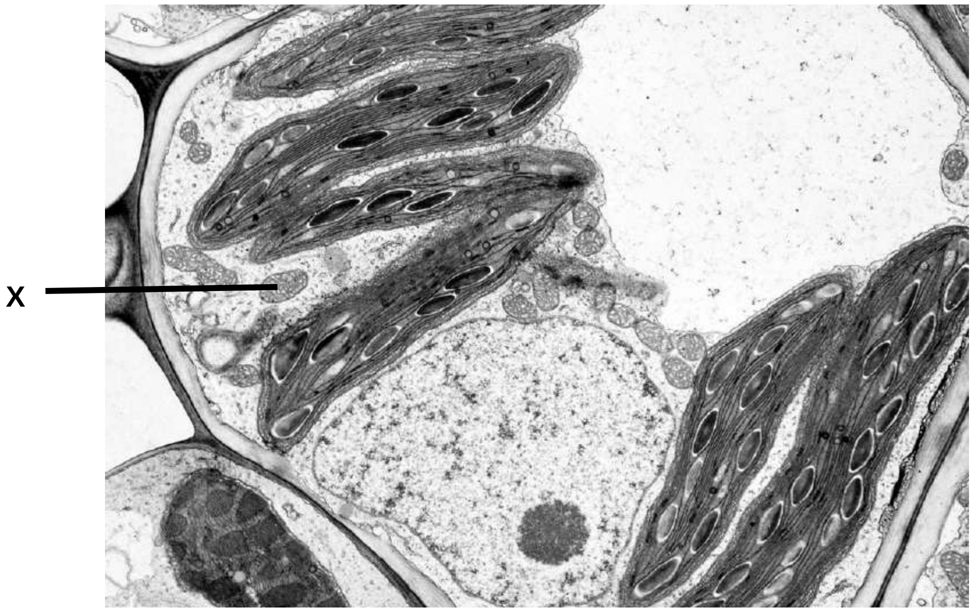


Fig. 1.1

(a) (i) Outline the role of the organelle labelled X.

[2]

(ii) Identify two molecules with different modes of transport across the double membrane of X and explain their modes of transport.

[4]

(b) **(i)** Explain the significance of glycolysis in aerobic respiration.

[4]

An experiment was carried out to investigate the effect of temperature on respiration in isolated mitochondria extracted from a worm. Respiratory substrate was provided and oxygen consumption was monitored at 15°C, 25°C and 35°C. Fig. 1.2 shows the temperature coefficients, Q_{10}, when temperature is increased from 15°C to 25°C and from 25°C to 35°C. Q_{10} measures the ratio of the rate of respiration when the temperature increases by 10°C.

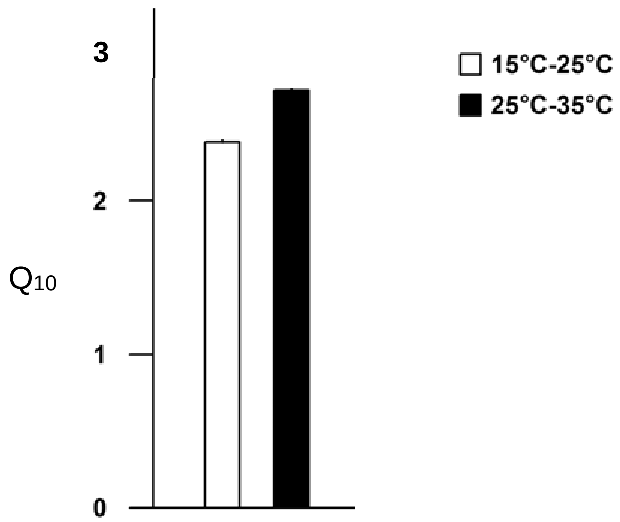


Fig. 1.2

(ii) Describe and explain the effect of temperature on the Q_{10} of mitochondria respiration.

[3]

[Total: 13 m]

2 Fig. 2.1 shows plant cells undergoing mitosis. Each of the cells A, B, C and D is in a different stage of mitosis.

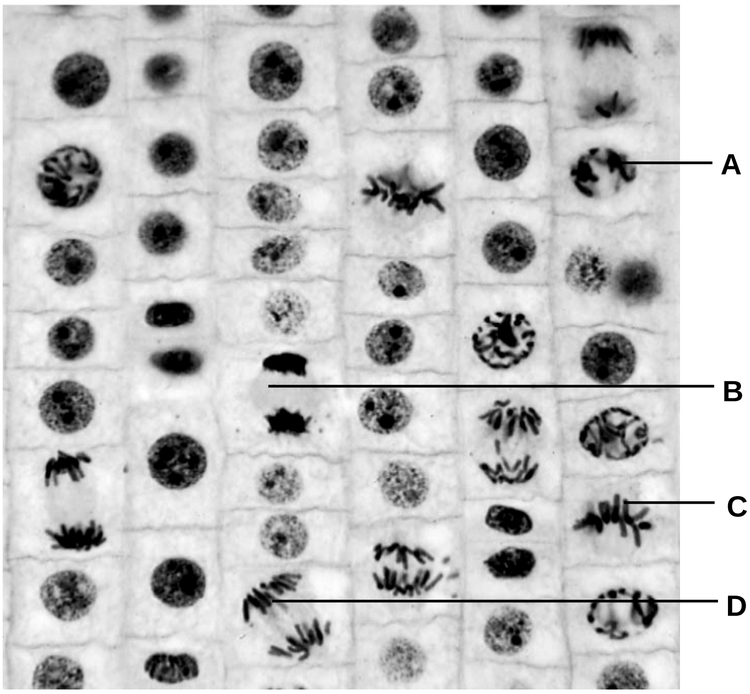


Fig. 2.1

(a) (i) Using the letters provided, write the correct order of the stages in mitosis.

....[1]

(ii) Describe the stage of mitosis in cell B.

....

....[3]

Fig. 2.2 shows the change in DNA content of a plant cell during one cell cycle

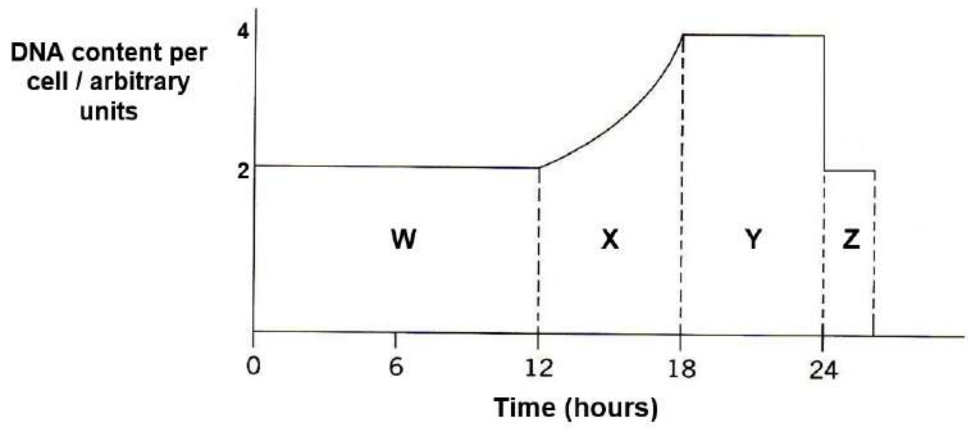


Fig. 2.2

(b) (i) With reference to Fig. 2.2, identify which period (W to Z) of the cell cycle the radioactivity of the nuclei would first increase if radioactive thymine was added to the cell culture at 0 hours. Explain your answer.

....

....

.... [3]

(ii) Explain why it is necessary for the cell cycle to be tightly regulated at various checkpoints that control the rate of cell division.

....

.... [1]

Horses were found to have three different coat colours – chestnut (brown), white and roan (patches of brown and white). The hair found on horses may be curly or smooth. These two traits are determined by two genes found on separate chromosomes, and each gene has two allelic forms.

When a true breeding chestnut horse with smooth hair was mated with a white horse with curly hair, all the progeny foals have roan coats with smooth hair.

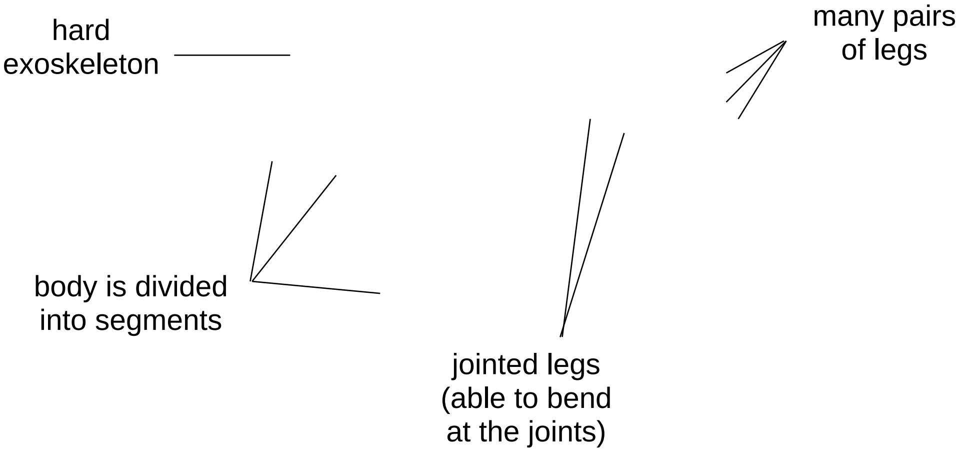
(c) Using appropriate symbols, construct a genetic diagram to show the expected genotypes and phenotypes of the F_2 progeny when two horses in the F_1 generation are crossed.

[5]

[Total: 13 m]

For examiner's use

3 Arthropods are a vast group of animals that have been on earth for about 500 million years. Fig. 3.1 shows the dorsal (top) and ventral (bottom) views of the horseshoe crab (genus *Limulus*) and some characteristics representative of all arthropods. Fig. 3.2 shows a fossil and an artist's impression of the Sanctacaris, which is one of the earliest arthropods and proposed by some scientists to be the ancestor of the horseshoe crab.



Dorsal view Ventral view

Fig. 3.1

Fossil Artist's impression

Fig. 3.2

(a) (i) With reference to Figs. 3.1 and 3.2, explain why anatomy can be used to establish evolutionary relationships between fossils and their living descendants.

[3]

For examiner's use

(ii) Based on its flap-like appendages, Sanctacaris was believed to be an aquatic arthropod. The horseshoe crab, however, utilises land habitats for certain parts of its life cycle - the eggs are laid on the coast and juveniles are found on the sandy tidal flats. Adults are found deeper in the ocean until they return to the beach to lay their eggs.

Using the theory of natural selection, suggest how horseshoe crabs evolved from Sanctacaris.

[4]

(b) (i) Explain why molecular homology is preferred over anatomical homology in determining relationships between organisms.

[2]

(ii) Suggest why molecular homology was not used in establishing the relationship between the horseshoe crab and the Sanctacaris.

[1]

For examiner's use

(c) Genetic variation is essential for evolution. Explain how DNA mutations give rise to phenotypic variation.

[4]

[Total: 14 m]

For examiner's use

Section B

Answer **EITHER 4 OR 5**.

Write your answers in the lined pages provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

EITHER

4 **(a)** Compare the structure of collagen and DNA. [6]

(b) With reference to the fluid mosaic model, describe the roles of phospholipids and proteins in a cell surface membrane. [8]

(c) Discuss the ethical concerns that have arisen from the human genome project. [6]

[Total: 20 m]

OR

5 **(a)** Explain the roles of membranes in transcription and translation. [6]

(b) Describe the role of enzymes in the cloning of human Insulin gene from mRNA using *E. coli.* [8]

(c) Explain the normal functions and features of two named stem cells in a living organism. [6]

[Total: 20 m]

END OF PAPER

Name	Subject Class	Class	Candidate Number
	2BIX01		

ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

BIOLOGY **8875/02**
17 AUGUST 2017
HIGHER 1 **2 hours**

Paper 2

Additional Material: Writing Paper

READ THESE INSTRUCTIONS FIRST
Write your name, index number and class on this answer booklet.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

At the end of the examination, circle the number of the Section B question you have answered in the grid opposite.
Fasten all your work securely together.

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

For Examiner's Use	
Section A	
1	
2	
3	
Section B	
4 or 5	
Total	**60**

This question paper consists of **10** printed pages.

1 Fig. 1.1 shows part of a cell.

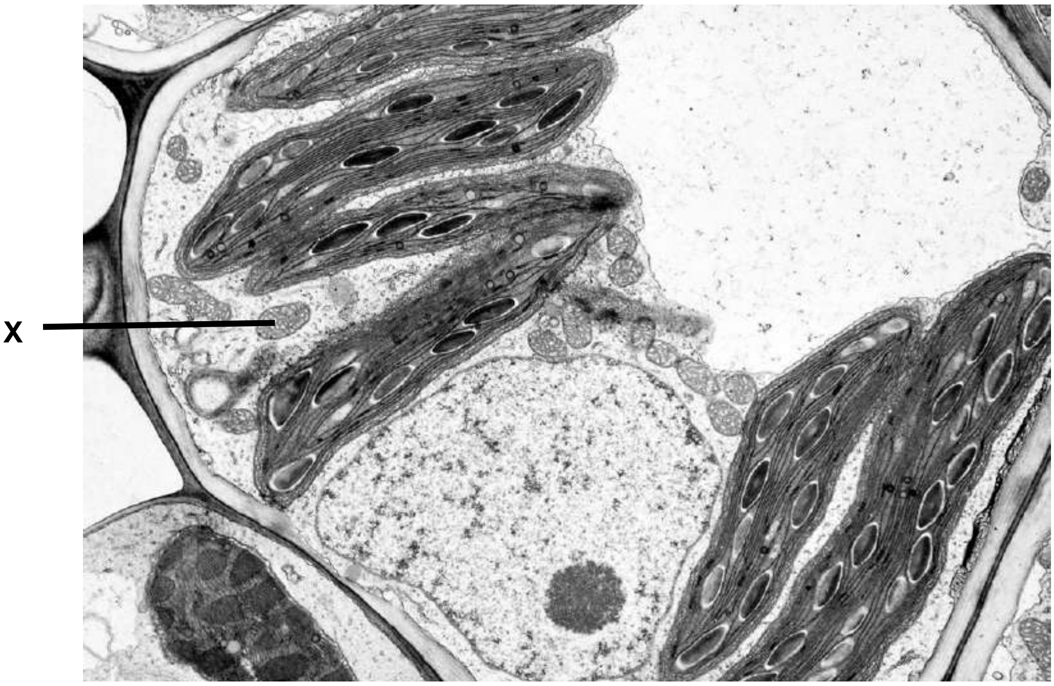


Fig. 1.1

(a) (i) Outline the role of the organelle labelled X.

1. **Link pathway where pyruvate undergoes oxidative decarboxylation to produces CO_2 and reduced NAD;**
2. **Krebs cycle where acetyl co-A undergoes oxidative decarboxylation to produces CO_2 and reduced NAD;**
3. **Oxidative phosphorylation to produce ATP via chemiosmosis;**

[2]

(ii) Identify two molecules with different modes of transport across the double membrane of X and explain their modes of transport.

1. CO_2 / oxygen by simple diffusion down the concentration gradient;
2. As CO_2 is a small molecule that can pass through the phospholipid bilayer;
3. Pyruvate / ADP /ATP by facilitated diffusion;
4. As pyruvate has negatively charged oxygen that cannot pass through the hydrophobic core of the membrane;
5. As ADP/ATP has negatively charged phosphate group that cannot pass through the hydrophobic core of the membrane;
6. Both pyruvate and ADP/ATP are large molecules;

[4]

For examiner's use

(b) (i) Explain the significance of glycolysis in aerobic respiration.

1. **Substrate level phosphorylation where 2 net ATP is produced**
2. **Via the oxidation of glucose into 2 molecules of pyruvate.**
3. **Pyruvate is a substrate for the Link pathway; (which is able to enter the mitochondria) for oxidative decarboxylation mitochondria matrix via the link pathway followed by the Krebs cycle;**
4. **Reduced NAD produced carries H to the cristae for the synthesis of more ATP via oxidative phosphorylation;**

[4]

An experiment was carried out to investigate the effect of temperature on respiration in isolated mitochondria extracted from a worm. Respiratory substrate was provided and oxygen consumption was monitored at 15°C, 25°C and 35°C. Fig. 1.2 shows the temperature coefficients, Q_{10}, when temperature is increased from 15°C to 25°C and from 25°C to 35°C. Q_{10} measures the ratio of the rate of respiration when the temperature increases by 10°C.

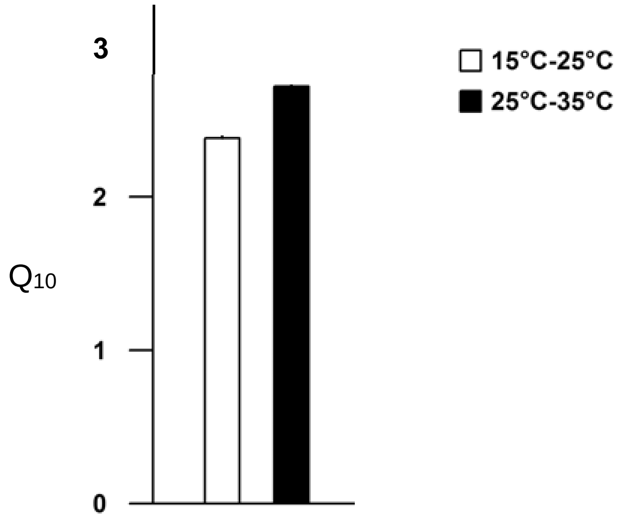


Fig. 1.2

(ii) Describe and explain the effect of temperature on the Q_{10} of mitochondria respiration.

1. **There is a higher Q_{10} from increasing the temperature from 25 °C – 35°C than from increasing from 15 °C – 25°C.**
2. **The Q_{10} for 15°C – 25°C is at 2.4 while that of 25°C – 35°C is 2.7.**
3. **Suggest that the enzyme is more efficient at 35°C;**
4. **Increase in temperature increases the kinetic energy of the enzyme and substrate, causing an increase in effective collision and formation of ES complex, increasing the rate of reaction;**

[3]

[Total: 13 m]

2 Fig. 2.1 shows plant cells undergoing mitosis. Each of the cells **A**, **B**, **C** and **D** is in a different stage of mitosis.

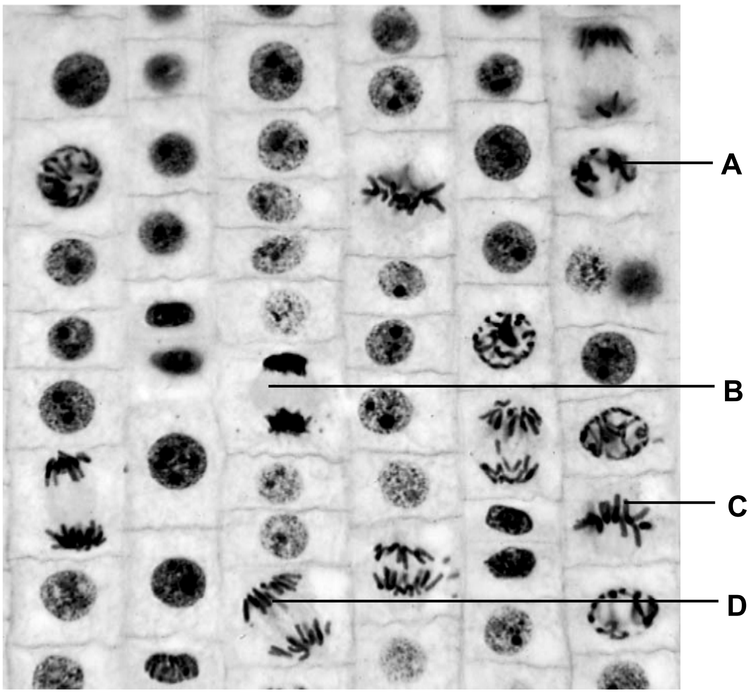


Fig. 2.1

(a) (i) Using the letters provided, write the correct order of the stages in mitosis.

A, C, D and B;

[1]

(ii) Describe the stage of mitosis in cell B.

1. **Telophase;**
2. **Chromosomes having reached the opposite poles start to decondense;**
3. **Spindle fibers disintegrate and nucleolus re-appears around the chromatin;**
4. **Nuclear membrane reforms around chromatin;**

[3]

For examiner's use

Fig. 2.2 shows the change in DNA content of a plant cell during one cell cycle

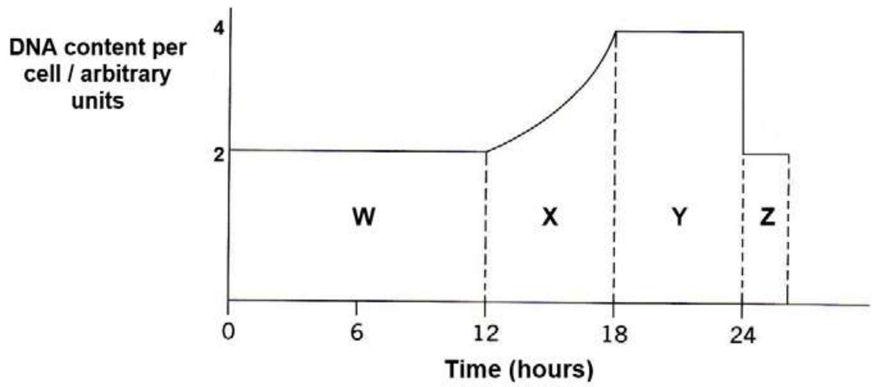


Fig. 2.2

(b) (i) With reference to Fig. 2.2, identify which period (W to Z) of the cell cycle the radioactivity of the nuclei would first increase if radioactive thymine was added to the cell culture at 0 hours. Explain your answer.

1. Period X;

2. Doubling of DNA amount from <u>2 to 4 a.u. due to semi-conservative replication</u> of DNA during <u>S phase of Interphase</u>;

3. Thymine incorporated into the new daughter strands/DNA formed; [3]

(b) (ii) Explain why it is necessary for the cell cycle to be tightly regulated at various checkpoints that control the rate of cell division.

Dysregulation of cell division would result in uncontrolled cell division/cancer;

[1]

For examiner's use

Horses were found to have three different coat colours – chestnut (brown), white and roan (patches of brown and white). The hair found on horses may be curly or smooth. These two traits are determined by two genes found on separate chromosomes, and each gene has two allelic forms.

When a true breeding chestnut horse with smooth hair was mated with a white horse with curly hair, all the progeny foals have roan coats with smooth hair.

(c) Using appropriate symbols, construct a genetic diagram to show the expected genotypes and phenotypes of the F_2 progeny when two horses in the F_1 generation are crossed.

Appropriate symbols given: 1m

Let C^B denotes the allele coding for chestnut/brown coat colour
C^W denotes the allele coding for white coat colour
H denotes the dominant allele coding for smooth hair
h denotes the recessive allele coding for curly hair

F_1 phenotype: **Roan coat with smooth hair**

F_1 genotype: **C^BC^WHh x C^BC^WHh** 1m

F_1 gametes $C^B H$ C^Bh C^WH C^Wh $C^B H$ C^Bh C^WH C^Wh 1m

Punnett Square:

	$C^B H$	C^Bh	C^WH	C^Wh
$C^B H$	**$C^B C^B HH$ Brown coat with smooth hair**	**C^BC^BHh Brown coat with smooth hair**	**C^BC^WHH Roan coat with smooth hair**	**C^BC^WHh Roan coat with smooth hair**
C^Bh	**$C^B C^BHh$ Brown coat with smooth hair**	**C^BC^Bhh Brown coat with curly hair**	**C^BC^WHh Roan coat with smooth hair**	**C^BC^Whh Roan coat with curly hair**
C^WH	**C^BC^WHH Roan coat with smooth hair**	**C^BC^WHh Roan coat with smooth hair**	**C^WC^WHH White coat with smooth hair**	**C^WC^WHh White coat with smooth hair**
C^Wh	**C^BC^WHh Roan coat with smooth hair**	**C^BC^Whh Roan coat with curly hair**	**C^WC^WHh White coat with smooth hair**	**C^WC^Whh White coat with curly hair**

All genotyypes and phenotypes correct in punnett square – 1m

F_2 phenotypic ratio - 3 brown coat with smooth hair : 1 brown coat with curly chair : 6 roan coat with smooth hair : 2 roan coat with curly hair : 3 white coat with smooth hair : 1 white coat with curly hair 1m

[5]

[Total: 13 m]

For examiner's use

3 Arthropods are a vast group of animals that have been on earth for about 500 million years. Fig. 3.1 shows the dorsal (top) and ventral (bottom) views of the horseshoe crab (genus *Limulus*) and some characteristics representative of all arthropods. Fig. 3.2 shows a fossil and an artist's impression of the Sanctacaris, which is one of the earliest arthropods and proposed by some scientists to be the ancestor of the horseshoe crab.

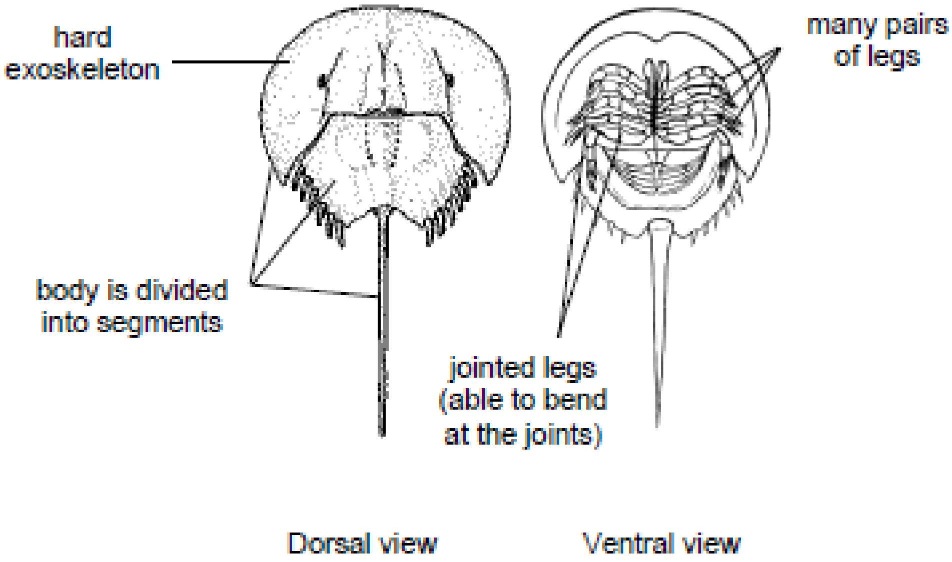


Fig. 3.1

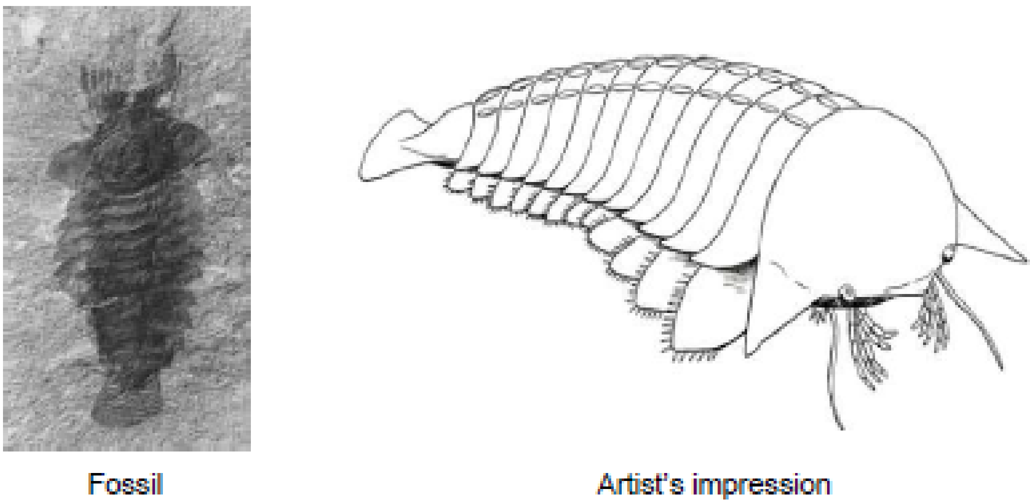


Fig. 3.2

(a) (i) With reference to Figs. 3.1 and 3.2, explain why anatomy can be used to establish evolutionary relationships between fossils and their living descendants.

1. Certain anatomical/physical structures of ancestors and descendants will be similar as descendants inherited a common set of genes from ancestors;

2. Over time, natural selection/ divergent evolution/ descent with modification may result in slight differences in these structures as they serve different functions in the descendants;

3. From the Sanctacaris fossil, it appears to have features of the horseshoe

For examiner's use

crab – segmented body (although it has more segments – support point 2), jointed legs, many pairs of legs, hard exoskeleton (and hence it can be fossilised);

4. **Ref to comparative anatomy to elucidate level of relation;**

[3]

(ii) Based on its flap-like appendages, Sanctacaris was believed to an aquatic arthropod. The horseshoe crab, however, utilises land habitats for certain parts of its life cycle - the eggs are laid on the coast and juveniles are found on the sandy tidal flats. Adults are found deeper in the ocean until they return to the beach to lay their eggs.

Using the theory of natural selection, suggest how horseshoe crabs evolved from Sanctacaris.

1. **Valid selection pressure, e.g. increasing area of land mass, lack/loss of suitable food for Sanctacaris juveniles in the ocean, predation of Sanctacaris eggs in ocean;**
2. **As genetic variation existed in the population of Sanctacaris, there is also phenotypic variation;**
3. **Individuals with traits which enable them to go on land will have a selective advantage → they are more likely to survive, reproduce and pass on the alleles for these traits to their offspring;**
4. **Over a long time, the population on land will have traits that make them more adapted for land, e.g. ventral, longer legs, which are different from Sanctacaris population in the ocean;**
5. **The Sanctacaris population in the ocean eventually died out;** [4]

(b) (i) Explain why molecular homology is preferred over anatomical homology in elucidating relationships between organisms.

Molecular evidence	Morphological evidence
1. Unambiguous and objective	**Subjective**
2. Quantifiable	**Traits may be qualitative and cannot be quantified**
3. Open to statistical analysis	**Statistical software cannot be used to quantify differences**
4. Silent mutation taken into consideration when quantifying differences	**Silent mutation not expressed in phenotype**
5. Able to distinguish between convergent and divergent evolution	**Similarities may be due to convergent evolution**

@1m, max 2

For examiner's use

(ii) Suggest why molecular homology was not used in establishing the relationship between the horseshoe crab and the Sanctacaris.

Sanctacaris fossil did not contain any DNA/proteins;

[1]

(c) Genetic variation is essential for evolution. Explain how DNA mutations give rise to phenotypic variation.

1. **Mutations refer to rare occurrences which change in the DNA nucleotide sequence, i.e. deletion, addition, substitution;**
2. **DNA codes for RNA during transcription and mRNA codes for polypeptides during translation;**
3. **Change in amino acid sequence may result in a change in 3D conformation of the protein and hence a change in function;**
4. **Function of the protein can change the phenotype of the organism e.g. structure, behaviour, which makes it different from the rest of the population;**

[4]

[Total: 14 m]

For examiner's use

Section B

Answer **EITHER 4 OR 5**.

Write your answers in the lined pages provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

EITHER

4 **(a)** Compare the structure of collagen and DNA. [6]

Differences:

1. **Monomers consisting of deoxynucleotides vs amino acids;**
2. **4 types of nucleotides vs 20 types of amino acids;**
3. **Bonds between monomers are phosphodiester bonds vs peptide bonds**
4. **Double stranded vs three polypeptide chains / α chains wound around to form tropocollagen;**
5. **Two strands wound to form a double helix vs tropocollagen associate to form collagen (fibrils and fibers);**
6. **No cross-links present vs cross-linked (between tropocollagen molecules);**
7. **No regular sequence in DNA versus Gly-X-Y sequence repeated in collagen.**

Similarity

1. **Bonding in between chains are H bonds for both DNA and collagen;**
2. **DNA and tropocollagen are both helical (Not: DNA and collagen are both helical.)**

Differences max 5, @1m

(b) With reference to the fluid mosaic model, describe the roles of phospholipids and proteins in a cell surface membrane. [8]

1. **Each phospholipid consists of one glycerol molecule condensed with two fatty acid chains and one phosphate group;**
2. **Amphipathic nature of phospholipid results in the formation of a bilayer;**
3. **Where the hydrophilic phosphate heads make contact with the aqueous environment;**
4. **And hydrophobic fatty acid tails face the interior to form a hydrophobic core;**
5. **Phospholipid molecules are held together by weak hydrophobic interactions (and not covalent bonds) which allows the membrane to be fluid;**
6. **This allows for the embedment of proteins in the cell surface membrane;**
7. **Hydrophobic core and proteins These allow the membrane to be selectively permeable;**
8. **Small hydrophobic / non-polar substances are able to pass through in the lipid bilayer;**
9. **Ions, hydrophilic/polar molecules and large molecules are unable to pass through;**
10. **Membrane fluidity allows for exocytosis and endocytosis / formation of vesicles;**
    Min. 3 m for phospholipids

11. **Presence of (transmembrane) channel proteins/carrier proteins (with hydrophilic channel/core) embedded in a scattered / random manner;**
12. **regulate movement of polar/hydrophilic substances into and out of cell;**
13. **To carry out facilitated diffusion and active transport;**
14. **Short carbohydrate groups can also attach to the proteins or phospholipids to form glycoproteins or glycolipids;**

For examiner's use

15. Helps in cell-cell recognition which enables the cells to distinguish between cell types;
16. Helps in cell-cell adhesion so that cells bind to form tissues;
17. Glycoproteins function as receptors for chemical signals;
18. Proteins can perform enzymatic activity;
19. Aid in attachment to cytoskeleton;
Min. 3 m for proteins

(c) Discuss the ethical concerns that have arisen from the human genome project. [6]

1. **The issue of who owns (and controls) genetic information – whether the individual has complete control over who has access to his genetic information, or is access controlled by the company/researcher who carries out the genome sequencing, or even controlled the government;**
2. **The issue of how insurers/employers/courts/schools/adoption agencies/military may request for and use DNA testing/have access to personal genetic information to discriminate people based on their genomes;**
3. **It is unclear how personal genetic information affects an individual and society's perceptions of that individual / how genomic information affect members of minority communities;**
4. **There is an issue of whether healthcare personnel are properly counseling parents about the risks and limitations of genetic technology (eg. with regards to the reliability of the genetic test, or whether the detected condition can be treated, and to help patients anticipate and deal with options to deal with the disease, if present, and whether relatives should be informed of the condition so that they can decide whether to test for the condition as well);**
5. **The reliability and usefulness of foetal genetic testing has not been verified in many cases;**
6. **To-be parents may have to make difficult decisions of whether to terminate pregnancy due to presence of genetic disorder (especially one for which there is currently no cure or treatment for);**
7. **The issue of whether testing should be performed when no treatment is available/treatment is extremely expensive and the patient cannot afford it, as diagnosing such a condition could lead to more anxiety and frustration;**
8. **The issue of whether parents have the right to have their children tested for adult-onset diseases, as there is potential for conflict between a parent's choice and a child's welfare (eg. a parent refuses to consent to a test that is clearly in their child's best interest, or a parent who decides to pursue a genetic "enhancement" that involves significant risks for a child, or that may limit a child's life prospects);**
9. **There is also the related issue of who has the right to determine whether newborns or others who are incapable of valid consent (eg. mentally incapacitated) should undergo genetic screening;**
10. **The genetic tests may only indicate a probability and not a certainty of a particular polymorphism/allele being associated with a disease or condition. (There is difficulty in interpreting a positive result because some people who carry a disease-associated mutation never develop the disease.) Hence the genetic tests may not be reliable;**

[Total: 20 m]

OR

5 **(a)** Explain the roles of membranes in transcription and translation. [6]

1. **Compartmentalisation increases efficiency of reactions;**
2. **Physically separate chemical reactions, which allows localisation of specific molecules in specific compartments/allows suitable environment to be created;**
3. **Transcription: RNA Polymerase works optimally in nucleus/nucleoplasm or any valid e.g.;**
4. **Translation: Enzymes catalysing chemical modifications in RER/Golgi body found in the lumen of cisternae or any valid e.g.;**
5. **Allow high concentration of enzymes and molecules to accumulate;**
6. **Transcription: RNA Polymerase accumulates in nucleus or any valid e.g.;**
7. **Translation: polypeptide chain enters RER lumen via pores in membrane or any valid e.g.;**
8. **Separate reactions in time/sequence;**
9. **Transcription: mRNA is synthesised in the nucleus before it leaves the nucleus via the nuclear pore to be used as a template for translation in the cytoplasm or any valid e.g.;**
10. **Translation: Enzymes found in RER catalyse reactions preceding those found in Golgi body or any valid e.g.;**
11. **Increase surface area for attachment of membrane proteins;**
12. **Translation: Ref to RER/Golgi body and relevant proteins/enzymes or any valid e.g.;**

@1m, max 6

The same example cannot be marked twice for different roles. There must be at least one role matched to a specific example (transcription or translation) before full marks can be awarded.

(b) Describe the role of enzymes in the cloning of human Insulin gene from mRNA using *E. coli*. [8]

Formation of ds cDNA with sticky ends:

1. **Insulin mRNA (isolated from beta cells of islets of Langerhans in pancreas) is reversed transcribed by reverse transcriptase;**
2. **to form a single stranded complementary DNA (cDNA);**
3. **RNase is used to remove the mRNA template strand from the DNA/RNA hybrid;**
4. **DNA polymerase then used to synthesize the complementary strand to cDNA strand to obtain a double stranded cDNA molecule;**
5. **DNA linkers with a (appropriate) restriction site are added to the blunt ends of the ds cDNA by terminal transferase;**
6. **Use of restriction enzyme to produce sticky ends on ds cDNA;**

Formation of recombinant plasmid:

7. **Plasmids with 2 selectable markers (e.g. ampicillin resistance gene and lacZ gene), one of which (lacZ) has the restriction site (of the restriction enzyme to be used) and will be inactivated by insertion of insulin cDNA/ OWTTE;**
8. **Cut by same restriction enzyme used to cleave ds cDNA;**
9. **to produce complementary sticky ends that will anneal with ds cDNA via complementary base pairing with formation of H bonds;**

10. DNA ligase added to the mixture of dsDNA and cut plasmids;
11. to form recombinant plasmids via the formation of phosphodiester bonds;
12. Transformation of competent *E. coli* via heat shock treatment before selection of transformed *E. coli* with recombinant plasmid;
13. Via selection of white bacteria colonies with the ability to grow on ampicillin- and X-gal-containing media (if lacZ gene indicated) / identifying transformed *E. coli* colonies containing human insulin gene by nucleic acid hybridisation;

(c) Explain the normal functions and features of two named stem cells in a living organism. [6]

1. **Named stem cell (in syllabus): embryonic stem cells and blood/haematopoietic stem cells; R! adult/somatic stem cells**
2. **They are unspecialised/undifferentiated;**
3. **Capable of dividing and renewing themselves for long periods via mitotic cell division (i.e. self-renewing), while still maintaining the undifferentiated state;**
4. **Can differentiate into specialised cell types under presence of appropriate chemical signals;**
5. **Embryonic stem cells are multipotent;**
6. **As they are able to differentiate into almost any cell type to form any organ or type of cell but not those of the extra-embryonic membranes;**
7. **They can differentiate into any of the three germ layers: endoderm, mesoderm and ectoderm;**
8. **While haemotopoietic stem cells are pluripotent;**
9. **As they are able to differentiate into all the blood cell types (but not other types of cells);**
10. **Hence allowing replacement of blood cells lost through normal wear and tear, injury or disease;**

@1m

[Total: 20 m]

Name:		Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H1 BIOLOGY

8875/01

Paper 1 Multiple Choice Questions

25 September 2017

1 hour

Additional Material: OTAS sheet

INSTRUCTIONS TO CANDIDATES:

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE TOLD TO DO SO.

READ THESE NOTES CAREFULLY.

Section A MCQ [30 marks]

There are **thirty** questions in this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

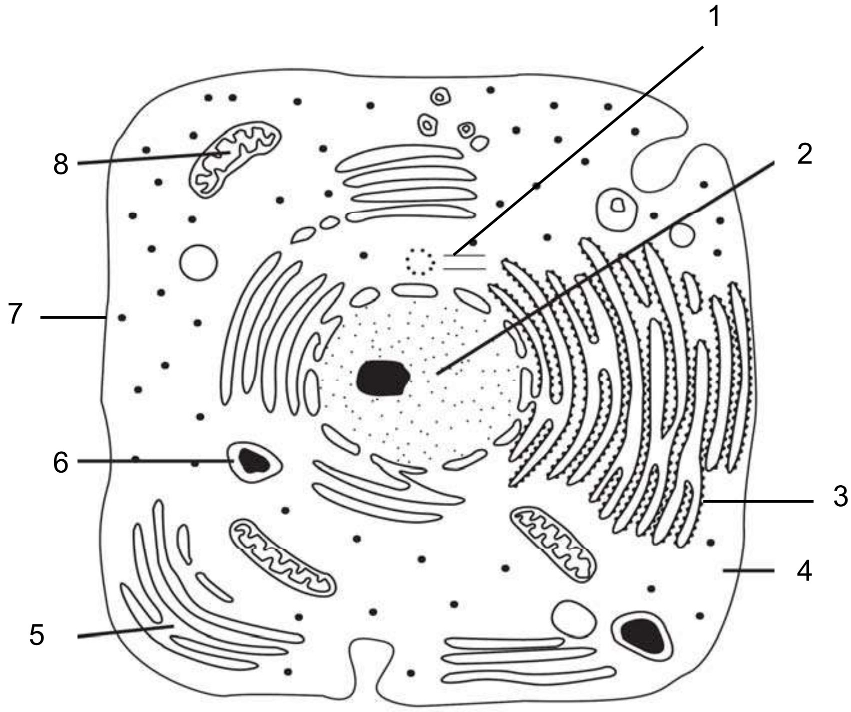
Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.

This document consists of **21** printed pages and **1** blank page.

[Turn over

Answer **all** questions in this section.

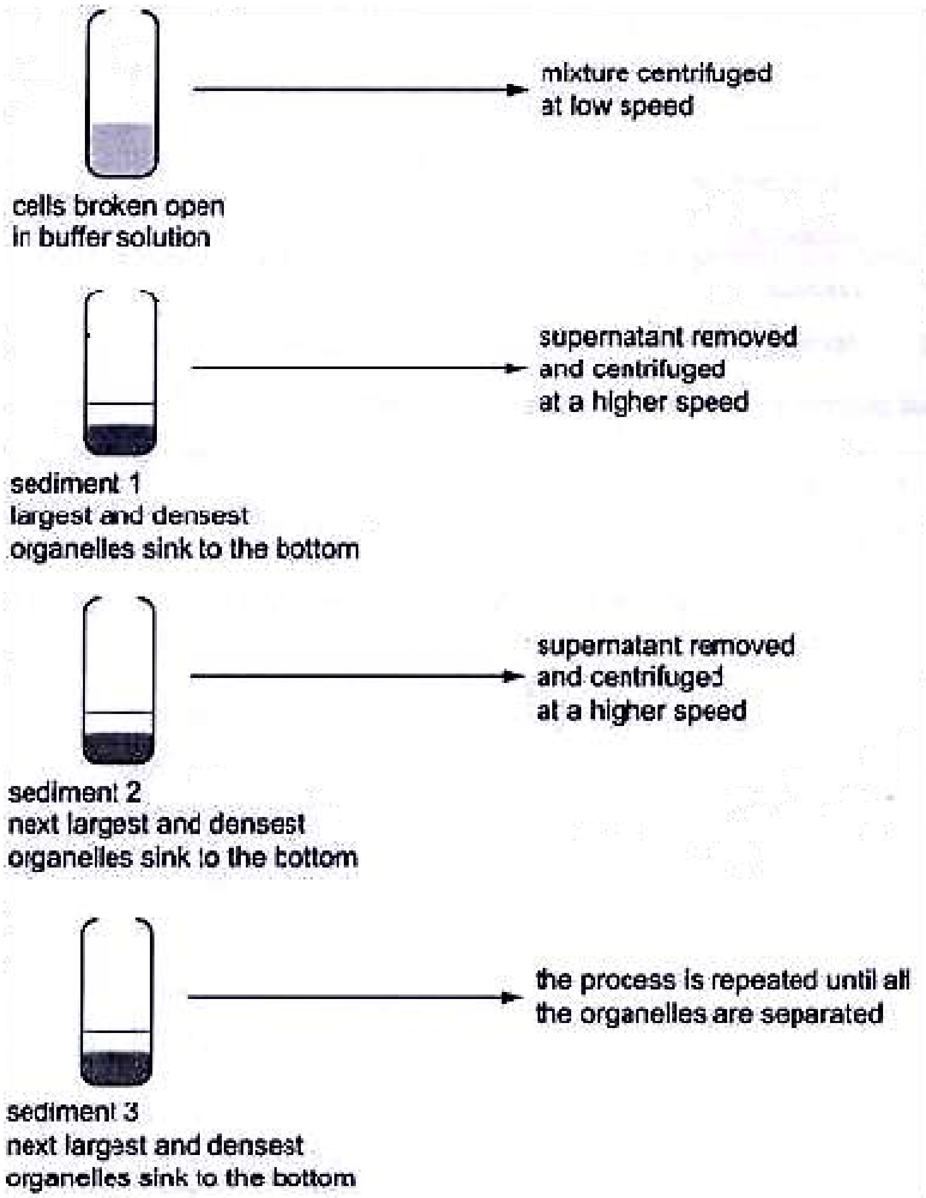
1 The diagram shows a drawing of an electron micrograph of an animal cell.



Which of the following describes the corresponding properties of the labelled structures?

	undergoes doubling during cell division	contain enzymes	contains nucleic acids
A	2	6, 8	2, 5, 8
B	2, 4, 8	5, 6, 8	2, 3, 8
C	1, 2, 8	2, 4, 6, 8	1, 2, 7, 8
D	1, 2	2, 3, 4, 5, 6	2, 3, 8

2 Fractionation is a process used to separate cell components according to their size and density. The diagram shows the main stages in fractionation of a plant cell.



DCPIP and buffer solution (containing glucose, fructose, sodium bicarbonate) were added to each of the sediments, and the mixtures were left in the dark for fifteen minutes. Sediment 2 caused the DCPIP to be reduced.

Which organelle present in Sediment 2 caused reduction of DCPIP?

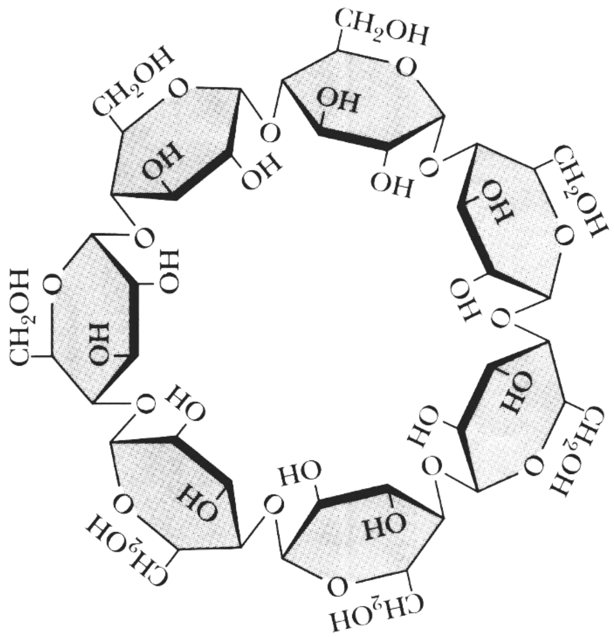
A chloroplast

B mitochondria

C nuclei

D ribosomes

3 The diagram shows a circular oligosaccharide molecule.



In which other molecule can a similar glycosidic bond be found?

A lactose

B maltose

C sucrose

D cellulose

4 Which statement is **TRUE** for phospholipids, but not for protein?

A It has hydrophilic and hydrophobic components.

B It is synthesized from non-identical sub-units.

C It can form a barrier to water soluble molecules.

D It is found in cell membranes.

5 The hydrolysis of triglycerides leads to ________________________.

1 formation of products which are more soluble in water than triglycerides.
2 formation of products which are less soluble in water than triglycerides.
3 an increase in pH.
4 a decrease in pH.

Choose the correct statements to complete the sentence.

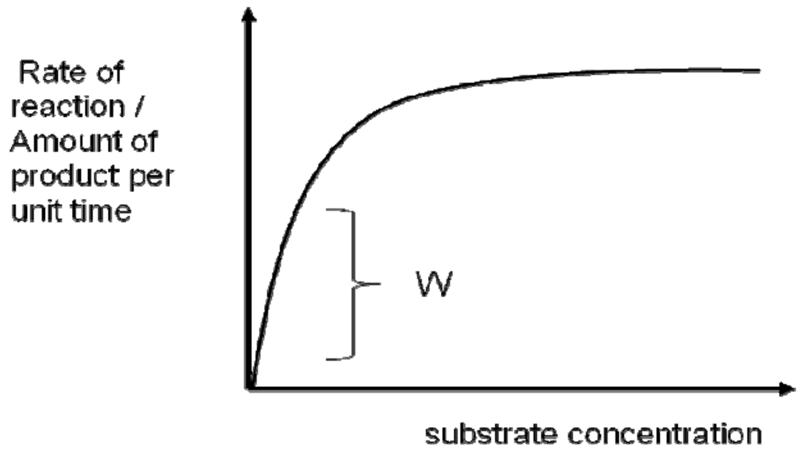
A 1 and 4

B 2 and 3

C 2 and 4

D 1 and 3

6 The graph below shows the rate of an enzyme catalyzed reaction occurring in lysosome with increasing substrate concentration. The reaction is carried out at 37°C and a pH of 4 for all substrate concentrations.



Which of the following(s) would result in a decrease in the rate of reaction at W?

1 Addition of co-factor
2 Decrease in temperature to 27°C
3 Increase in pH to 9
4 Addition of competitive inhibitor

A 1 and 4

B 2 and 3

C 2 , 3 and 4

D 1, 2, 3 and 4

7 Some inhibitors of enzyme reactions bind to the enzyme-substrate complex. Which statements about this type of inhibition are correct?

1 The active site changes shape.
2 The inhibitor is non-competitive.
3 The initial rate of reaction is reduced.
4 The maximum rate of reaction (Vmax) is increased.

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 2, 3, and 4 only

8 A 19-base pair long DNA molecule was analysed to find the number of nucleotide bases in each of the polynucleotide strands. Some of the results are shown.

	number of nucleotide bases			
	A	C	G	T
strand 1				4
strand 2		7		5

How many hydrogen bonds are present in this DNA molecule?

A 31 **B** 48 **C** 39 **D** 57

9 When DNA replicates, new nucleotides containing the common isotope of nitrogen (^{14}N) are used to build new nucleic acids.

In the laboratory, nucleotides can be synthesised using the heavy isotope of nitrogen (^{15}N). Cells grown in ^{14}N nucleotides for many generations are allowed to replicate once using these ^{15}N nucleotides, then twice more using ^{14}N nucleotides.

What will be the percentage of ^{14}N to ^{15}N nucleotides in the final molecules?

A 50% **B** 75% **C** 83% **D** 87.5%

10 An insertion mutation occurs in the gene coding for an enzyme, tyrosinase. Nucleotide sequences of the gene (the non-template strand), as well as the corresponding amino acid sequence of tyrosinase, are shown below.

	Wild-type allele	**ATG**	**AAG**	**TTG**	**GCT**	**AAA**	**TGG**	**GGA**
	Wild-type protein	**Met**	**Lys**	**Leu**	**Ala**	**Lys**	**Trp**	**Gly**
	Mutant allele	**ATG**	**AAG**	**TTA**	**GGC**	**TAA**	**ATG**	**GGG**
	Mutant protein	**Met**	**Lys**	**Leu**	**Gly**	**-**		

↑
Insertion of adenine

Which feature of the genetic code cannot be observed based on the information given?

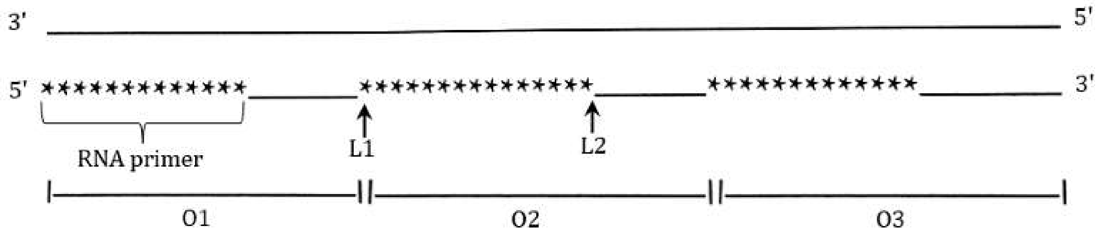
A The genetic code is degenerate.

B The genetic code is punctuated.

C The code is non-overlapping.

D The code is universal.

11 The diagram shows a DNA template with the lagging strand prior to the removal of the RNA primers.



Which row correctly shows the events taking place during the synthesis of the lagging strand?

	first Okazaki fragment synthesised	site of phosphodiester bond formation catalysed by DNA ligase
A	O1	L1
B	O1	L2
C	O3	L1
D	O3	L2

12 The following statements describe various steps in translation.

1 Large ribosomal subunit binds to mRNA.

2 Small ribosomal subunit binds to mRNA.

3 Anticodon of activated tRNA base pairs with codon AUG at the A site.

4 Anticodon of activated tRNA base pairs with codon AUG at the P site.

Which of the following statements describe the initiation phase?

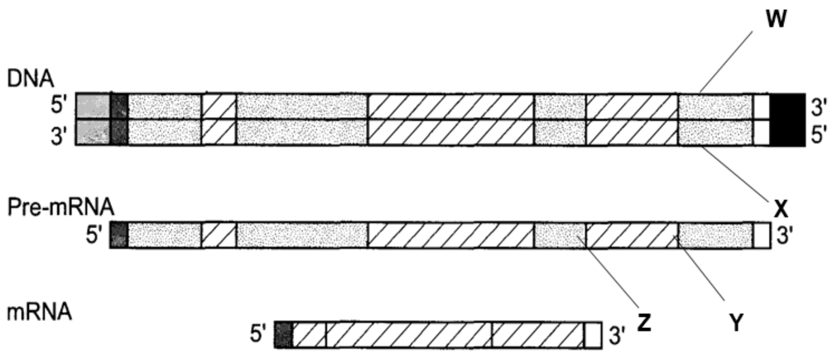
A 1 and 2 only

B 1, 2 and 3

C 1, 2 and 4

D All of the above

13 The diagram shows the processing of transcribed pre-mRNA in a eukaryotic cell.



Which of the following identifies structures **W** to **Z**?

	W	X	Y	Z
A	non-template strand	template strand	exon	intron
B	non-template strand	template strand	intron	exon
C	template strand	non-template strand	intron	exon
D	template strand	non-template strand	exon	intron

14 5' – CAU – 3' is a codon in mRNA that specifies the amino acid histidine (His) in position 58 in the α chain of haemoglobin. What is the corresponding anti-codon in tRNA?

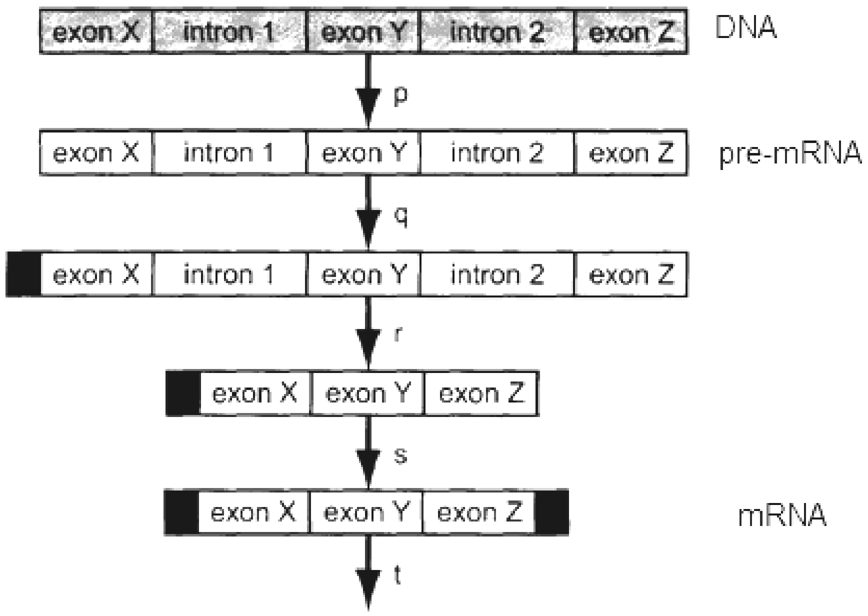
A 5' – CAU – 3'

B 3' – AUG – 5'

C 3' – GUA – 5'

D 5' – GUA – 3'

15 The diagram represents the processing of pre-messenger RNA.



During the process of pre-messenger RNA each of the listed events occurs:

1 capping

2 polyadenylation

3 splicing

4 transcription

5 translation

Which correctly identifies the processes **p**, **q**, **r**, **s** and **t**?

	p	**q**	**r**	**s**	**t**
A	5	1	3	2	4
B	4	1	3	2	5
C	5	2	1	3	4
D	4	2	1	3	5

16 Vincristine is a chemical which binds to the tubulin microtubules of the spindle and prevents them from functioning normally.

What effect would vincristine have on meiosis?

A Bivalents would fail to separate.

B Centromeres would fail to form.

C Centrioles would fail to move to the poles of the cell.

D Crossing over would fail to occur.

17 Below are descriptions of different gene mutations.

1 deletion toward the end of the code sequence

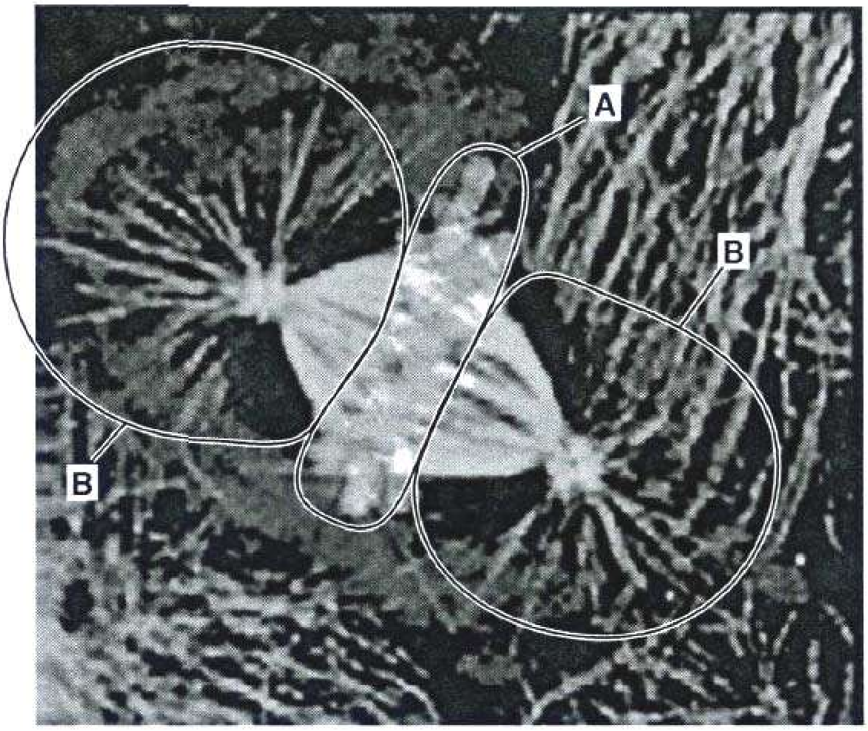
2 insertion in the middle of the code sequence

3 substitution close to the beginning of the code sequence

Which row correctly identifies the possible effects of these mutations on the synthesis of polypeptides?

	premature ending of a polypeptide	a non-functional polypeptide	a polypeptide with unchanged function	a polypeptide with a different function
A	2, 3 only	2, 3 only	1, 2, 3	2, 3 only
B	1, 2, 3	2 only	1, 3 only	1, 2 only
C	1, 3 only	1, 2, 3	3 only	1, 2, 3
D	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3

18 The figure below shows an immune-fluorescent image of a cell undergoing mitosis. In immune-fluorescence, specific antibodies with fluorescent dyes attached are used to target specific bio-molecules within a cell. In the figure, dark regions contained little fluorescent dye. The pale regions within A and B show the location of structures that have been stained with two fluorescent dyes.



Which of the following correctly explains the mitotic stage shown in the figure?

	Mitotic stage	Explanation
A	Metaphase	Structures in region B are the centrioles and they are at opposite poles.
B	Metaphase	Structures in region A are the chromosomes and they are seen aligned along the metaphase plate.
C	Anaphase	Structures in region A are the spindle fibres organised at the centrosome and are pulling the chromosomes in region B towards the pole.
D	Anaphase	Structures in region B are the spindle fibres and they are no longer attached at region A.

19 The diagram shows the banding pattern of two human chromosomes. **P** is a normal chromosome and **Q** carries a mutation.

What type of mutation occurred on chromosome **Q**?

A deletion of part of the chromosome

B duplication of part of the chromosome

C inversion of part of the chromosome

D translocation of part of another chromosome

20 Purple buds of the morning glory flower, *Ipomoea,* open into blue flowers. As the flower opens, the pH on the vacuoles of the flower epidermal cells increases and this results in a change of colour from purple to blue.

A mutant purple-flowered morning glory plant carries recessive alleles of a gene **B/b**, coding for a membrane-bound ion pump, and is unable to increase the pH of the vacuole.

Both normal blue flowers and mutant purple flowers have the same anthocyanin pigment, coded by the dominant allele of the gene **A/a**. Plants with **aa** cannot produce anthocyanin and they have white flowers.

The genes **A/a** and **B/b** are on different chromosomes.

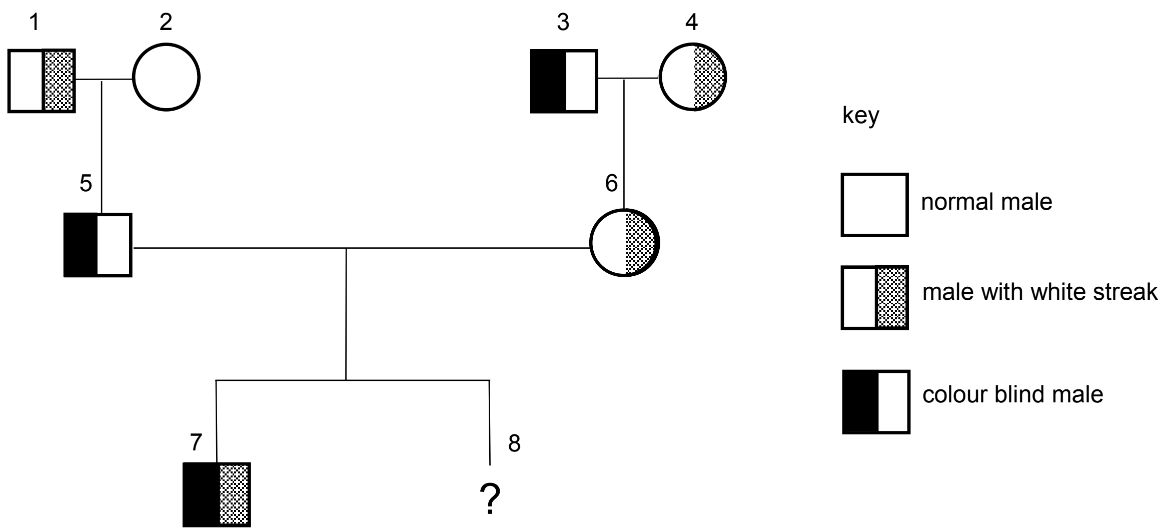
A blue-flowered morning glory plant was crossed with a purple-flowered plant. Their offspring consisted of plants which are blue-flowered, purple-flowered as well as white-flowered.

What were the genotypes of the blue-flowered and purple-flowered parents?

	Blue-flowered parent	**Purple-flowered parent**
A	AABB	AaBb
B	AaBb	Aabb
C	AaBB	Aabb
D	AABb	aabb

21 Colour blindness is controlled by a gene on the X chromosome. The allele for colour blindness, X^b, is recessive to the allele for normal colour vision, X^B. The gene controlling the presence of a white streak in the hair is not sex-linked, with the allele for the presence of a white streak, H, being dominant to the allele for the absence of a white streak, h.

The diagram shows a pedigree in which some of the individuals have colour blindness or have a white streak present in the hair.



What is the probability that individual 8 is a male with the same phenotype as individual 7?

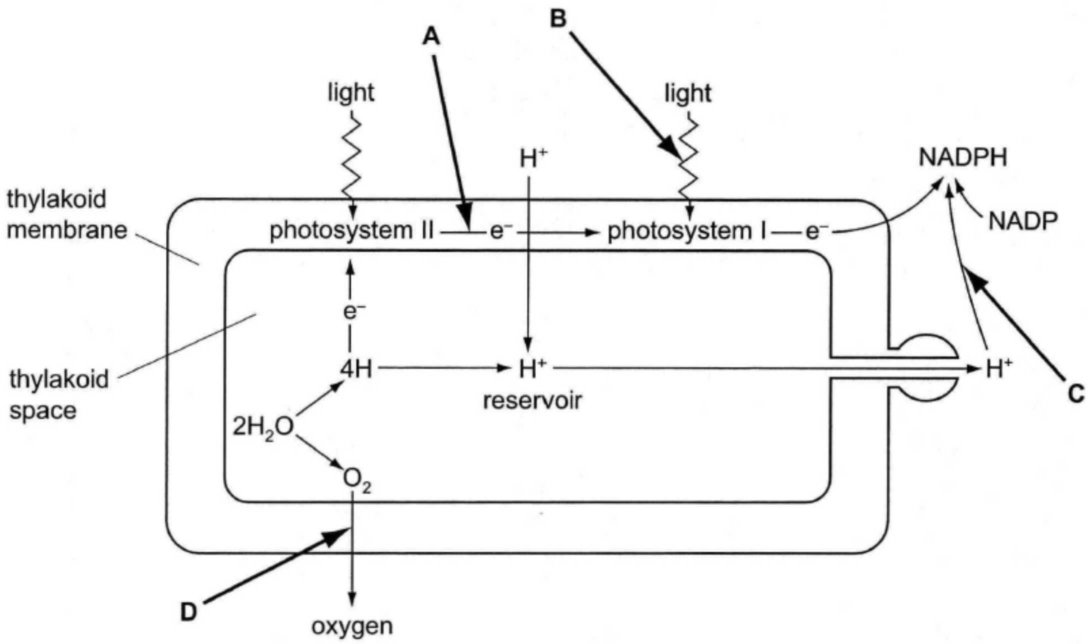
A 0.125

B 0.25

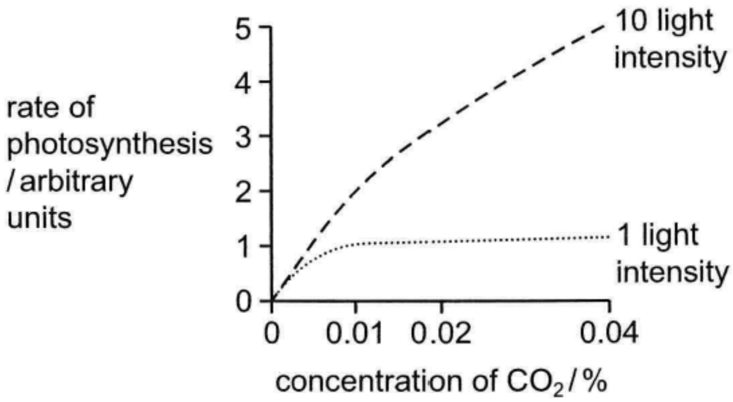
C 0.5

D 0.75

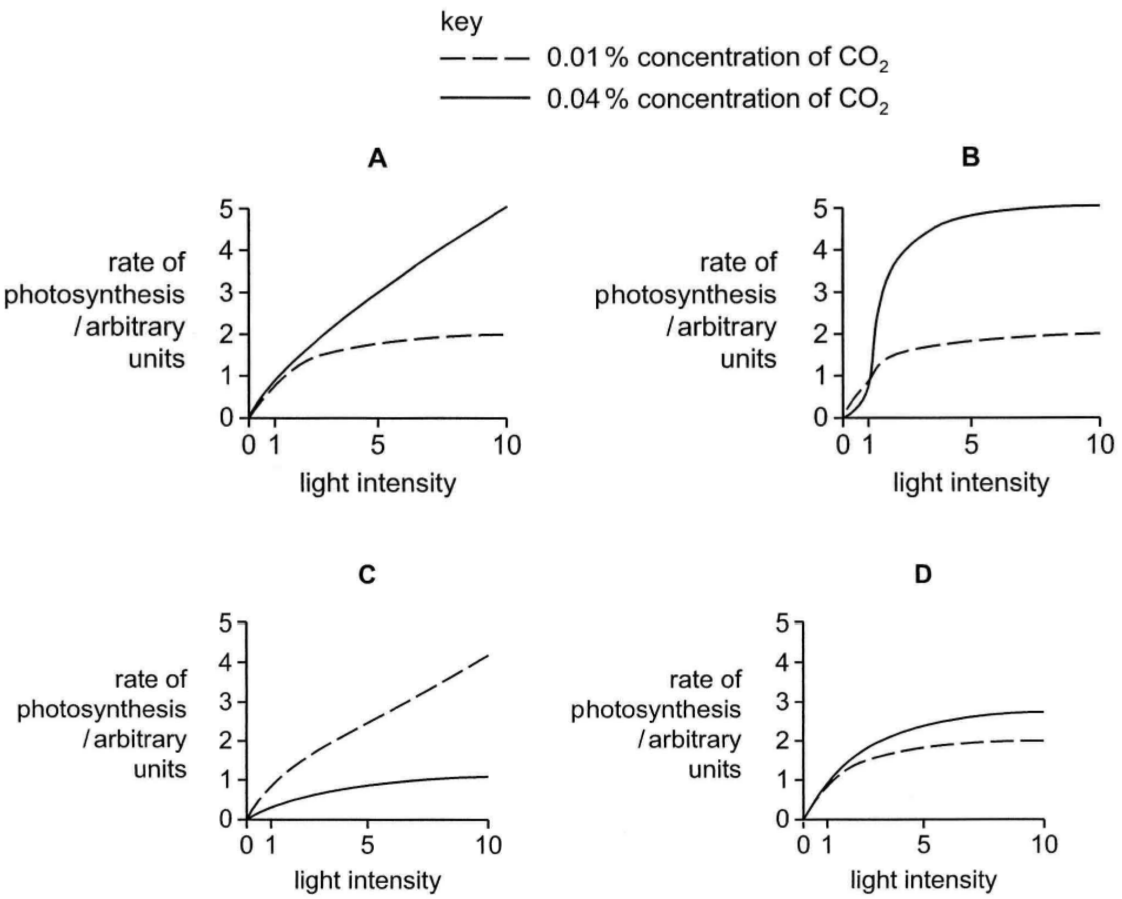
22 The diagram shows light dependent reactions of photosynthesis in a chloroplast. Where does the transfer of some of the energy required for the subsequent reduction of carbon dioxide occur?



23 The graph shows the effect of carbon dioxide concentration on the rate of photosynthesis, at two different light intensities.



Which graph correctly shows the effect of light intensity on the rate of photosynthesis, at two different carbon dioxide concentrations?



24 Which of the following will increase the pH of the chloroplast stroma?

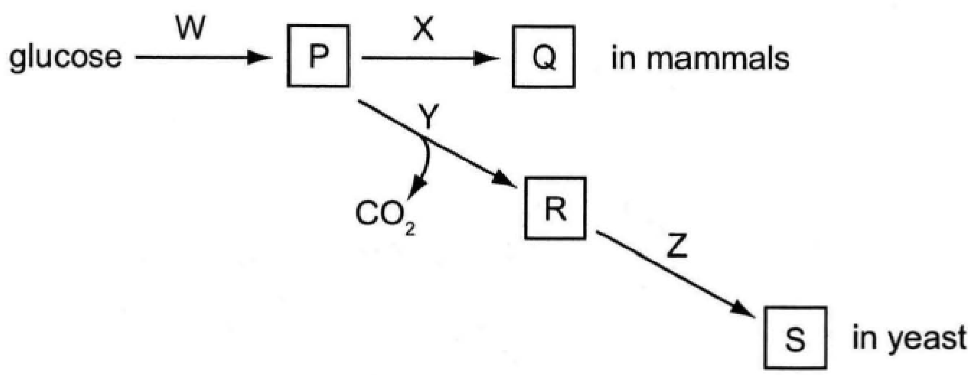
A Increasing O_2 concentration

B Increasing temperature

C Addition of electron transport chain inhibitor

D Addition of ATP synthase inhibitor

25 The diagram shows a summary of the processes of anaerobic respiration.



Which process(es) results in the formation of reduced NAD?

A W only

B X and Z only

C W, X and Y only

D W, X and Z only

26 Before the settlement of California in the 1800s, the elk population was very large. By about 1900 there were only a few dozen elk left. Owing to protection, there are now about 3000 elk living in a small number of isolated herds. Unfortunately, some of the elk in all the herds have difficulty grazing due to a shortened lower jaw.

1 The early settlers only hunted elk that could graze.

2 There was a mutation affecting jaw size.

3 There is random mating within each herd.

4 There was directional selection favouring short jaws

Which statements best explain this?

A 1 and 2

B 1 and 3

C 2 and 3

D 3 and 5

27 A piece of mouse DNA sequence is to be amplified by PCR.

5’ AGAGGGCGGT CCGTATCGGC CAATCTGCTC ACCACTAAGC 3’

Which pair of primers should be used?

A	5’ AGAGGGCGGT3’	5’ CGTTAGTGGT 3’
B	5’ CCGTATCGGC 3’	5’ TGGTGATTCG 3’
C	5’ CCGTATCGGC 3’	5’ GCTTAGTGGT 3’
D	5’ AGAGGGCGGT3’	5’ GCTTAGTGGT 3’

28 Some stages of a procedure involved in paternity testing are listed.

1 Alkali denatures DNA

2 Fragments migrate at different rate depending on the number of base pairs

3 Probes bind to DNA are identified using autoradiography

4 DNA samples are obtained from different individuals

5 Fragments are transferred from agarose gel to nylon membrane

6 Several STR loci are isolated using suitable restriction enzymes

Which sequence shows the correct order of these stages?

A 6 → 4 → 2 → 5 → 1 → 3

B 6 → 4 → 2 → 1 → 5 → 3

C 4 → 6 → 2 → 5 → 1 → 3

D 4 → 6 → 2 → 1 → 3 → 5

29 It has been found that stem cells transferred from the intestinal lining to the bone marrow produce all of the different types of blood cells instead of intestinal cells.

Which statement explains this?

A All stem cells are totipotent.

B Environmental factors change the expression of specific genes.

C Specific genes are destroyed by endonucleases.

D Specific genes are hidden by condensation of some chromosomes.

30 Which genetic modification would enable higher yield in crops grown on fertile soil in a tropical region?

A Drought tolerance

B Increased carbon fixation

C Increased vitamin A content

D Salt tolerance

END OF PAPER

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2017 Y6 Preliminary Exam H2
MCQ Answer Scheme

1	**D**	16	**A**
2	**B**	17	**D**
3	**B**	18	**B**
4	**C**	19	**C**
5	**A**	20	**B**
6	**C**	21	**A**
7	**C**	22	**C**
8	**B**	23	**A**
9	**D**	24	**D**
10	**D**	25	**A**
11	**D**	26	**C**
12	**C**	27	**D**
13	**A**	28	**C**
14	**C**	29	**B**
15	**B**	30	**B**

Name:		Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H1 BIOLOGY

8875/02

Paper 2 Structured and Free-Response Questions

14 September 2017

2 hours

Additional Materials: Writing paper

INSTRUCTIONS TO CANDIDATES:

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE TOLD TO DO SO.

READ THESE NOTES CAREFULLY.

Section B Structured Questions

Answer **all** questions.

Write your answers on space provided in the Question Paper.

Section C Free-Response Questions

Answer **one** question. Your answer to Section C must be in continuous prose, where appropriate. Write your answers on the writing paper provided. **Answer each part (a) and (b) on a fresh piece of writing paper.**

For Examiner's Use	
Section A [30]	
Section B [40]	
1	**/ 7**
2	**/ 8**
3	**/ 5**
4	**/ 7**
5	**/ 6**
6	**/ 7**
Section C [20]	
1 / 2	
Total [90]	

This document consists of **15** printed pages and **1** blank page.

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Section B: Structured Questions (40 marks)
Answer **all** questions in this section.

Question 1

(a) **Fig. 1** shows replication of a part of the glucagon receptor gene.

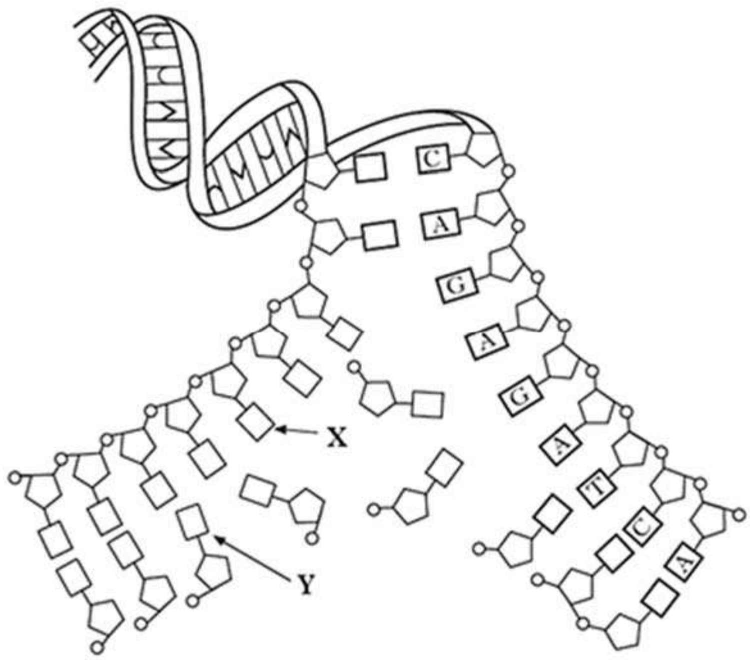


Fig. 1

(i) Name the bases labelled **X** and **Y** on **Fig. 1**. [1]

X ______________________________

Y ______________________________

(ii) Explain how **Fig. 1** shows semi-conservative replication DNA. [3]

____

____

____

____

____

For Examiner's use

(b) Contrast the elongation stage in DNA replication with translation. [3]

Total:[7]

For Examiner's use

Question 2

Fig. 2 shows the early development of a human embryo after fertilisation.

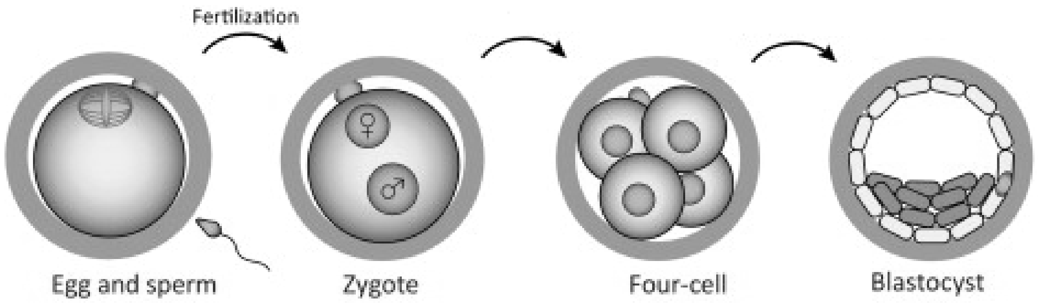
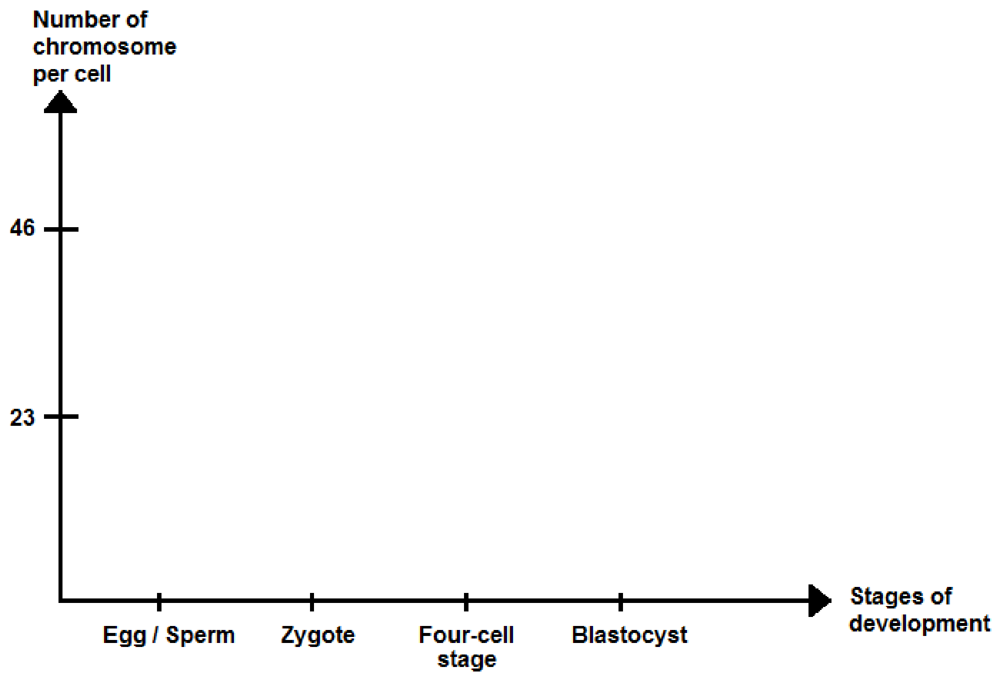


Fig. 2

(b) **(i)** Name the type of cell division undergone by the zygote to form the four-cell stage. [1]

(ii) Plot accurately, in the graph below, the number of chromosome per cell for the four stages of development. [1]



For Examiner's use

Hematopoietic stem cells divide ***asymmetrically*** to give specialized cells such as the red blood cells.

(b) **(i)** Explain the term "***asymmetrically***". [1]

(ii) How are hematopoietic stem cells different from their specialized cells? [2]

(c) Haemoglobin A (HbA) is the oxygen carrier protein that is found in normal red blood cells. HbS is found in sickle-shaped red blood cells.

Table 2.1

Hb A β globin	val – his – leu – thr – pro – glu – glu –lys…..
Hb S β globin	val – his – leu – thr – pro – val – glu –lys…..

(i) **Table 2.1** shows a segment of the HbA and HbS polypeptide sequence. Identify this mutation. [1]

For Examiner's use

Table 2.2 shows the DNA triplet code.

Table 2.2

First Letter	Second Letter: T	Second Letter: C	Second Letter: A	Second Letter: G	Third Letter
T	TTT, TTC **Phe** TTA, TTG **Leu**	TCT, TCC, TCA, TCG **Ser**	TAT, TAC **Tyr** TAA Stop TAG Stop	TGT, TGC **Cys** TGA Stop TGG **Trp**	T C A G
C	CTT, CTC, CTA, CTG **Leu**	CCT, CCC, CCA, CCG **Pro**	CAT, CAC **His** CAA, CAG **Gln**	CGT, CGC, CGA, CGG **Arg**	T C A G
A	ATT, ATC, ATA **Ile** ATG **Met**	ACT, ACC, ACA, ACG **Thr**	AAT, AAC **Asn** AAA, AAG **Lys**	AGT, AGC **Ser** AGA, AGG **Arg**	T C A G
G	GTT, GTC, GTA, GTG **Val**	GCT, GCC, GCA, GCG **Ala**	GAT, GAC **Asp** GAA, GAG **Glu**	GGT, GGC, GGA, GGG **Gly**	T C A G

(ii) With reference to **Table 2.1** and **2.2**, Explain the **minimum** number of mutation that resulted in HbS. [2]

Total: [8]

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For Examiner's use

Question 3

Cats possess a gene for producing tails. The tailless Manx phenotype in cats is produced by an allele that is lethal in the homozygous state. The Manx allele M^L severely interferes with normal spinal development. In heterozygotes (M^LM), this results in the absence of tail.

Female cats are homogametic while male cats are heterogametic. The gene for black/orange/tortoiseshell coat colour is located on X chromosome and has two alleles X^O and X^o. Table below shows the genotypes of cats of different colours.

X^oX^o, X^oY	Black coated female, male
X^OX^O, X^OY	Orange coated female, male
X^OX^o	Tortoiseshell (intermingled black and orange in fur) in female only

The table below shows the genotypes of two cats.

	Female cat	**Male cat**
Coat colour	Orange	black
tail	No tail	No tail
Genotype	$X^OX^OM^LM$	X^oYM^LM

Construct a genetic diagram to illustrate the outcome of the above cross on the next page.
[5]

Answer Question 3 on this page.

For Examiner's use

Total: [5]

Question 4

In Lake Tanganyika in Africa, there are six species of fish of the genus Tropheus and a much larger number of distinctly coloured subspecies of each of the six species. Tropheus species are small fish that are confined to isolated rocky habitats around the shores of Lake Tanganyika.

The six species evolved during the primary radiation phase when the lake was first filled, about 1.25 million years ago. They arose from river dwelling ancestors and then filled all available niches in the lake.

Secondary radiations into the many subspecies occurred during the last 200 000 years. Sometime during this period, the water level in the lake fell, resulting in the formation of three separate lake basins. These basins persisted for many thousands of years before the water level rose again.

Fig. 4 shows an outline map of the lake and the location of the three temporary basins caused by lowering of lake levels.

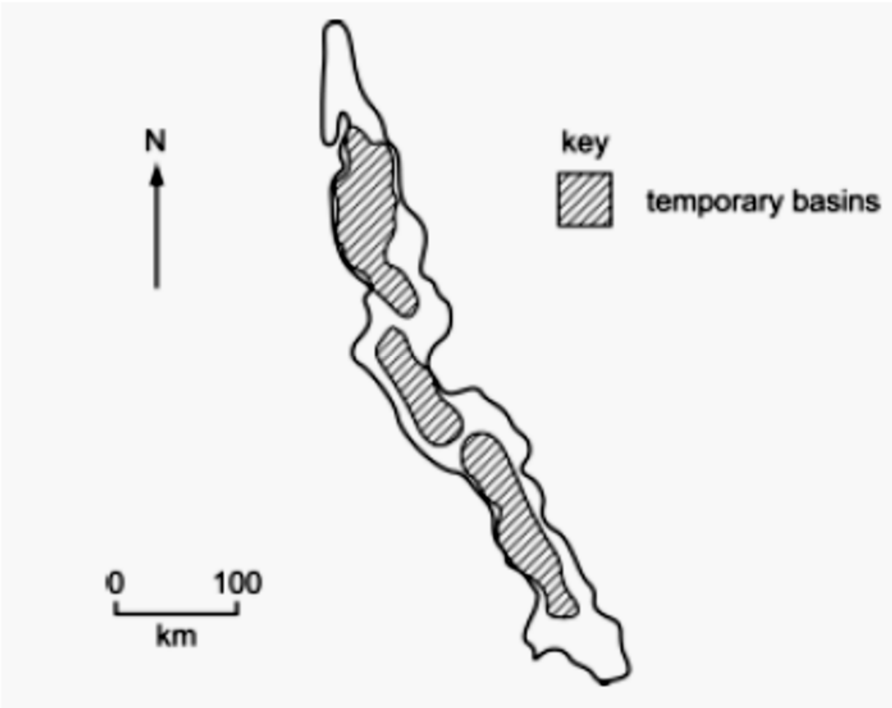

Fig. 4

For Examiner's use

(a) Explain how natural selection could have caused the evolution of the six closely related species in the primary radiation. [4]

(b) Outline how each type of homology (anatomical, embryological and molecular) supports Darwin's theory of descent with modification. [3]

Total:[7]

Question 5

For Examiner's use

Fig. 5.1 shows the pCMV6-XL5 plasmid. It is a plasmid with a multiple cloning site (MCS) that lies downstream of the CMV promoter. This plasmid can be inserted into both eukaryotic and prokaryotic host cells. The arrows denote the direction in which the genes are transcribed.

An artificially-synthesised human Growth hormone (hGH) gene with flanking HindIII restriction site sequences was created. The restriction sites for the restriction enzymes HindIII and SacI are shown in **Fig. 5.2**.

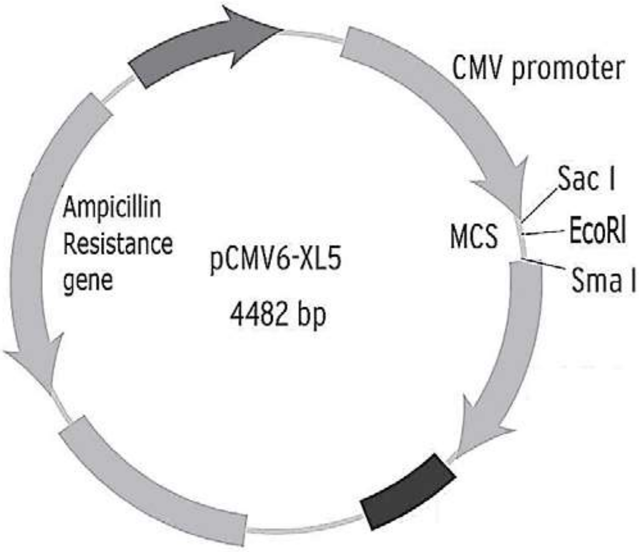

Fig. 5.1

HindIII
▼
5′ . . . A A G C T T . . . 3′
3′ . . . T T C G A A . . . 5′
▲
HindIII

SacI
▼
5′ . . . G A G C T C . . . 3′
3′ . . . C T C G A G . . . 5′
▲
SacI

▲ - point at which restriction enzymes cleave DNA.

Fig. 5.2

For Examiner's use

(a) With reference to **Fig. 5.1** and **Fig. 5.2**, explain how the hGH gene can be inserted into pCMV6-XL5. [3]

(b) The final step in determining the presence of the hGH gene involves the use of a radioactive gene probe.

Explain why there is a need to use a radioactive gene probe, instead of selecting using ampicillin. [2]

(c) State one problem of cloning human genes in bacteria. [1]

Total:[6]

For Examiner's use

Question 6

Scientists have identified the pectinase gene encoding an enzyme involved in the ripening of the tomatoes and have developed a genetic modification for the FlavrSavr tomatoes using an antisense RNA technology. During normal transcription, only one strand of a DNA is transcribed to mRNA. The complementary strand of DNA is the 'non-template' strand, which is not normally transcribed. By inserting a promoter at the end of a non-template sequence, thus forming an anti-mRNA gene, RNA transcription can occur from it. The sequence of events is shown **Fig. 6**.

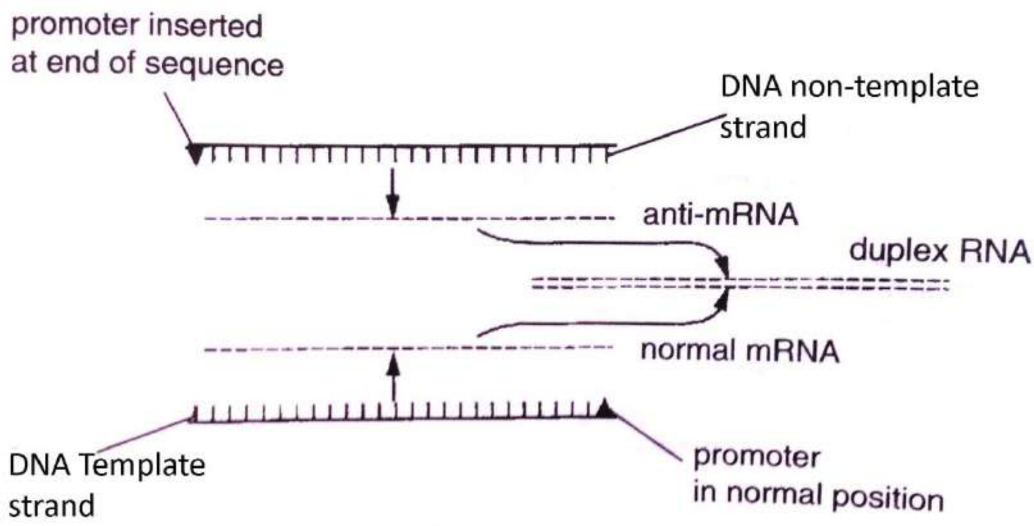

Fig. 6

(a) With reference to the **Fig. 6**, explain how duplex RNA is formed. [2]

For Examiner's use

(b) Explain how this genetic modification on the tomato plant benefits the farmers and merchants. [3]

(c) Outline the ethical implications of transgenic plants. [2]

Total: [7]

Section C: Free-Response Question (20 marks)

Answer only **<u>one</u>** question.
Write your answers on the writing paper provided.
Answer each part (a) and (b) on a fresh piece of writing paper.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.
A **NIL RETURN** is required.

Question 1

(a) Describe the various roles of RNA in eukaryotes. [10]

(b) Describe ATP synthesis in respiration. [10]

Total: [20]

<u>OR</u>

Question 2

(a) Describe the various bonds and their importance in carbohydrates. [10]

(b) Describe the differences between Calvin and Krebs cycles. [10]

Total: [20]

END OF PAPER

DUNMAN HIGH SCHOOL
PRELIMINARY EXAMINATION 2017
YEAR SIX
H1 BIOLOGY (8875)

Suggested Answers

Question 1
(a)(i)
X – Cytosine
Y – Thymine

(a)(ii)
- parental strand acts as template for the synthesis of the new strand
- parental strand CAGAGATCA will result in the newly synthesised strand with sequences GTCTCTAGT
- newly synthesised daughter DNA molecule consists of one original strand and one newly synthesised strand

(b)
- The enzyme required for elongation in DNA replication is DNA polymerase while the enzyme involved in translation is peptidyl transferase
- The bonds catalysed between subunits of monomers in DNA replication is phosphodiester bond while the bonds catalyzed for translation is peptide bonds
- The monomers used for DNA replication is deoxyribonucleotides while the monomers for translation is amino acids

Question 2
a(i)
Mitosis

a(ii)
1M correct plot
1M joining the dots with a straight line

(b) (i)
The parental stem cell divides to give 2 different cells. One remains as a stem cell while the other differentiate into a specialized cell

(b) (ii)
- Hematopoietic stem cell is undifferentiated while its specialised cells are differentiated to have a specific function / structure
- Stem cell can divide and renew itself indefinitely / without limit but red blood cells cannot divide

c(i)
missense mutation

c(ii)
- **1 nucleotide** change from A to U
- Changes the codon from GAA / GAG, coding for Glu, to GTA / GTG, coding for Val

Question 3

Parental phenotypes:	Orange, no tail female	x	Black, no tail male	
Parental genotype:	$X^OX^OM^LM$	x	X^oYM^LM	
Gametes formed:	X^OM^L X^OM	x	X^oM^L X^oM YM^L YM	√

F1 genotypes:

	X^oM^L	X^oM	YM^L	YM
X^OM^L	$X^OX^oM^LM^L$	$X^OX^oM^LM$	$X^OYM^LM^L$	X^OYM^LM
X^OM	$X^OX^oM^LM$	X^OX^oMM	X^OYM^LM	X^OYMM

√

√

F1 genotypes: $X^OX^oM^LM^L$ (died) $2X^OX^oM^LM$ X^OX^oMM $2X^OYM^LM$ X^OYMM

$X^OYM^LM^L$ (died)

√

F1 phenotypes:	Tortoiseshell No tail female	Tortoiseshell **Normal** tail female	Orange No tail male	Orange **Normal** tail male
F1 phenotypic ratio:	2 :	1 :	2 :	1

√

Question 4
(a)
- Variations in population due to random mutation resulting in different alleles;
- primary radiation phase, different niches in the lake with different selection pressure;
- fish with at selective advantage survive and reproduce viable offspring, passing on advantageous genes/alleles to the next generation;
- accumulation of many genetic changes over a long period of time to evolve into different species;
- geographical isolation/ accept hundreds of km apart thus no gene flow between different populations;

<u>4 max</u>

(b)

- Anatomy homology can be used to support Darwin's Theory by comparing anatomy, observing vestigial organ and Imperfect adaptations. These physical traits can used to hypothesize the relatedness of species

- Comparative embryology reveals additional anatomical homologies not visible in adult organisms. All vertebrate embryos look very similar during the earlier stages of development, including having gill pouches and tails

- In Molecular homology, as the descendents evolve independently, more and more differences are accumulated in their DNA. Two species that are more distantly related have more differences in their DNA whereas two species that are more closely related share a more similarities in their DNA

Question 5
(a)

- Cleave gene using HindIII to generate sticky ends
- Cleave plasmid with SacI to generate complementary sticky ends to the HindIII sticky ends flanking the hGH gene
- Mix the cleaved gene and plasmid together and add DNA ligase to seal the nicks / form phosphodiester bond between gene and plasmid

(b)

- Gene probe identifies bacterial colonies that contain hGH gene
- However, ampicillin selects for all transformed bacteria containing wither re-annealed plasmid or recombinant plasmid

(c)

- Introns in human gene which cannot be spliced out in bacteria and resulting in the protein produced to be non-functional
- Lack of organelles in bacteria such as the Golgi apparatus for final chemical modification of proteins such as glycosylation / phosphorylation resulting in the protein produced to be non-functional

Question 6
(a)

- DNA non-template strand with the inserted promoter is transcribed in the GM tomato plant to form the anti-mRNA
- anti-mRNA and the normal mRNA binds via hydrogen bonds between complementary base pairs of A-U and G-C to form duplex RNA

(b)

- The pectin in the GM tomato plant breaks down more slowly
- Hence the tomatoes can be harvested later to allow production of bigger / better quality fruits for sale for increased profit
- The delay in ripening also allowed the tomatoes to have a longer shelf-life so that they can be sold for more profit

(c)

- Animal genes may be introduced to plant genomes, leading to concern of vegetarians and some religious groups which followers are not allowed to consume certain animals
- GM plants grown as crops may lead to consumers having allergies as foreign proteins are produced in the plants, companies need to label their GM crops for consumers to make informed choices
- development and growing of GM crops requires large amounts of funds and technology which only large companies have access to, monopolizing agriculture, resulting in inequality against small scale farmers
- AVP;

<u>**2 max**</u>

Essay

1a Describe the various roles of RNA in eukaryotes. [10]

mRNA

1. role in transferring genetic information from nucleus to cytoplasm
2. DNA triplet codes are carried in the form of codons in mRNA
3. Each codon corresponds to one amino acid

tRNA

4. role in carrying the corresponding amino acid to ribosome to match with the condon in translation
5. 3'end binds to corresponding amino acid via covalent bond Attached by to amino acid by aminoacyl tRNA synthetase
6. Contains anti-codon which is complementary to codon on mRNA for translation

rRNA

7. Role in forming ribosome for translation
8. makes up peptidyl transferase which catalysed peptide bond between adjacent amino acid
9. align tRNA and mRNA in ribosome

RNA primer

10. providing 3'OH group for addition of complementary deoxyribonucleotide to growing DNA strand
11. Synthesize by primase

RNA template in telomerase

12. Role in lengthening telomere
13. Expressed in stem cells

1b Describe ATP synthesis in respiration. [10]

1. ATP is synthesized by substrate level photophosphorylation and oxidative phosphorylation

2. ATP is synthesized during glycolysis, in the cytoplasm, and during Kreb cycle in the mitochondrial matrix
3. 4 ATP / 2 nett ATP is synthesized per glucose molecule during glycolysis
4. In anaerobic respiration, ATP is synthesized only by substrate level phosphorylation in glycolysis
5. In the Kreb cycle, 2 ATP is synthesized per glucose when succinyl-CoA is converted to succinate

6. NAD and FAD are reduced during glycolysis, link reaction and Kreb cycle
7. Reduced NAD and FAD donates electrons to the electron transport chain on the inner mitochondrial membrane
8. As electrons are transported along a series of electron carriers of progressively lower energy levels, some energy is used to pump H^+ from the matrix to the intermembrane space
9. This creates a proton gradient across the inner mitochondrial membrane, driving protons to diffuse down its concentration gradient via ATP synthase on the inner mitochondrial membrane.
10. ATP synthase harness the proton motive force for phosphorylation of ADP to ATP
11. O_2 is the final electron carrier of the electron transport chain.
12. 3 ATP is synthesized per reduced NAD and 2 ATP per reduced FAD.

2a Describe the various bonds and their importance in carbohydrates. [10]

1. Form glycosidic bond by condensation with elimination of one water molecule

α(1→4) glycosidic bond

2. Form between between anomeric carbon 1 of α glucose and carbon 4 of the other
3. Chain coils helically
4. resulting in a more compact shape for storage

hydrogen bond

5. intra-chain H-bonding between hydroxyl groups helps stabilise helical structure

α(1→6) glycosidic bond

6. occurs at branch points
7. more compact for storage

β(1→4) glycosidic bond

8. form between β glucose which has180º rotation of alternating glucose residues
9. forms linear structure of cellulose chain

hydrogen bond

10. Hydroxyl groups project outwards, alternately from both sides of each chain, allowing for the formation of hydrogen bonds between adjacent chains, thus establishing a rigid cross-linking between the chains.
11. great tensile strength in cell wall

2b Describe the differences between Calvin and Krebs cycles. [10]

Marking Point		Krebs cycle	Calvin cycle
1	Location	Mitochondrial matrix	Chloroplast stroma
2	Substrate	Acetyl-CoA and oxaloacetate combines to form citrate	CO_2 and Ribulose bisphosphate (RuBP)
3	Products	Each glucose molecule gives rise to: 6 NADH 2 $FADH_2$ 2 ATP 4 CO_2	For every 3 molecules of CO_2 that enter the cycle, one triose phosphate / G3P is made
4	Regenerated / Starting material	Oxaloacetate is the starting material that is eventually regenerated	Ribulose bisphosphate (RuBP) is the starting material that is eventually regenerated
5, 6	ATP	Produced via susbstrate level phosphorylation	Used in reduction of glycerate-3-phosphate where energy Is required through hydrolysis of ATP
7, 8	Electron carriers / donors	Use NAD^+ and FAD for the oxidation of the intermediates of the cycle by serving as electron acceptors	Uses NADPH / reduced $NADP^+$ to reduce glycerate-3-phosphate to triose phosphate by serving as electron donors
9	Overall	Catabolic	Anabolic
10, 11	Role of CO_2	CO_2 is released as a result of decarboxylation reactions	Required for carbon fixation. CO_2 is used to convert Ribulose bisphosphate (RuBP) to form an unstable 6C compound that breaks down to form glycerate-3-phosphate
12	Role of O_2	Occurs only when O_2 is present	Does not require O_2

INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME

CLASS

INDEX NUMBER

BIOLOGY 8875/01

Paper 1 Multiple Choice

15 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

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This document consists of **16** printed pages.

1 A certain organelle in a eukaryotic cell was isolated and analysed. It was found that the organelle contains proteins, nucleotides and phospholipids.

Which organelle(s) could it possibly be?

1 nucleus

2 lysosome

3 ribosome

4 mitochondrion

A 1 only

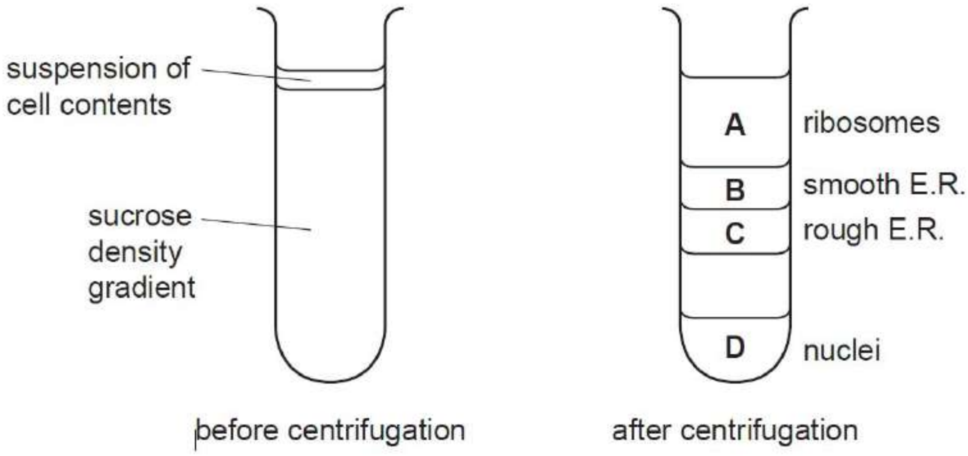
B 2 and 3 only

C 1 and 4 only

D 1, 3 and 4 only

2 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?

3 Which statement shows a correct feature of collagen linked to a correct analysis of the amino acid sequence?

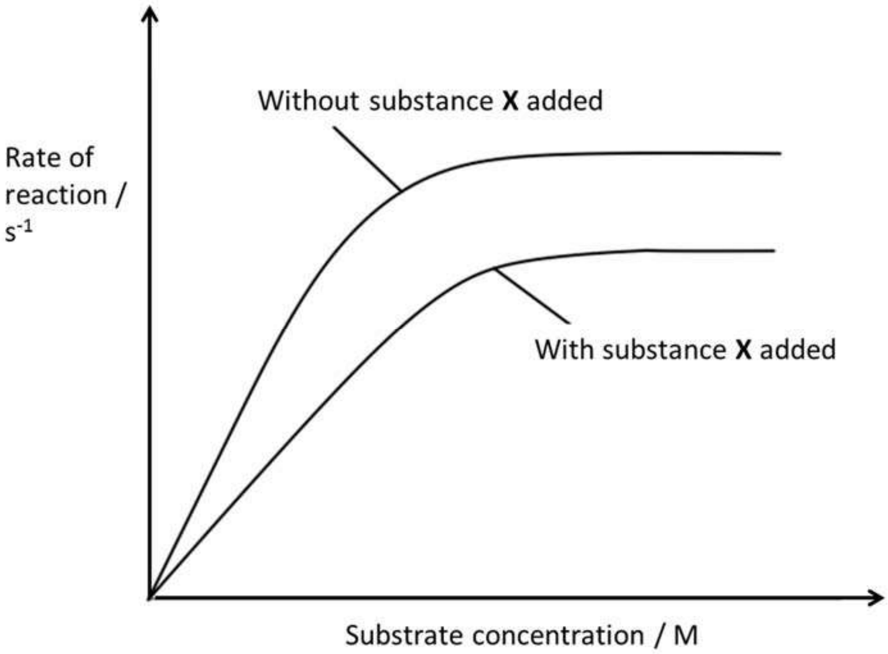
A Collagen has polypeptides arranged parallel to each other and the sequence contains a large variety of amino acids with different sized R-groups.

B Collagen has polypeptides that are arranged very closely together and the sequence has every third amino acid as glycine.

C Collagen has three polypeptides that can fold into a globular structure and the sequence contains cysteine and amino acids with hydrophobic R-groups.

D Collagen is an insoluble molecule and the sequence contains a large proportion of amino acids with hydrophilic R-groups.

4 The graph below shows the change in the rate of reaction of an enzyme with and without the addition of substance **X**.



Which of the following statements about substance **X** is true?

A The effect of substance **X** cannot be reduced by increasing the substrate concentration.

B Substance **X** binds to the active site of the enzyme and competes with the substrate.

C Substance **X** binds reversibly to the enzyme and changes the shape of its active site.

D The effect of substance **X** can be reduced by decreasing the enzyme concentration.

5 A chemical known to affect mitosis was added, at different stages of mitosis, to actively dividing plant cells with 12 chromosomes.

The results showed that adding this chemical during prophase resulted in cells with 24 chromosomes. Adding the chemical at any other stage resulted in cells with 12 chromosomes.

Which process during mitosis is affected by this chemical?

A Condensing of chromosomes

B Organizing the spindle

C Producing the centromeres

D Separating centrioles

6 The retinoblastoma protein (Rb protein) is coded for by the *RB1* gene. Rb protein prevents a cell from progressing into the S phase of a cell cycle when damaged DNA is detected. When both copies of the *RB1* gene are mutated and dysfunctional, cells with damaged DNA may continue to divide uncontrollably to form a tumour.

Which of the following statements is true?

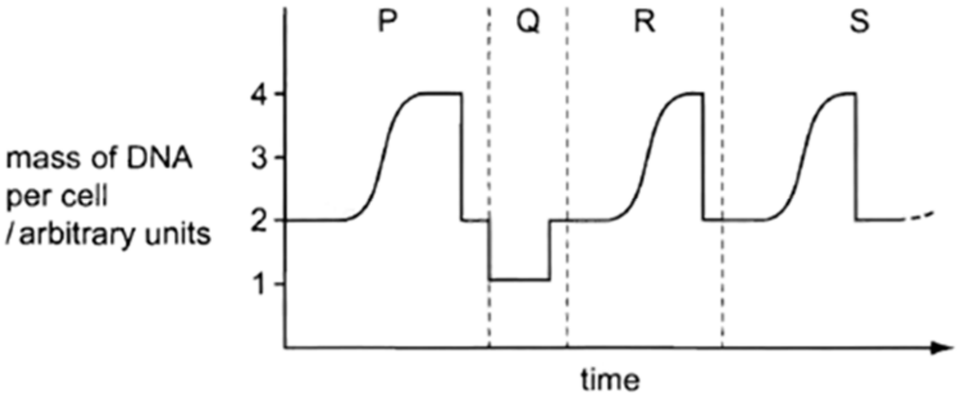
A *RB1* gene is a proto-oncogene.

B The mutated *RB1* allele acts in a recessive manner.

C The mutated *RB1* allele codes for a hyperactive Rb protein.

D A gain-of-function mutation has occurred.

7 A single cell from a female mammal undergoes changes that result in an ovum being formed. If the ovum is fertilised then further changes occur to form an embryo. The graph shows the changes in the mass of DNA per cell during these events.



During which stages might variation occur as a result of changes in the number of sets of chromosomes?

A P, Q and R only

B Q, R and S only

C P and Q only

D R and S only

8 The descriptions below are of nucleic acids in eukaryotes.

1 A polynucleotide of variable length formed by base pairing.
2 A small polynucleotide with a specific three-dimensional shape.
3 A large polynucleotide with a specific shape associated with proteins.
4 A large polynucleotide with super coiled sections associated with proteins.

Which row correctly matches each description to its function?

	Stores coded information	**Carries coded information**	**Carries specific amino acids**	**Provides a site for protein synthesis**
A	3	4	1	2
B	3	4	2	1
C	4	1	2	3
D	4	3	1	2

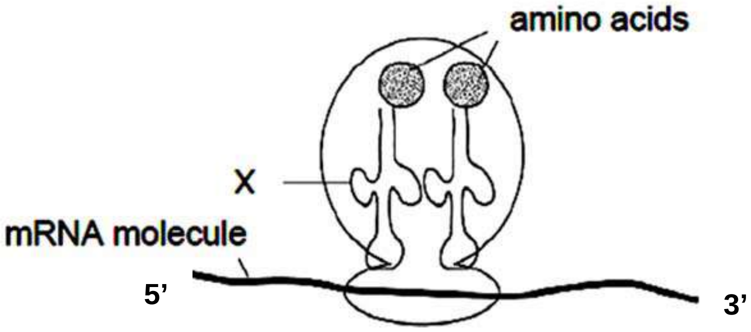
9 The mechanism of action of four drugs that inhibit DNA replication is stated below.

1 Aphidicholine inhibits DNA polymerase.
2 Cytarabine is converted into a molecule that can substitute for a DNA nucleotide and also inhibits DNA repair mechanisms.
3 Epirubicin inhibits an enzyme involved in the unwinding and separation of DNA strands.
4 Hydroxycarbamide inhibits an enzyme involved in the production of deoxyribonucleotides.

Which row correctly matches the effects of these drugs on DNA replication?

	Effects of Drug on DNA Replication			
	Decreased pool of available nucleotides inhibits chain elongation	DNA damaged during replication and cell death occurs	DNA strands not available as templates for replication	Exposed DNA template strands unable to be copied
A	aphidicholine	cytarabine	epirubicin	hydroxycarbamide
B	hydroxycarbamide	epirubicin	aphidicholine	cytarabine
C	epirubicin	hydroxycarbamide	cytarabine	aphidicholine
D	hydroxycarbamide	cytarabine	epirubicin	aphidicholine

10 The diagram below shows part of a molecule of mRNA bound to a ribosome.



Which of the following is **false** about molecule X?

1 It is formed by RNA polymerase in the nucleus.

2 It is able to form hydrogen bonds with mRNA.

3 An amino acid was attached to it by the enzyme amino-acyl tRNA transferase.

4 It is held in the amino-acyl tRNA binding site of the ribosome.

A 3 only

B 4 only

C 1 and 2 only

D 3 and 4 only

11 Gene mutations involve changes in the nucleotide sequence of DNA.

Which of the following descriptions regarding gene mutations is correct?

A Frameshift mutations can be caused by base substitution.

B Frameshift mutations can result from an inversion of bases.

C Missense mutations can be selectively neutral.

D Silent mutations may not be selectively neutral.

12 Two pure-bred lines of different plant varieties, which differed markedly in bean seed mass, were crossed. The mass of bean seeds produced by the two parental varieties and their offspring were measured to the nearest gram. The number of bean seeds in each mass category was counted.

The table below shows the results.

mass of bean / mg		51-150	151-250	251-350	351-450	451-550	551-650	651-750	751-850	851-950
number of beans	Parental	5	375	177				352	955	10
	Offspring			13	544	974	48	2		

Which statement **incorrectly** explains these experimental data?

A The range of phenotypes for the characteristic of bean seed mass is continuous and is due to several different nucleotide sequences at different chromosomal positions controlling the characteristic.

B The greater variation in bean seed mass observed in the offspring generation as compared to the parental generation is due to crossing over between homologous chromosomes, random fusion of gametes, different survival rates of the gametes and zygotes.

C The phenotypic effects of different nucleotide sequences at different chromosomal positions can be summated to determine the bean seed mass in each plant.

D Various environmental factors affect the mass of bean seeds in plants.

13 The speech defect known as stuttering may involve two genes, **G** and **N**. Most people who are homozygous for the alleles **g** and **n** are not stutterers.

However, recent research has shown that the presence of either of the mutant alleles **G** or **N** can cause stuttering in heterozygotes.

Using this information, which proportion of the children of a couple, the father with genotype **Ggnn** and the mother **ggNn**, are likely to be stutterers?

A 3/16

B 6/16

C 9/16

D 12/16

14 A cross between a round-leafed, tall plant and round-leafed dwarf plant produced the following offspring:

	Key
121 round-leafed, tall plant	**R** – round leaf
124 round-leafed, dwarf plant	**r** – oval leaf
42 oval-leafed, tall plant	**T** – tall
37 oval-leafed, dwarf plant	**t** – dwarf

What were the genotypes of the parents?

A RrTt x Rrtt

B RrTt x RRtt

C RrTT x Rrtt

D RrTT x RRtt

15 In fruit flies, one gene controls wing form (normal or vestigial) and one gene controls eye colour (red or normal brown). A fly with normal wings and normal brown eyes is crossed with a fly with vestigial wings and red eyes. All the F_1 are normal for both characteristics.

However, when F_1 are crossed with each other, the resulting F_2 is:

45 normal wing, normal brown eye

17 normal wing, red eye

16 vestigial wing, normal brown eye

5 vestigial wing, red eye

1 normal wing, orange eye

What is the **best** explanation for the results of this dihybrid cross?

A codominance

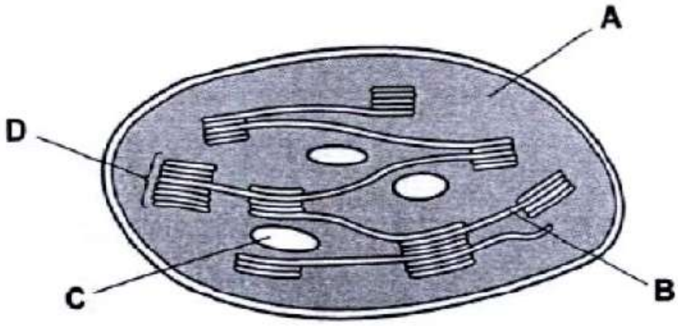
B gene mutation

C multiple alleles

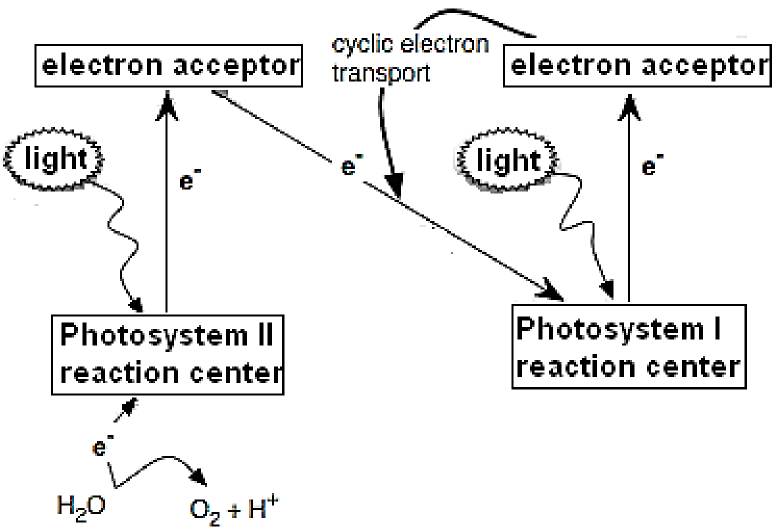
D sex linkage

16 The diagram shows a section through a chloroplast.

Where the products of photophosphorylation would be used?



17 The figure below shows the Z scheme for cyclic phosphorylation and non-cyclic phosphorylation.



Which of the following statements are true?

1 Hydrolysis of ATP occurs in both cyclic and non-cyclic phosphorylation.

2 Energy released from the electron transport chain is used to pump protons from the stroma into the thylakoid lumen.

3 $NADP^+$ is oxidized in non-cyclic phosphorylation.

4 The products of non-cyclic phosphorylation are NADPH, ATP and oxygen.

A 1 and 4 only

B 3 and 4 only

C 2 and 4 only

D 2, 3 and 4 only

18 After vigorous exercise, changes occur in the muscle tissue. Compared with 'at rest' conditions, what will the changes be?

	glycogen	ATP	lactate	pH
A	decreased	decreased	increased	decreased
B	decreased	increased	increased	increased
C	increased	increased	increased	increased
D	increased	decreased	decreased	decreased

19 What is the 'link reaction' in eukaryotic respiration?

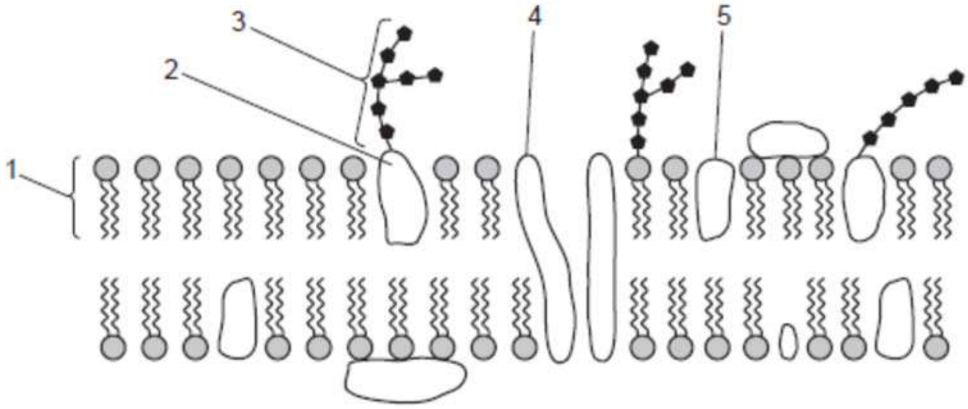
A Oxidation of NADH to yield electrons and protons

B Passage of coenzyme A through the mitochondrial membrane

C Pyruvate combining with coenzyme A to produce CO_2 and $NADH/H^+$

D Acetyl coenzyme A combining or joining with a C_4 compound to give C_6 + coenzyme

20 The diagram shows part of a cell surface membrane.



Which molecules have both hydrophobic and hydrophilic regions?

A 1 and 5

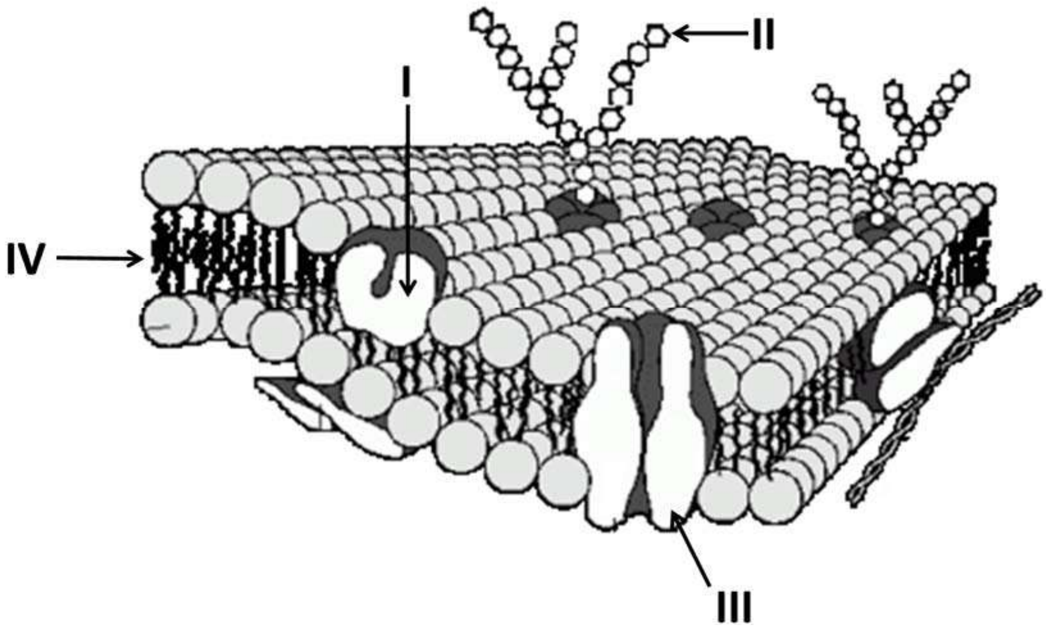
B 1, 3 and 5

C 2, 3 and 4

D 1, 2, 4 and 5

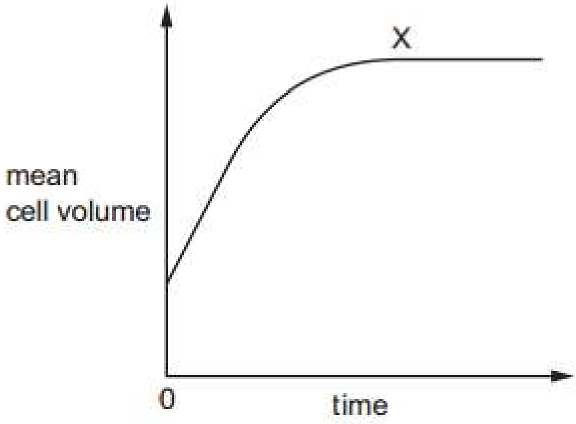
21 The diagram below shows a section of the cell surface membrane from an arctic fish.

Which of the following options regarding the labelled components of the membrane is correct?



	I	II	III	IV
A	Plays a role in cell-cell adhesion	Plays a role in cell-cell recognition	Allows transport of proteins like insulin	Contains a high amount of saturated lipids
B	Plays an enzymatic role	Variation in branching of oligosaccharide allows for cell-cell recognition	Allows transport of amino acids	Contains a high amount of cholesterol
C	Maintains the fluidity of the cell surface membrane	Variation in branching of amino acids allows cell-cell recognition	Plays a role in maintaining membrane potential	Is produced at the Rough Endoplasmic Reticulum
D	Is involved in active transport of ions	Is termed collectively with other glycolipids as the glycocalyx	Is localised to a specific region in the cell surface membrane	Plays a role in cell-cell recognition

22 A tissue composed of plasmolysed plant cells was put into distilled water. The graph shows how the mean cell volume changes with time.



What is the cause of the plateau at **X**?

1 water potential in the plant cell has become more negative

2 cells have become fully turgid

3 no net movement of water into cells

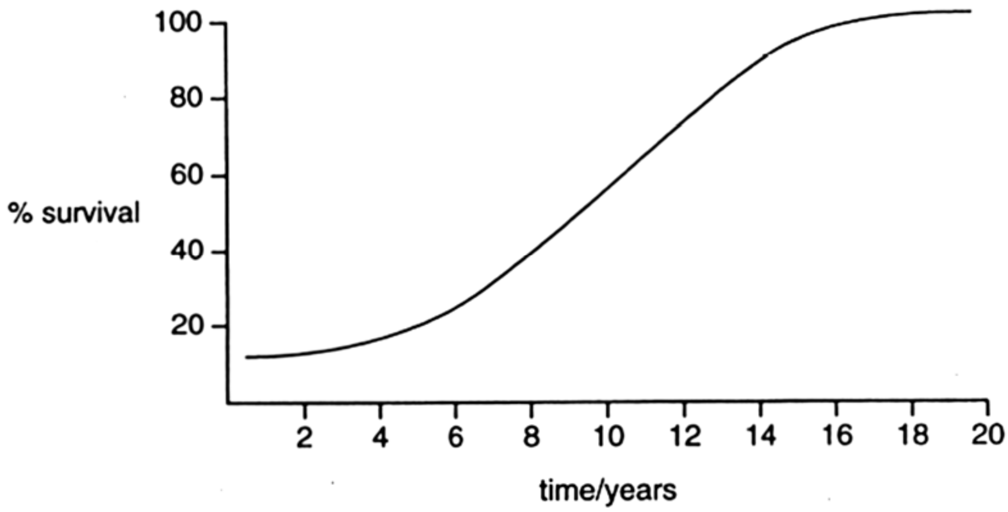
A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

23 The graph shows the effect of pesticide treatment on houseflies over a number of years. A standard amount of pesticide was used each year in summer.



How is the effect of the pesticide best explained?

A A few resistant flies reproduced more successfully and the resistance allele increased in frequency.

B At every generation an increasing proportion of flies mutated to become resistant.

C Repeated exposure to the pesticide caused the flies to become more resistant.

D The allele for resistance mutated from the recessive form to the dominant form.

24 Which effect of natural selection is likely to lead to speciation?

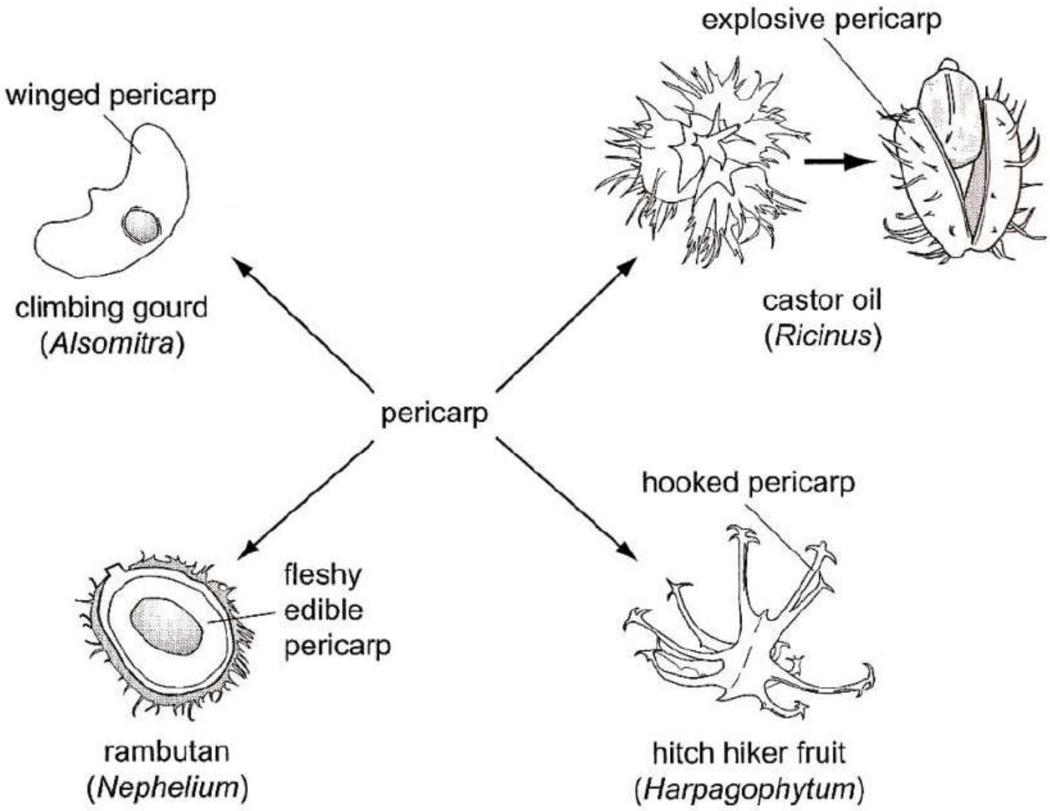
A Differences between populations are increased.

B Favourable genotypes are maintained in the population.

C Genetic diversity is reduced.

D Selection pressure on some alleles reduces reproductive success.

25 The diagram illustrates variation in the pericarp (fruit wall) for a variety of methods of seed dispersal.



What do these examples illustrate?

A The adaptive radiation of analogous structures showing convergent evolution.

B The adaptive radiation of analogous structures showing divergent evolution.

C The adaptive radiation of homologous structures showing convergent evolution.

D The adaptive radiation of homologous structures showing divergent evolution.

26 Which of the following is **not** a reason for plasmids being used as cloning vector?

A They are small.

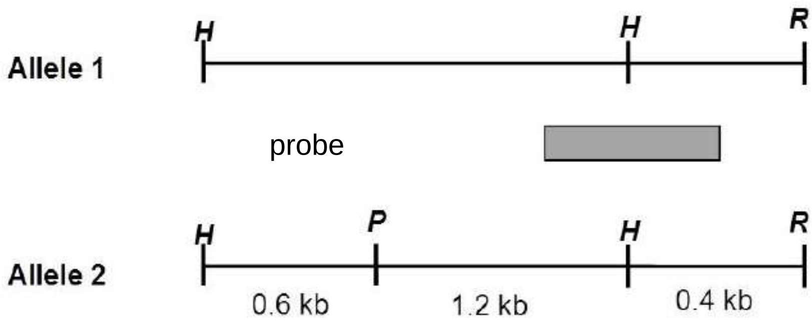
B They have an origin of replication.

C They can undergo independent replication.

D They always produce sticky ends when cut by restriction enzymes.

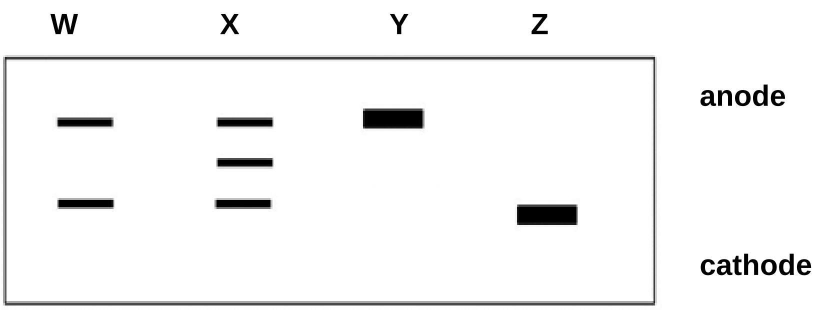
27 Cystic fibrosis is a genetic disease that affects the respiratory and digestive systems. Individuals with cystic fibrosis have two copies of the mutated *CFTR* allele.

Diagram below shows the positions of various restriction sites of a segment of KM-19, an RFLP (restriction fragment length polymorphism) marker that is closely linked to the CFTR gene locus. Position complementary to a radioactive probe is also shown. Allele 2 is linked to the mutant CFTR allele.



Legend
H represents *Hin*dIII restriction site
P represents *Pst*I restriction site
R represents *Eco*RI restriction site

DNA from different individuals are digested using *Pst*I and separated using gel electrophoresis. Results of the autoradiograph are shown below.



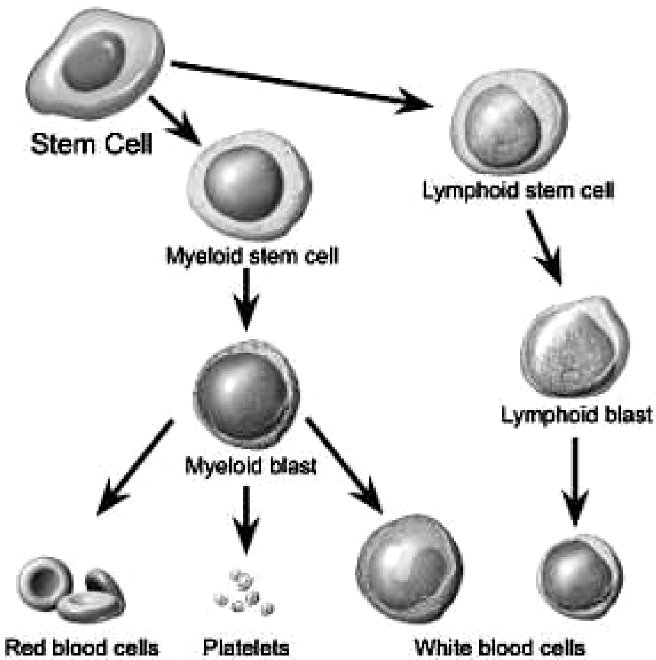
Which of the following individual suffers from CF?

A W
B X
C Y
D Z

28 Why are primers added to polymerase chain reaction (PCR) mixture?

A Because Taq polymerase cannot initiate synthesis of a polynucleotide strand.
B So that there would not be leading and lagging strand.
C To anneal to the 3' OH end to the target DNA.
D To separate the double stranded DNA into 2 single strands.

29 The following diagram shows how a stem cell can differentiate into different specialized cell types.



Which of these statements is **false** with regards to the stem cells shown?

A The stem cells are multipotent.

B The stem cells can be found in both a fetus and an adult body.

C The stem cells can differentiate into the three germ layers in the adult body.

D The stem cells may be used in a bone marrow transplant to treat a patient with leukemia, a form of blood cancer.

30 Some scientists are concerned about the release of genetically modified microorganisms into their natural habitat.

What is the most likely reason for this concern?

A The microorganisms may reproduce quickly.

B The microorganisms may not survive.

C The mutation rate of the microorganisms would increase.

D The transfer of changed genes to other organisms.

INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME: **ANSWERS**

CLASS:

INDEX NUMBER:

BIOLOGY 8875/01

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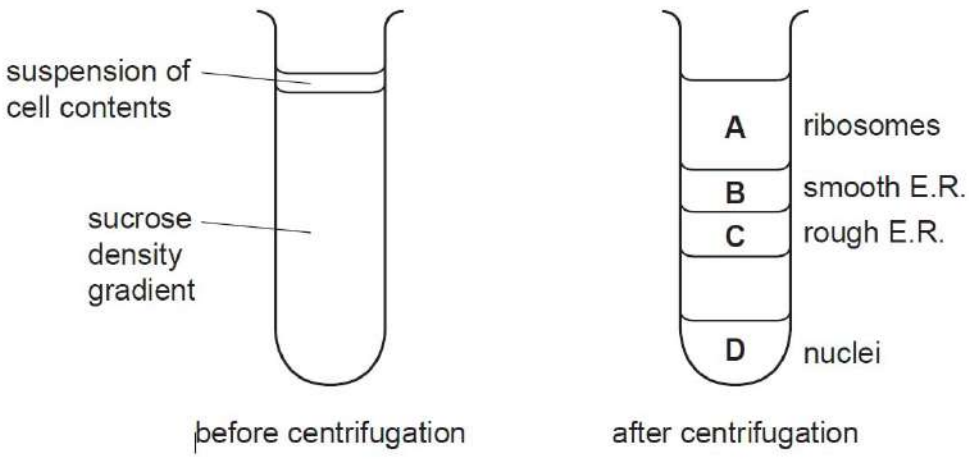

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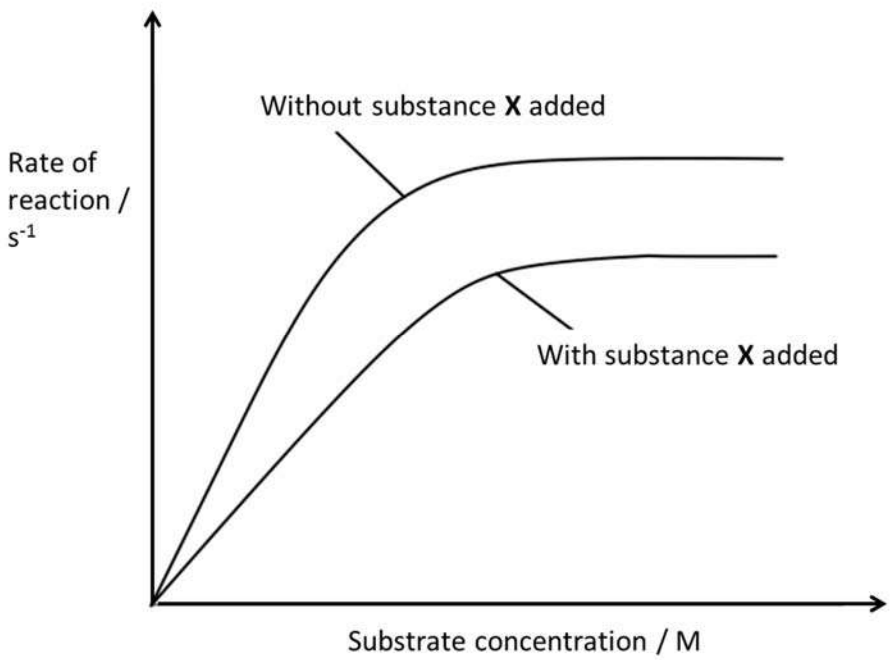


Which of the following statements about substance **X** is true?

- **A** The effect of substance **X** cannot be reduced by increasing the substrate concentration.
- **B** Substance **X** binds to the active site of the enzyme and competes with the substrate.
- **C** Substance **X** binds reversibly to the enzyme and changes the shape of its active site.
- **D** The effect of substance **X** can be reduced by decreasing the enzyme concentration.

5 A chemical known to affect mitosis was added, at different stages of mitosis, to actively dividing plant cells with 12 chromosomes.

The results showed that adding this chemical during prophase resulted in cells with 24 chromosomes. Adding the chemical at any other stage resulted in cells with 12 chromosomes.

Which process during mitosis is affected by this chemical?

A Condensing of chromosomes

B Organizing the spindle

C Producing the centromeres

D Separating centrioles

6 The retinoblastoma protein (Rb protein) is coded for by the *RB1* gene. Rb protein prevents a cell from progressing into the S phase of a cell cycle when damaged DNA is detected. When both copies of the *RB1* gene are mutated and dysfunctional, cells with damaged DNA may continue to divide uncontrollably to form a tumour.

Which of the following statements is true?

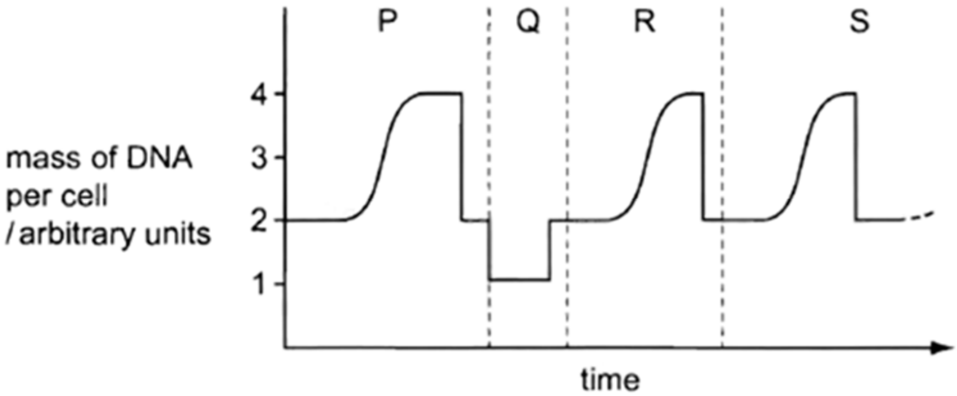
A *RB1* gene is a proto-oncogene.

B The mutated *RB1* allele acts in a recessive manner.

C The mutated *RB1* allele codes for a hyperactive Rb protein.

D A gain-of-function mutation has occurred.

7 A single cell from a female mammal undergoes changes that result in an ovum being formed. If the ovum is fertilised then further changes occur to form an embryo. The graph shows the changes in the mass of DNA per cell during these events.



During which stages might variation occur as a result of changes in the number of sets of chromosomes?

A P, Q and R only

B Q, R and S only

C P and Q only

D R and S only

8 The descriptions below are of nucleic acids in eukaryotes.

1 A polynucleotide of variable length formed by base pairing.
2 A small polynucleotide with a specific three-dimensional shape.
3 A large polynucleotide with a specific shape associated with proteins.
4 A large polynucleotide with super coiled sections associated with proteins.

Which row correctly matches each description to its function?

	Stores coded information	**Carries coded information**	**Carries specific amino acids**	**Provides a site for protein synthesis**
A	3	4	1	2
B	3	4	2	1
C	4	1	2	3
D	4	3	1	2

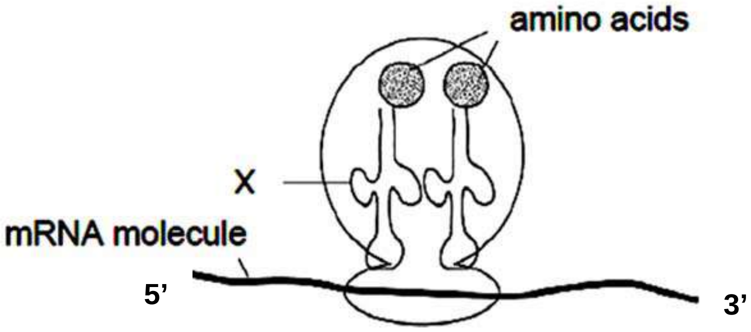
9 The mechanism of action of four drugs that inhibit DNA replication is stated below.

1 Aphidicholine inhibits DNA polymerase.
2 Cytarabine is converted into a molecule that can substitute for a DNA nucleotide and also inhibits DNA repair mechanisms.
3 Epirubicin inhibits an enzyme involved in the unwinding and separation of DNA strands.
4 Hydroxycarbamide inhibits an enzyme involved in the production of deoxyribonucleotides.

Which row correctly matches the effects of these drugs on DNA replication?

	Effects of Drug on DNA Replication			
	Decreased pool of available nucleotides inhibits chain elongation	DNA damaged during replication and cell death occurs	DNA strands not available as templates for replication	Exposed DNA template strands unable to be copied
A	aphidicholine	cytarabine	epirubicin	hydroxycarbamide
B	hydroxycarbamide	epirubicin	aphidicholine	cytarabine
C	epirubicin	hydroxycarbamide	cytarabine	aphidicholine
D	hydroxycarbamide	cytarabine	epirubicin	aphidicholine

10 The diagram below shows part of a molecule of mRNA bound to a ribosome.



Which of the following is **false** about molecule X?

1 It is formed by RNA polymerase in the nucleus.

2 It is able to form hydrogen bonds with mRNA.

3 An amino acid was attached to it by the enzyme amino-acyl tRNA transferase.

4 It is held in the amino-acyl tRNA binding site of the ribosome.

A 3 only

B 4 only

C 1 and 2 only

D 3 and 4 only

11 Gene mutations involve changes in the nucleotide sequence of DNA.

Which of the following descriptions regarding gene mutations is correct?

A Frameshift mutations can be caused by base substitution.

B Frameshift mutations can result from an inversion of bases.

C Missense mutations can be selectively neutral.

D Silent mutations may not be selectively neutral.

12 Two pure-bred lines of different plant varieties, which differed markedly in bean seed mass, were crossed. The mass of bean seeds produced by the two parental varieties and their offspring were measured to the nearest gram. The number of bean seeds in each mass category was counted.

The table below shows the results.

mass of bean / mg		51-150	151-250	251-350	351-450	451-550	551-650	651-750	751-850	851-950
number of beans	Parental	5	375	177				352	955	10
	Offspring			13	544	974	48	2		

Which statement **incorrectly** explains these experimental data?

A The range of phenotypes for the characteristic of bean seed mass is continuous and is due to several different nucleotide sequences at different chromosomal positions controlling the characteristic.

B The greater variation in bean seed mass observed in the offspring generation as compared to the parental generation is due to crossing over between homologous chromosomes, random fusion of gametes, different survival rates of the gametes and zygotes.

C The phenotypic effects of different nucleotide sequences at different chromosomal positions can be summated to determine the bean seed mass in each plant.

D Various environmental factors affect the mass of bean seeds in plants.

13 The speech defect known as stuttering may involve two genes, **G** and **N**. Most people who are homozygous for the alleles **g** and **n** are not stutterers.

However, recent research has shown that the presence of either of the mutant alleles **G** or **N** can cause stuttering in heterozygotes.

Using this information, which proportion of the children of a couple, the father with genotype **Ggnn** and the mother **ggNn**, are likely to be stutterers?

A 3/16

B 6/16

C 9/16

D 12/16

14 A cross between a round-leafed, tall plant and round-leafed dwarf plant produced the following offspring:

	Key
121 round-leafed, tall plant	**R** – round leaf
124 round-leafed, dwarf plant	**r** – oval leaf
42 oval-leafed, tall plant	**T** – tall
37 oval-leafed, dwarf plant	**t** – dwarf

What were the genotypes of the parents?

A RrTt x Rrtt

B RrTt x RRtt

C RrTT x Rrtt

D RrTT x RRtt

15 In fruit flies, one gene controls wing form (normal or vestigial) and one gene controls eye colour (red or normal brown). A fly with normal wings and normal brown eyes is crossed with a fly with vestigial wings and red eyes. All the F_1 are normal for both characteristics.

However, when F_1 are crossed with each other, the resulting F_2 is:

45 normal wing, normal brown eye

17 normal wing, red eye

16 vestigial wing, normal brown eye

5 vestigial wing, red eye

1 normal wing, orange eye

What is the **best** explanation for the results of this dihybrid cross?

A codominance

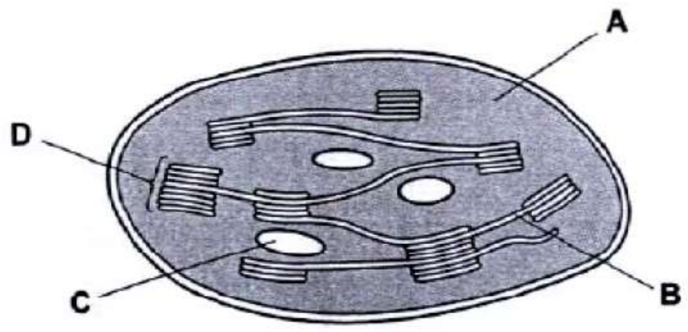
B gene mutation

C multiple alleles

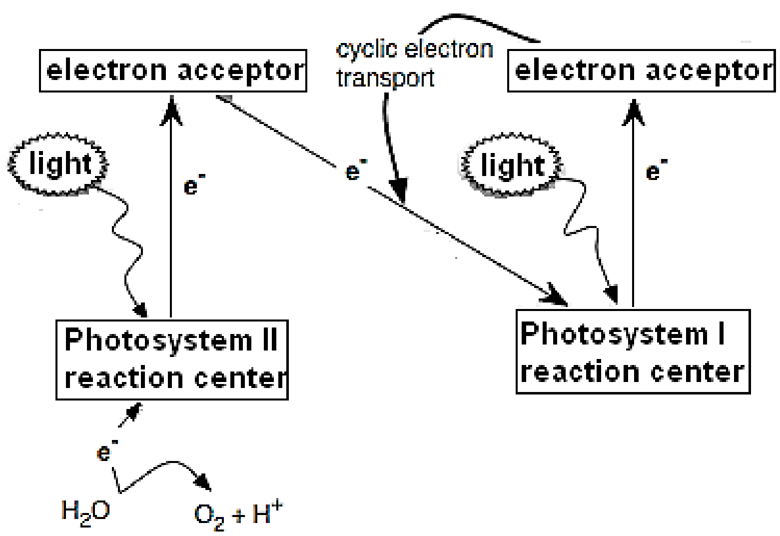
D sex linkage

16 The diagram shows a section through a chloroplast.

Where the products of photophosphorylation would be used?



17 The figure below shows the Z scheme for cyclic phosphorylation and non-cyclic phosphorylation.



Which of the following statements are true?

1 Hydrolysis of ATP occurs in both cyclic and non-cyclic phosphorylation.

2 Energy released from the electron transport chain is used to pump protons from the stroma into the thylakoid lumen.

3 $NADP^+$ is oxidized in non-cyclic phosphorylation.

4 The products of non-cyclic phosphorylation are NADPH, ATP and oxygen.

A 1 and 4 only

B 3 and 4 only

C 2 and 4 only

D 2, 3 and 4 only

18 After vigorous exercise, changes occur in the muscle tissue. Compared with 'at rest' conditions, what will the changes be?

	glycogen	ATP	lactate	pH
A	decreased	decreased	increased	decreased
B	decreased	increased	increased	increased
C	increased	increased	increased	increased
D	increased	decreased	decreased	decreased

19 What is the 'link reaction' in eukaryotic respiration?

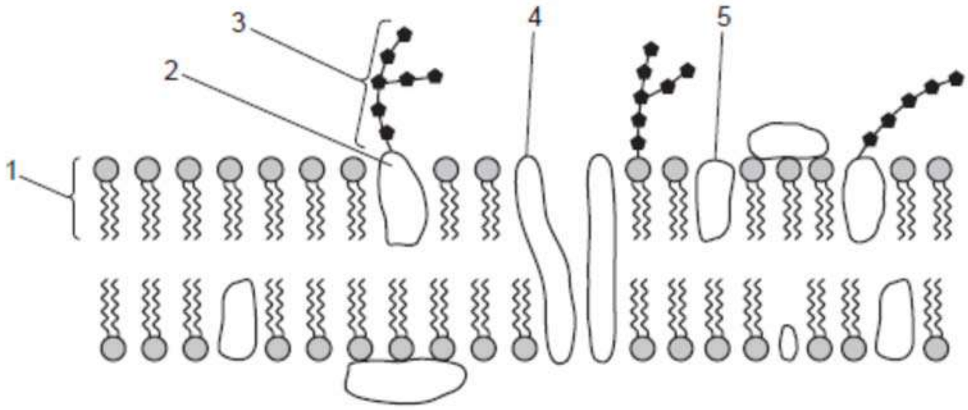
A Oxidation of NADH to yield electrons and protons

B Passage of coenzyme A through the mitochondrial membrane

C Pyruvate combining with coenzyme A to produce CO_2 and NADH/H^+

D Acetyl coenzyme A combining or joining with a C_4 compound to give C_6 + coenzyme

20 The diagram shows part of a cell surface membrane.



Which molecules have both hydrophobic and hydrophilic regions?

A 1 and 5

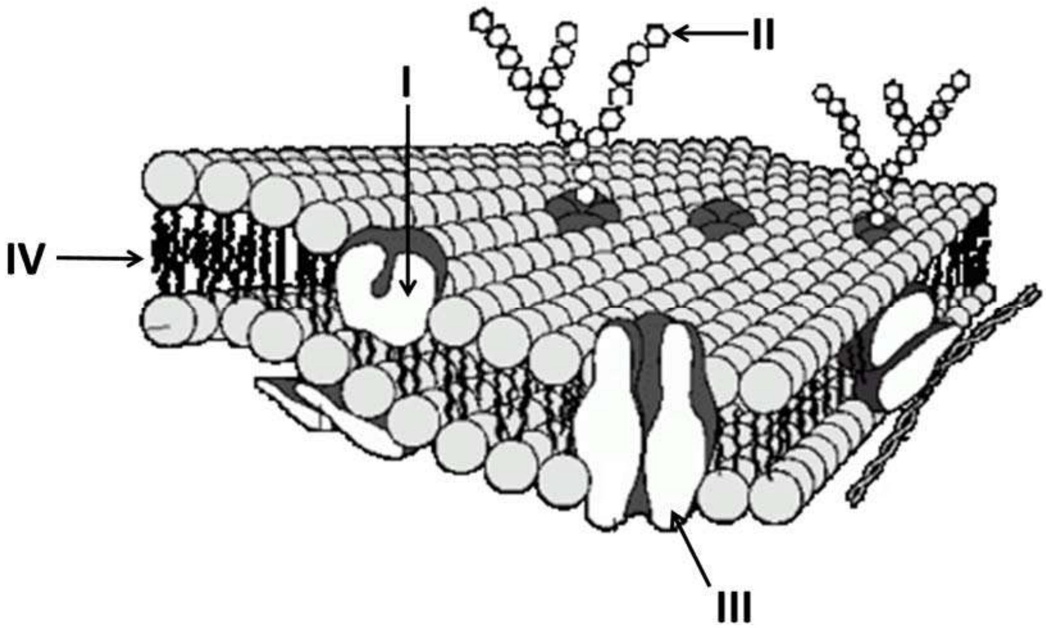
B 1, 3 and 5

C 2, 3 and 4

D 1, 2, 4 and 5

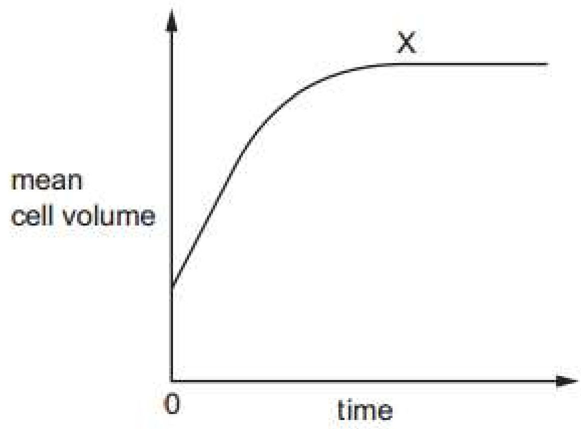
21 The diagram below shows a section of the cell surface membrane from an arctic fish.

Which of the following options regarding the labelled components of the membrane is correct?



	I	II	III	IV
A	Plays a role in cell-cell adhesion	Plays a role in cell-cell recognition	Allows transport of proteins like insulin	Contains a high amount of saturated lipids
B	Plays an enzymatic role	Variation in branching of oligosaccharide allows for cell-cell recognition	Allows transport of amino acids	Contains a high amount of cholesterol
C	Maintains the fluidity of the cell surface membrane	Variation in branching of amino acids allows cell-cell recognition	Plays a role in maintaining membrane potential	Is produced at the Rough Endoplasmic Reticulum
D	Is involved in active transport of ions	Is termed collectively with other glycolipids as the glycocalyx	Is localised to a specific region in the cell surface membrane	Plays a role in cell-cell recognition

22 A tissue composed of plasmolysed plant cells was put into distilled water. The graph shows how the mean cell volume changes with time.



What is the cause of the plateau at **X**?

1 water potential in the plant cell has become more negative

2 cells have become fully turgid

3 no net movement of water into cells

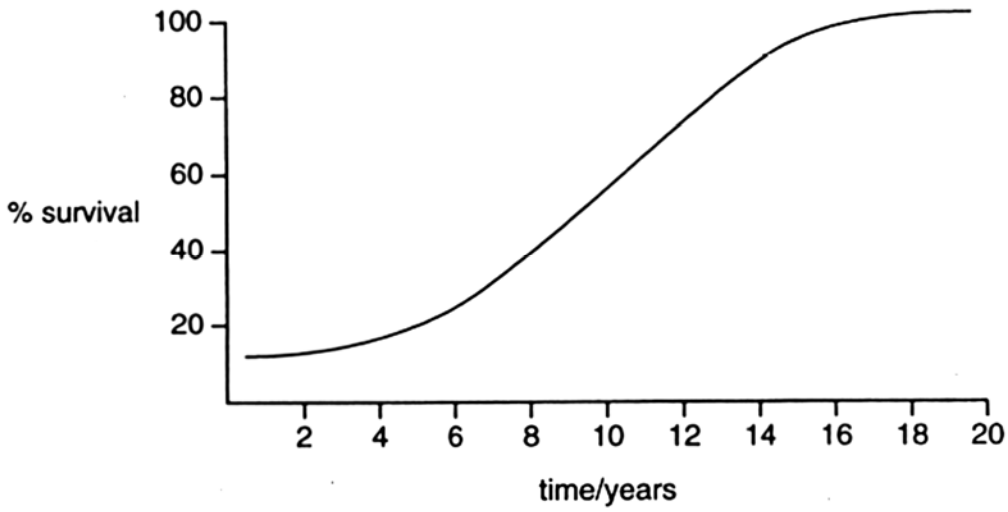
A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

23 The graph shows the effect of pesticide treatment on houseflies over a number of years. A standard amount of pesticide was used each year in summer.



How is the effect of the pesticide best explained?

A A few resistant flies reproduced more successfully and the resistance allele increased in frequency.

B At every generation an increasing proportion of flies mutated to become resistant.

C Repeated exposure to the pesticide caused the flies to become more resistant.

D The allele for resistance mutated from the recessive form to the dominant form.

24 Which effect of natural selection is likely to lead to speciation?

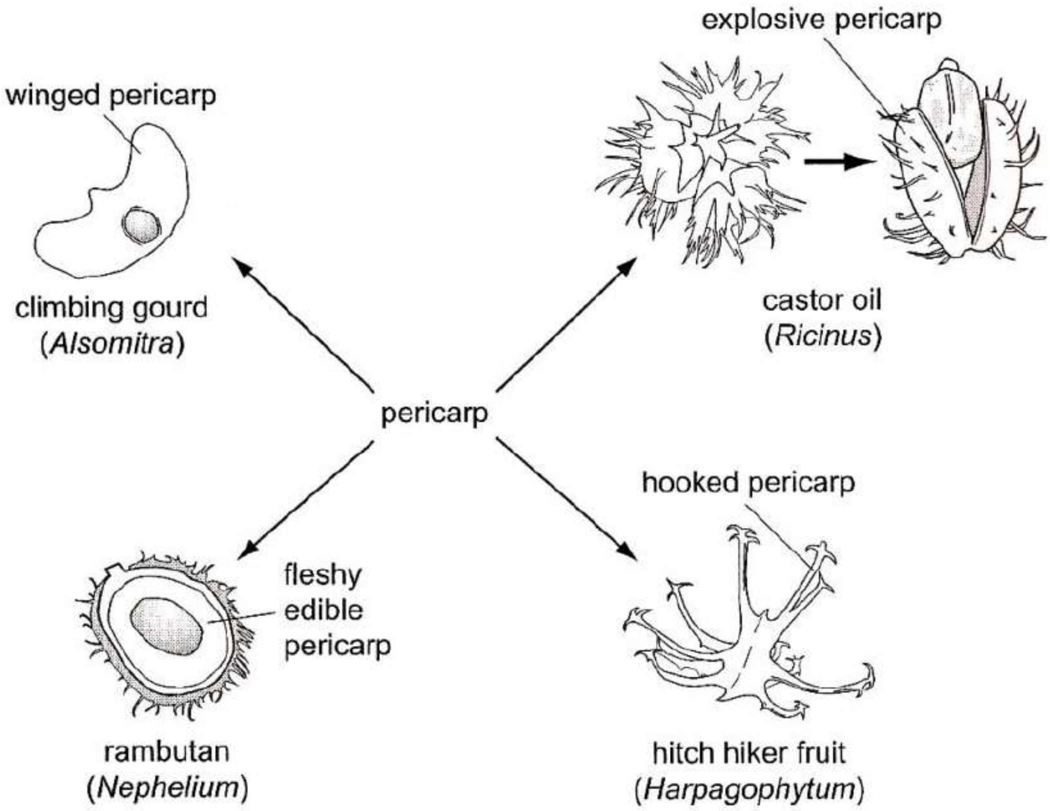
A Differences between populations are increased.

B Favourable genotypes are maintained in the population.

C Genetic diversity is reduced.

D Selection pressure on some alleles reduces reproductive success.

25 The diagram illustrates variation in the pericarp (fruit wall) for a variety of methods of seed dispersal.



What do these examples illustrate?

A The adaptive radiation of analogous structures showing convergent evolution.

B The adaptive radiation of analogous structures showing divergent evolution.

C The adaptive radiation of homologous structures showing convergent evolution.

D The adaptive radiation of homologous structures showing divergent evolution.

26 Which of the following is **not** a reason for plasmids being used as cloning vector?

A They are small.

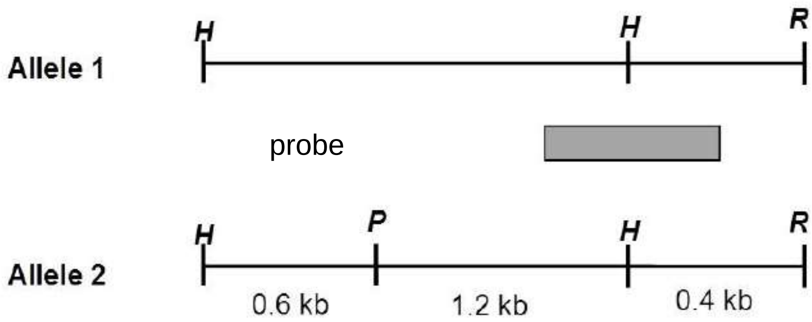
B They have an origin of replication.

C They can undergo independent replication.

D They always produce sticky ends when cut by restriction enzymes.

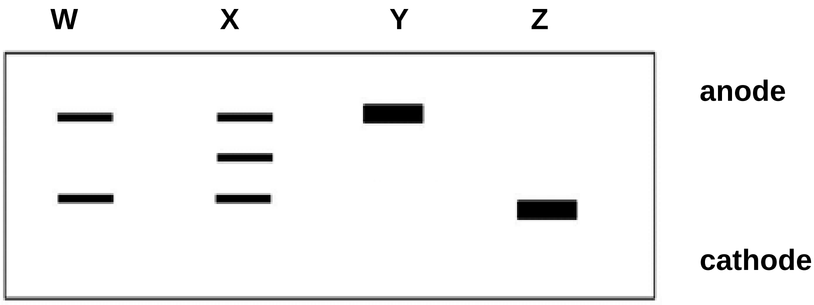
27 Cystic fibrosis is a genetic disease that affects the respiratory and digestive systems. Individuals with cystic fibrosis have two copies of the mutated *CFTR* allele.

Diagram below shows the positions of various restriction sites of a segment of KM-19, an RFLP (restriction fragment length polymorphism) marker that is closely linked to the CFTR gene locus. Position complementary to a radioactive probe is also shown. Allele 2 is linked to the mutant CFTR allele.



Legend
H represents *Hin*dIII restriction site
P represents *Pst*I restriction site
R represents *Eco*RI restriction site

DNA from different individuals are digested using *Pst*I and separated using gel electrophoresis. Results of the autoradiograph are shown below.



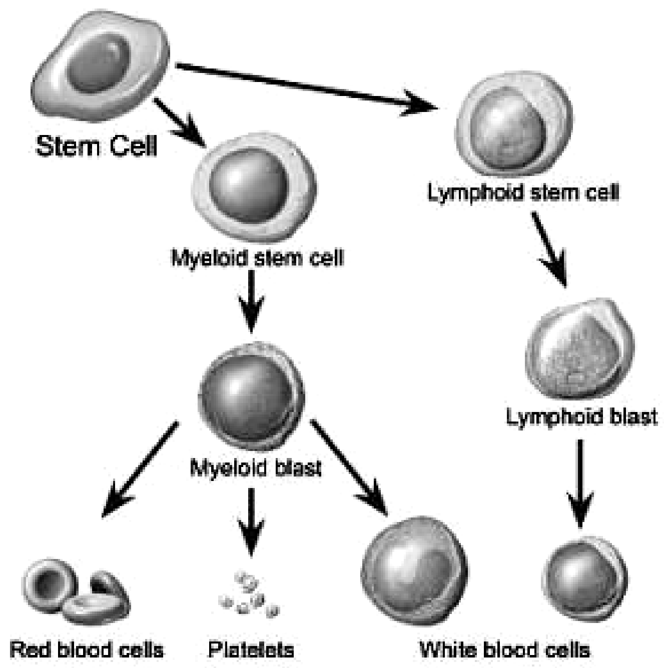
Which of the following individual suffers from CF?

A W
B X
C Y
D Z

28 Why are primers added to polymerase chain reaction (PCR) mixture?

A Because Taq polymerase cannot initiate synthesis of a polynucleotide strand.
B So that there would not be leading and lagging strand.
C To anneal to the 3' OH end to the target DNA.
D To separate the double stranded DNA into 2 single strands.

29 The following diagram shows how a stem cell can differentiate into different specialized cell types.



Which of these statements is **false** with regards to the stem cells shown?

A The stem cells are multipotent.

B The stem cells can be found in both a fetus and an adult body.

C The stem cells can differentiate into the three germ layers in the adult body.

D The stem cells may be used in a bone marrow transplant to treat a patient with leukemia, a form of blood cancer.

30 Some scientists are concerned about the release of genetically modified microorganisms into their natural habitat.

What is the most likely reason for this concern?

A The microorganisms may reproduce quickly.

B The microorganisms may not survive.

C The mutation rate of the microorganisms would increase.

D The transfer of changed genes to other organisms.

Answers

1	C	16	A
2	D	17	C
3	B	18	A
4	A	19	C
5	B	20	D
6	B	21	B
7	C	22	D
8	C	23	A
9	D	24	A
10	D	25	D
11	C	26	D
12	B	27	C
13	D	28	A
14	A	29	C
15	B	30	D

INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME

CLASS

INDEX NUMBER

BIOLOGY 8875/02

Paper 2

29 August 2017

2 hours

Additional Materials: Answer Paper
Cover Page

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **one** question.

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

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

For Examiner's Use	
Section A	
1	**14**
2	**14**
3	**12**
Section B	
4 OR 5	**20**
Total	**60**

This document consists of **11** printed pages and **1** blank page.

For Examiner's Use

Section A

Answer **all** questions.

1 **(a)** Describe the importance of ATP in cells, giving **two** examples of processes in which it is used.

-- [3]

Cells generate ATP by adding a phosphate group (P_i) to ADP. During the complete oxidation of glucose, cells have two ways of doing this:

- Substrate level phosphorylation
- Oxidative phosphorylation

Fig 1.1 and 1.2 are diagrams that show the main details of these two processes (not drawn to the same scale).

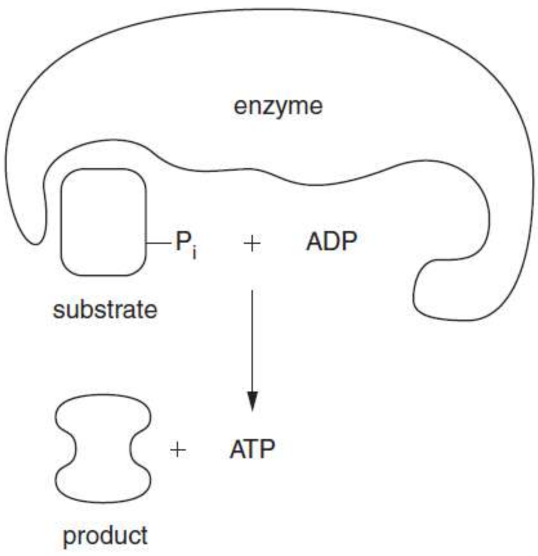


Fig. 1.1

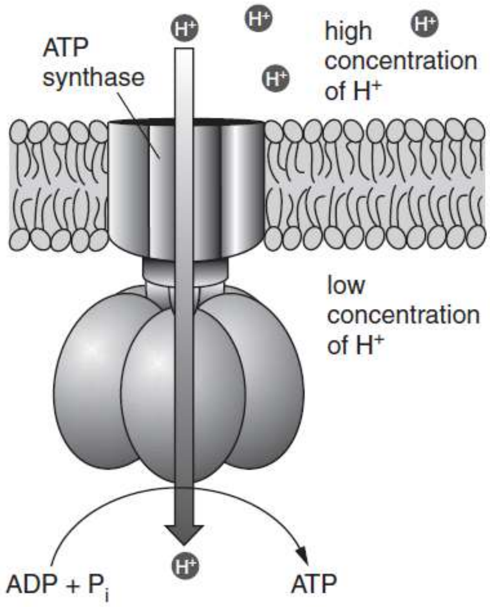


Fig. 1.2

(b) State precisely where these two processes occur in a cell.

substrate level phosphorylation;

----

oxidative phosphorylation.

-- [2]

For Examiner's Use

(c) Compare the relative amounts of ATP produced by the two processes when a molecule of glucose is completely oxidised.

....

....

....

.... [2]

(d) Only substrate level phosphorylation is possible in the absence of oxygen.

Explain why oxidative phosphorylation is not possible in the absence of oxygen.

....

....

....

....

....

.... [3]

(e) Fig. 1.3 shows how glucose is transported into a cell via a transport protein held within the cell surface membrane.

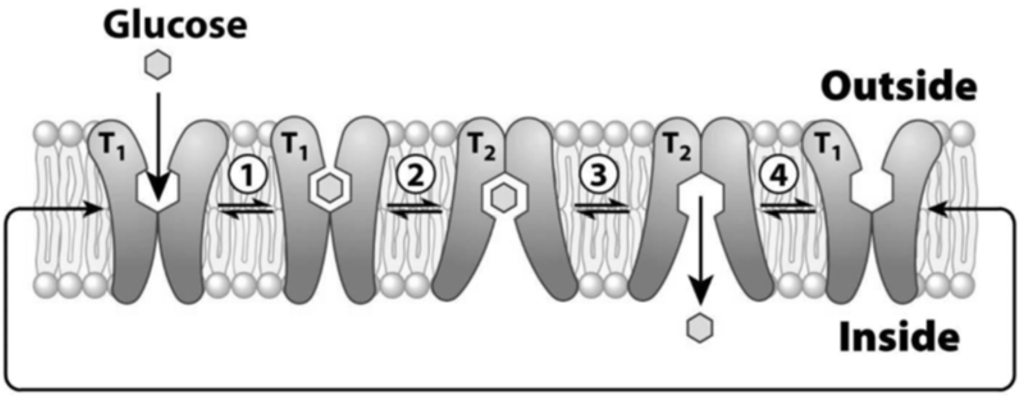


Fig. 1.3

(i) Describe the structure of the cell surface membrane shown in Fig. 1.3.

....

....

....

.... [2]

(ii) With reference to Fig. 1.3, describe how glucose is transported into the cell.

....

....

....

.... [2]

[Total: 14]

2 Fig. 2.1 shows a diagram of DNA replication.

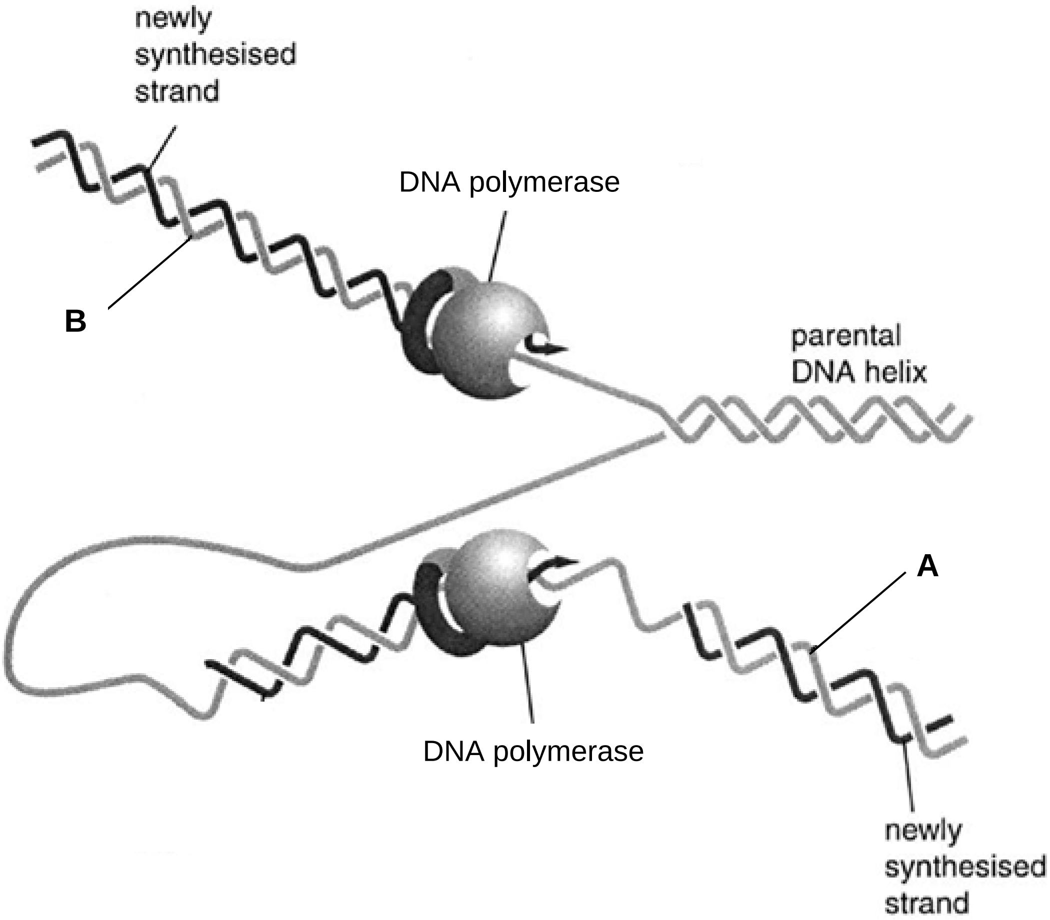


Fig. 2.1

(a) **(i)** On Fig. 2.1, indicate 3' and 5' ends on both the parental template strands of the DNA molecule. [1]

(ii) Circle which strand, **A** or **B**, is the lagging strand template used in the synthesis of new DNA daughter strand resulting in Okazaki fragments. [1]

For Examiner's Use

(b) Explain why the newly synthesised strand is formed continuously from the leading strand template while Okazaki fragments are formed using the lagging strand template.

....

....

....

.... [2]

(c) Describe how gene mutations may occur during replication of DNA.

....

....

....

.... [2]

Cell cycle checkpoints are used by a cell to monitor and regulate the progress of the cell cycle. Checkpoints prevent cell cycle progression at specific points, allowing verification of necessary phase processes and repair of DNA damage. The cell cannot proceed to the next phase until checkpoint requirements have been met.

Checkpoints typically consist of a network of regulatory proteins that monitor and dictate the progression of the cell through the different stages of the cell cycle. However, these checkpoints may be dysregulated which can result in uncontrolled cell division and eventually cancer.

Fig. 2.2 shows a typical cell cycle with the various checkpoints.

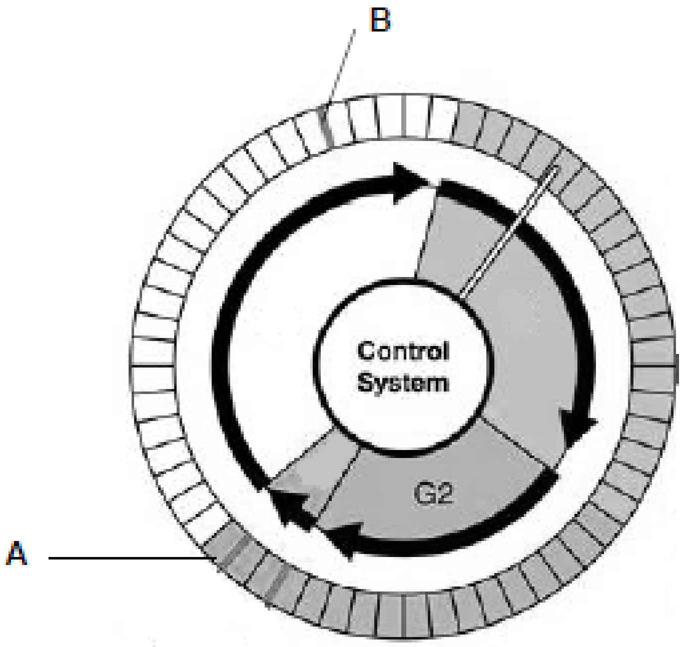


Fig. 2.2

(d) With reference to Fig. 2.2,

(i) name checkpoints **A** and **B**;

A ....

B .... [1]

(ii) Describe the role of checkpoints **A** and **B**.

A ....

B .... [1]

(iii) Explain what occurs in the G2 phase of cell cycle.

....

....

....

.... [2]

(e) Describe how dysregulation of the checkpoints in cell cycle may lead to cancer.

[2]

(f) Some types of cancer can be treated by chemotherapy, which involves the injection of chemicals into the bloodstream.

Vincristine is a drug used for chemotherapy. This drug works partly by binding to the tubulin protein, stopping the cell from proceeding in the M phase of the cell cycle.

Explain how the use of vincristine will stop the proliferation of cancer cells.

.... [2]

[Total: 14]

3 The fruitfly, *Drosophila*, has many different species. Three of these species, *Drosophila pseudoobscura*, *D. persimilis* and *D. miranda*, are thought to be closely related.

Samples of these three species were collected from the western United States of America.

Fig. 3.1 shows where these species naturally occur.

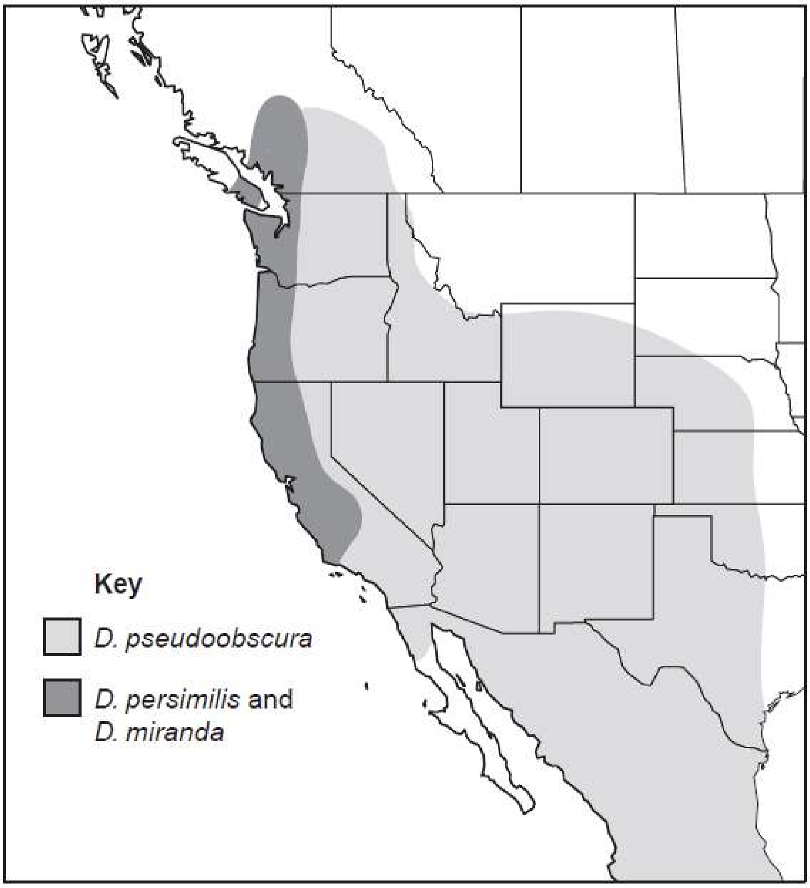


Fig. 3.1

(a) State what must exist in a population for natural selection to occur.

.... [1]

The base sequences of four regions of DNA of each species were sequenced. The divergence of these base sequences in *D. pseudoobscura* and *D. persimilis* from the sequences in *D. miranda* was calculated. The results are shown in Table 3.

Table 3

DNA region	*Drosophila* species	percentage divergence of base sequence from that of *D. Miranda* /%
1	*pseudoobscura*	2.5
	persimilis	2.4
2	*pseudoobscura*	8.1
	persimilis	7.3
3	*pseudoobscura*	2.1
	persimilis	1.7
4	*pseudoobscura*	1.9
	persimilis	1.7

(b) With reference to Table 3, describe the evidence that *D.miranda* may be more closely related to *D.persimilis* than to *D.pseudoobscura.*

-- [2]

(c) Suggest why there is more divergence in some regions of DNA than in others.

-- [1]

(d) Explain how *D.persimilis* and *D.pseudoobscura* could have speciated from *D.miranda.*

--- [4]

Beside molecular homology, scientists can also use anatomical homology to study the evolutionary relationship among vertebrate species.

Fig. 3.2 shows the relationship between six vertebrate species by comparing the bone arrangement in the forelimbs.

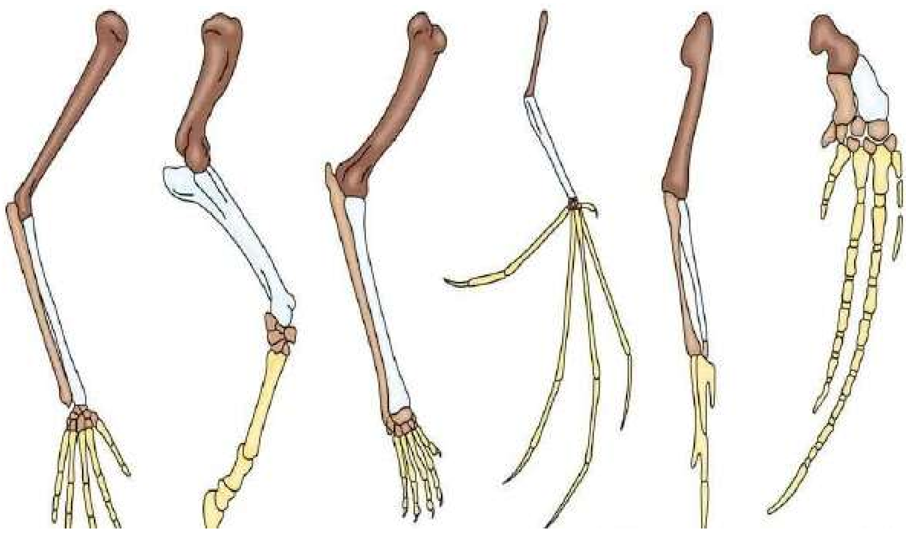


Fig. 3.2

For Examiner's Use

(e) Explain what is meant by 'homology'.

--- [1]

(f) Explain how the anatomical homology shown in Fig. 3.2 supports Darwin's theory of evolution.

--- [3]

[Total: 12]

For Examiner's Use

Section B

Answer EITHER 4 OR 5.

Write your answers on the separate answer paper provided.
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 section **(a)**, **(b)** etc., as indicated in the question.

Either

4 **(a)** Describe the polymerase chain reaction and explain the advantages and limitations of the procedures. [12]

(b) Explain how gel electrophoresis is used to analyse DNA. [8]

[Total: 20]

Or

5 **(a)** Describe the unique features of zygotic stem cells, embryonic stem cells and blood stem cells and explain the normal functions of stem cells in a living organism. [10]

(b) With reference to two examples, explain how genetic engineering can be used to improve quality and yield of crop plants. [10]

[Total: 20]

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INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME	**ANSWERS**		
CLASS		INDEX NUMBER	

BIOLOGY

8875/02

Paper 2

29 August 2017

2 hours

Additional Materials: Answer Paper
Cover Page

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For Examiner's Use	
Section A	
1	
2	
3	
Section B	
4 OR 5	
Total	

For Examiner's Use

Section A

Answer **all** questions.

1 **(a)** Describe the importance of ATP in cells, giving **two** examples of processes in which it is used.

1. ATP is the universal energy carrier in living org

where hydrolysis of phosphate grps releases energy;;

2. muscle contraction;; OR

3. DNA replication;; OR

active transport, cell movement, amino acid activation, AVP;; [3]

Cells generate ATP by adding a phosphate group (P_i) to ADP. During the complete oxidation of glucose, cells have two ways of doing this:

- Substrate level phosphorylation
- Oxidative phosphorylation

Fig 1.1 and 1.2 are diagrams that show the main details of these two processes (not drawn to the same scale).

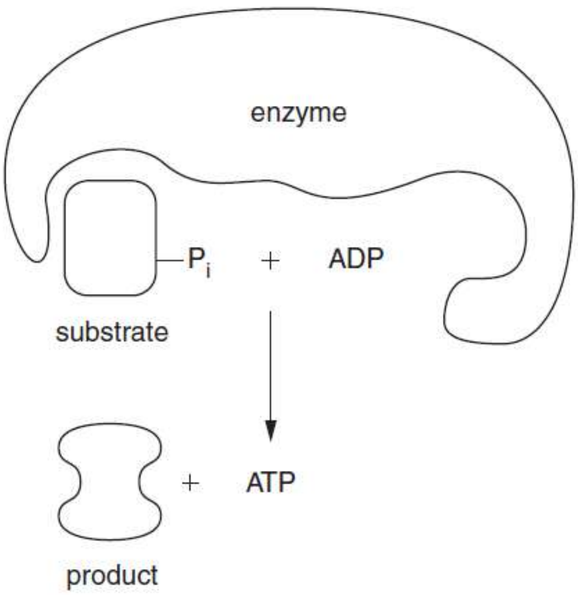

Fig 1.1

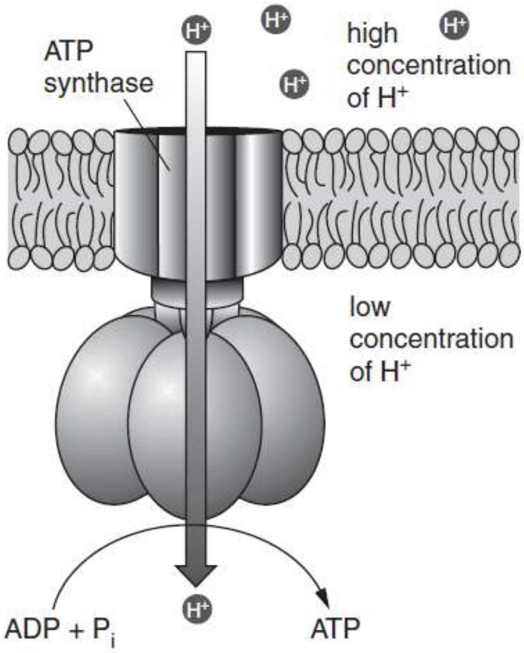

Fig 1.2

(b) State precisely where these two processes occur in a cell.

substrate level phosphorylation

Cytoplasm @cytosol (during glycolysis)/ mitochondrion matrix (during Krebs cycle);;

oxidative phosphorylation

inner memb of mitochondrion;; [2]

(c) Compare the relative amounts of ATP produced by the two processes when a molecule of glucose is completely oxidised.

1. OP pdces more ATP than SLP;;

2. SLP pdces 4 ATP (2 in glycolysis, 2 in Krebs Cycle) while OP pdces 28 ATP;; [2]

(d) Only substrate level phosphorylation is possible in the absence of oxygen.
Explain why oxidative phosphorylation is not possible in the absence of oxygen.

1. O_2 is final e- & proton acceptor in ETC

producing water in process, catalyzed by cytochrome oxidase;;

2. w/o O_2, there is no flow of e- down ETC

thus electrochemical proton grad is not generated across inner mitochondrial memb;;

3. H+ ions does not diffuse across inner mitochondrial memb via ATP synthase

catalytic sites of ATP synthase not activated, thus no phosphorylation of ADP with P_i;; [3]

(e) Fig 1.3 shows how glucose is transported into a cell via a transport protein held within the cell surface membrane.

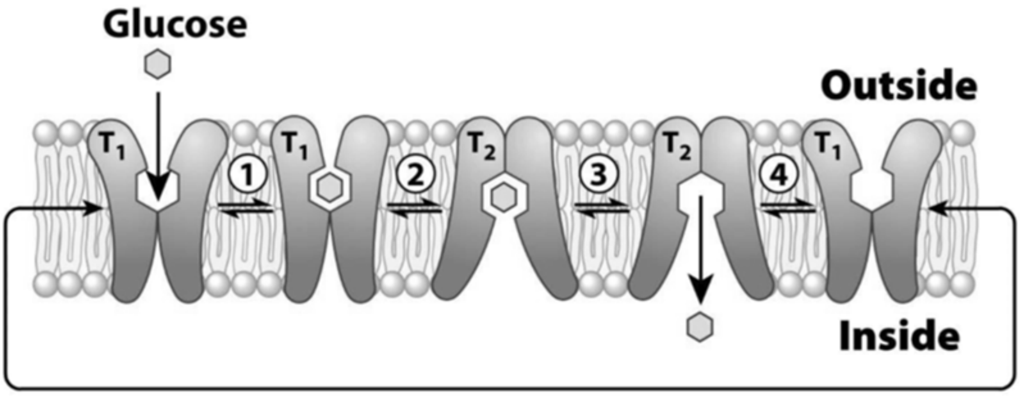

Fig 1.3

(i) Describe the structure of the cell surface membrane shown in Fig 1.3.

1. It has a fluid mosaic model composed of phospholipid bilayer & prots;;

2. hydrophilic phosphate heads faces aqueous medium while hydrophobic hydrocarbon tails face each other away from aqueous medium;; [2]

(ii) With reference to Fig 1.3, describe how glucose is transported into the cell.

1. high conc of glucose outside cell, glucose binds complementarily to binding site of carrier prot in T1 conformation;; ®transport protein

2. upon binding, carrier prot changes from T1 conformation to T2 conformation, where it releases glucose inside of cell;; [2]

[Total: 14]

2 Fig. 2.1 shows a diagram of DNA replication.

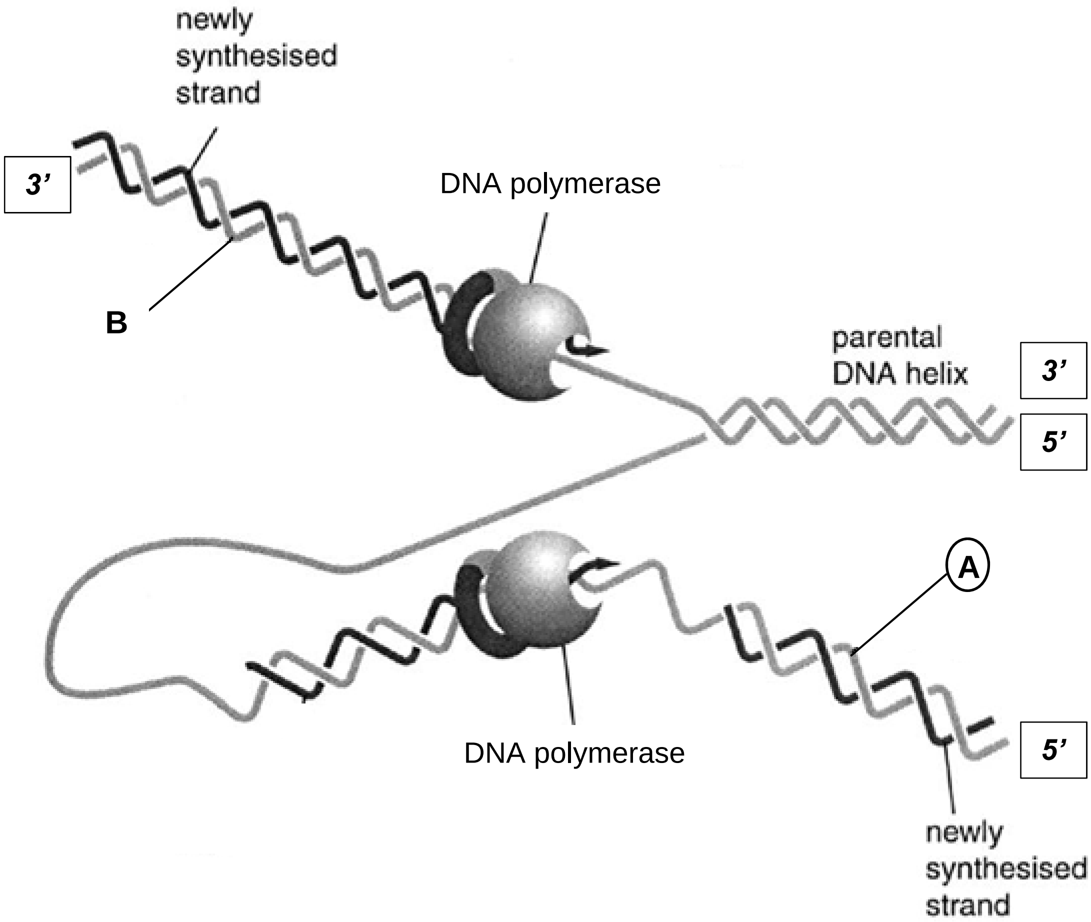

Fig. 2.1

(a) **(i)** On Fig. 2.1, indicate 3’ and 5’ ends on both the parental template strands of the DNA molecule. [1]

(ii) Circle which strand, **A** or **B**, is the lagging strand template used in the synthesis of new DNA daughter strand resulting in Okazaki fragments. [1]

(b) Explain why the newly synthesised strand is formed continuously from the leading strand template while Okazaki fragments are formed using the lagging strand template.

1. ***2 DNA strands synthesized are antiparallel***

   DNA pol can only add nucleotides to 3’ end of growing daughter strand in 5’ to 3’ direction
2. ***leading strand synthesised in 5’ to 3’ direction continuously towards replication fork***
   lagging strand synthesised as Okazaki fragments in 5’ to 3’ direction away from replication fork [2]

(c) Describe how gene mutations may occur during replication of DNA.

error in complementary base pairing occurs during DNA replication by DNA pol III;;

point substitution mutations not corrected by DNA repair prots or DNA pol III during proofreading;;

[2]

Cell cycle checkpoints are used by a cell to monitor and regulate the progress of the cell cycle. Checkpoints prevent cell cycle progression at specific points, allowing verification of necessary phase processes and repair of DNA damage. The cell cannot proceed to the next phase until checkpoint requirements have been met.

Checkpoints typically consist of a network of regulatory proteins that monitor and dictate the progression of the cell through the different stages of the cell cycle. However, these checkpoints may be dysregulated which can result in uncontrolled cell division and eventually cancer.

Fig. 2.2 shows a typical cell cycle with the various checkpoints.

Fig. 2.2

(d) With reference to Fig. 2.2,

(i) name checkpoints **A** and **B**;

A ***spindle/ M phase checkpoint;***

B ***G1/ restriction checkpoint/ DNA damage checkpoint;***

[1]

(ii) Describe the role of checkpoints **A** and **B**.

A ***checks chromosomes are <u>all properly attached</u> to spindle fibres before cell cycle continues;***

B ***checks for presence of growth factors, DNA damage, cell size, nutrients*** [1]

(iii) Explain what occurs in the G2 phase of cell cycle.

1. cell's growth phase after DNA replication in S phase of interphase

cells continue to build up synthesis ATP (energy), synthesises proteins and organelles (mitochondrion, rER);;

2. duplication of centrosome occurs, each containing pair of centrioles

prepare cell to enter M phase of cell cycle;; [2]

(e) Describe how dysregulation of the checkpoints in cell cycle may lead to cancer.

1. cells will continue to proceed to next phase of cell cycle continuously bypassing checkpoints

cells are not checked for their readiness to proceed to next phase of cell cycle;;

2. leads to uncontrolled cell division & over - proliferation of cells

resulting in formation of a mass of non-functional cells called tumour resulting in cancer;; [2]

(f) Some types of cancer can be treated by chemotherapy, which involves the injection of chemicals into the bloodstream.

Vincristine is a drug used for chemotherapy. This drug works partly by binding to the tubulin protein, stopping the cell from proceeding in the M phase of the cell cycle.

Explain how the use of vincristine will stop the proliferation of cancer cells.

1. tubulin is a component of spindle fibre/ microtubules

when drug binds to tubulin, spindle fibre/ microtubules could not be formed;;

2. cells are unable to pass the spindle/ M phase checkpoint

Thus does not divide successfully thereby stopping proliferation of cancer cells;; [2]

[Total: 14]

3 The fruitfly, *Drosophila*, has many different species. Three of these species, *Drosophila pseudoobscura*, *D. persimilis* and *D. miranda*, are thought to be closely related.

Samples of these three species were collected from the western United States of America.

Fig. 3.1 shows where these species naturally occur.

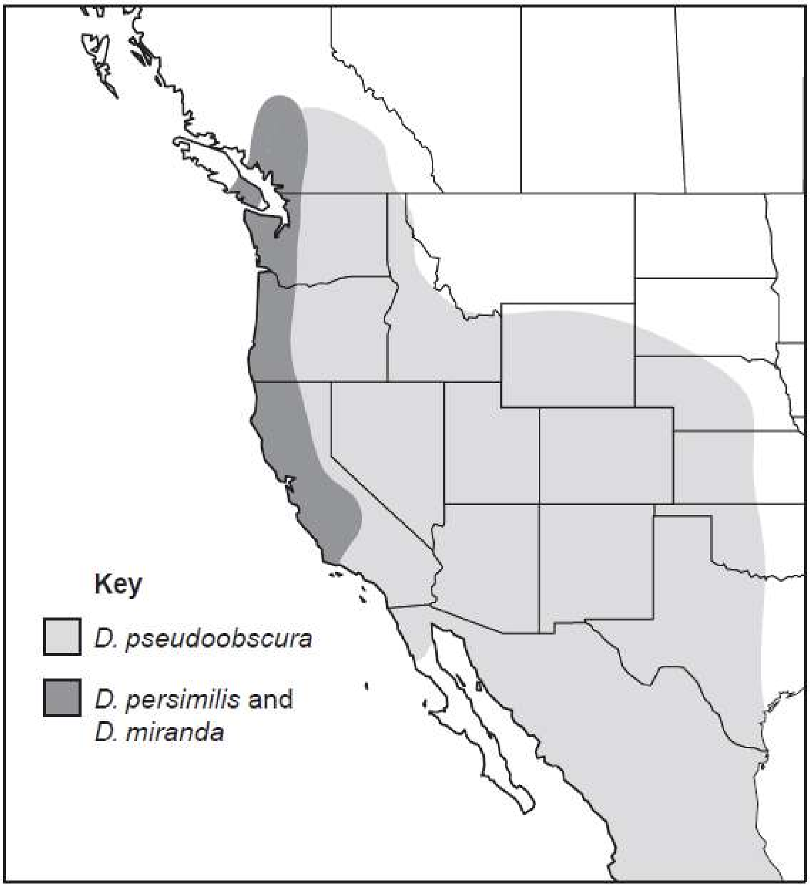

Fig. 3.1

(a) State what is must exist in a population for natural selection to occur.

variation;;

[1]

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The base sequences of four regions of DNA of each species were sequenced. The divergence of these base sequences in *D. pseudoobscura* and *D. persimilis* from the sequences in *D. miranda* was calculated. The results are shown in Table 3.

Table 3

DNA region	*Drosophila* species	percentage divergence of base sequence from that of *D. miranda*
1	*pseudoobscura*	2.5
	persimilis	2.4
2	*pseudoobscura*	8.1
	persimilis	7.3
3	*pseudoobscura*	2.1
	persimilis	1.7
4	*pseudoobscura*	1.9
	persimilis	1.7

(b) With reference to Table 3, describe the evidence that *D. miranda* may be more closely related to *D. persimilis* than to *D. pseudoobscura.*

1. % divergence of D. persimilis from D. miranda is less than that of D. pseudoobscura from D. miranda

for all 4 DNA regions;;

2. at DNA region 4, % divergence of D. persimilis is 1.7 & 1.9 for D.pseudoobscura

at DNA region 2, % divergence of D. persimilis is 7.3 & 8.1 for D.pseudoobscura;; [2]

(c) Suggest why there is more divergence in some regions of DNA than in others.

1. some regions of DNA have higher mutation rates / more prone to mutations

mutation changes are less harmful when exact seq of amino acid is not critical to survival of org;; OR

2. lower divergence / mutation rates if DNA is part of an impt gene

mutations in some regions are likely to be fatal hence not seen in popn; [1]

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(d) Explain how *D.persimilis* and *D.pseudoobscura* could have speciated from *D.miranda.*

1. variations exist in the 2 popns of D. miranda

due to diff genetic makeup;;

2. diff selection pressures in diff env[tal] cond[ns]

those with favourable phenotypes are selected for;;

3. survive to reproductive age & pass down advantageous/ favourable alleles to offspring,

leading to changes in freq of alleles in gene pool;;

4. 2 popns cannot interbreed due to geographical barrier (water bodies/ high mountains), there will be accumulation of genetic differences over time which results in the formation of different species, unable to interbreed to give viable, fertile offspring;; [4]

Beside molecular homology, scientists can also use anatomical homology to study the evolutionary relationship among vertebrate species.

Fig. 3.2 shows the relationship between six vertebrate species by comparing the bone arrangement in the forelimbs.

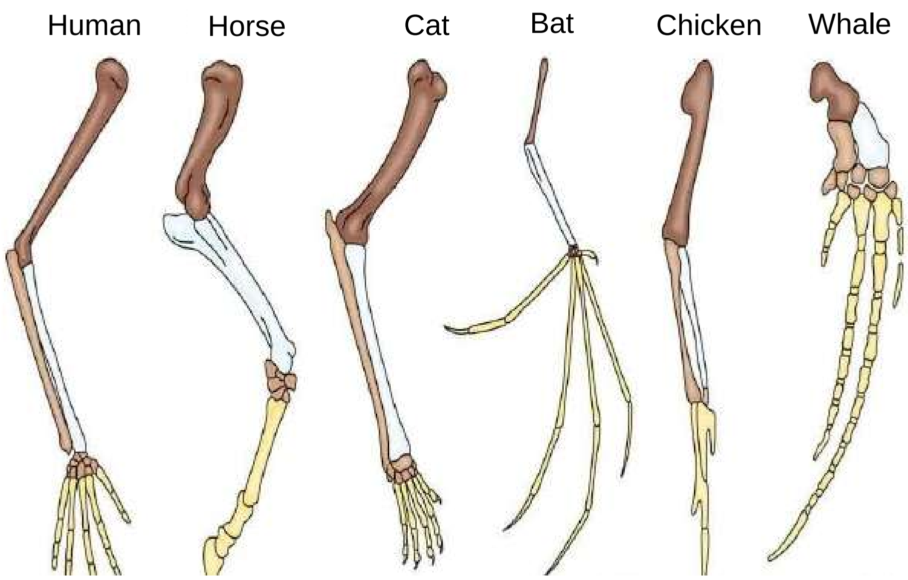

Fig. 3.2

(e) Explain what is meant by ‘homology’.

1. Homology refers to similarities due between diff species due to a common ancestor;;

[1]

(f) Explain how the anatomical homology shown in Fig. 3.2 supports Darwin’s theory of evolution.

1. forelimbs of various species hv same basic pentadactyl/ five digit forelimb struc

differences in shape which are largely due to specialisation for a particular function;;

2. e.g. whale for swimming, bat for flying etc;;

3. struc likely to have originated/ derived from a common ancestor

indicating descent with modification over time;;

[3]

[Total: 12]

For Examiner's Use

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
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 section **(a)**, **(b)** etc., as indicated in the question.

4 **(a)** Describe the polymerase chain reaction and explain the advantages and limitations of the procedures. [12]

PCR Process (max 6m)

1. ***PCR is an in vitro method of replicating short DNA seq into millions of copies/ amplifying short DNA seq within short period of time***

2. ***PCR rxn requires forward & reverse primers, heat-stable Taq pol, free deoxyribonucleotides, & target DNA seq to be amplified & buffer soln***

3. ***PCR is carried out in a thermal cycler in 3 step cycle – denaturation, annealing and elongation to take place***

4. ***denaturation takes place at 95ºC to separate ds DNA into ss DNA by breaking H-bonds b/w compl bp. ss DNA will then act as template for elongation***

5. ***annealing occurs when rxn mixture is cooled to 55ºC to allow forward & reverse primers to bind to complementary seq flanking target seq via H-bonds b/w compl bp.***

6. ***elongation occurs at 72ºC when Taq pol synthesizes compl DNA strands by adding free deoxyribonucleotides to free 3'OH ends of primers using target DNA seq as template***

each cycle results in doubling of the target DNA seq (2^n)

Advantages (max 3m)

7. ***Rapid and efficient***

Each cycle takes only 3 - 5 min thus large number of DNA molecules to be amplified.

8. ***Relatively easy***

   PCR can be performed using relatively simple equipment, a thermal cycler. The process is fully automated with initial setting of conditions, adding all reagents in appropriate amounts and the cycles can run unattended overnight.

9. ***Sensitive and robust***

   The process is sensitive and can amplify minute amounts of target DNA.

10. ***Specific***

    The elongation process in PCR synthesises the target DNA sequence that lies specifically between the forward and reverse primers.

11. ***Relatively high fidelity***

    The amplification is relatively accurate with error rates ranging between 1 in 10,000 bases to 1 in 100,000 bases. Error rates vary with the choice of polymerase.

Limitations (max 3m)

12. ***Primer design***

    base sequence flanking the target sequence needs to be known first in order to synthesize specific primers.

13. ***Limited length of target sequence***

    The length of target DNA restricted to 0.1 to 5 kb with an optimum length of 2 to 3 kb. Further increase in length of target sequence decreases efficiency of amplification because polymerase tends to detach before chain extension is complete.

14. ***Error in replication***

    Taq polymerase lacks proofreading activity. This results in an error rate of approximately 1 in 10,000 bases. If the error occurs early in the PCR cycle, the erroneous sequence will be amplified together with the target sequence.

(b) Explain how gel electrophoresis is used to analyse DNA. [8]

(max 8m)

1. ***Agarose gel electrophoresis is used in the separation of DNA fragments after digestion by restriction enzymes.***

2. ***Agarose powder is dissolved buffer and poured into gel casting tray. A comb is inserted to form wells. After the gel is cooled and harden, it placed in the gel chamber together with buffer and the comb removed.***

3. ***DNA fragments are mixed with loading and tracking dye and loaded in wells of the agarose gel near the cathode using a micropipette.***

4. ***The loading dye contains glycerol that helps weigh the DNA fragments into the wells.***

5. ***Tracking dye containing a low and a high molecular weight coloured compound is added during loading. These coloured compounds act as front and back markers of migration.***

6. ***A voltage between 90V to 150V is applied across the gel. The buffer maintains appropriate pH and contains ions that conduct a direct current across the gel.***

7. ***DNA fragments which are negatively charged due to presence of phosphate groups, will migrate across the gel from the negative electrode (cathode) towards the positive electrode (anode).***

8. ***Agarose gel acts as a molecular sieve to separate nuclei acids by size/ molecular weight/ fragment length. Smaller fragments are less impeded by the gel and migrate faster (further) than larger fragments. @vice versa, idea of migrate rate is inversely proportional to fragment length/ size***

9. ***After electrophoresis, DNA fragments of the same size/ length are localised in the same region of the gel forming a band.***

10. ***As DNA molecules are not visible to the naked eye. Gels need to be stained with methylene blue/ ethidium bromide for the DNA bands to be seen.***

[Total: 20]

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5 (a) Describe the unique features of zygotic stem cells, embryonic stem cells and blood stem cells and explain the normal functions of stem cells in a living organism. [10]

Features

1. ***Zygotic stem cells are produced from the fusion of an egg and sperm cell are they are totipotent;;***

2. ***They can differentiate into any cell types to form whole organisms, and so are also pluripotent and multipotent;;***

3. ***Embryonic stem cells from the inner cell mass of blastocyst (a hollow ball-shaped mass of cell formed a week after fertilisation) are pluripotent. They are the descendants of totipotent cells;;***

4. ***These cells can differentiate into almost any cell type to form any organ or type of cell except extra-embryonic tissues and so are not totipotent but are multipotent;;***

5. ***Blood stem cells are from the bone marrow are multipotent;;***

6. ***Blood / hematopoietic stem cells are multipotent as they can only differentiate into a limited range of cell type - red blood cells, white blood cells, platelets. They are not totipotent or pluripotent;;***

Functions

7. ***Embryonic stem cells give rise to all derivatives of the three primary germ layers: ectoderm, endoderm and mesoderm during development;;***

8. ***These germ layers subsequently give rise to the multiple specialized cell types that make up the heart, lung, skin, and other tissue;;***

9. ***Adult stem cells like blood stem cells maintain the steady state functioning of a cell;;***

10. ***by generating replacements for cells lost through disease, tissue injury or normal wear-and-tear;;***

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(b) With reference to two examples, explain how genetic engineering can be used to improve quality and yield of crop plants. [10]

Example 1: Bt Corn (max 5m)

1. ***Corn are often damaged by the larvae (caterpillar) of the moth, European corn borer. The larvae bore and eat into the stem of the corn plant, damaging and often killing it;;***

2. ***The use of spray insecticides is ineffective as the larva is protected from the insecticides once it enters the stem;;***

3. ***Bt corn - corn plant genetically modified to be resistant to insects like the European corn borer by introducing a gene coding for a toxin that kills the larvae;;***

4. ***The cry gene isolated from soil bacterium Bacillus thuringiensis is transformed into corn plants via the use of the Ti plasmid from the bacterium Agrobacterium tumefaciens;;***

5. ***Corn that has been transformed with the cry gene (i.e. Bt corn) is able to produce Bt toxin;;***

6. ***When a larvae feeds on any tissue of the Bt corn plant, it ingests the Bt toxin. The Bt toxin is cleaved by intestinal protease, active Bt toxin binds to receptors on the surface of epithelial cells and inserts into the cell membrane, forming pores. This causes gut cells of insect to lyse, eventually leading to insects' death;;***

7. ***This reduced the use of insecticides while ensuring that corn plants are enable to grow healthily to maturity, thereby ensuring increase in yield;;***

Example 2: Golden Rice (max 5m)

8. ***In developing countries, vitamin A deficiency is a leading cause of vision impairment and blindness in children;;***

9. ***Rice grain is a staple food in many developing countries. But the precursor to vitamin A - β-carotene is produced in the rice leaves and not the rice grain which is eaten;;***

10. ***The rice plant can be genetically modified to express β-carotene in its rice***

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grain. GM rice is known as Golden Rice due to its yellow-orange colour;;

11. ***In Golden Rice, two β-carotene biosynthesis genes are inserted into the rice genome to produce enzymes that synthesise and accumulate β-carotene in the rice grain;;***

12. ***they are psy gene from the plant daffodil coding for phytoene synthase and crt1 gene from soil bacterium that codes a bacterial phytoene desaturase which produces the substrates for the subsequent steps to conversion to β carotene;;***

13. ***This allowed β carotene to be produced in the rice grain, improving the quality (nutritional content) of the rice. Golden rice consumed by people will then allow our bodies to produce Vitamin A without the consumption of additional supplements;;***

[Total: 20]

H

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CANDIDATE NAME

CLASS

BIOLOGY 8875/01

Paper 1 Multiple Choice

15 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and class on the Answer Sheet in the spaces provided unless this has been done for you.

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

Read the instructions on the Answer Sheet very carefully.

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

This document consists of **20** printed pages and **2** blank pages.

[Turn over

1 An actively growing cell is supplied with radioactive amino acids.

Which cell component would first show an increase in radioactivity?

A Golgi body

B mitochondrion

C nucleus

D rough endoplasmic reticulum

2 When mucus is secreted from a goblet cell in the trachea, these events take place.

1 addition of carbohydrate to protein

2 fusion of the vesicle with the plasma membrane

3 secretion of a glycoprotein

4 separation of a vesicle from the Golgi body

What is the sequence in which these events take place?

A 1 → 4 → 2 → 3

B 1 → 4 → 3 → 2

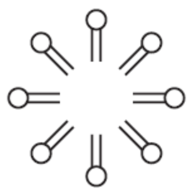
C 4 → 1 → 2 → 3

D 4 → 1 → 3 → 2

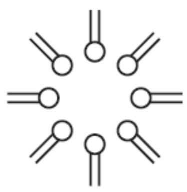
3 When a small quantity of phospholipid is added to a test tube of water and then shaken vigorously, an emulsion is formed by small droplets called liposomes.

Which diagram shows the arrangement of phospholipid molecules in a cross-section of a liposome? **ANSWER: C**

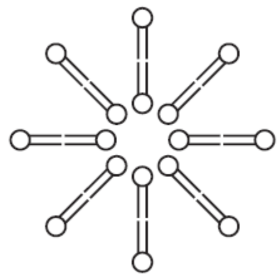
A



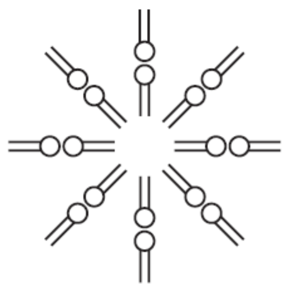
B



C

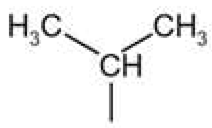


D

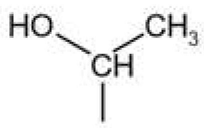


4 Threonylvaline is a dipeptide formed from the two amino acids, valine and threonine. A peptide bond forms between the amine group of valine and carboxyl group of threonine.

The side-chains (R groups) of the two amino acids are shown.



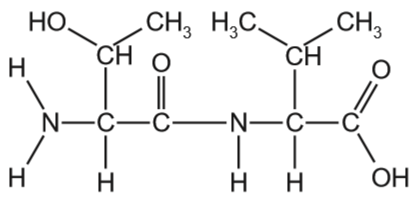
valine



threonine

Which molecular structure is threonylvaline? **ANSWER: A**

A



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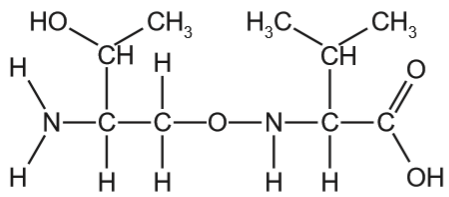

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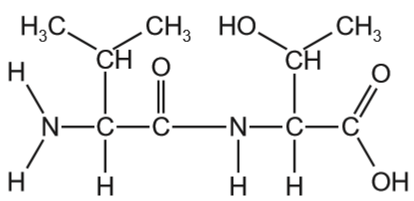
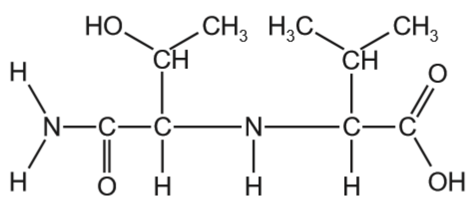


D



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5 Which set of statements correctly describes haemoglobin?

	1	2	3	4
A	four polypeptide chains, each containing a haem group	iron ions can associate with oxygen forming oxyhaemoglobin	in each chain, hydrophobic R groups of amino acids point towards the centre of the molecule	at 50% saturation, two oxygen molecules are transported by the molecule
B	polypeptide chains interact to produce a globular chain	each chain contains a haem group of amino acids surrounding an iron ion	consists of two identical alpha chains and two identical beta chains	each chain can transport an oxygen molecule
C	polypeptide chains interact to produce an almost spherical molecule	an iron ion is present within each haem group	quaternary structure has two alpha chains and two beta chains	each molecule can transport a total of four oxygen atoms
D	polypeptide chains produce a loose helical shape, which folds to form a spherical molecule	iron ions in the molecule can bind reversibly with oxygen	in each chain, hydrophobic R groups of amino acids surround the iron ion	each molecule can transport a total of eight oxygen atoms

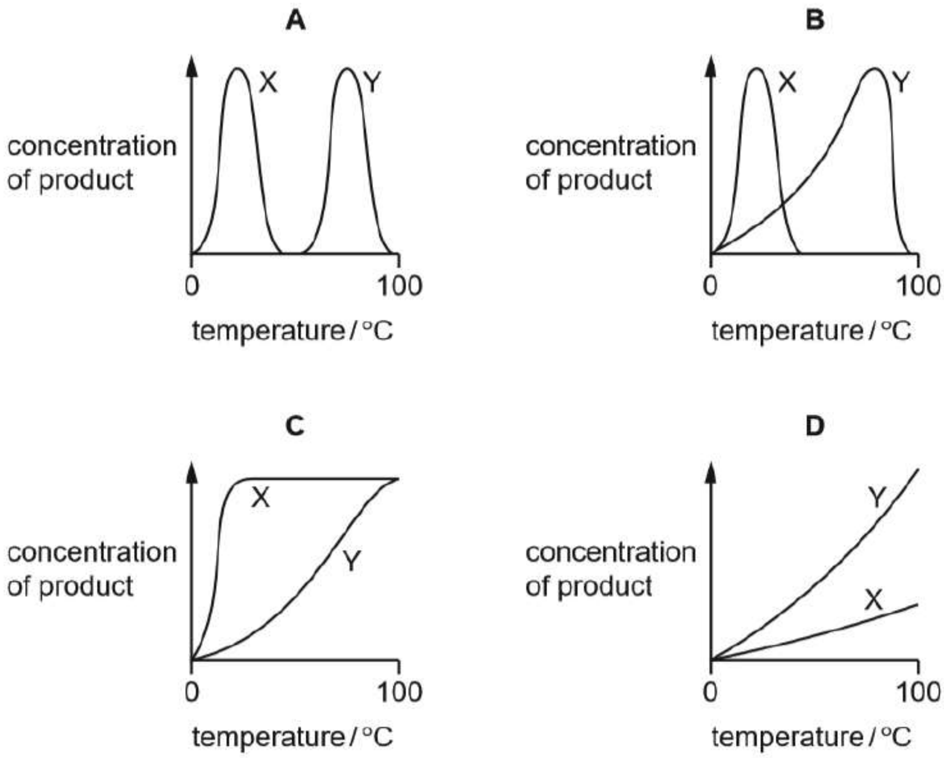
6 Two enzymes, X and Y, were used in an experiment.

Enzyme X was from bacteria that live in rivers and lakes at temperatures from 5°C to 20°C.

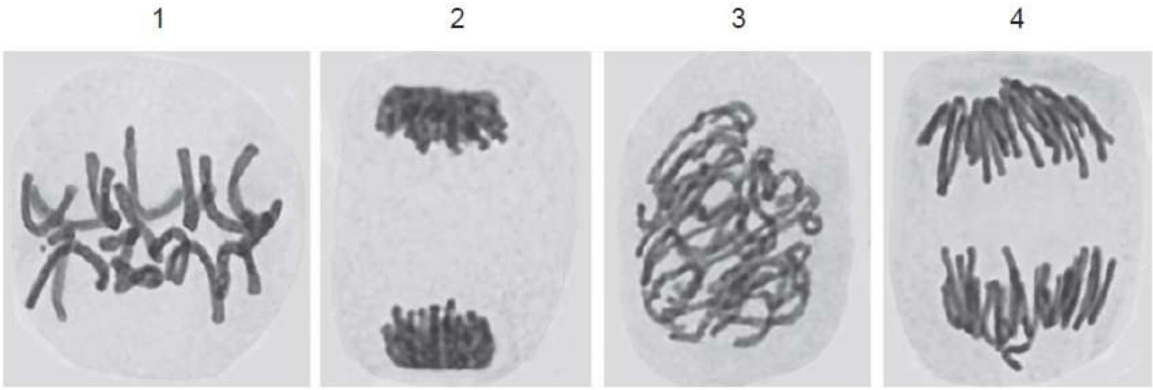
Enzyme Y was from bacteria that live in hot water springs at temperatures from 40°C to 85°C.

The experiment measured the concentration of product produced by each enzyme at temperatures between 0°C and 100°C after 5 minutes.

Which graph shows the results? **ANSWER: B**



7 The photomicrographs show cells in various stages of the cell cycle.



Which cells contain twice as many DNA molecules as a cell from the same organism after cytokinesis?

A 1, 2, 3 and 4

B 1, 2 and 4 only

C 1 and 3 only

D 2 and 4 only

8 Yeast cells without a *cdc25* gene cannot divide. This gene is active throughout the cell cycle, steadily building up the concentration of a protein, p80cdc25. This protein activates a kinase which regulates other proteins involved in cell division, but does not seem to affect other cell processes. When the p80cdc25 protein reaches a critical concentration, mitosis starts.

Which changes will be seen if p80cdc25 is produced at a faster rate than usual?

1 faster cell cycle

2 slower cell cycle

3 smaller cells

4 larger cells

A 1 and 3

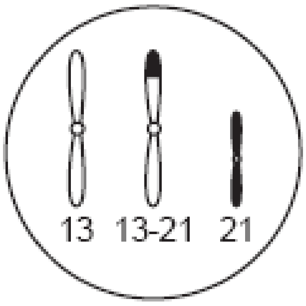
B 1 and 4

C 2 and 3

D 2 and 4

9 Down's syndrome can be caused by a trisomy of chromosome 21, but can also result from the translocation of chromosome 21 into 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

10 Which row represents the correct features of the nitrogenous base guanine?

	has a single ring structure	is a purine	joins its complementary base by three hydrogen bonds
A	✗	✓	✓
B	✓	✗	✓
C	✓	✓	✓
D	✗	✗	✓

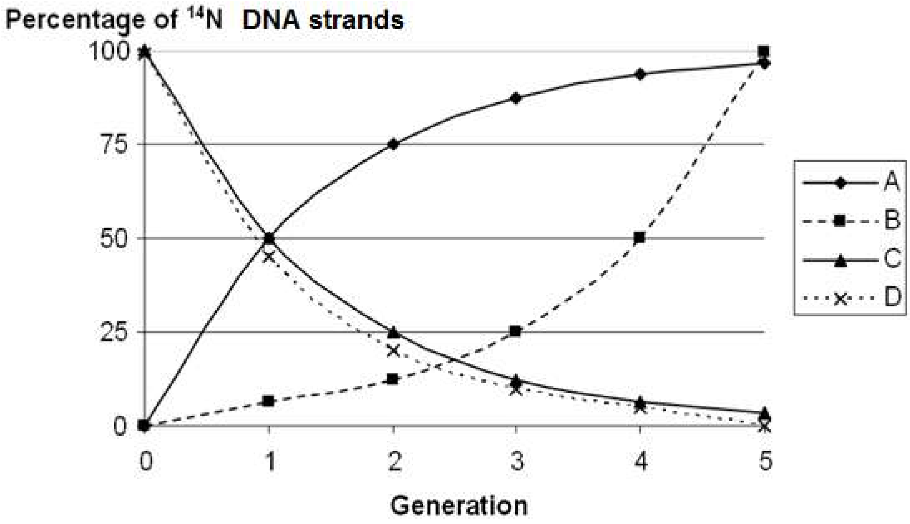
key

✓= true

✗ = false

11 Bacteria were cultured in a medium containing heavy nitrogen (^{15}N) until all DNA was labelled. These bacteria were then grown in a medium containing only normal nitrogen (^{14}N) for 5 generations. The percentage of ^{14}N DNA strands in each generation was estimated.

Which curve provides evidence that DNA replication is semi-conservative? **ANSWER: A**



12 An unidentified single-stranded molecule was described as having the following features:

- complementary base pairing along some of its length
- an area that can attach to a ribosome
- a site to which a specific amino acid attaches

What is the unidentified molecule?

A ribosomal RNA

B messenger RNA

C RNA polymerase

D transfer RNA

13 In order to synthesise a polypeptide, the DNA triplet code of the template (non-coding) strand of the DNA is transcribed to mRNA.

What correctly describes this process?

A mRNA is made from free bases complementary to those of the template strand of DNA.

B mRNA is made from free bases identical to those of the template strand of DNA.

C mRNA is made from free RNA nucleotides complementary to those of the template strand of DNA.

D mRNA is made from free RNA nucleotides identical to those of the template strand of DNA.

14 Some antibacterial drugs can affect the synthesis of proteins.

antimicrobial drug	rifampicin	streptomycin	tetracycline
mode of action	binds to RNA polymerase	genetic code misread during translation	prevents binding of tRNA to ribosome

Which is the correct set of immediate effects of these drugs?

antimicrobial drug	rifampicin	streptomycin	tetracycline
A	defective protein synthesised	mRNA does not bind to ribosome	amino acids not added to growing chain
B	mRNA not synthesised	defective protein synthesised	amino acids not added to growing chain
C	mRNA not synthesised	mRNA does not bind to ribosome	transcription prevented
D	transcription prevented	defective protein synthesised	mRNA does not bind to ribosome

15 The table shows the DNA triplet codes for some amino acids from the strand complementary to mRNA.

amino acid	DNA triplet codes
glycine	CCA, CCG, CCT, CCC
leucine	AAT, AAC, GAA, GAG, GAT, GAC
lysine	TTT, TTC
methionine	TAC
proline	GGA, GGG, GGT, GGC
threonine	TGA, TGG, TGT, TGC

The sequence of DNA triplets from the strand complementary to mRNA for part of a gene is shown.

… T A C T T T A A T G G C C C T G A G G G C T A C T G T …

Which mutated DNA sequence of this part of a gene would result in the same amino acid sequence as the original gene sequence?

A … T A C T T T A A T G G C C C T G A G G G T C C A T G T …

B … T A C T T C G A T G G C C C T G A G G G C T A C T G T …

C … T A C T T T A A T G G C C C G G A G T G A T A C T G T …

D … T A C T T T A A T G G C C C T G A G G G C T T C T G T …

16 The feather colour of a certain breed of chicken is controlled by codominant alleles. A cross between a homozygous black-feathered chicken and a homozygous white-feathered chicken produces all speckled chickens.

What phenotypic ratios would be expected from a cross between two speckled chickens?

A all speckled

B 1 black feathers : 1 white feathers

C speckled, black feathers and white feathers in equal numbers

D 1 black feathers : 2 speckled feathers : 1 white feathers

17 The presence of freckles is a characteristic controlled by a dominant gene. Two parents who are heterozygous for the characteristic have three children, all of whom have freckles.

Which statement is true if they have a fourth child?

A There is a 100% chance that their next child will have freckles.

B There is a 75% chance that their next child will have freckles.

C There is a 50% chance that their next child will have freckles.

D The next child will have no freckles as the ratio is 3 with freckles to 1 without freckles.

18 Isolated chloroplasts, suspended in buffer solution, are often used to study the light dependent stage of photosynthesis.

During this stage, electrons (e^-) are transferred by carriers and provide energy so that a proton (H^+) gradient can be formed. Protons diffuse through membrane proteins that are linked to synthase enzymes.

Three compounds that can be added to isolated chloroplasts are:

1 DCMU, which inactivates a carrier that accepts electrons from photosystem II

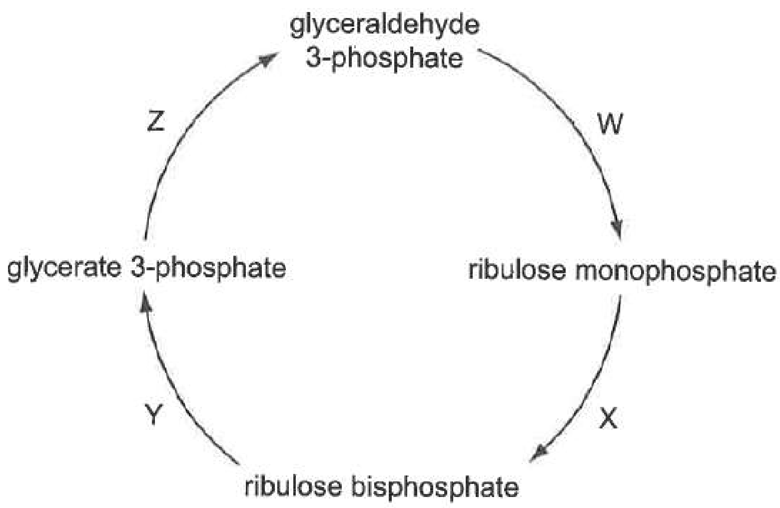
2 DCPIP, which can act as a final electron acceptor

3 ammonium hydroxide solution, which absorbs protons

Which compounds, when added separately to isolated chloroplasts, would allow the light dependent stage of photosynthesis to occur and which would inhibit it?

	allow	inhibit
A	1	2 and 3
B	1 and 3	2
C	2	1 and 3
D	2 and 3	1

19 The diagram shows the main stages in the Calvin cycle.

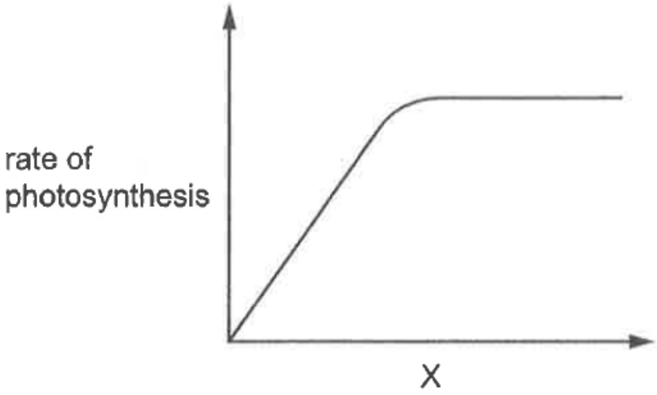


At which stages are ATP and reduced NADP used and carbon dioxide taken up?

	ATP used	reduced NADP used	carbon dioxide taken up
A	W and Z	X	Y
B	X	W and Y	Z
C	Y	X and Z	W
D	X and Z	Z	Y

20 The rate of photosynthesis in pondweed was measured when one variable was changed and all others were standardised.

The graph shows the rate of photosynthesis at different values of a variable, X.



Which variables could be represented by X?

1 carbon dioxide availability

2 light intensity

3 oxygen availability

4 temperature

5 leaf area exposed to direct light

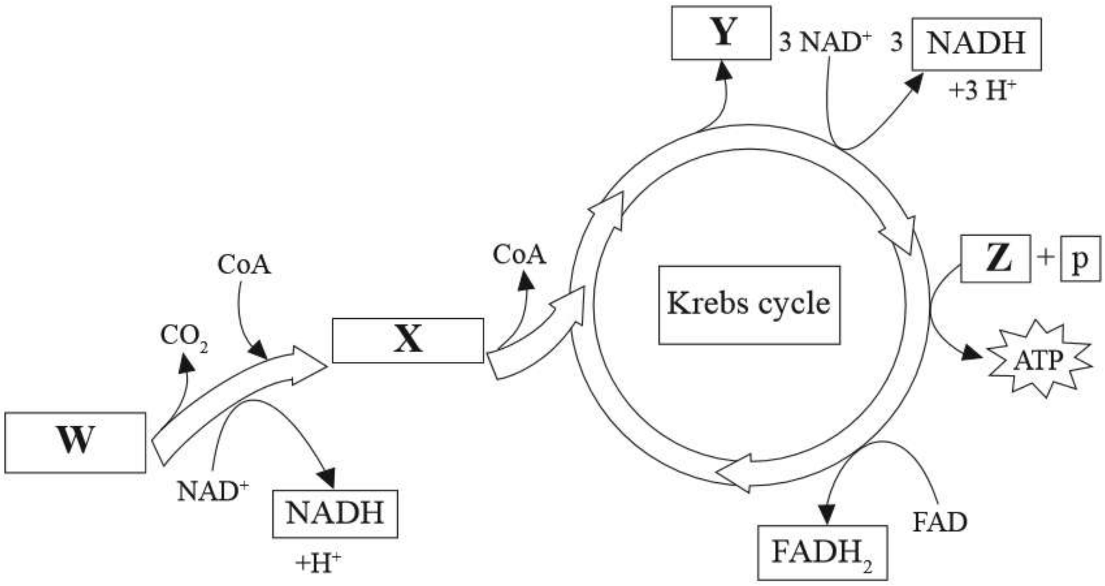
A 1, 2 and 5

B 1 and 2 only

C 2, 4 and 5

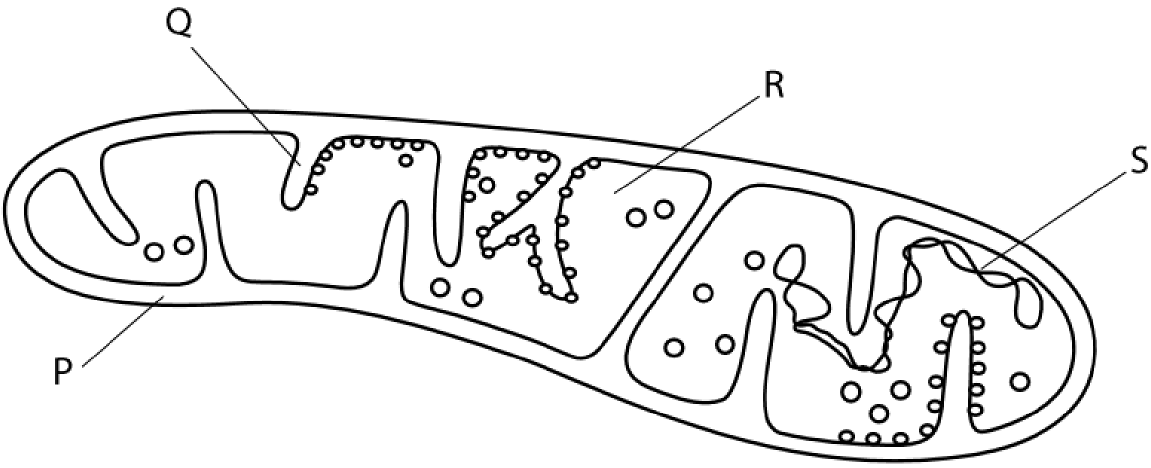
D 3 and 4

21 The diagram below shows the link reaction and stages of the Krebs cycle. Which molecules are represented by the letters W, X, Y and Z?



	W	X	Y	Z
A	acetyl CoA	carbon dioxide	ADP	pyruvate
B	pyruvate	acetyl CoA	carbon dioxide	ADP
C	ADP	carbon dioxide	acetyl CoA	pyruvate
D	acetyl CoA	pyruvate	carbon dioxide	ADP

22 Aerobic respiration is a series of reactions that occur in the cytoplasm and mitochondria of animal and plant cells. The diagram shows a mitochondrion.

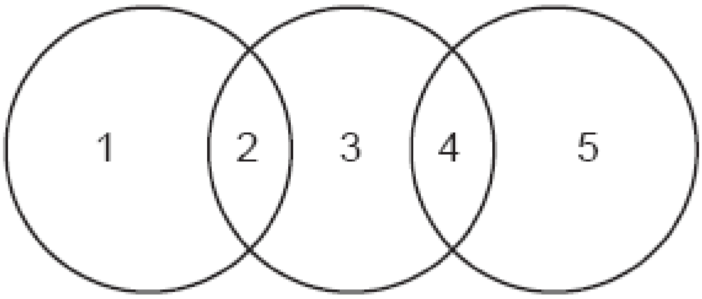


Which row shows where each process takes place in a mitochondrion?

	diffusion of hydrogen ions	production of reduced NAD
A	P	Q
B	Q	R
C	R	S
D	S	P

23 The diagram shows the relationship between different polysaccharides and the glycosidic bonds formed between the monomers.

Which row is correct?



	1	2	3	4	5
A	amylopectin	α-1,6	cellulose	β-1,4	glycogen
B	amylose	α-1,4	glycogen	β-1,4	amylopectin
C	cellulose	β-1,4	amylose	α-1,4	glycogen
D	glycogen	α-1,6	amylopectin	α-1,4	amylose

24 Which roles of the cell surface membrane are a result of the properties of the phospholipids?

1 to allow cytokinesis to occur in mitotic cell division

2 to allow entry and exit of oxygen and carbon dioxide

3 to allow the phagocytosis of a bacterium into a cell

A 1, 2 and 3

B 1 and 2 only

C 1 and 3 only

D 2 and 3 only

25 Which statements are acceptable parts of 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

B 2 and 3

C 3 and 4

D 4 only

26 Myxomatosis is a viral disease of rabbits. It spreads rapidly and most rabbits die within 14 days of being infected. Myxomatosis has been deliberately used to reduce the number of rabbits in countries where they are a significant crop pest.

The initial release of the virus caused populations of rabbits to fall by 90%. Resistance to myxomatosis increased in the 70 years following initial release, so at the present time up to 50% of infected rabbits are able to survive.

Which statement could explain the increasing frequency of resistance to myxomatosis in the years following release?

A During disease outbreaks there is greater food availability for the remaining rabbits, increasing the probability that infected rabbits will survive and breed.

B In populations with high incidences of myxomatosis, mutations leading to resistance are more likely to occur.

C Rabbits with genotypes that increase resistance to the disease are more likely to survive disease outbreaks and pass on their genes to the next generation.

D Since rabbits breed very rapidly, in between outbreaks of the disease the frequency of alleles for resistance to myxomatosis quickly increases.

27 Some comparisons of mRNA with DNA from a eukaryote are listed.

1 A body cell has two copies of DNA coding for a particular protein but it can have thousands of copies of mRNA coding for the same protein.

2 Each DNA molecule in human cells codes for hundreds of proteins, but each mRNA molecule codes for the translation of only one protein.

3 mRNA contains the base uracil, but DNA has thymine instead.

4 mRNA is single-stranded but DNA is double-stranded.

5 Unlike DNA, mRNA has no introns.

Which are reasons why mRNA is the preferred starting point for genetically engineering bacteria to produce human proteins?

A 1, 2 and 3

B 1, 2 and 5

C 2, 3 and 4

D 3, 4 and 5

28 Which uses of the information from the human genome project are generally considered to be unethical?

1 an insurance company only giving cheap rates to people with genetic predispositions to fewer diseases

2 genetic archaeologists identifying the earliest forms of genes to show evolutionary relationships

3 cytologists developing tests for only some defective genes

4 doctors only giving specific drugs to block the actions of faulty genes to carriers of those genes

5 genetic councillors giving specific lifestyle information only to people genetically predisposed to risks

6 parents choosing embryos for implantation only after ante-natal tests for acceptable genes

A 1 and 3

B 1 and 6

C 2 and 5

D 3 and 4

29 A gene for an insecticidal toxin was introduced into crop plants via genetic engineering. The toxin causes death to only a specific type of insect.

What is not likely to be affected by this genetic engineering?

A ratio of population size between different insect species within the region

B growth of other crop plants within the region

C use of insecticides in the area of crop growth

D the number of insects resistant to the toxin

30 Blood transfusion laboratories around the world are hoping to produce large numbers of red blood cells (RBCs) from unused human embryos produced during *in vitro* fertilisation procedures.

Embryonic stem cells are removed from an embryo and cultured in a growth medium that stimulates their differentiation into RBCs.

Which statement correctly describes this differentiation?

A Multipotent stem cells differentiate into pluripotent blood stem cells and then into RBCs.

B Pluripotent stem cells differentiate into multipotent blood stem cells and then into RBCs.

C Totipotent stem cells differentiate into multipotent blood stem cells and then into RBCs.

D Totipotent stem cells differentiate into pluripotent blood stem cells and then into RBCs.

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JURONG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE NAME

CLASS

BIOLOGY 8875/02

Paper 2 Structured Questions **25 August 2017**

Additional Materials: Answer Paper **2 hours**

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** the questions.

Section B
Answer **one** question.
Circle the question number of the question attempted.

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

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

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
5 / 6	
Total	

This document consists of **15** printed pages.

[Turn over

Section A

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

1 White blood cells such as dendritic cells synthesise intracellular enzymes.

Fig. 1.1 is a summary diagram of events that occur in a dendritic cell.

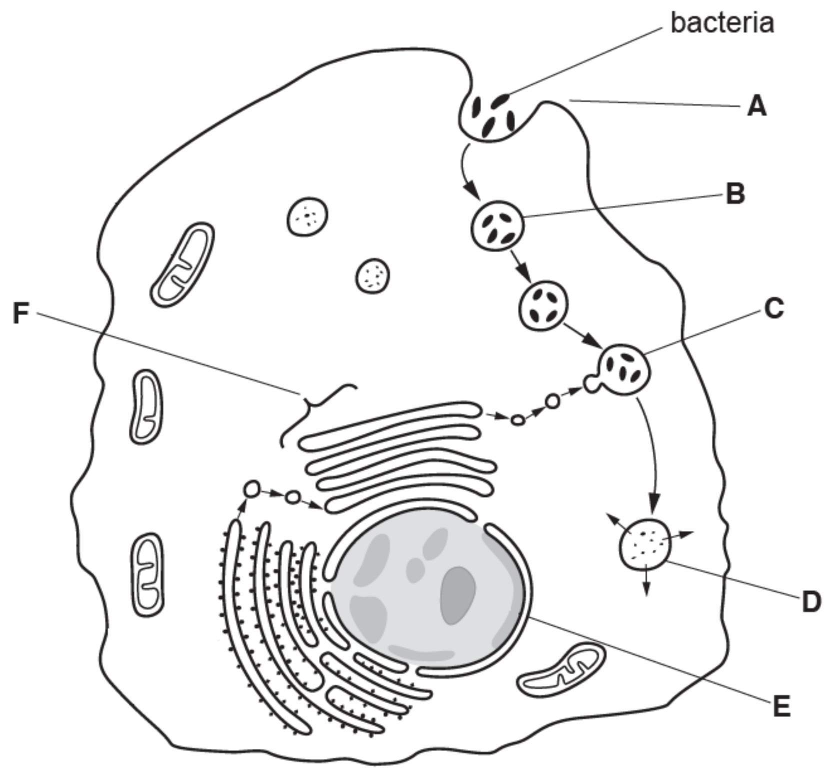


Fig. 1.1

(a) (i) Name the process at A. [1]

1. **phagocytosis / endocytosis;;**
R pinocytosis I engulfing

(ii) Name structures B, E and F. [3]

B: phagocytic / endocytic vacuole / phagosome;;
A vesicle
R incorrectly qualified vacuole or vesicle (e.g. large / secretory / Golgi / excretory)
(Ignore) food / pathogenic

E: (outer) nuclear envelope;;

F: Golgi body;;

(b) Describe what happens to the bacteria between C and D. [2]

1. **the bacteria are destroyed / digested / broken down / hydrolysed;;**
2. **(by lysosomes containing) hydrolytic enzymes, e.g. carbohydrase, lysozymes, proteases, nucleases, lipases *(any one)*;;**
3. **catalysed the breakage of glycosidic bond, peptide, ester, phosphodiester bond, ester bond in peptidoglycan, polysaccharide(s), polypeptides, nucleic acids, lipids;; *(bond broken must match substrate) (any one)***

(Ignore) fusion of lysosomes with phagosome and diffusion of products of digestion

(c) The gene coding for transcription factor in dendritic cells is known as *Batf3*. The transcription factor is essential for the development of dendritic cells.

(i) Explain what is meant by a *gene*. [1]

1. **a specific sequence of nucleotides in the DNA which codes for a polypeptide;;**

A protein for polypeptide / information to produce a polypeptide /codes for sequence of amino acids / primary structure (of a, polypeptide / protein)
R genetic code for a polypeptide

(ii) There are a number of known mutations for *Batf3*.

Outline how a mutation in *Batf3* can lead to the formation of an altered polypeptide where one amino acid is replaced by a different amino acid. [3]

1. **Results in changes in the sequence of DNA nucleotides in the gene;;**
2. **This includes base-pair substitution / replacement of one nucleotide base pair with another base pair in a gene;;**
3. **result in a change in the <u>codon</u> in the <u>mRNA</u>;;**
4. **new amino acid coded for may have different property due to different R groups and result in a change in polypeptide sequence /primary structure;;**

[Total: 10]

2 Fig. 2.1 shows some stages in mammalian respiration.

glucose

↓ **A**

hexose phosphate

↓ **B**

triose phosphate

↓ **C**

pyruvate

↓ **D**

carbon dioxide and water

Fig. 2.1

(a) Name the processes taking place during Stage D and state precisely where they occur. [3]

1. **Link reaction – mitochondrial matrix;;**
2. **Krebs cycle – mitochondrial matrix;;**
3. **Oxidative phosphorylation – inner mitochondrial membrane;;**

(b) Intermediates produced at the end of Stages B and C are important in the conversion of carbohydrates to lipids such as triglycerides. Some of the triose phosphate can be converted into glycerol-3-phosphate, while pyruvate can undergo further reactions to form intermediates required for the synthesis of fatty acids.

Describe the formation of triglycerides. [3]

1. **A triglyceride is formed by condensation reactions between 1 glycerol and 3 fatty acids;;**
2. **Each of glycerol's hydroxyl/–OH groups condenses with the carboxyl/–COOH group of a fatty acid;;**
3. **In each condensation reaction, one water molecule is removed, resulting in the formation of an ester bond/linkage;;**

(c) The first reaction in Stage A is catalysed by the enzyme hexokinase. It has been observed that hexokinase is bound to the outer mitochondrial membrane in muscle cells which undergo high rates of glycolysis.

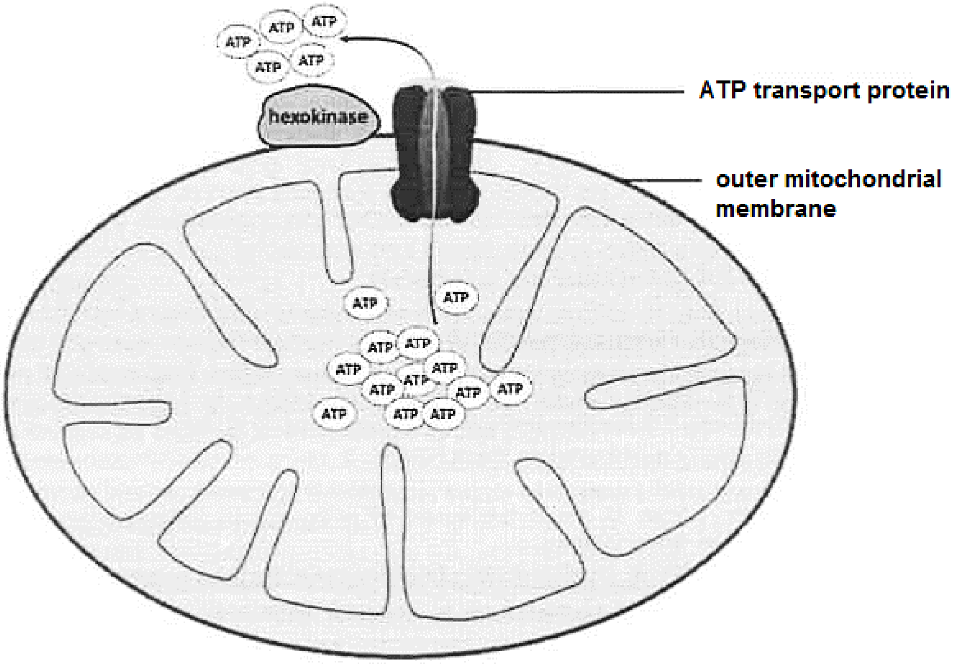


Fig. 2.2

With reference to the role of mitochondria and Fig. 2.2, suggest how the association of hexokinase with mitochondria can lead to high rates of glycolysis. [2]

1. **Mitochondria are the site of aerobic respiration to synthesise ATP;;**
2. **Due to the <u>close proximity</u> of hexokinase to the mitochondria *(mark for idea)*, <u>ATP produced</u> by the mitochondria <u>can easily be used</u> by hexokinase <u>to phosphorylate glucose</u>;; increasing the rate of glycolysis.**

(d) Fig. 2.3 shows an electron micrograph of a mitochondrion.

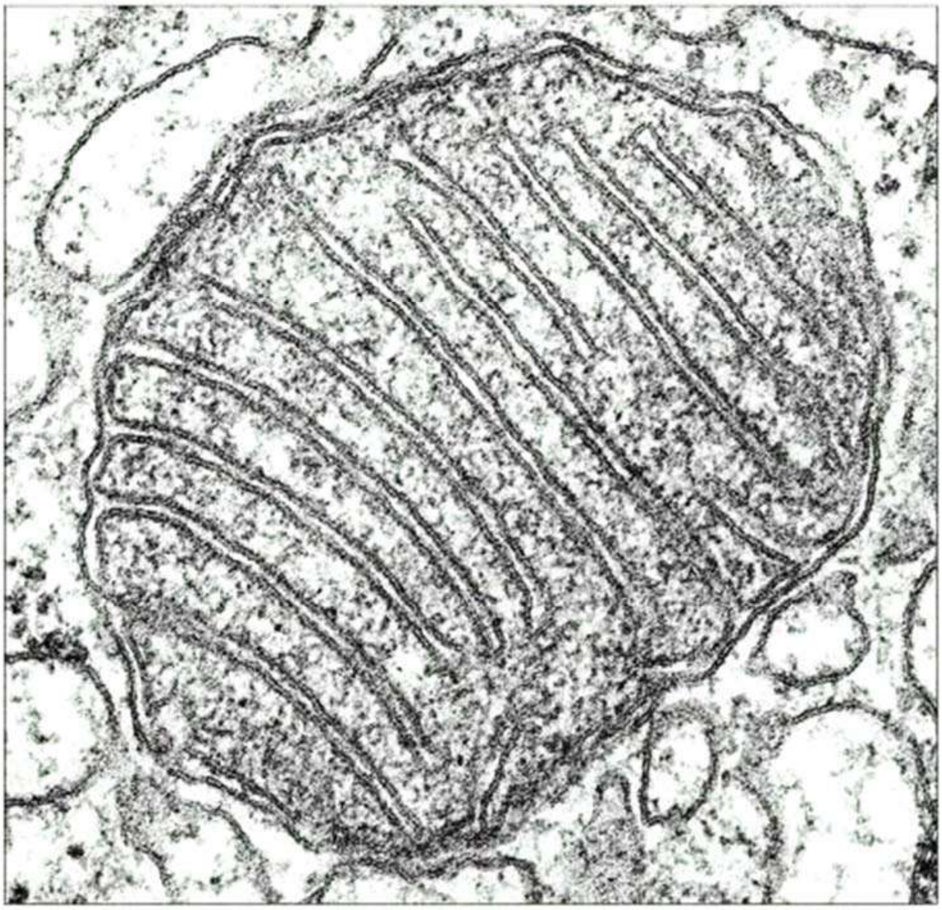


Fig. 2.3

With reference to features visible in Fig. 2.3, outline how the structure of the mitochondrion is adapted for its function. [1]

1. **The inner mitochondrial membrane is <u>highly folded</u>, providing <u>a large surface area</u> where stalked particles, enzymes and electron carriers of the electron transport chain (ETC) *(any 1 e.g.)* needed for <u>aerobic respiration</u> can be located;;**
2. **The mitochondrion is enclosed by <u>double membranes</u> separated by (an extremely narrow fluid-filled space) intermembrane <u>space</u>, allowing for <u>compartmentalisation</u> within the mitochondrion / specialised metabolic pathways to take place in different areas;;**

(e) Phosphatidylcholine (a phospholipid) is present in membranes such as those of the mitochondrion. The molecular structures of tristearin (a triglyceride) and phosphatidylcholine are shown in Fig. 2.4.

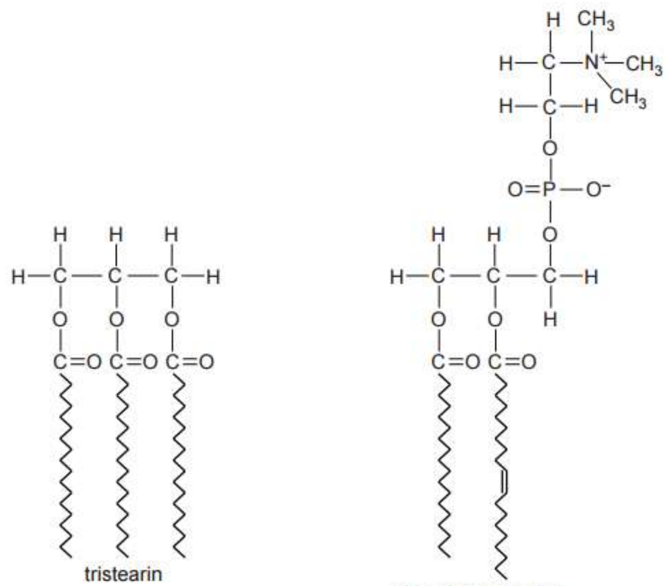


Fig. 2.4

State two structural differences between tristearin and phosphatidylcholine, other than in numbers of the different types of atoms. [2]

structural feature	triglyceride	phospholipid
phosphate (group) / contains phosphorus	×	✓
nitrogen	×	✓
charged / polar	×	✓
(number of) fatty acids	3	2
number of ester bonds	3	2
number of phosphate ester bonds	0	1
award one mark for any of the following comparisons		
number of double bonds (in hydrocarbon chain)	0	1
number of saturated fatty acids / ORA	3	1
presence of double bonds	×	✓
presence of unsaturated fatty acids	×	✓

These are alternatives – award one mark only

[Total: 11]

3 A type of pheasant occurs in a range of colours, especially when bred in captivity. It may, for example, have green or purple plumage as seen in Fig. 3.1.

Fig. 3.1

Sometimes when a green male is crossed with a green female all the offspring, male and female, are green. However, sometimes a green male crossed with a green female results in offspring in which the majority of the offspring are green, but in which some of the females are purple, as shown in Table 3.1.

Table 3.1

phenotype	number of offspring
green male	7
green female	3
purple female	4

Plumage colour in pheasants is sex-linked.

In birds, the sex chromosomes are referred to as W and Z, rather than Y and X as in mammals. The W chromosome has no genes that affect plumage colour. The heterogametic sex is the female, **not** the male. Thus the male has two Z chromosomes (ZZ) and the female has one W and one Z chromosome (WZ).

(a) Use a genetic diagram to explain the results in Table 3.1. [3]

Parental phenotypes:	**green male**	**x**	**green female**	
Parental genotypes:	$\mathbf{Z^GZ^g}$	**x**	$\mathbf{WZ^G}$	**;;**
Gametes	$\mathbf{Z^G}$ $\mathbf{Z^g}$		**W** $\mathbf{Z^G}$	**;;**

Punnett Square

	$\mathbf{Z^G}$	$\mathbf{Z^g}$
W	$\mathbf{WZ^G}$	$\mathbf{WZ^g}$
$\mathbf{Z^G}$	$\mathbf{Z^GZ^G}$	$\mathbf{Z^GZ^g}$

Offspring genotype :	$\mathbf{Z^GZ^G}$ $\mathbf{Z^GZ^g}$	**:**	$\mathbf{WZ^G}$	**:**	$\mathbf{WZ^g}$	**;**
Offspring phenotype :	**green male**	**:**	**green female**	**:**	**purple female**	**;**
Offspring phenotypic ratio:	**2**	**:**	**1**	**:**	**1**	

(b) Using the same symbols as in **(a)**, indicate the genotypes of the parents which could give rise to purple male offspring. [1]

1. $\mathbf{Z^GZ^g \times WZ^g}$ **;;**
OR
2. $\mathbf{Z^gZ^g \times WZ^g}$ **;;**

(c) Using the information provided, state which allele for plumage colour is dominant and explain your answer. [2]

1. *dominant allele –*
allele coding for green feather (**carried on the Z chromosome);;**

2. explanation –
Heterozygote male appeared green, thus showing the gene product of the allele coding for green feather masked the effect of the gene product expressed by the allele coding for purple feather;;

(d) Describe how you would determine the unknown genotype of a green male. [2]

1. **Carry out a test cross by breeding with a purple female;;**
2. **If all the offspring have green plumage then the male must be homozygous dominant;;**
   OR
3. **If some of the offspring have purple plumage then the male must be heterozygous;;**

[Total: 8]

4 Human growth hormone (hGH) is a peptide hormone that is important for human development. Recombinant hGH can be synthesised via genetic engineering with the use of plasmids.

(a) **(i)** State the type of organism that contains plasmids. [1]

1. **Bacterium/prokaryotes;;**

(ii) Describe one feature of plasmids that make them suitable to be used for genetic engineering. [2]

1. **contain an <u>origin of replication</u>;;**
2. **so that the vector and the inserted gene of interest can <u>replicate independently of the bacteria chromosome</u> to produce <u>multiple copies</u> within the host cell;;**
   OR
3. **contain <u>genetic/selectable markers</u>;;**
4. **e.g. antibiotic resistant genes that confer resistance of the host cell to antibiotics / lacZ gene coding for β-galactosidase which <u>enable selection</u>;;**
   OR
5. **possess <u>restriction sites</u>;;**
6. **which can be recognised, bound and cut by restriction enzymes for insertion of gene of interest;;**

The polymerase chain reaction (PCR) can be used to amplify the gene coding for hGH before genetic engineering is carried out.

(b) Describe what occurs during the first two stages in PCR.

(i) Stage 1 [2]

1. **Denaturation by heating to 95°C;; (A) 90-100°C**
2. **Hydrogen bonds between (complementary bases of) double-stranded DNA break, separating the double-stranded DNA into single-stranded DNA;;**

(ii) Stage 2 [2]

1. **Annealing of DNA primers by cooling to 65°C;; (A) 30-65°C**
2. **Primers base pair via complementary base pairing with (complementary sequences at the) <u>3' end</u> of the <u>single-stranded DNA</u>;;**

(c) Outline how a recombinant plasmid can be produced for genetic engineering after the gene coding for hGH was isolated from human cells and amplified using PCR. [3]

1. **<u>Same restriction enzyme</u> was used to recognise, bind and cut the gene coding for hGH and plasmid;;**
2. **to produce restriction fragments with <u>complementary sticky ends</u> that would <u>anneal/complementary base pair via hydrogen bond formation</u>;;**
3. **<u>DNA ligase</u> would then <u>seal the nicks</u> between fragments by formation of <u>phosphodiester bonds between adjacent nucleotides</u>, forming a <u>recombinant plasmid</u>;;**

(d) With the advancement in technology, plasmid-free bacteria cells have been constructed for the production of hGH with the gene coding for hGH inserted directly into the host chromosome instead of using plasmid.

Suggest how this new method is an improvement over the previous method. [1]

1. **No need for antibiotic selection / lower costs as no antibiotics needed/no need to remove the antibiotics used for selection;;**
2. **Less metabolic burden on host strain;;**
3. **Genes are more stable;;**

[Total: 11]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

4 Early ancestors of today's horses were browsers. Their teeth were adapted for eating woody shrubs and trees. In the early Miocene (23 million years ago), the first groups adapted for grazing emerged. Modern horses are grazers, with teeth adapted for grinding tougher, grassy materials.

The foot structure evolved from four separate toes to three, then to only one that touched the ground with two smaller side toes higher than the ground. In more modern horses, the two side bones are fused together. Modern horses are of much greater size than their ancestors.

(a) Describe the causes of variation in horses. [6]

Causes of variation

1. Gene mutations and chromosomal aberrations;;

OR

2. Gene mutations + one example e.g. base pair substitution / insertion / deletion;;

3. Chromosomal aberrations + one example e.g. duplication / translocation;;

4. Independent assortment and segregation of chromosomes in meiosis;;

OR

5. Independent assortment and segregation of homologous chromosomes during metaphase I and anaphase I, respectively;;

6. Independent assortment and segregation of chromatids during metaphase II and anaphase II, respectively;;

7. Crossing over between non-sister chromatids of homologous chromosomes during prophase I in meiosis I;;

8. Give new combination of alleles;;

9. Random fusion of gametes during sexual reproduction;;

(b) Explain how natural selection could lead to evolution of modern horses with distinct phenotypic differences. [6]

1. **Spontaneous mutation results in genetic variation in horses within a population;;**
2. **There were phenotypic variation / difference in characteristics in the populations in each habitat e.g. teeth / foot structure;;**
3. **The horses were exposed to different environments in each habitat and were subjected to different selection pressures;;**
4. **Examples of phenotypic variation e.g. teeth / foot structure OR different selection pressures e.g. type of foot and ground type / habitat;;**
5. **Since there was variation within the populations, individuals who are better adapted to the environment / with favourable characteristics will be at a selective advantage;;**
6. **These individuals will survive to maturity, reproduce and pass down their favourable alleles to their offspring;;**
7. **With each succeeding generation, the proportion of individuals having the favourable characteristics increases while the proportion of individuals lacking the characteristics decreases;;**
8. **Over time / successive generations, there is a change in allele frequency in the populations, leading to evolution and thus distinct phenotypic differences between the populations of horses;;**
9. **Diverse forms of horses have thus arisen by descent with modifications from ancestral species by accumulation of modifications as the population of horses adapt to the new environment;;**

(c) Explain, with examples, what is meant by anatomical and molecular homologies in horses. [8]

1. **Diverse forms of horses have thus arisen by descent with modifications from ancestral species by accumulation of modifications as the population of horses adapt to the new environment;;**
   OR
2. **Homologies show "descent with modification + Comparisons of homologies between species show how an ancestral homology in a population may have been modified in descendent species through natural selection and changes in allele frequency;;**
3. **Homology is similarity in characteristics resulting from common ancestry;;**
4. **and developed as a result of natural selection and changes in allele frequency;;**
5. **Homologies suggest common ancestry + Similarity in anatomical / molecular homology between species suggests that they are descended from a common ancestor which had a basic form of the structure / homologous genes;;**
6. **Species with common ancestors should display underlying similarities even in features that no longer match in function;;**
7. **Species with a higher level of similarity diverged from a common ancestor more recently (than species with a lower level of similarity) and thus are more closely related;;**

8. **Organisms with anatomical homologies have physical structures that are derived from a common ancestor;;**
9. **E.g. teeth, foot structure in horses, with different forms in different species;;**
10. **Organisms with molecular homology have similar DNA nucleotide / amino acid sequences of homologous genes that are derived from a common ancestor;;**
11. **Examples of homologous genes in different horses are the haemoglobin genes and the cytochrome oxidase genes which are derived from a common ancestor;;**

Pt 8-11 are required.

12. **Homologies provide the basis of comparison + Comparison of molecular homologies between species by comparing homologous DNA nucleotides/amino acid sequence OR Comparison of homologous traits/structures/teeth/foot structure between species (as they are derived from a common ancestor) shows the modification process from a basic ancestral form;;**

[Total: 20]

5 Invertase, a major enzyme present in plant tissues such as the developing roots of carrots, catalyses the hydrolysis of sucrose (a non-reducing sugar) to fructose and glucose (reducing sugars).

A scientist carried out an investigation into the effect of pH on the activity of invertase in carrots, by recording the time taken for the reducing sugars to change the colour of pink potassium manganite (VII) solution to a colourless end point. From the results obtained, the scientist concluded that the optimum pH of invertase was pH 5.0.

After additional analyses, the scientist also found that the invertase is:

- made up of several subunits
- synthesised with a signal peptide required for entry into the rough endoplasmic reticulum and thus into the secretory pathway
- glycosylated and bound to the cell wall

(a) Describe how invertase can be synthesised from mRNA. [8]

<u>Amino acid activation</u> [max 1m]

1. **A specific amino acid is joined to the 3’ end of a tRNA, forming an amino acyl-tRNA, reaction catalysed by a specific aminoacyl-tRNA synthetase;;**
2. **The amino acid that the tRNA attaches to is determined by the specific anticodon of the tRNA (which is complementary to the mRNA codon);;**

<u>Initiation</u>

3. **A small ribosomal subunit recognises and binds to the 5’ end of the mRNA and travels along the mRNA until it reaches the first AUG codon that serves as the start codon;;**
4. **An initiator tRNA carrying the amino acid methionine (Met), with anticodon UAC, binds to the start codon AUG on the mRNA (via complementary base pairing);;**
5. **The union of mRNA, initiator tRNA and a small ribosomal subunit is followed by the attachment of large ribosomal subunit, completing a translation initiation complex;;**
6. **Initiation factors and GTP are required to bring all these components together;;**
7. **At the completion of the initiation process, the initiator tRNA fits into the P site of the large ribosomal subunit and the vacant A site is ready for the next aminoacyl tRNA;;**

Elongation

8. The anticodon of the next incoming aminoacyl-tRNA, carrying its specific amino acid, undergoes complementary base pairing and forms hydrogen bonds with the mRNA codon in the A site of the ribosome;;
9. A peptide bond is formed between the amino end of the amino acid in the A site and the carboxyl end of the growing chain in the P site, catalysed by peptidyl transferase;;
10. After the peptide bond has been formed, the ribosome translocates one codon downstream along the mRNA in a 5' to 3' direction;;
11. This moves the tRNA, carrying the growing polypeptide in the A site, to the P site and the tRNA in the P site now moves to the E site and leaves the ribosome and A site is free to receive the next aminoacyl-tRNA;;

Termination

12. Elongation continues until a stop codon, UAA, UAG or UGA reaches the A site of the ribosome;;
13. A protein release factor recognises and binds to the stop codon on the mRNA, causes the addition of a water molecule to the polypeptide chain;;
14. This reaction hydrolyses the completed polypeptide from the tRNA that is in the P site, freeing the polypeptide from the ribosome;;
15. remainder of translational complex then comes apart / are disassembled;;

(pt 3-15: must have at least 1 pt from each stage of translation for full credit)

Extra points

16. (Each) polypeptide chain/subunit may undergo folding into a specific shape due to formation of hydrophobic interactions, disulfide bonds, ionic bonds and hydrogen bonds between (R groups of) amino acids;;
17. and aggregate with other polypeptide chains/subunits to form a functional protein, invertase;;

(b) Outline structural features and roles of the rough endoplasmic reticulum. [4]

<u>Structure of rER</u>

1. **consists of a <u>network of sheets</u> (called cisternae);;**
2. **<u>ribosomes are present / bound / attached</u> to the membrane of the rough ER;;**

<u>Roles of rER</u>

3. **<u>Site of protein/invertase synthesis</u> – (the polypeptides of) invertase are synthesised by <u>ribosomes</u> attached to the rough ER;;**

4. **<u>Biochemical/Chemical modification</u> – the polypeptides/invertase is transported through the pore in the ER membrane into the ER lumen, where <u>carbohydrate chains are added</u> to them – glycosylation;;**

5. **Intracellular transport – the rough ER forms part of the intracellular transport system which <u>transports</u> the synthesised/modified (polypeptides of) <u>invertase to other compartments</u> within the cell <u>by transport vesicles budding off from the ER membrane</u>;;**

(c) Describe the investigation carried out by the scientist to examine the effect of pH on the activity of invertase in carrots. [8]

<u>Variables</u>

1. **The independent variable of the experiment would be pH;;**
2. **The dependent variable would be the rate of reaction, measured by the <u>time taken for the reducing sugars to change the colour of pink potassium manganite (VII) solution to a colourless end point</u>;;**

<u>Variables to be kept constant</u> [max 2m]

3. **Volume and concentration of invertase**
   ***Carrot discs/cubes of identical sizes were cut from a single carrot and 5 discs/slices were added to a boiling tube*;;**
   OR
   ***Invertase is obtained by blending a single carrot to obtain a homogenous liquid carrot solution to ensure that the concentration of invertase is constant throughout the solution. 5 cm^3 of invertase solution was placed in the boiling tube*;;**

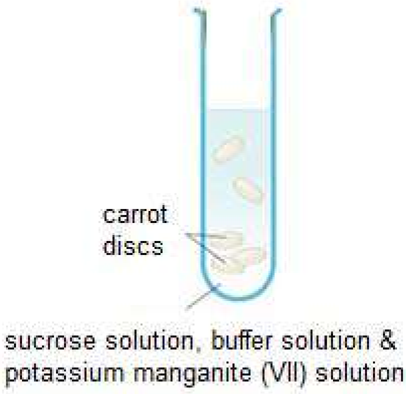
4. **Volume and concentration of sucrose solution**
   ***Equal volumes of sucrose solution (of a fixed concentration) to be placed in the boiling tube, e.g. 5 cm^3 of (10.0%) sucrose solution was placed in the boiling tube*;;**

5. **Temperature – enzyme activity is affected by temperature**
   Temperature of experiment must be kept constant at 35^{o}C by placing boiling tubes in a thermostatically controlled water bath;;
   OR
   ***The experiment was carried out at room temperature of 26ºC, which is assumed to remain constant throughout the experiment*;;**

(pt 3-5: award 1m for stating 2 variables to keep constant; 1m for describing how variables are to be kept constant)

Procedure

6. Set up the apparatus as shown (fully labelled diagram);;



OR

7. Add 5 carrot discs/cubes containing invertase / Add (5 cm^3 of) invertase solution to the boiling tube containing (5 cm^3 of) sucrose solution, (5 cm^3 of) potassium manganite (VII) solution and (5 cm^3 of) pH 3.0 buffer solution;;
8. The buffer solution helps to keep the pH constant at pH 3.0;;

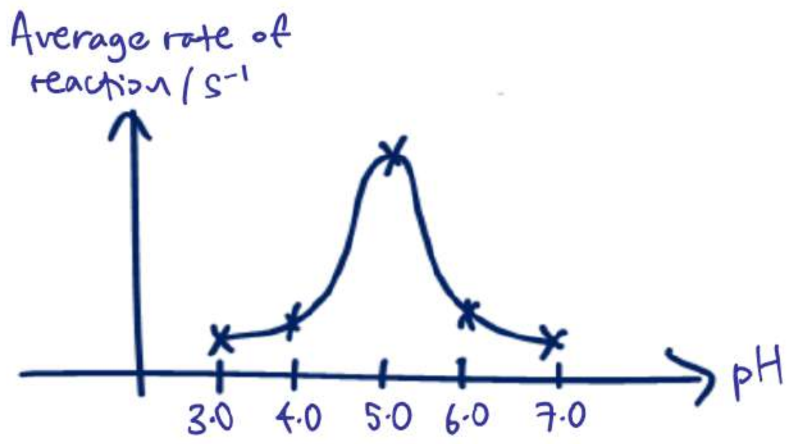
9. Using a stopwatch, start timing and measure the time taken for the reducing sugars to change the colour of pink potassium manganite (VII) solution to a colourless end point;;
10. Repeat twice to get a total of 3 readings;;
11. Repeat steps 6 to 10 using different buffers at pH 4.0, pH 5.0, pH 6.0 and pH 7.0;;
12. Calculate the average rate of reaction (1 / average time taken for the reducing sugars to change the colour of pink potassium manganite (VII) solution to a colourless end point) and record these data in a table;;

13. Table of results

pH	Time taken for the reducing sugars to change the colour of pink potassium manganite (VII) solution to a colourless end point / s				Average rate of reaction / s^{-1}
	Reading 1	Reading 2	Reading 3	Average Reading	
3.0					
4.0					
5.0					
6.0					
7.0					

Graph

14. Plot a graph of average rate of reaction against pH using the data in the table;;



Safety issues

15. As the buffers used are corrosive, wear gloves / protective goggles when handling the buffer solutions to prevent contact with skin / eyes;;

16. As the scalpel is sharp / glassware is fragile, handle them carefully / place them away from the main work area after use;;

[Total: 20]

H	JURONG JUNIOR COLLEGE JC 2 PRELIMINARY EXAMINATIONS Higher 1

CANDIDATE NAME	
CLASS	

BIOLOGY 8875/02

Paper 2 Structured Questions **25 August 2017**

Additional Materials: Answer Paper **2 hours**

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** the questions.

Section B
Answer **one** question.
Circle the question number of the question attempted.

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

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

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
5 / 6	
Total	

This document consists of **15** printed pages and **3** blank pages.

[Turn over

Section A

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

1 White blood cells such as dendritic cells synthesise intracellular enzymes.

Fig. 1.1 is a summary diagram of events that occur in a dendritic cell.

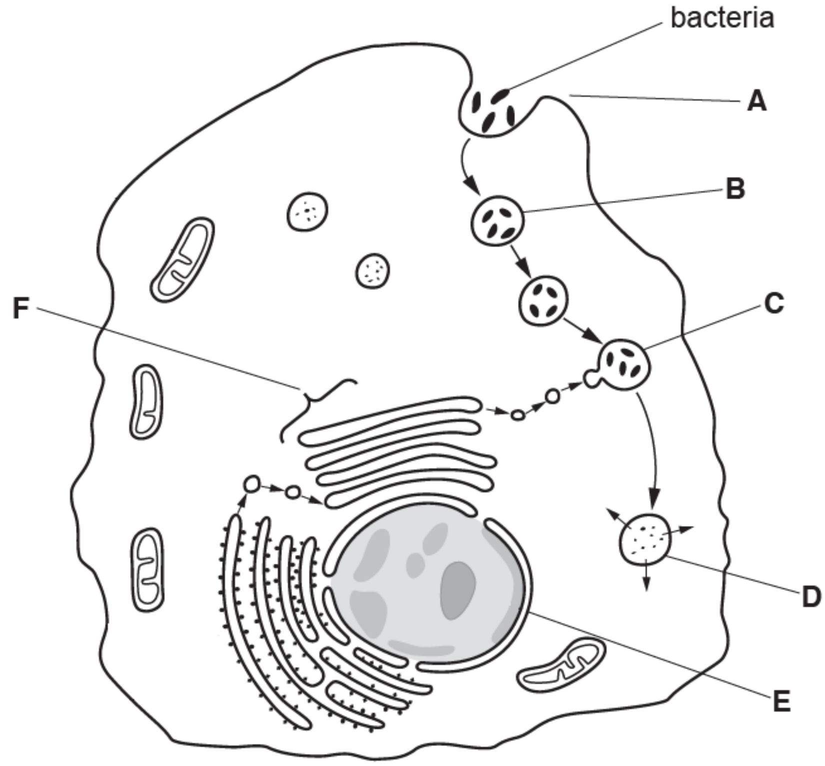


Fig. 1.1

(a) (i) Name the process at A. [1]

____

(ii) Name structures B, E and F. [3]

B ____

E ____

F ____

(b) Describe what happens to the bacteria between C and D. [2]

(c) The gene coding for transcription factor in dendritic cells is known as *Batf3*. The transcription factor is essential for the development of dendritic cells.

(i) Explain what is meant by a *gene*. [1]

(ii) There are a number of known mutations for *Batf3*.

Outline how a mutation in *Batf3* can lead to the formation of an altered polypeptide where one amino acid is replaced by a different amino acid. [3]

[Total: 10]

2 Fig. 2.1 shows some stages in mammalian respiration.

glucose

$\downarrow$ **A**

hexose phosphate

$\downarrow$ **B**

triose phosphate

$\downarrow$ **C**

pyruvate

$\downarrow$ **D**

carbon dioxide and water

Fig. 2.1

(a) Name the processes taking place during Stage D and state precisely where they occur. [3]

___

___

___

(b) Intermediates produced at the end of Stages B and C are important in the conversion of carbohydrates to lipids such as triglycerides. Some of the triose phosphate can be converted into glycerol-3-phosphate, while pyruvate can undergo further reactions to form intermediates required for the synthesis of fatty acids.

Describe the formation of triglycerides. [3]

(c) The first reaction in Stage A is catalysed by the enzyme hexokinase. It has been observed that hexokinase is bound to the outer mitochondrial membrane in muscle cells which undergo high rates of glycolysis.

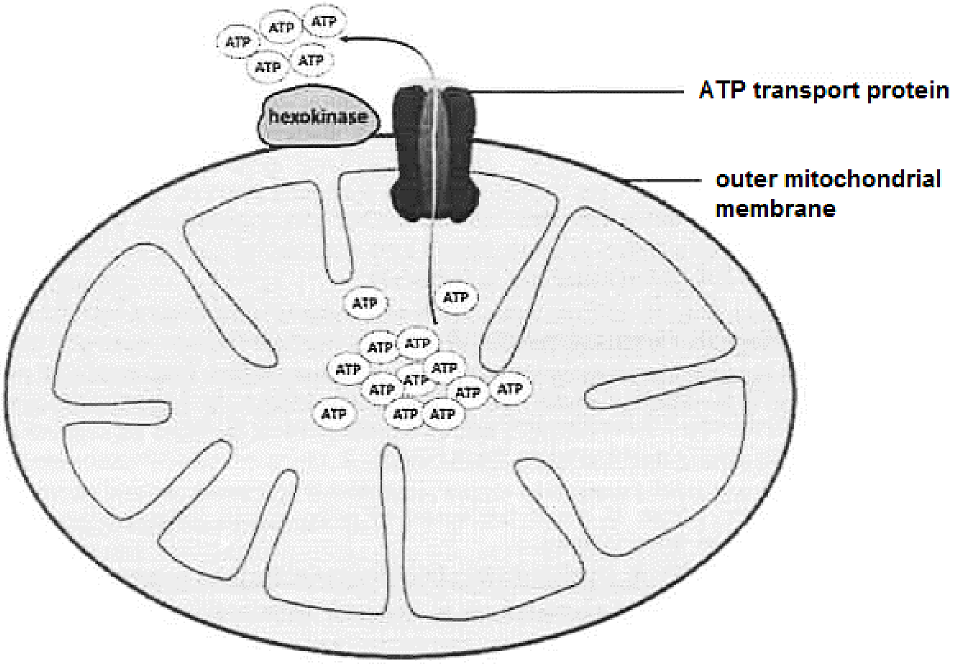


Fig. 2.2

With reference to the role of mitochondria and Fig. 2.2, suggest how the association of hexokinase with mitochondria can lead to high rates of glycolysis. [2]

(d) Fig. 2.3 shows an electron micrograph of a mitochondrion.

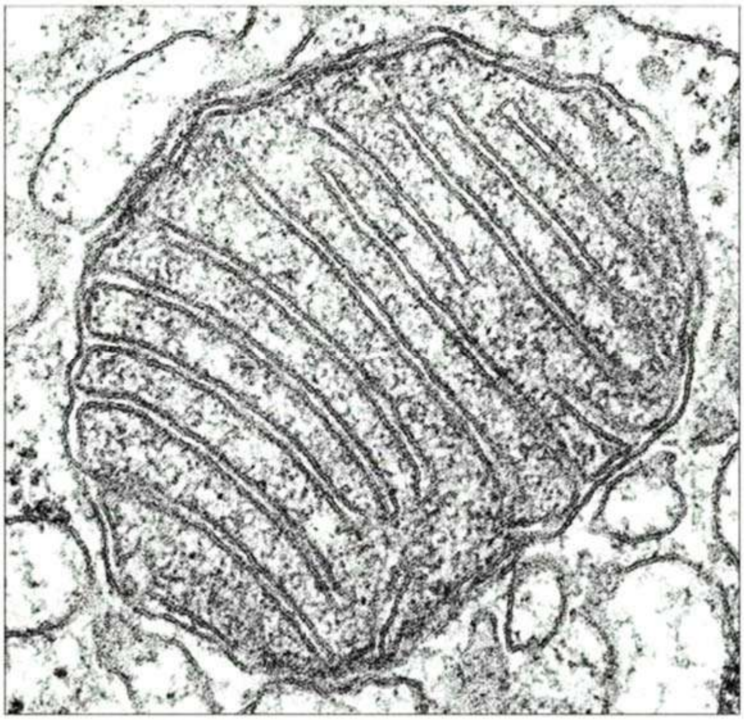


Fig. 2.3

With reference to features visible in Fig. 2.3, outline how the structure of the mitochondrion is adapted for its function. [1]

(e) Phosphatidylcholine (a phospholipid) is present in membranes such as those of the mitochondrion. The molecular structures of tristearin (a triglyceride) and phosphatidylcholine are shown in Fig. 2.4.

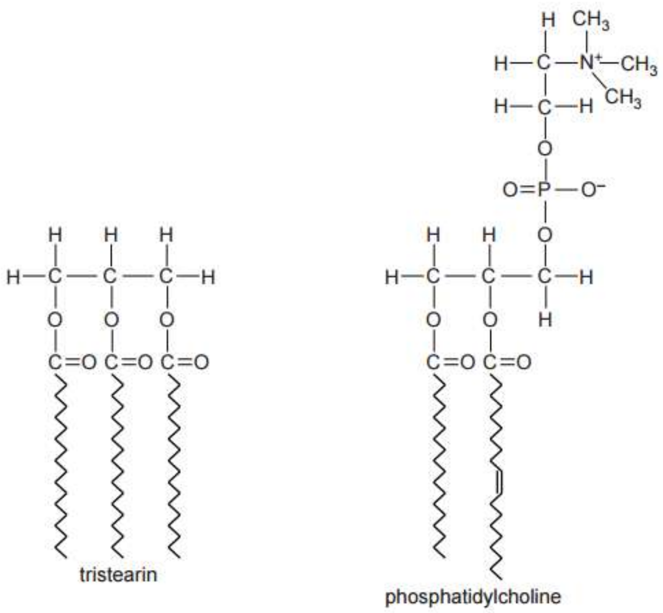


Fig. 2.4

State two structural differences between tristearin and phosphatidylcholine, other than in numbers of the different types of atoms. [2]

____

____

____

____

[Total: 11]

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3 A type of pheasant occurs in a range of colours, especially when bred in captivity. It may, for example, have green or purple plumage as seen in Fig. 3.1.

Fig. 3.1

Sometimes when a green male is crossed with a green female all the offspring, male and female, are green. However, sometimes a green male crossed with a green female results in offspring in which the majority of the offspring are green, but in which some of the females are purple, as shown in Table 3.1.

Table 3.1

phenotype	number of offspring
green male	7
green female	3
purple female	4

Plumage colour in pheasants is sex-linked.

In birds, the sex chromosomes are referred to as W and Z, rather than Y and X as in mammals. The W chromosome has no genes that affect plumage colour. The heterogametic sex is the female, **not** the male. Thus the male has two Z chromosomes (ZZ) and the female has one W and one Z chromosome (WZ).

(a) Use a genetic diagram to explain the results in Table 3.1. [3]

(b) Using the same symbols as in **(a)**, indicate the genotypes of the parents which could give rise to purple male offspring. [1]

(c) Using the information provided, state which allele for plumage colour is dominant and explain your answer. [2]

(d) Describe how you would determine the unknown genotype of a green male. [2]

[Total: 8]

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4 Human growth hormone (hGH) is a peptide hormone that is important for human development. Recombinant hGH can be synthesised via genetic engineering with the use of plasmids.

(a) **(i)** State the type of organism that contains plasmids. [1]

(ii) Describe one feature of plasmids that make them suitable to be used for genetic engineering. [2]

The polymerase chain reaction (PCR) can be used to amplify the gene coding for hGH before genetic engineering is carried out.

(b) Describe what occurs during the first two stages in PCR.

(i) Stage 1 [2]

(ii) Stage 2 [2]

(c) Outline how a recombinant plasmid can be produced for genetic engineering after the gene coding for hGH was isolated from human cells and amplified using PCR. [3]

(d) With the advancement in technology, plasmid-free bacteria cells have been constructed for the production of hGH with the gene coding for hGH inserted directly into the host chromosome instead of using plasmid.

Suggest how this new method is an improvement over the previous method. [1]

[Total: 11]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

4 Early ancestors of today's horses were browsers. Their teeth were adapted for eating woody shrubs and trees. In the early Miocene (23 million years ago), the first groups adapted for grazing emerged. Modern horses are grazers, with teeth adapted for grinding tougher, grassy materials.

The foot structure evolved from four separate toes to three, then to only one that touched the ground with two smaller side toes higher than the ground. In more modern horses, the two side bones are fused together. Modern horses are of much greater size than their ancestors.

(a) Describe the causes of variation in horses. [6]

(b) Explain how natural selection could lead to evolution of modern horses with distinct phenotypic differences. [6]

(c) Explain, with examples, what is meant by anatomical and molecular homologies in horses. [8]

[Total: 20]

5 Invertase, a major enzyme present in plant tissues such as the developing roots of carrots, catalyses the hydrolysis of sucrose (a non-reducing sugar) to fructose and glucose (reducing sugars).

A scientist carried out an investigation into the effect of pH on the activity of invertase in carrots, by recording the time taken for the reducing sugars to change the colour of pink potassium manganite (VII) solution to a colourless end point. From the results obtained, the scientist concluded that the optimum pH of invertase was pH 5.0.

After additional analyses, the scientist also found that the invertase is:

- made up of several subunits
- synthesised with a signal peptide required for entry into the rough endoplasmic reticulum and thus into the secretory pathway
- glycosylated and bound to the cell wall

(a) Describe how invertase can be synthesised from mRNA. [8]

(b) Outline structural features and roles of the rough endoplasmic reticulum. [4]

(c) Describe the investigation carried out by the scientist to examine the effect of pH on the activity of invertase in carrots. [8]

[Total: 20]

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MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 1

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | | | | |

INDEX NUMBER | | |

H1 BIOLOGY

8875/01

Paper 1 Multiple Choice

21 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

Write in soft pencils.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name, civics group and index number on the Multiple Choice Answer Sheet 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 Multiple Choice Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

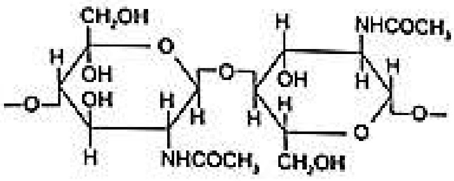
You may keep this booklet after the examination.

This paper consists of **16** printed pages.

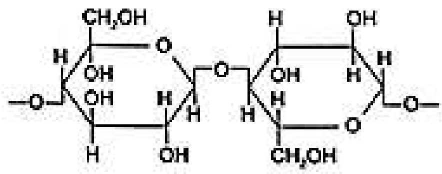
[Turn over]

QUESTION 1

The diagrams show short sections of some common polysaccharides and modified polysaccharides.



1



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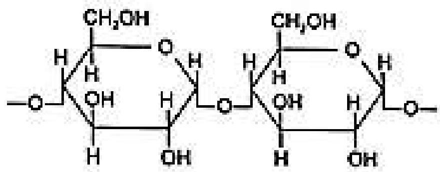

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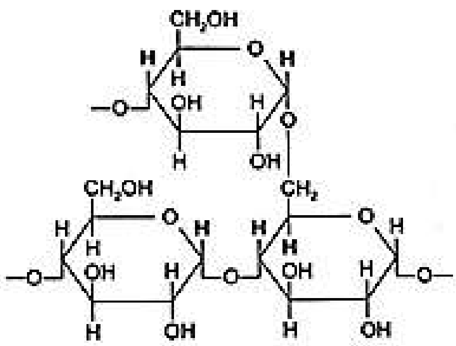

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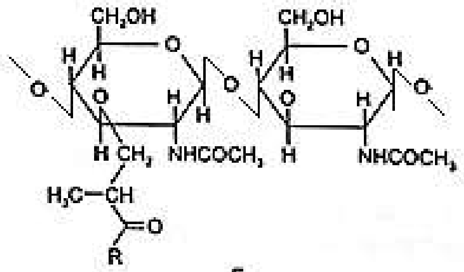


5

The polysaccharides can be described as below.

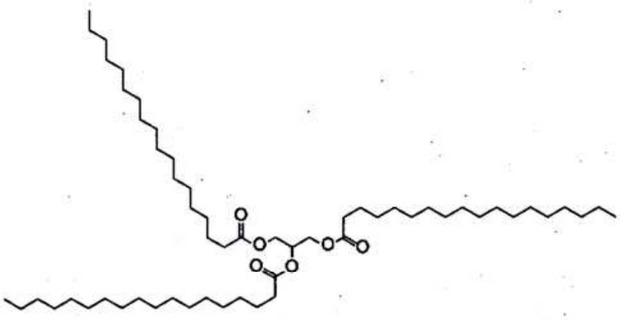
- Polysaccharide **F** is composed of β-glucose monomers with 1,4 glycosidic bonds
- Polysaccharide **G** is composed of α-glucose monomers with 1,4 and 1,6 glycosidic bonds
- Polysaccharide **H** is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β-1,4 glycosidic bonds.
- Polysaccharide **J** is composed of α-glucose monomers with 1,4 glycosidic bonds
- Polysaccharide **K** is composed of N-acetylglucosamine monomers with β-1,4 glycosidic bonds

Which shows the correct pairings of polysaccharide descriptions and diagrams?

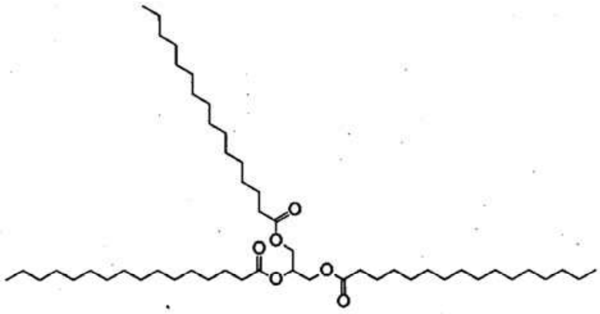
	Polysaccharide				
	F	**G**	**H**	**J**	**K**
A.	2	4	5	3	1
B.	2	5	4	1	3
C.	3	4	1	2	5
D.	3	5	4	1	2

QUESTION 2

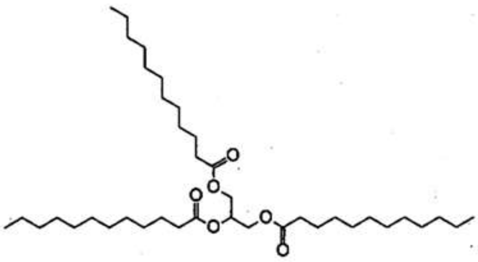
The formulae and melting points of five triglycerides are shown in the diagram. Each triglyceride contains three identical fatty acids.



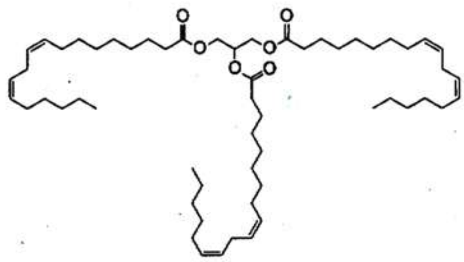
tristearin 72 °C



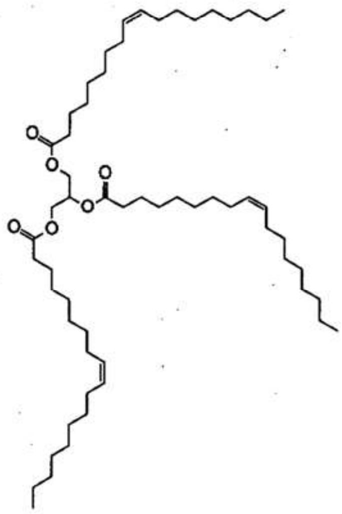
tripalmitin 65.5 °C



trilaurin 46 °C



trilinolein –13 °C



triolein –4 °C

Which two structural features of the molecules make the melting point higher?

	number of double bonds	length of fatty acid chains
A.	fewer	longer
B.	fewer	shorter
C.	more	longer
D.	more	shorter

QUESTION 3
Four students, **A, B, C** and **D**, were given the same sequence of amino acids removed from a collagen molecule. Each student was asked to analyse the sequence and to explain how their analysis could be linked to a feature of collagen

Which student's statement shows a correct feature of collagen linked to a correct analysis of the amino acid sequence?

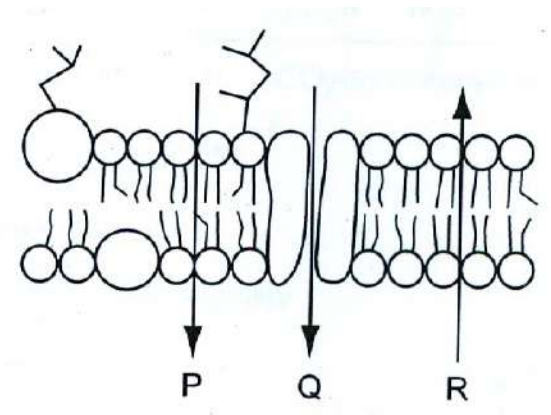
A. Collagen has polypeptides arranged parallel to each other and the sequence contains a large variety of amino acids with different sized R-groups.

B. Collagen has polypeptides that are arranged very closely together and the sequence has every third amino acid as glycine.

C. Collagen has three polypeptides that can fold into a globular structure and the sequence contains cysteine and amino acids with hydrophobic R groups.

D. Collagen is an insoluble molecule and the sequence contains a large proportion of amino acids with hydrophilic R-groups.

QUESTION 4
The diagram shows the cell surface membrane of an actively respiring cell in a tissue that has been placed in a solution of glucose with a lower water potential than that of the tissue cells.



What correctly describe the movements of molecules across the cell surface membrane shown by arrows **P**, **Q** and **R**?

	P	**Q**	**R**
A.	diffusion of glucose	diffusion of oxygen	diffusion of water
B.	diffusion of oxygen	diffusion of water	diffusion of glucose
C.	diffusion of water	active transport of glucose	diffusion of oxygen
D.	diffusion of oxygen	Facilitated diffusion of glucose	diffusion of water

QUESTION 5
What could be a possible explanation for the ability of lysosomes to withstand self-digestion?

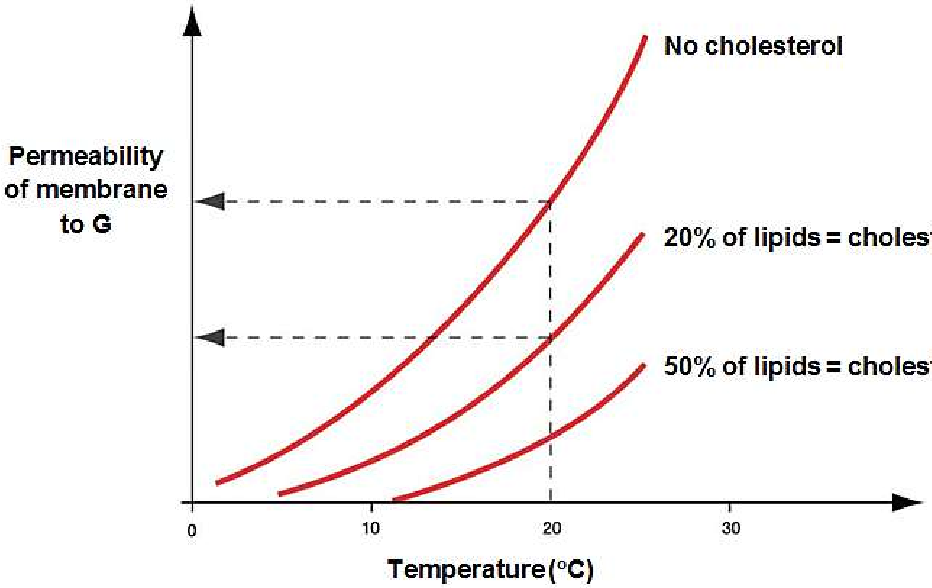
A. Lysosomes contain inactive hydrolytic enzymes.

B. Lysosome membrane has numerous modified proteins with carbohydrate side-chains.

C. Lysosomes do not contain lipases which are the enzymes capable of digesting the lipid membrane.

D. Hydrolases in the lysosomes are inhibited by the acidic internal environment of the lysosomes.

QUESTION 6
The graph below shows the permeability of three different membranes to chemical **G** at different temperatures. These three membranes differ in the amount of cholesterol present in the phospholipid bilayers.



Which of the following is a possible explanation for the observed data?

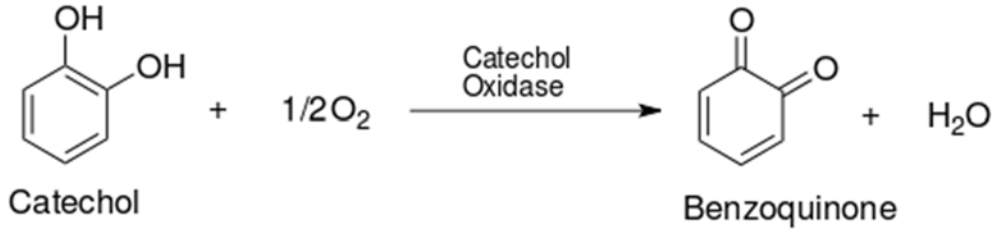
A. Increase in temperature increases the permeability of the membrane to **G** as cholesterol increases the fluidity of the phospholipids.

B. At 20°C, an increase in the proportion of cholesterol in the membrane increases the permeability of membrane to **G** as both cholesterol and **G** are non-polar.

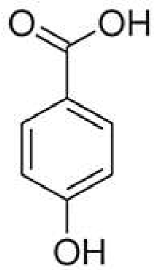
C. Increase in the proportion of cholesterol decreases the permeability of the membrane to **G** as cholesterol decreases the fluidity of the phospholipids.

D. With an increase in the proportion of cholesterol in the membrane, a lower temperature is required to achieve the same level of permeability for **G** as **G** will gain a higher kinetic energy to penetrate the membrane.

QUESTION 7
Catechol is oxidised to benzoquinone, as shown in the equation, resulting in darkening of peeled fruits.



Catechol oxidase is an enzyme which is inhibited by parahydroxybenzoic acid (PHBA). When PHBA binds to catechol oxidase, it does not change the shape of the enzyme. The structure of PHBA is shown below.



PHBA

Which of the following statements are **not** correct?

1. PHBA acts as a competitive inhibitor because its structure is similar to the active site of catechol oxidase.
2. PHBA acts as a non-competitive inhibitor because it does not change the shape of the active site of catechol oxidase.
3. In the presence of PHBA, the same Vmax can be attained at higher catechol concentration.
4. PHBA prevents the formation of enzyme-substrate complex between catechol oxidase, catechol and O_2.

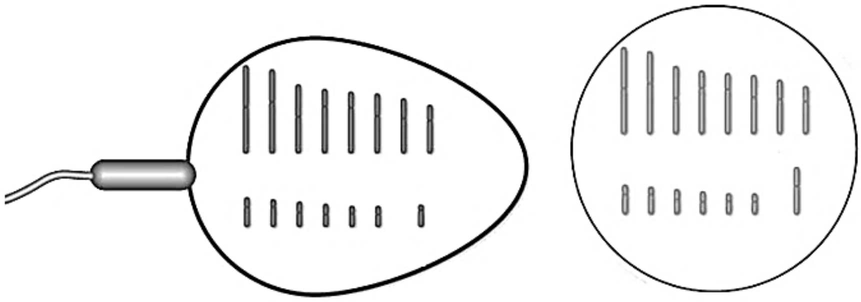
A. 1 and 2 only

B. 3 and 4 only

C. 1, 2 and 3 only

D. All of the above

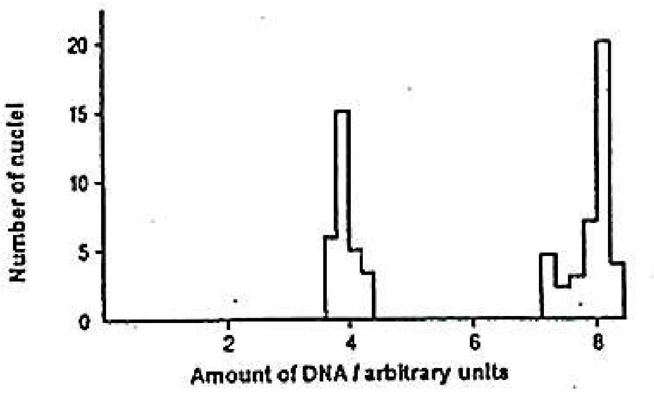
QUESTION 8
The diagram below shows the egg cell and sperm cell formed by one mammal species, as well as the number of chromosomes they contain.



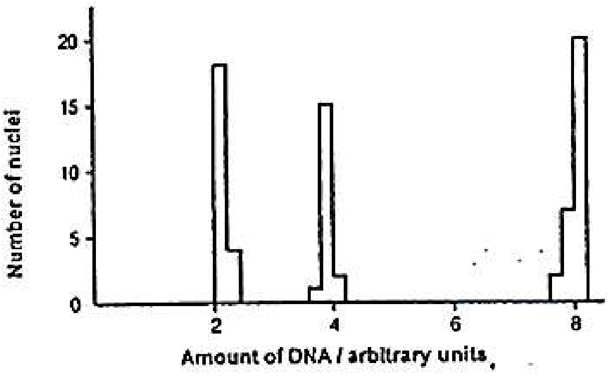
How many DNA molecules would be found in a germ cell (cell that gives rise to gametes) from this organism at prophase II of meiosis II?

A. 15 **B.** 30 **C.** 60 **D.** 120

QUESTION 9
The graphs below show the amount of DNA in the nuclei of cells taken from two different parts of a mammalian testis undergoing different nuclear division processes.



Graph 1



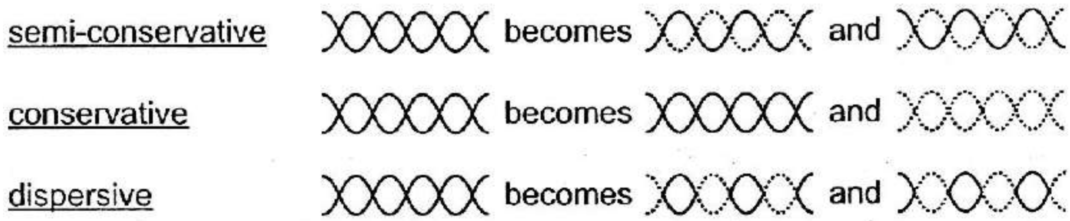
Graph 2

Which correctly describes one **unique** event taking place in the cells from graph **1** and graph **2** respectively?

	Graph 1	Graph 2
A.	Duplication of DNA	Separation of homologous chromosomes
B.	Separation of identical sister chromatids	Separation of non-identical sister chromatids
C.	Separation of non-identical sister chromatids	Formation of gametes
D.	Breaking and rejoining of homologous regions of chromosomes	Separation of homologous chromosomes

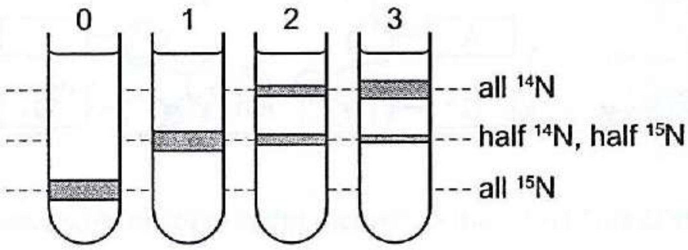
QUESTION 10
Meselson and Stahl found that in dividing cells, DNA is copied by semi-conservative replication. At the time of their discovery it was thought that DNA might be copied in one of three ways.

In the diagram, the original DNA strands are shown by solid lines and the copy strands by dotted lines.

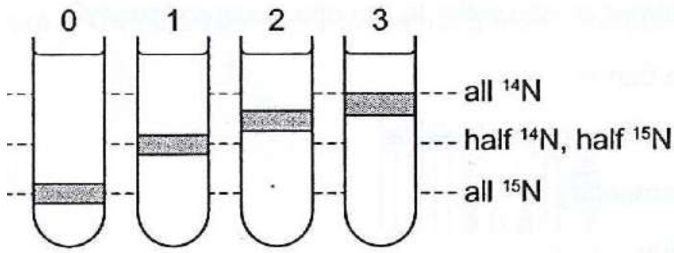


Which set of results would have proved that the DNA replication was **conservative**?

A.



B.



key

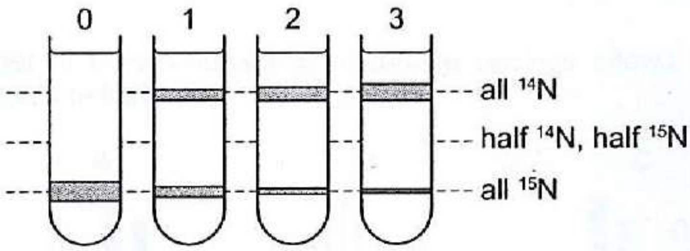
0 = original culture in ^{15}N

1 = first generation in ^{14}N

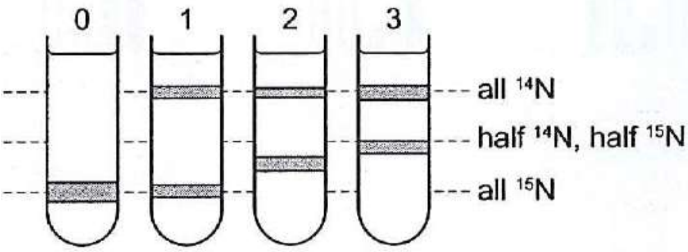
2 = second generation in ^{14}N

3 = third generation in ^{14}N

C.



D.



QUESTION 11
Which statements about the genetic code are correct?

1. The genetic code has redundancy and is degenerate.
2. There is only one codon for the amino acid methionine.
3. Codons act as 'stop' and 'start' signals during transcription and translation.
4. Prokaryotes generally use the same genetic code as eukaryotes.
5. Stop codons are UAA, UGG and UGA.
6. mRNA codons have the same nucleotide sequence as DNA triplets on template strand.

A. 1, 2 and 4 **B.** 1, 3 and 5 **C.** 2, 4 and 6 **D.** 3, 5 and 6

QUESTION 12
In three different possible genetic dictionaries, the genetic code for the amino acid cysteine is given as:

I **ACA** or **ACG**
II **TGT** or **TGC**
III **UGU** or **UGC**

The explanation for this may be:

1. Some genetic dictionaries show mRNA codons, others show DNA triplets.
2. The genetic code can be read in either the 3' or 5' direction along the DNA.
3. Some genetic dictionaries show the triplet code on the DNA strand complementary to the mRNA code, others show the triplet code on the other DNA strand.
4. The genetic code is a degenerate triplet code.

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

QUESTION 13
Fabry's Disease is a disease that results from a mutation that occurs in the *α-galactosidase A* gene.

The sequence of part of the normal and mutated alleles for *α-galactosidase A* gene is shown below.

Normal allele

Codon	37	38	39	40	41	42	43	44	45
mRNA	CCU	UGG	ACC	CAG	AGG	UUC	UAA	GGC	GGA

Mutated allele

Codon	37	38	39	40	41	42	43	44	45
mRNA	CCU	UGG	ACC	CCG	CAG	AGG	UUC	UAA	GGC

Using the information of the normal and mutated alleles above, it is reasonable to conclude that

A. A frame shift mutation has occurred.

B. A duplication has occurred.

C. An insertion of an amino acid has occurred in the mRNA.

D. The polypeptide that is translated from the mutated allele will be longer.

QUESTION 14
Which statement concerning polypeptide synthesis is correct?

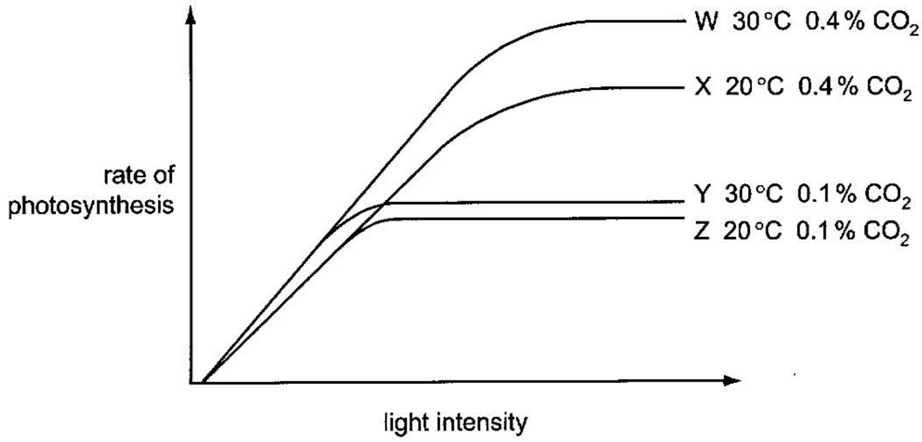
A. A particular cell type will transcribe all the genes present in one set of chromosomes but will only process particular pre-mRNA transcripts to enable polypeptide synthesis.

B. Different cell types will transcribe different sets of genes to produce different pre-mRNA transcripts and synthesise different polypeptides.

C. The same pre-mRNA transcripts are synthesised by all cell types but different introns are removed from the transcripts before translation to synthesise polypeptides.

D. The same set of genes will be transcribed by different cell types but different RNA transcripts in each cell type proceed to translation to synthesise different polypeptides.

QUESTION 15
The diagram shows the results of an investigation into the effect of changing light intensity on the rate of photosynthesis at two different carbon dioxide concentrations and two different temperatures.



Which factor is limiting the rate of photosynthesis shown in curve X at high light intensities and which curve supports this?

A. carbon dioxide, curve Y as a decrease in carbon dioxide concentration decreases rate

B. carbon dioxide, curve Z as rate becomes constant at lower light intensities

C. temperature, curve W as an increase in temperature increases rate

D. temperature, curve Z as rate becomes constant at lower light intensities

QUESTION 16
Which of the following is correct?

A. Cellular respiration uses ATP to produce energy for activities and reactions in the cell.

B. Cellular respiration oxidises ATP for activities and reactions in the cell.

C. Cellular respiration produces ATP for activities and reactions in the cell.

D. Cellular respiration hydrolyses ATP for activities and reactions in the cell.

QUESTION 17
Rotene, oligomycin and DNP are metabolic poisons which affect cellular respiration. The effects of rotene, oligomycin and DNP on aerobic respiration are summarised in the following table.

Metabolic Poisons	Effect of metabolic poison on cells		
	ability to use glucose	ability to use oxygen and amount used	ATP yield
rotene	yes	No	decreases
oligomycin	yes	Yes – same amount used	decreases
DNP	yes	Yes – increase amount used	decreases

Which of the following correctly identifies the specific functions of these metabolic poisons?

	rotene	oligomycin	DNP
A.	Increases inner membrane permeability	inhibits ATP synthase	Inhibits electron transport
B.	inhibits ATP synthase	Inhibits electron transport	Increases inner membrane permeability
C.	Inhibits electron transport	inhibits ATP synthase	Increases inner membrane permeability
D.	Inhibits electron transport	Increases inner membrane permeability	Inhibits ATP synthase

QUESTION 18
A child with Down syndrome has the genotype P^1 P^2 P^3 for a polymorphism on chromosome 21 that has four different alleles — allele P^1, allele P^2, allele P^3, allele P^4. The child's mother has the genotype P^1 P^2 and the father has the genotype P^3 P^4.

In which parent did chromosomes fail to separate, and did this event occur in the first or second meiotic division?

A. Mother; Meiosis I

B. Mother; Meiosis II

C. Father; Meiosis I

D. Father; Meiosis II

QUESTION 19
Achondroplastic dwarfism is an autosomal dominant disorder and red-green colour blindness is an X-linked recessive disorder.

An achondroplastic male dwarf with normal vision marries a colour-blind woman of normal height. The man's father is 1.7 meters tall while both the woman's parents are of average height.

What is the probability that their son will be colour-blind and of normal height?

A. 0.25 **B.** 0.5 **C.** 0.75 **D.** 1.0

QUESTION 20

A genetic cross performed on the fruit fly, *Drosophila melanogaster*, involved two independently-assorting (unlinked) genes.

gene	alleles
eye shape	bar (narrow) round
wing shape	Normal vestigial (reduced)

The F2 generation was observed to show the expected 9:3:3:1 phenotypic ratio, with the majority of the F2 offspring possessing bar eyes and normal wings.

Two different individuals with bar eyes and normal wings were removed from the F2 group each subjected to a test cross. The ratios of the resulting phenotypes are shown below.

test cross x individual P = 1 bar eye, normal wing **:** 1 bar eye, vestigial wing

test cross x individual Q = 1 bar eye, normal wing **:** 1 round eye, normal wing

What is the expected phenotypic ratio for the offspring of a cross between individual P and individual Q?

A. all bar eye, normal wing

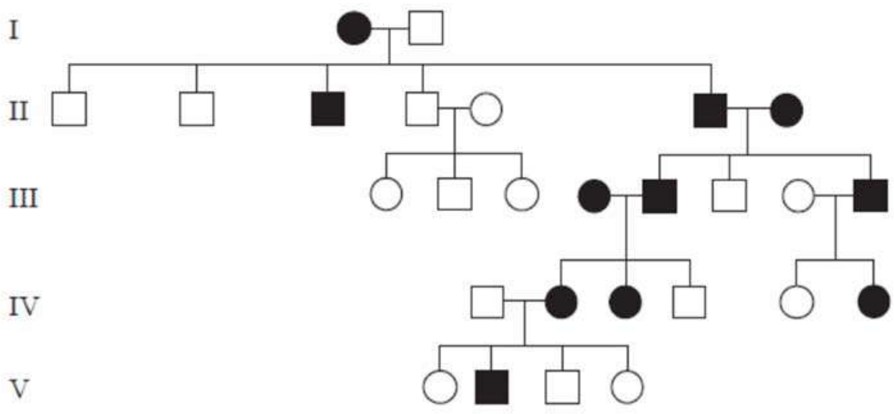
B. 1 bar eye, normal wing **:** 1 bar eye, vestigial wing

C. 3 bar eye, normal wing **:** 1 bar eye, vestigial wing

D. 3 bar eye, normal wing **:** 1 round eye, normal wing

QUESTION 21

The pedigree chart below shows the inheritance of a genetic disease in a family.



What is the nature of the allele that causes this disease?

A. autosomal dominant

B. sex-linked dominant

C. autosomal recessive

D. sex-linked recessive

QUESTION 22
Which statement concerning chrysanthemum plants, of the genus *Dendranthema,* is a valid example of how the environment may affect the phenotype?

A. Anthocyanins and anthoxanthins are vacuolar pigments, whereas xanthophylls and carotenes are pigments found in membrane-bound oragnelles known as plasmids. These, together with molecules known as co-pigments, are responsible for the variation observed in petal colur in *Dendranthema.*

B. Identical genetic crosses performed between varieties of *Dandrathema* result in a greater proportion of offspring plants with plastids exhibiting a yellow colour when grown in a field and a greater proportion of offspring plants with colourless plastids when grown in a glasshouse.

C. The seeds of a cross between *Dendranthema weyrichii* and *Dendranthema grandiflora* produce plants that are far more frost-tolerant and exhibit an exhibit an extended flowering season compared with both parents.

D. The seeds of a cross between *Dendrathema weyrichii* (height varying between 12.5 – 15.0cm) and *Dendranthema grandiflora* (height varying between 8.0 – 25.0 cm) produce plants, when grown in natural day length, of a height varying between 55.0 – 71.0 cm.

QUESTION 23
The diagram shows part of the aligned DNA sequences for the same gene in six species of aquatic animals.

Fin whale	TAAACCCCAATAGTCACAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Humpback whale	TAAACCCTAATAGTCACAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Sperm whale	TAAACCCAGGTAGTCATAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Beaked whale	TAAACCTAAATAGTCTCAAAACAAGACTATTCGCCAGAGTACTACTAGCAAT
Dolphin	TAAACTTAAATAATCCCAAAACAAGATTATTCGCCAGAGTACTATCGGCAAC
Porpoise	TAAACCTAAATAGTCCTAAAACAAGACTATTCGCCAGAGTACTATCGGCAAC

Which is a correct assumption when using this information as evidence for evolutionary relationships?

A. Differences and similarities in DNA sequences reflect evolutionary relationships.

B. DNA sequences in different genes from the same six species will suggest different evolutionary relationships.

C. Point mutations in DNA sequences are not acted on by natural selection.

D. Mutations that do not change amino acid sequences in proteins are important for natural selection.

QUESTION 24
Which of the following is **not** an evidence for evolution?

A. A beetroot and a carrot are modified parts of plants

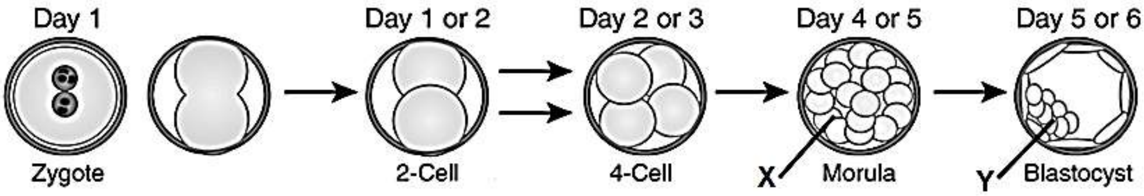
B. Presence of wing bones in the wingless bird, kiwi.

C. Presence of gills slits in human embryos.

D. Codon coding for a particular amino acid

QUESTION 25
The figure below shows several stages in the development of an embryo.

Which of the following statements are true about the cells labelled X and Y?



A. X is a pluripotent cell while Y is a multipotent cell.

B. X is a pluripotent cell while Y can give rise to multipotent cells.

C. Y will develop into the entire foetus including its placenta.

D. X can only give rise to totipotent cells but Y will give rise to pluripotent cells.

QUESTION 26
Induced pluripotent stem cells are stem cells that can be generated directly from differentiated somatic cells under the influence of molecular signals.

Which of the following statements are true?

1. An induced pluripotent stem cell can become any cell of the developed organism, but cannot produce trophoblast and placenta to support organismal development, whereas a totipotent stem cell can produce a whole organism including extraembryonic tissue.
2. A totipotent stem cell and induced pluripotent stem cell can give rise to any cell type, including the extraembryonic membranes.
3. An induced pluripotent stem cell can give rise to a single cell lineage whereas a totipotent stem cell can give rise to multiple, but limited number of cell lineages.
4. A totipotent stem cell can become any cell of a developed organism, but cannot produce trophoblast and placenta to support organismal development, whereas an induced pluripotent stem cell can produce a whole organism including extraembryonic tissue.
5. Induced pluripotent stem cells have the same developmental potential as embryonic stem cells.

A. 1 only

B. 1 and 5 only

C. 2, 3 and 4 only

D. 3, 4 and 5 only

QUESTION 27
Which of the following is the restriction sequence for *Bam*HI?

A 5’ GGATCC 3’

B 5’ GACGAC 3’

C 5’ AATGCC 3’

D 5’ ACTACT 3’

QUESTION 28
What are the possible arguments against the use of genetically modified organisms (GMOs)?

1. Insufficient testing of genetically modified crop for their side effects
2. Unforeseen long-term effects of genetic manipulation
3. Accidental genetic recombination in humans as a result of consuming food derived from GMOs
4. Control of food supply by a small number of companies that have access to genetic engineering technology

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

QUESTION 29
Which of the following technique does **not** involve any nucleic acid hybridization?

A. Gel electrophoresis
B. Gene probing
C. Polymerase Chain Reaction
D. DNA fingerprinting

QUESTION 30
A student performed the following steps in a Southern blot experiment to determine if a particular gene has been inserted in a genetically modified organism.

1. Transfer of DNA to nitrocellulose membrane.
2. Restriction digestion of genomic DNA.
3. Cleaved DNA separated using gel electrophoresis.
4. Synthesize radioactive probe.
5. Incubate probe and membrane.

Which is the correct sequence to the above steps?

A. $2 \rightarrow 3 \rightarrow 1 \rightarrow 4 \rightarrow 5$
B. $2 \rightarrow 3 \rightarrow 1 \rightarrow 5 \rightarrow 4$
C. $4 \rightarrow 5 \rightarrow 1 \rightarrow 2 \rightarrow 3$
D. $5 \rightarrow 4 \rightarrow 3 \rightarrow 2 \rightarrow 1$

☺ End of Paper ☺

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 1

CANDIDATE NAME	

CIVICS GROUP	1	6					INDEX NUMBER		

H1 BIOLOGY 8875/01

Paper 1 Multiple Choice

21 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

Write in soft pencils.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name, civics group and index number on the Multiple Choice Answer Sheet 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 Multiple Choice Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

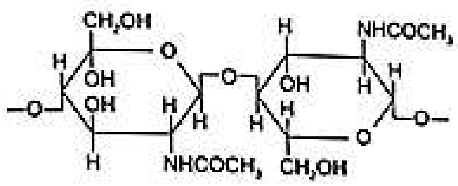
Any rough working should be done in this booklet.

You may keep this booklet after the examination.

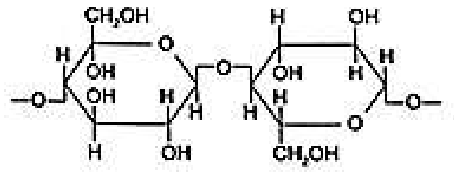
This paper consists of **19** printed pages.

QUESTION 1

The diagrams show short sections of some common polysaccharides and modified polysaccharides.



1



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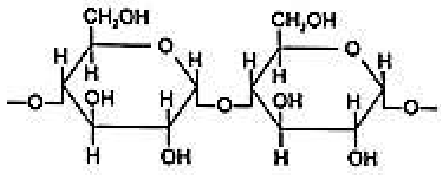

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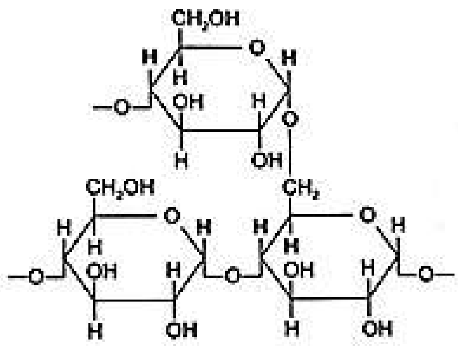

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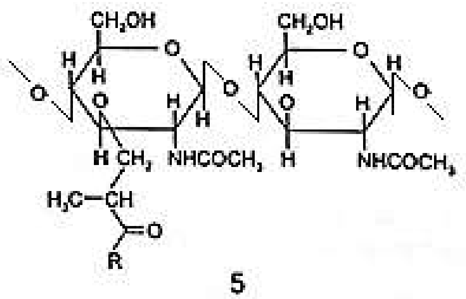


5

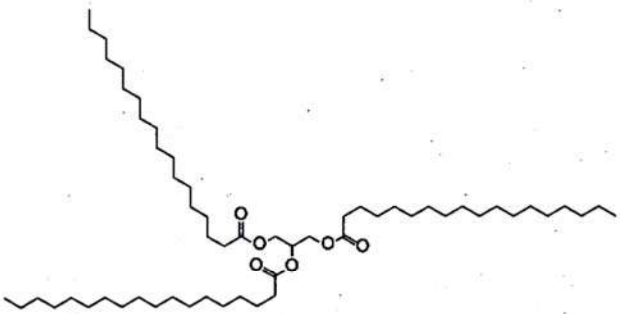
The polysaccharides can be described as below.

- Polysaccharide **F** is composed of β-glucose monomers with 1,4 glycosidic bonds
- Polysaccharide **G** is composed of α-glucose monomers with 1,4 and 1,6 glycosidic bonds
- Polysaccharide **H** is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β-1,4 glycosidic bonds.
- Polysaccharide **J** is composed of α-glucose monomers with 1,4 glycosidic bonds
- Polysaccharide **K** is composed of N-acetylglucosamine monomers with β-1,4 glycosidic bonds

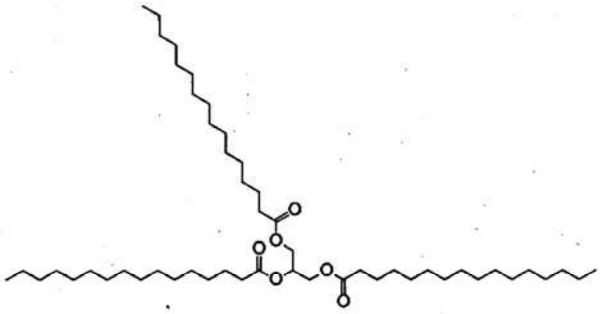
Which shows the correct pairings of polysaccharide descriptions and diagrams?

	Polysaccharide				
	F	**G**	**H**	**J**	**K**
A.	2	4	5	3	1
B.	2	5	4	1	3
C.	3	4	1	2	5
D.	3	5	4	1	2

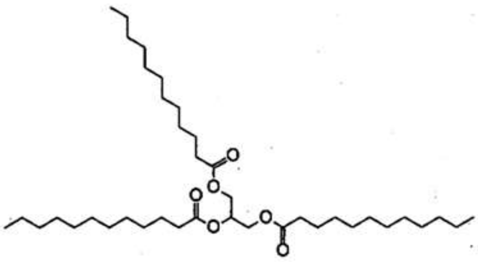
QUESTION 2
The formulae and melting points of five triglycerides are shown in the diagram. Each triglyceride contains three identical fatty acids.



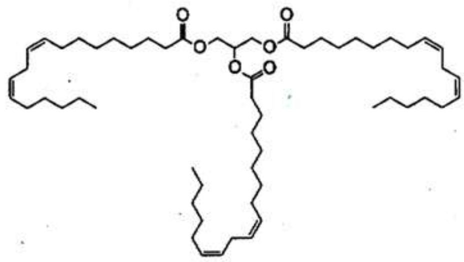
tristearin 72 °C



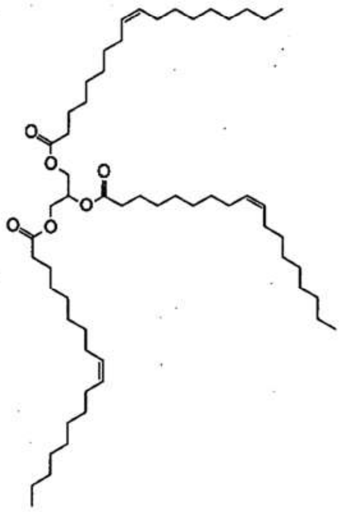
tripalmitin 65.5 °C



trilaurin 46 °C



trilinolein –13 °C



triolein –4 °C

Which two structural features of the molecules make the melting point higher?

	number of double bonds	length of fatty acid chains
A.	fewer	longer
B.	fewer	shorter
C.	more	longer
D.	more	shorter

QUESTION 3
Four students, **A, B ,C** and **D**, were given the same sequence of amino acids removed from a collagen molecule. Each student was asked to analyse the sequence and to explain how their analysis could be linked to a feature of collagen

Which student's statement shows a correct feature of collagen linked to a correct analysis of the amino acid sequence?

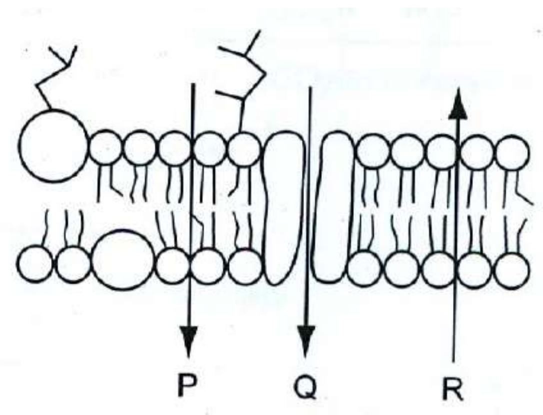
A. Collagen has polypeptides arranged parallel to each other and the sequence contains a large variety of amino acids with different sized R-groups.

B. Collagen has polypeptides that are arranged very closely together and the sequence has every third amino acid as glycine.

C. Collagen has three polypeptides that can fold into a globular structure and the sequence contains cysteine and amino acids with hydrophobic R groups.

D. Collagen is an insoluble molecule and the sequence contains a large proportion of amino acids with hydrophilic R-groups.

QUESTION 4
The diagram shows the cell surface membrane of an actively respiring cell in a tissue that has been placed in a solution of glucose with a lower water potential than that of the tissue cells.



What correctly describe the movements of molecules across the cell surface membrane shown by arrows **P**, **Q** and **R**?

	P	Q	R
A.	diffusion of glucose	diffusion of oxygen	diffusion of water
B.	diffusion of oxygen	diffusion of water	diffusion of glucose
C.	diffusion of water	active transport of glucose	diffusion of oxygen
D.	diffusion of oxygen	Facilitated diffusion of glucose	diffusion of water

QUESTION 5
What could be a possible explanation for the ability of lysosomes to withstand self-digestion?

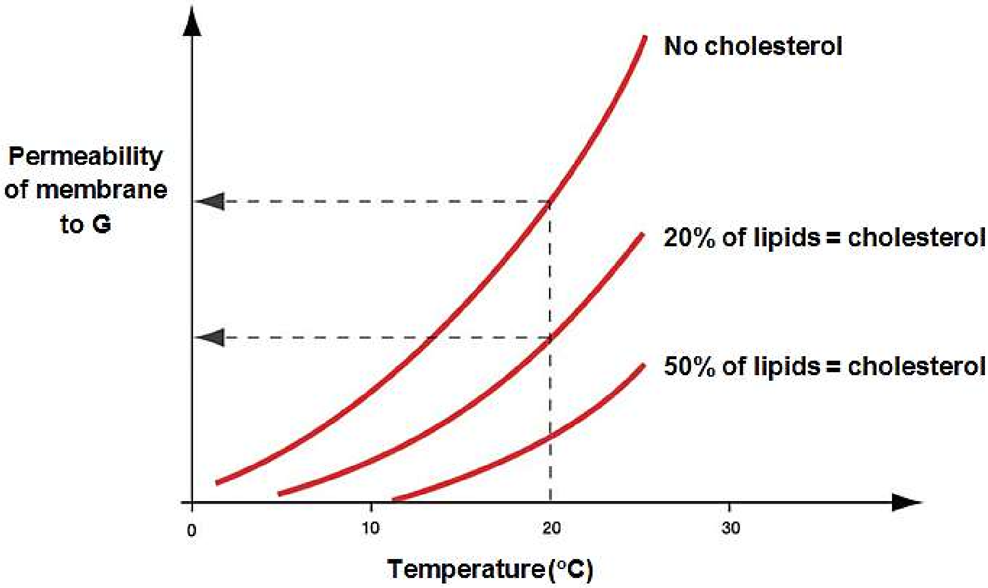
A. Lysosomes contain inactive hydrolytic enzymes.

B. Lysosome membrane has numerous modified proteins with carbohydrate side-chains.

C. Lysosomes do not contain lipases which are the enzymes capable of digesting the lipid membrane.

D. Hydrolases in the lysosomes are inhibited by the acidic internal environment of the lysosomes.

QUESTION 6
The graph below shows the permeability of three different membranes to chemical **G** at different temperatures. These three membranes differ in the amount of cholesterol present in the phospholipid bilayers.



Which of the following is a possible explanation for the observed data?

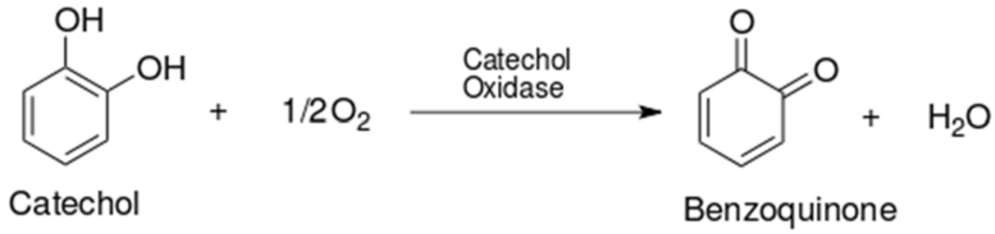
A. Increase in temperature increases the permeability of the membrane to **G** as cholesterol increases the fluidity of the phospholipids.

B. At 20°C, an increase in the proportion of cholesterol in the membrane increases the permeability of membrane to **G** as both cholesterol and **G** are non-polar.

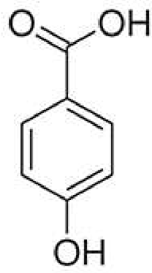
C. Increase in the proportion of cholesterol decreases the permeability of the membrane to **G** as cholesterol decreases the fluidity of the phospholipids.

D. With an increase in the proportion of cholesterol in the membrane, a lower temperature is required to achieve the same level of permeability for **G** as **G** will gain a higher kinetic energy to penetrate the membrane.

QUESTION 7
Catechol is oxidised to benzoquinone, as shown in the equation, resulting in darkening of peeled fruits.



Catechol oxidase is an enzyme which is inhibited by parahydroxybenzoic acid (PHBA). When PHBA binds to catechol oxidase, it does not change the shape of the enzyme. The structure of PHBA is shown below.



PHBA

Which of the following statements are **not** correct?

1. PHBA acts as a competitive inhibitor because its structure is similar to the active site of catechol oxidase.
2. PHBA acts as a non-competitive inhibitor because it does not change the shape of the active site of catechol oxidase.
3. In the presence of PHBA, the same Vmax can be attained at higher catechol concentration.
4. PHBA prevents the formation of enzyme-substrate complex between catechol oxidase, catechol and O_2.

A. 1 and 2 only

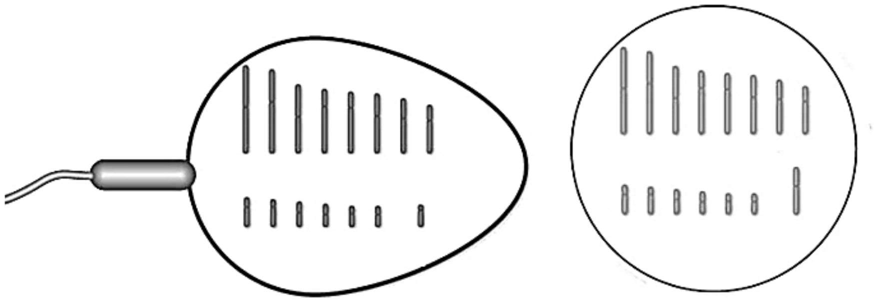
B. 3 and 4 only

C. 1, 2 and 3 only

D. All of the above

QUESTION 8

The diagram below shows the egg cell and sperm cell formed by one mammal species, as well as the number of chromosomes they contain.

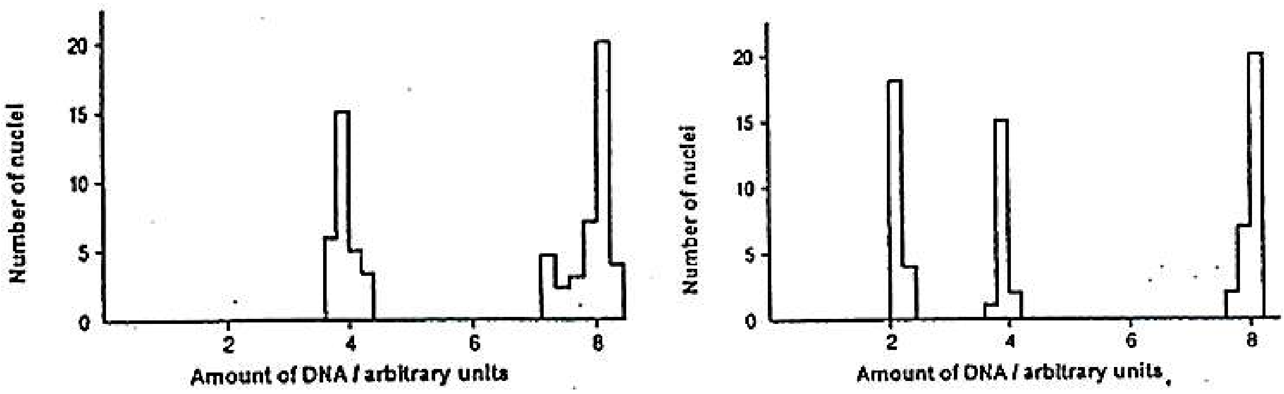


How many DNA molecules would be found in a germ cell (cell that gives rise to gametes) from this organism at prophase II of meiosis II?

A. 15 **B.** 30 **C.** 60 **D.** 120

QUESTION 9

The graphs below show the amount of DNA in the nuclei of cells taken from two different parts of a mammalian testis undergoing different nuclear division processes.

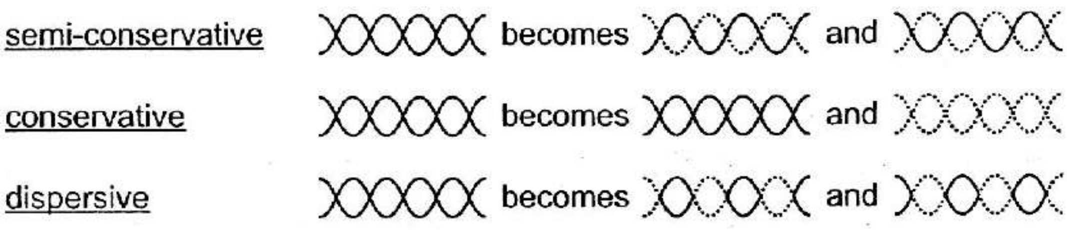


Which correctly describes one **unique** event taking place in the cells from graph **1** and graph **2** respectively?

	Graph 1	Graph 2
A.	Duplication of DNA	Separation of homologous chromosomes
B.	Separation of identical sister chromatids	Separation of non-identical sister chromatids
C.	Separation of non-identical sister chromatids	Formation of gametes
D.	Breaking and rejoining of homologous regions of chromosomes	Separation of homologous chromosomes

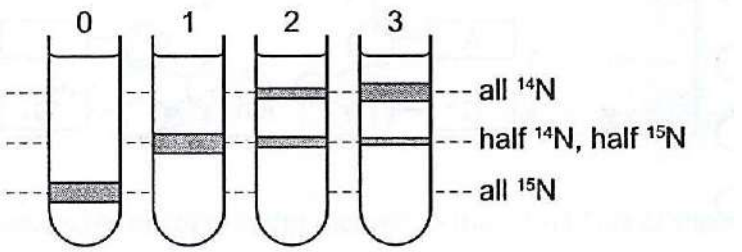
QUESTION 10
Meselson and Stahl found that in dividing cells, DNA is copied by semi-conservative replication. At the time of their discovery it was thought that DNA might be copied in one of three ways.

In the diagram, the original DNA strands are shown by solid lines and the copy strands by dotted lines.



Which set of results would have proved that the DNA replication was **conservative**?

A.



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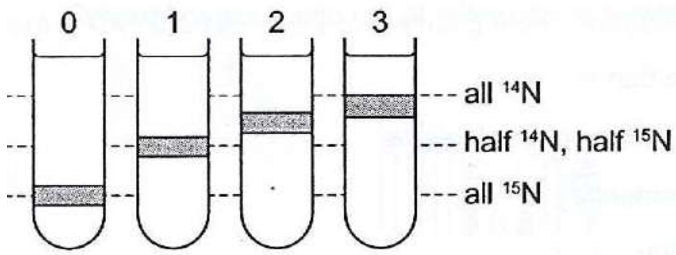


key

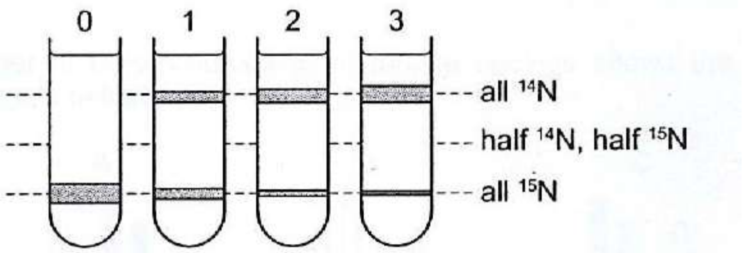
0 = original culture in ^{15}N

1 = first generation in ^{14}N

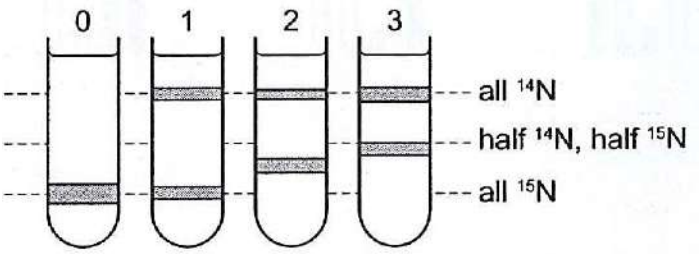
2 = second generation in ^{14}N

3 = third generation in ^{14}N

C.



D.



QUESTION 11
Which statements about the genetic code are correct?

1. The genetic code has redundancy and is degenerate.
2. There is only one codon for the amino acid methionine.
3. Codons act as 'stop' and 'start' signals during transcription and translation.
4. Prokaryotes generally use the same genetic code as eukaryotes.
5. Stop codons are UAA, UGG and UGA.
6. mRNA codons have the same nucleotide sequence as DNA triplets on template strand.

A. 1, 2 and 4 **B.** 1, 3 and 5 **C.** 2, 4 and 6 **D.** 3, 5 and 6

QUESTION 12
In three different possible genetic dictionaries, the genetic code for the amino acid cysteine is given as:

I **ACA** or **ACG**
II **TGT** or **TGC**
III **UGU** or **UGC**

The explanation for this may be:

1. Some genetic dictionaries show mRNA codons, others show DNA triplets.
2. The genetic code can be read in either the 3' or 5' direction along the DNA.
3. Some genetic dictionaries show the triplet code on the DNA strand complementary to the mRNA code, others show the triplet code on the other DNA strand.
4. The genetic code is a degenerate triplet code.

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

QUESTION 13
Fabry's Disease is a disease that results from a mutation that occurs in the *α-galactosidase A* gene.

The sequence of part of the normal and mutated alleles for *α-galactosidase A* gene is shown below.

Normal allele

Codon	37	38	39	40	41	42	43	44	45
mRNA	CCU	UGG	ACC	CAG	AGG	UUC	UAA	GGC	GGA

Mutated allele

Codon	37	38	39	40	41	42	43	44	45
mRNA	CCU	UGG	ACC	CCG	CAG	AGG	UUC	UAA	GGC

Using the information of the normal and mutated alleles above, it is reasonable to conclude that

A. A frame shift mutation has occurred.

B. A duplication has occurred.

C. An insertion of an amino acid has occurred in the mRNA.

D. The polypeptide that is translated from the mutated allele will be longer.

QUESTION 14
Which statement concerning polypeptide synthesis is correct?

A. A particular cell type will transcribe all the genes present in one set of chromosomes but will only process particular pre-mRNA transcripts to enable polypeptide synthesis.

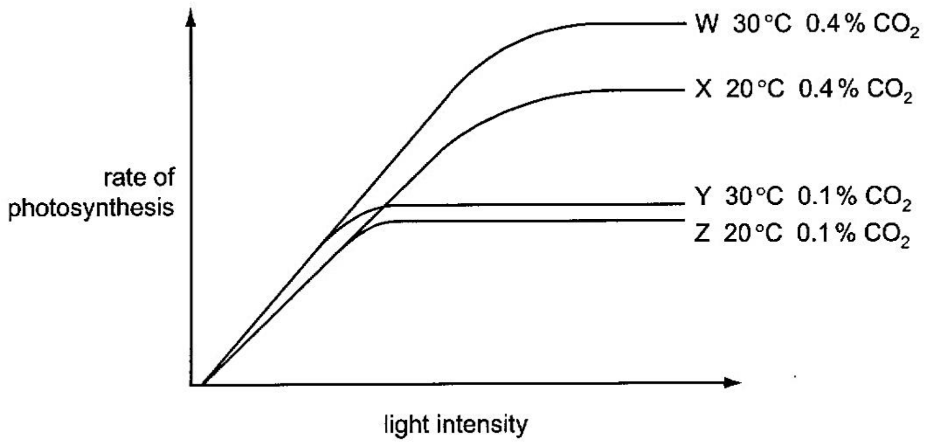
B. Different cell types will transcribe different sets of genes to produce different pre-mRNA transcripts and synthesise different polypeptides.

C. The same pre-mRNA transcripts are synthesised by all cell types but different introns are removed from the transcripts before translation to synthesise polypeptides.

D. The same set of genes will be transcribed by different cell types but different RNA transcripts in each cell type proceed to translation to synthesise different polypeptides.

QUESTION 15

The diagram shows the results of an investigation into the effect of changing light intensity on the rate of photosynthesis at two different carbon dioxide concentrations and two different temperatures.



Which factor is limiting the rate of photosynthesis shown in curve X at high light intensities and which curve supports this?

A. carbon dioxide, curve Y as a decrease in carbon dioxide concentration decreases rate

B. carbon dioxide, curve Z as rate becomes constant at lower light intensities

C. temperature, curve W as an increase in temperature increases rate

D. temperature, curve Z as rate becomes constant at lower light intensities

QUESTION 16

Which of the following is correct?

A. Cellular respiration uses ATP to produce energy for activities and reactions in the cell.

B. Cellular respiration oxidises ATP for activities and reactions in the cell.

C. Cellular respiration produces ATP for activities and reactions in the cell.

D. Cellular respiration hydrolyses ATP for activities and reactions in the cell.

QUESTION 17
Rotene, oligomycin and DNP are metabolic poisons which affect cellular respiration. The effects of rotene, oligomycin and DNP on aerobic respiration are summarised in the following table.

Metabolic Poisons	Effect of metabolic poison on cells		
	ability to use glucose	ability to use oxygen and amount used	ATP yield
rotene	yes	No	decreases
oligomycin	yes	Yes – same amount used	decreases
DNP	yes	Yes – increase amount used	decreases

Which of the following correctly identifies the specific functions of these metabolic poisons?

	rotene	oligomycin	DNP
A.	Increases inner membrane permeability	inhibits ATP synthase	Inhibits electron transport
B.	inhibits ATP synthase	Inhibits electron transport	Increases inner membrane permeability
C.	Inhibits electron transport	inhibits ATP synthase	Increases inner membrane permeability
D.	Inhibits electron transport	Increases inner membrane permeability	Inhibits ATP synthase

QUESTION 18
A child with Down syndrome has the genotype P^1 P^2 P^3 for a polymorphism on chromosome 21 that has four different alleles — allele P^1, allele P^2, allele P^3, allele P^4. The child's mother has the genotype P^1 P^2 and the father has the genotype P^3 P^4.

In which parent did chromosomes fail to separate, and did this event occur in the first or second meiotic division?

A. Mother; Meiosis I

B. Mother; Meiosis II

C. Father; Meiosis I

D. Father; Meiosis II

QUESTION 19
Achondroplastic dwarfism is an autosomal dominant disorder and red-green colour blindness is an X-linked recessive disorder.

An achondroplastic male dwarf with normal vision marries a colour-blind woman of normal height. The man's father is 1.7 meters tall while both the woman's parents are of average height.

What is the probability that their son will be colour-blind and of normal height?

A. 0.25 **B.** 0.5 **C.** 0.75 **D.** 1.0

QUESTION 20
A genetic cross performed on the fruit fly, *Drosophila melanogaster*, involved two independently-assorting (unlinked) genes.

gene	alleles
eye shape	bar (narrow) round
wing shape	Normal vestigial (reduced)

The F2 generation was observed to show the expected 9:3:3:1 phenotypic ratio, with the majority of the F2 offspring possessing bar eyes and normal wings.

Two different individuals with bar eyes and normal wings were removed from the F2 group each subjected to a test cross. The ratios of the resulting phenotypes are shown below.

test cross x individual P = 1 bar eye, normal wing **:** 1 bar eye, vestigial wing

test cross x individual Q = 1 bar eye, normal wing **:** 1 round eye, normal wing

What is the expected phenotypic ratio for the offspring of a cross between individual P and individual Q?

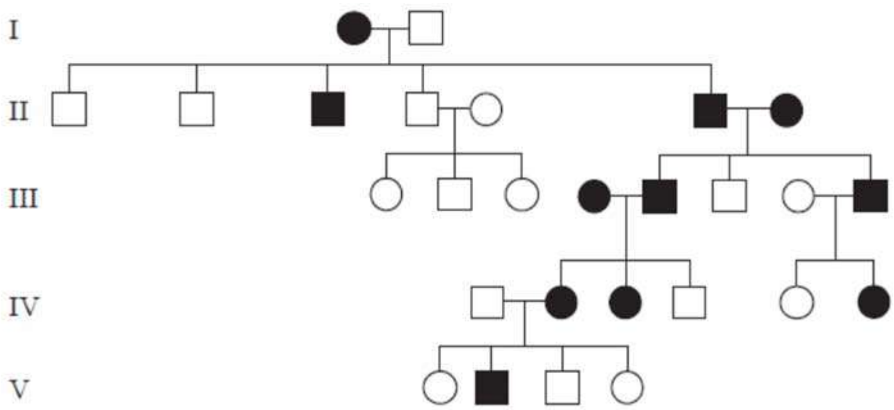
A. all bar eye, normal wing

B. 1 bar eye, normal wing **:** 1 bar eye, vestigial wing

C. 3 bar eye, normal wing **:** 1 bar eye, vestigial wing

D. 3 bar eye, normal wing **:** 1 round eye, normal wing

QUESTION 21
The pedigree chart below shows the inheritance of a genetic disease in a family.



What is the nature of the allele that causes this disease?

A. autosomal dominant

B. sex-linked dominant

C. autosomal recessive

D. sex-linked recessive

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QUESTION 22
Which statement concerning chrysanthemum plants, of the genus *Dendranthema,* is a valid example of how the environment may affect the phenotype?

A. Anthocyanins and anthoxanthins are vacuolar pigments, whereas xanthophylls and carotenes are pigments found in membrane-bound oragnelles known as plasmids. These, together with molecules known as co-pigments, are responsible for the variation observed in petal colur in *Dendranthema.*

B. Identical genetic crosses performed between varieties of *Dandrathema* result in a greater proportion of offspring plants with plastids exhibiting a yellow colour when grown in a field and a greater proportion of offspring plants with colourless plastids when grown in a glasshouse.

C. The seeds of a cross between *Dendranthema weyrichii* and *Dendranthema grandiflora* produce plants that are far more frost-tolerant and exhibit an exhibit an extended flowering season compared with both parents.

D. The seeds of a cross between *Dendrathema weyrichii* (height varying between 12.5 – 15.0cm) and *Dendranthema grandiflora* (height varying between 8.0 – 25.0 cm) produce plants, when grown in natural day length, of a height varying between 55.0 – 71.0 cm.

QUESTION 23
The diagram shows part of the aligned DNA sequences for the same gene in six species of aquatic animals.

Fin whale	TAAACCCCAATAGTCACAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Humpback whale	TAAACCCTAATAGTCACAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Sperm whale	TAAACCCAGGTAGTCATAAAACAAGACTATTCGCCAGAGTACTACTAGCAAC
Beaked whale	TAAACCTAAATAGTCTCAAAACAAGACTATTCGCCAGAGTACTACTAGCAAT
Dolphin	TAAACTTAAATAATCCCAAAACAAGATTATTCGCCAGAGTACTATCGGCAAC
Porpoise	TAAACCTAAATAGTCCTAAAACAAGACTATTCGCCAGAGTACTATCGGCAAC

Which is a correct assumption when using this information as evidence for evolutionary relationships?

A. Differences and similarities in DNA sequences reflect evolutionary relationships.

B. DNA sequences in different genes from the same six species will suggest different evolutionary relationships.

C. Point mutations in DNA sequences are not acted on by natural selection.

D. Mutations that do not change amino acid sequences in proteins are important for natural selection.

QUESTION 24
Which of the following is **not** an evidence for evolution?

A. A beetroot and a carrot are modified parts of plants

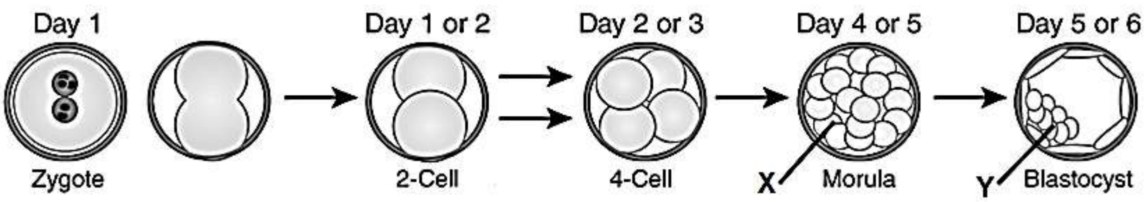
B. Presence of wing bones in the wingless bird, kiwi.

C. Presence of gills slits in human embryos.

D. Codon coding for a particular amino acid

QUESTION 25
The figure below shows several stages in the development of an embryo.

Which of the following statements are true about the cells labelled X and Y?



A. X is a pluripotent cell while Y is a multipotent cell.

B. X is a pluripotent cell while Y can give rise to multipotent cells.

C. Y will develop into the entire foetus including its placenta.

D. X can only give rise to totipotent cells but Y will give rise to pluripotent cells.

QUESTION 26
Induced pluripotent stem cells are stem cells that can be generated directly from differentiated somatic cells under the influence of molecular signals.

Which of the following statements are true?

1. An induced pluripotent stem cell can become any cell of the developed organism, but cannot produce trophoblast and placenta to support organismal development, whereas a totipotent stem cell can produce a whole organism including extraembryonic tissue.
2. A totipotent stem cell and induced pluripotent stem cell can give rise to any cell type, including the extraembryonic membranes.
3. An induced pluripotent stem cell can give rise to a single cell lineage whereas a totipotent stem cell can give rise to multiple, but limited number of cell lineages.
4. A totipotent stem cell can become any cell of a developed organism, but cannot produce trophoblast and placenta to support organismal development, whereas an induced pluripotent stem cell can produce a whole organism including extraembryonic tissue.
5. Induced pluripotent stem cells have the same developmental potential as embryonic stem cells.

A. 1 only

B. 1 and 5 only

C. 2, 3 and 4 only

D. 3, 4 and 5 only

QUESTION 27
Which of the following is the restriction sequence for *Bam*HI?

A 5’ GGATCC 3’

B 5’ GACGAC 3’

C 5’ AATGCC 3’

D 5’ ACTACT 3’

QUESTION 28
What are the possible arguments against the use of genetically modified organisms (GMOs)?

1. Insufficient testing of genetically modified crop for their side effects
2. Unforeseen long-term effects of genetic manipulation
3. Accidental genetic recombination in humans as a result of consuming food derived from GMOs
4. Control of food supply by a small number of companies that have access to genetic engineering technology

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

QUESTION 29
Which of the following technique does **not** involve any nucleic acid hybridization?

A. Gel electrophoresis
B. Gene probing
C. Polymerase Chain Reaction
D. DNA fingerprinting

QUESTION 30
A student performed the following steps in a Southern blot experiment to determine if a particular gene has been inserted in a genetically modified organism.

1. Transfer of DNA to nitrocellulose membrane.
2. Restriction digestion of genomic DNA.
3. Cleaved DNA separated using gel electrophoresis.
4. Synthesize radioactive probe.
5. Incubate probe and membrane.

Which is the correct sequence to the above steps?

A. $2 \rightarrow 3 \rightarrow 1 \rightarrow 4 \rightarrow 5$
B. $2 \rightarrow 3 \rightarrow 1 \rightarrow 5 \rightarrow 4$
C. $4 \rightarrow 5 \rightarrow 1 \rightarrow 2 \rightarrow 3$
D. $5 \rightarrow 4 \rightarrow 3 \rightarrow 2 \rightarrow 1$

• **THE END** •

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 1

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | | | | |

INDEX NUMBER

H1 BIOLOGY

8875/02

Paper 2

15 September 2017
2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Section A
Answer **all** questions.

Section B
Answer **one** question.

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

For examiner's Use	
Section A	
1	/ 14
2	/ 7
3	/ 9
4	/ 10
Section B	
5 or 6	/ 20
Total	/ 60

This paper consists of **16** printed pages.

[Turn over]

Section A

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

QUESTION 1

Pepsin is an enzyme that digests protein. It is synthesized in the cells of the stomach as a longer, inactive proenzyme called pepsinogen. Secretion of pepsinogen into the acidic environment of the stomach then activates it.

Fig. 1.1 shows the structures of pepsinogen and pepsin. The active site of pepsin is indicated.

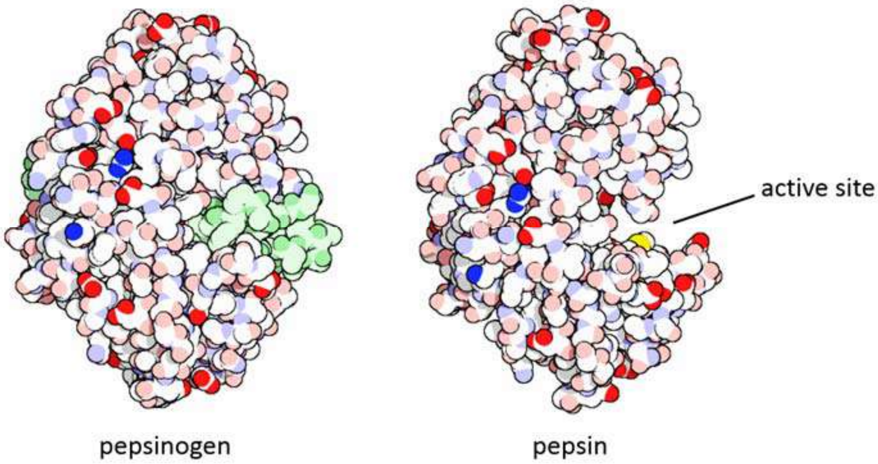


Fig. 1.1

a) With reference to Fig. 1.1, explain how the structure of pepsinogen allows it to be inactive. [2]

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b) Explain how a point mutation on DNA can change the primary structure of pepsin but not its globular structure. [4]

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c) Pepsinogen is secreted by the gastric chief cells of the stomach. These cells also synthesize and secrete gastric lipases that hydrolyze lipids.

Explain how gastric chief cells are structurally adapted for its role. [3]

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d) Another enzyme, DNA polymerase, carries out DNA replication with tight coordination of leading and lagging strand synthesis.

Describe **two** structural differences between DNA polymerase and its substrate. [2]

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2. ……………………………………………………………………………………………………...

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e) Fig. 1.2 shows the transport of substances in and out of the nucleus via the nuclear pore.

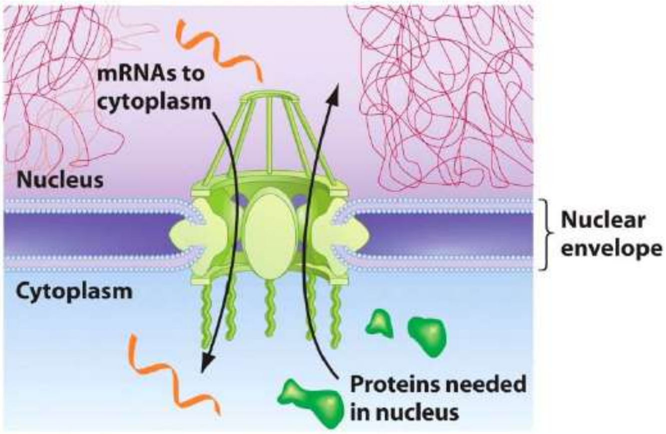

Fig. 1.2

i) Apart from enzymes and proteins that are directly involved in DNA replication and transcription, suggest **two** other substances that are transported from the cytosol into the nucleus. [2]

1. ……………………………………………………………………………………………….

2. ……………………………………………………………………………………………….

ii) Apart from messenger RNAs that exit the nucleus into the cytosol, suggest **one** other substances that are transported out of the nucleus. [1]

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[Total: 14]

QUESTION 2

In 1865, Gregor Mendel performed dihybrid crosses on pea plants for a variety of characteristics including flower colour, flower position and height (length of stem). From his observations he developed a fundamental law of genetics that some genetic characteristics are inherited independently.

For example, pure-breeding pea plants with red flowers on the sides of stems (axial) can be crossed with pure-breeding pea plants with white flowers on the ends of stems (terminal).

All the resultant plants (F_1 generation) have red flowers that are axial.

One set of results for the offspring from self-pollinating these F_1 plants is shown below.

261	red, axial flowers
86	red, terminal flowers
76	white, axial flowers
28	white, terminal flowers

a) Draw a genetic diagram to explain both crosses.

Use the following symbols to represent the different alleles involved:

R/r – Flower colour **A/a** – Flower position [5]

b) Explain how different characteristics are inherited independently in dihybrid inheritance. [2]

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[Total: 7]

QUESTION 3
A recent study of populations of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations:

- There are six distinct populations.
- The mice are associated with human settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes

As a result of these observations, it has been suggested that evolution is taking place, leading to the formation of six different species.

Fig. 3.1 is a schematic representation of Madeira showing the distribution of the six populations.

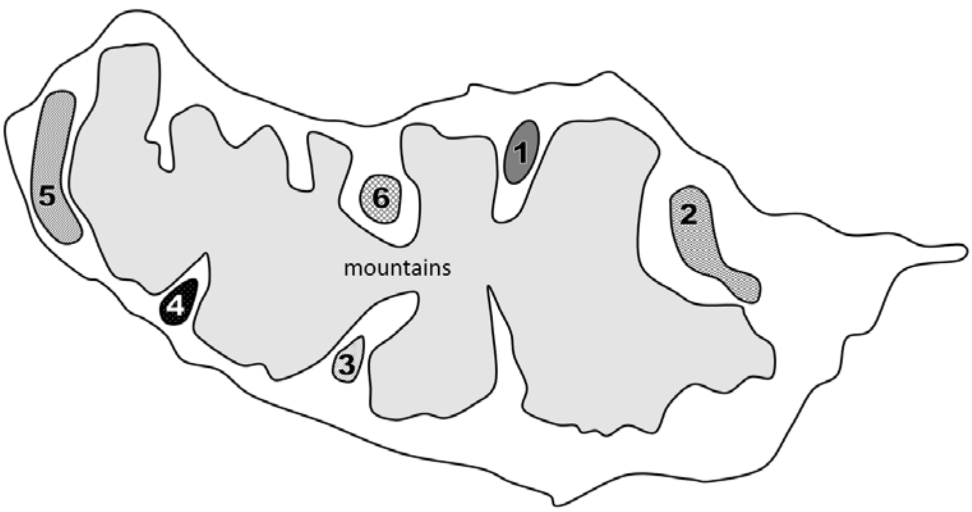

Fig. 3.1

a) '*It has been suggested that evolution is taking place, leading to the formation of six different species*.'

Explain how this process is occurring in the house mouse populations of Madeira. [4]

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b) Explain the likely outcome of individuals from two separate populations being mated in captivity. [2]

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c) Cytochrome c is a protein that is found in all living organisms. Analysis of the amino acid sequences of proteins, such as cytochrome c, provides data that taxonomists use to produce more accurate classifications.

Explain why analyzing the amino acid sequences of proteins could provide useful data for taxonomists. [3]

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[Total: 9]

QUESTION 4
The artificial plasmid, pBR322, was constructed to act as a vector. It has often been used to insert human genes, such as the human insulin gene, into the bacterium, *Escherichia coli*.

The plasmid was constructed to include two genes, each giving resistance to a different antibiotic: an ampicillin-resistant gene and a tetracycline-resistant gene. The plasmid also has a target site for the restriction enzyme, *Bam*HI, in the middle of the tetracycline-resistance gene.

A pBR322 plasmid was cut using *Bam*HI and the cDNA gene for human insulin inserted into it.

Fig. 4.1 shows pBR322 and the recombinant plasmid.

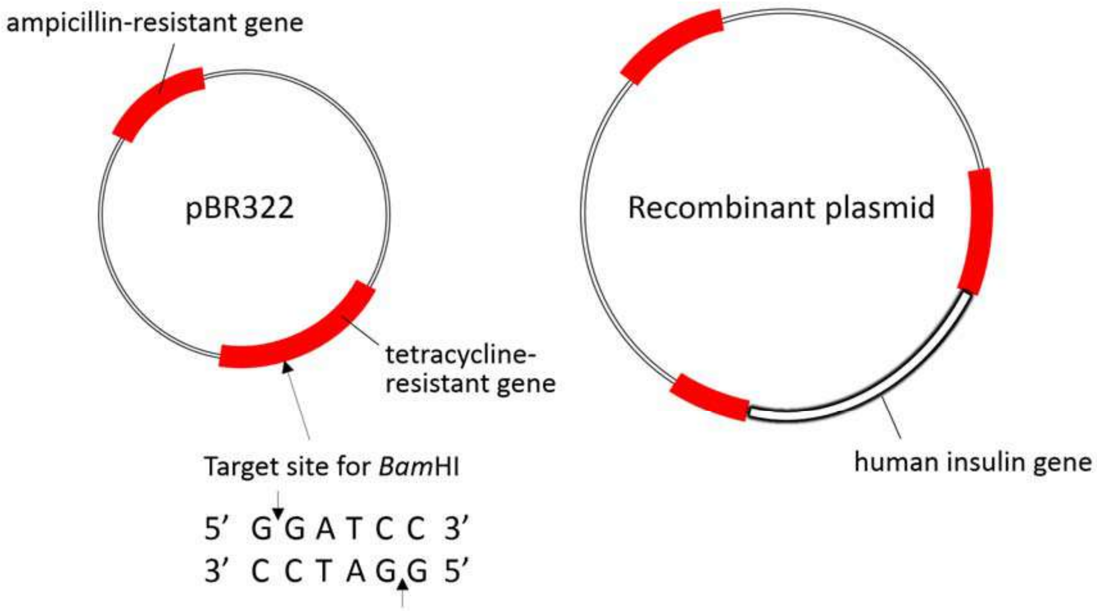

Fig. 4.1

a) The cDNA of human insulin gene obtained by reverse transcription does not contain sticky ends.

With reference to Fig. 4.1, describe how a cDNA of human insulin gene can be inserted into pBR322 that has been cut by *Bam*HI. [3]

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b) Bacteria were then mixed with the recombinant plasmids. Those bacteria which had successfully taken up recombinant plasmids were identified using the following steps:

Step 1 – the bacteria were spread onto culture plates containing nutrient agar and ampicillin and incubated to allow colonies to form

Step 2 – some bacteria from each of the colonies growing on these plates were transferred to plates (replica plating) containing nutrient agar and tetracycline, as shown in Fig. 4.2.

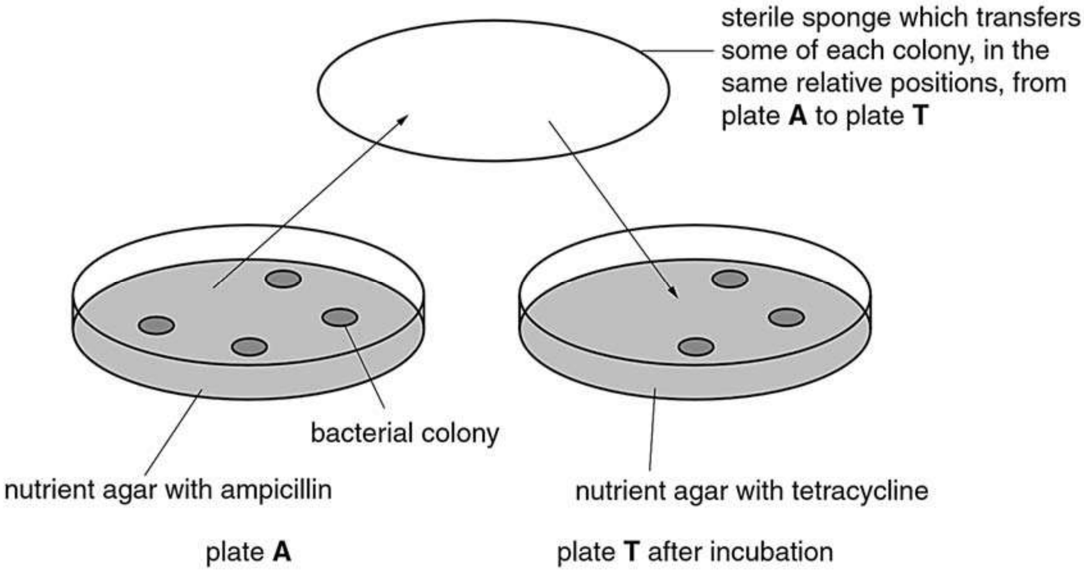

Fig. 4.2

i) Explain why the bacteria were first spread onto plates containing ampicillin. [2]

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ii) Explain why it is important that on the pBR322 plasmid, the target site for *Bam*HI is in the middle of the tetracycline resistance gene. [3]

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iii) Use a label line and the letter **C** to identify, on Fig. 4.2, a colony of bacteria that contains the recombinant plasmid. [1]

c) Plasmid vectors carrying antibiotic-resistant genes are now rarely used in gene technology because of the risk of transferring these genes to other bacteria that are previously susceptible to that antibiotic, hence conferring antibiotic-resistance to these bacteria.

State one type of gene that has replaced antibiotic-resistant genes in plasmid vectors **and** indicate how bacteria carrying this gene can be detected. [1]

Gene …………………………………………………………………………………………….

Detection …………………………………………………………………………………………….

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[Total: 10]

Section B
Answer **ONE** questions

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be in set out in questions **(a)**, **(b)**, etc., as indicated in the question.

QUESTION 5

a) DNA molecules replicate with a high degree of accuracy, yet not always perfectly.

Describe how this occurs and discuss why the survival of a species depends on DNA molecules being stable, yet not *absolutely* stable. [10]

b) Explain the underlying principles of the polymerase chain reaction (PCR) **and** explain how the specificity of PCR is achieved. [5]

c) Describe the process of endocytosis.
[5]

[Total: 20]

QUESTION 6

a) Discuss the importance of hydrogen bonding in ensuring the continuity of life. [10]

b) Outline the functions of membranes **within** cells.
[5]

c) With reference to specific examples, discuss the roles of coenzymes in yeast.
[5]

[Total: 20]

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☺ **End of Paper** ☺

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 1

CANDIDATE NAME

CIVICS GROUP	1	6				

INDEX NUMBER

H1 BIOLOGY 8875/02

Paper 2

15 September 2017
2 hours

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Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Section A
Answer **all** questions.

Section B
Answer **all** questions.

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

For examiner's Use	
Section A	
1	/ 14
2	/ 7
3	/ 9
4	/ 10
Section B	
5 or 6	/ 20
Total	/ 60

ANSWER SCHEME

This paper consists of **12** printed pages.

[Turn over]

Section A

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

QUESTION 1

Pepsin is an enzyme that digests protein. It is synthesized in the cells of the stomach as a longer, inactive proenzyme called pepsinogen. Secretion of pepsinogen into the acidic environment of the stomach then activates it.

Fig. 1.1 shows the structures of pepsinogen and pepsin. The active site of pepsin is indicated.

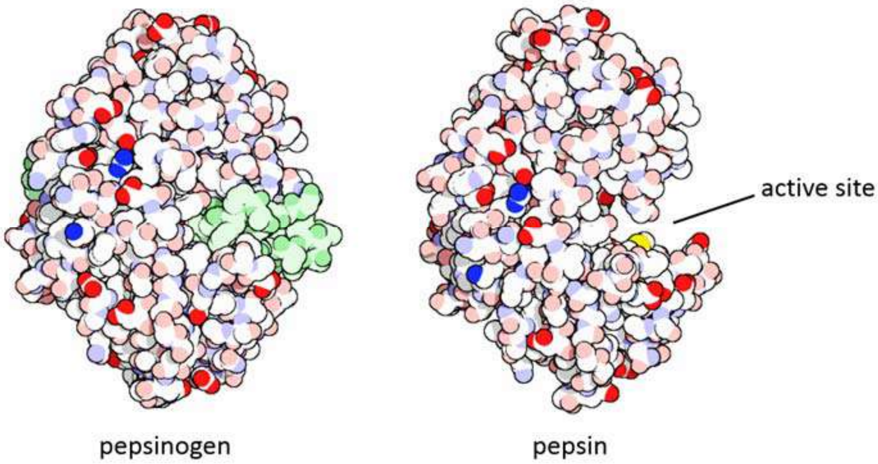


Fig. 1.1

a) With reference to Fig. 1.1, explain how the structure of pepsinogen allows it to be inactive. [2]

- Pepsinogen has **extra amino acids** in its primary structure, which **occupies the active site** of pepsin / active site is not exposed.

- **Prevents substrate from binding** to active site, because it is **not complementary in shape** to the substrate.

b) Explain how a point mutation on DNA can change the primary structure of pepsin but not its globular stcuture. [4]

[DNA level]
- **Single-base substitution** on a **triplet** on **DNA** on pepsin gene

[mRNA level]
- Changes the corresponding **mRNA codon**, and changes corresponding **amino acid**

[Polypeptide level]
- Amino acid has **similar property**, hence same R-group interactions occur
- **Folding** of the polypeptide chain **unchanged**, hence the **3D configuration** of pepsin **unchanged**

OR
- Amino acid is not involved in the formation of bonds important in maintaining three-dimensional configuration of pepsin
- **Folding** of the polypeptide chain **unchanged**, hence the **3D configuration** of pepsin **unchanged**

Reject: Silent mutation, since primary structure is changed.

c) Pepsinogen is secreted by the gastric chief cells of the stomach. These cells also synthesize and secrete gastric lipases that hydrolyze lipids.

Explain how gastric chief cells are structurally adapted for its role. [3]

- **Large number** of **rough endoplasmic reticulum** and **Golgi apparatus**.
- RER – for synthesis of **pepsinogen** and **lipases** [context], which are proteins.
- Golgi – for **biochemical modification** of pepsinogen and lipases and for formation for **secretory vesicles**

d) Another enzyme, DNA polymerase, carries out DNA replication with tight coordination of leading and lagging strand synthesis.

Describe **two** structural differences between DNA polymerase and its substrate. [2]

	Features	DNA polymerase	Substrate (DNA)
1	Overall structure	Compact spherical/ globular shape	Double helical shape
2	Monomers	Amino acids	Deoxyribonucleotides
3	Types of different monomers.	20	4
4	Bonds between monomers	Peptide bond	Phosphodiester bond
5	Other bonds supporting overall structure	hydrogen bonds, ionic bonds, disulfide bonds, hydrophobic and hydrophilic interactions	hydrogen bonding between nitrogenous bases, and hydrophobic interaction between stacked bases
6	Elements present	May contain sulphur (e.g. cysteine) **OR** Carbon, Hydrogen, Oxygen Nitrogen, Sulfur	Phosphorus **OR** Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorous

e) Fig. 1.2 shows the transport of substances in and out of the nucleus via the nuclear pore.

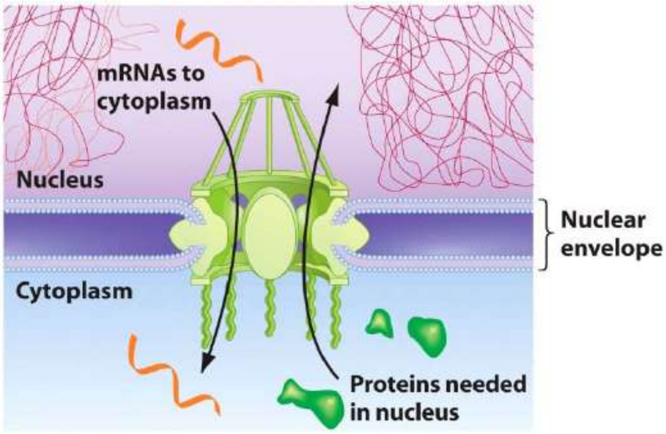


Fig. 1.2

i) Apart from enzymes and proteins that are directly involved in DNA replication and transcription, suggest **two** other substances that are transported from the cytosol into the nucleus. [2]

- Deoxyribonucleotides for DNA replication / ribonucleotides for transcription
- ATP as an energy molecule for energy-requiring processes in the nucleus
- Ribosomal proteins
- Histones (involved in DNA packing but not DNA replication)
- **AVP**

ii) Apart from messenger RNAs that exit the nucleus into the cytosol, suggest **one** other substances that are transported out of the nucleus. [1]

- Ribosomes / 80S ribosomes / large subunit of ribosome / small subunit of ribosome
- Transfer RNA / tRNA
- Nucleoside diphosphates / monophosphates
- **AVP**

[Total: 14]

QUESTION 2

In 1865, Gregor Mendel performed dihybrid crosses on pea plants for a variety of characteristics including flower colour, flower position and height (length of stem). From his observations he developed a fundamental law of genetics that some genetic characteristics are inherited independently.

For example, pure-breeding pea plants with red flowers on the sides of stems (axial) can be crossed with pure-breeding pea plants with white flowers on the ends of stems (terminal).

All the resultant plants (F_1 generation) have red flowers that are axial.

One set of results for the offspring from self-pollinating these F_1 plants is shown below.

261	red, axial flowers
86	red, terminal flowers
76	white, axial flowers
28	white, terminal flowers

a) Draw a genetic diagram to explain both crosses.

Use the following symbols to represent the different alleles involved:

R/r – Flower colour **A/a** – Flower position [5]

Parental phenotype:	Red, axial flowers	X	White, terminal flowers
Parental genotype (2n):	RRAA	X	rraa
Gametes (n):	RA	X	ra **[1]**

F_1 genotype: RrAa

F_1 phenotype: Red, axial flowers **[1]**

Selfing F_1

F_1 phenotype:	Red, axial flowers	X	Red, axial flowers
F_1 genotype (2n):	RrAa	X	RrAa
Gametes (n):	RA rA Ra ra	X	RA rA Ra ra **[1]**

F_2 genotype and phenotype (2n): **[1]**

	RA	Ra	rA	ra
RA	RRAA Red, axial	RRAa Red, axial	RrAA Red, axial	RrAa Red, axial
Ra	RRAa Red, axial	RRaa Red, terminal	RrAa Red, axial	Rraa Red, terminal
rA	RrAA Red, axial	RrAa Red, axial	rrAA White, axial	rrAa White, axial
ra	RrAa Red, axial	Rraa Red, terminal	rrAa White, axial	rraa White, terminal

	Red, axial	Red, terminal	White, axial	White, terminal
F_2 phenotypic ratio:	9 :	3 :	3 :	1
Which is close to observed number:	261	86	76	28 **[1]**

b) Explain how different characteristics are inherited independently in dihybrid inheritance. [2]

- Different **genes** coding for different proteins can be located on **different chromosomes**
- Based on the **law of independent assortment and segregation**, alleles of one gene on a chromosome independently assort and segregate from the alleles of another gene on another chromosome, during gamete formation/meiosis.

[Total: 7]

QUESTION 3

A recent study of populations of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations:

- There are six distinct populations.
- The mice are associated with human settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes

As a result of these observations, it has been suggested that evolution is taking place, leading to the formation of six different species.

Fig. 3.1 is a schematic representation of Madeira showing the distribution of the six populations.

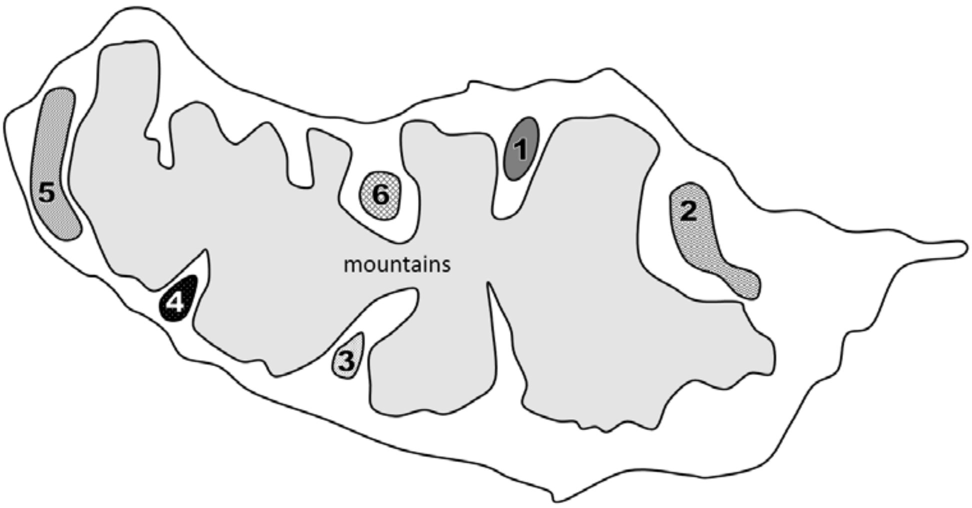


Fig. 3.1

a) '*It has been suggested that evolution is taking place, leading to the formation of six different species*.'

Explain how this process is occurring in the house mouse populations of Madeira. [4]

1. Due to **association with human settlements**, the mouse **population was scattered**.
2. **Steep mountains** serves as **geographical barriers** for the scattered populations, hence **no breeding / gene flow** between the separated populations.
3. **Different selection pressures** in each area where each population resides, hence **different alleles** are **selected for and against**.
4. **Random mutations** also occurred in each population.
5. Results in **change in allele frequency** / gene pool.
6. Develop **different chromosome numbers**, hence different species.

b) Explain the likely outcome of individuals from two separate populations being mated in captivity. [2]

- Due to **<u>different chromosome number</u>** / diploid number
- As there is **<u>no pairing of homologous chromosomes</u>** in offspring, **<u>meiosis cannot take place</u>**, thus **<u>no gametes</u>** will be produced by offspring, hence **<u>infertile</u>**.

c) Cytochrome c is a protein that is found in all living organisms. Analysis of the amino acid sequences of proteins, such as cytochrome c, provides data that taxonomists use to produce more accurate classifications.

Explain why analyzing the amino acid sequences of proteins could provide useful data for taxonomists. [3]

- DNA codes for amino acid sequences
- Mutations result in altered DNA sequences, which results in differences in amino acid sequences
- Hence, large (small) difference in amino acid sequence between two species reflects distant (close) evolutionary relationship

[Total: 9]

QUESTION 4

The artificial plasmid, pBR322, was constructed to act as a vector. It has often been used to insert human genes, such as the human insulin gene, into the bacterium, *Escherichia coli*.

The plasmid was constructed to include two genes, each giving resistance to a different antibiotic: an ampicillin-resistant gene and a tetracycline-resistant gene. The plasmid also has a target site for the restriction enzyme, *Bam*HI, in the middle of the tetracycline-resistance gene.

A pBR322 plasmid was cut using *Bam*HI and the cDNA gene for human insulin inserted into it.

Fig. 4.1 shows pBR322 and the recombinant plasmid.

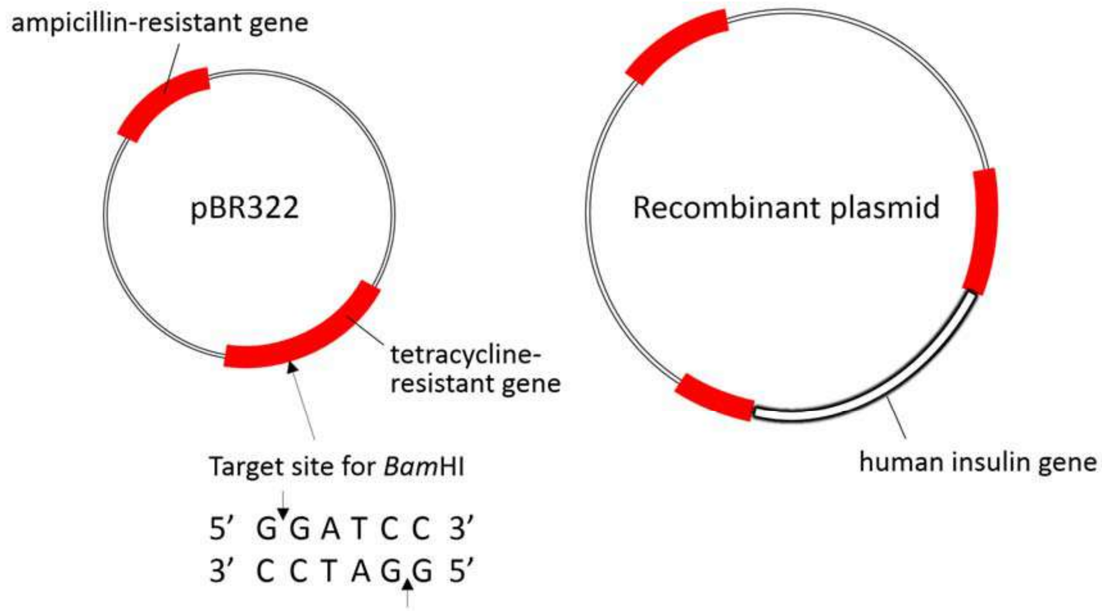


Fig. 4.1

a) The cDNA of human insulin gene obtained by reverse transcription does not contain sticky ends.

With reference to Fig. 4.1, describe how a cDNA of human insulin gene can be inserted into pBR322 that has been cut by *Bam*HI. [3]

- ***Bam*HI linkers** are added to the two ends of the cDNA gene and cut with *Bam*HI enzyme to produce *Bam*HI sticky ends GATC and CTAG
- Mix the cDNA with the *Bam*HI-cut plasmid
- Both have **same sticky ends**, hence can anneal by **complementary base pairing** through formation of **hydrogen bonds**
- **DNA ligase** seals the sugar-phosphate backbone by forming **phosphodiester bonds**

b) Bacteria were then mixed with the recombinant plasmids. Those bacteria which had successfully taken up recombinant plasmids were identified using the following steps:

Step 1 – the bacteria were spread onto culture plates containing nutrient agar and ampicillin and incubated to allow colonies to form

Step 2 – some bacteria from each of the colonies growing on these plates were transferred to plates (replica plating) containing nutrient agar and tetracycline, as shown in Fig. 4.2.

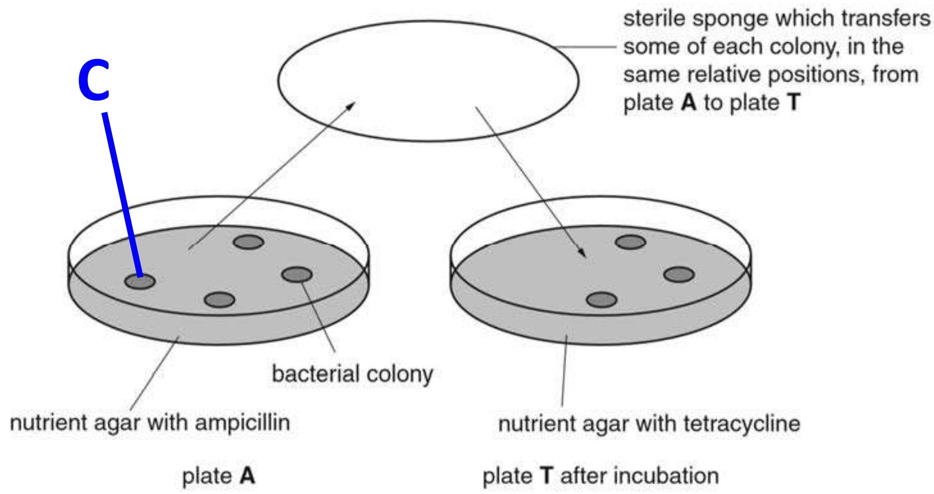


Fig. 4.2

i) Explain why the bacteria were first spread onto plates containing ampicillin. [2]

- To eliminate bacteria (>99%) which did not take up any plasmid / non-transformed bacteria
- Transformed bacteria took up (recombinant/re-annealed) **plasmid**, thus **acquiring ampicillin-resistant gene** on the plasmid
- Hence are **resistant to ampicillin** and able to **survive on ampicillin plate.**

ii) Explain why it is important that on the pBR322 plasmid, the target site for *Bam*HI is in the middle of the tetracycline resistance gene. [3]

- **Insertional inactivation / disruption of Tet^R gene** due to insertion of human insulin gene
- Colonies that are ampicillin-resistant but **not tetracycline-resistant** have taken up **recombinant plasmid**
- Colonies that survive on Tet plate have taken up the **re-annealed plasmid**
- **Compare** Amp plate and Tet plate. Colonies missing on Tet plate but present on Amp plate is the bacteria with recombinant plasmids.

iii) Use a label line and the letter **C** to identify, on Fig. 4.2, a colony of bacteria that contains the recombinant plasmid. [1]

c) Plasmid vectors carrying antibiotic-resistant genes are now rarely used in gene technology because of the risk of transferring these genes to other bacteria that are previously susceptible to that antibiotic, hence conferring antibiotic-resistance to these bacteria.

State one type of gene that has replaced antibiotic-resistant genes in plasmid vectors **and** indicate how bacteria carrying this gene can be detected. [1]

Gene	lacZ gene / β-galactosidase gene
Detection	bacterial colonies turn blue on X-GAL agar
	green fluorescent protein gene
	bacterial colonies fluoresce green under UV light
	luciferase gene
	bacterial colonies emit light on luciferin agar

[Total: 10]

Section B
Answer all questions

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be in set out in questions (a), (b), etc., as indicated in the question.

QUESTION 5

a) DNA molecules replicate with a high degree of accuracy, yet not always perfectly.

Describe how this occurs and discuss why the survival of a species depends on DNA molecules being stable, yet not *absolutely* stable. [10]

[How DNA replication takes place accurately] – max 3

1. DNA is **double-stranded**, each strand is **complementary** to the other
2. Each strand acts as the **template** for synthesis of daughter strand by **complementary base pairing** (A=T, C≡G)
3. **DNA polymerase III** with **proofreading function** / 3'→5' exonuclease activity
4. Able to excise previous nucleotide that is wrongly paired and replace with the correct nucleotide
5. DNA polymerase I with proofreads newly-synthesized daughter strand / 5'→3' exonuclease activity

[Why DNA replication is not always perfect] – max 3

6. Exposure to radiation / chemical carcinogens / AVP
7. Causes structural damage to DNA + *cite an example below*
   a) e.g. UV light causes thymine dimer formation
   b) e.g. chemicals (such as nitrous acid) chemically reacts with base
   c) e.g. ethidium bromide intercalates into DNA
8. Such structural damage causes wrong nucleotide(s) / extra nucleotide(s) / missing nucleotide(s) to be added during DNA replication.
9. Spontaneous mutation – DNA polymerase adds the wrong base, and is not being rectified.

[Why survival of offspring depends on DNA being stable] – max 2

10. *Idea that* Ensures sequence of DNA in genes is intact so that (normal amount of) functional proteins can be made
11. *Idea that* Mutation results in non-functional / hyperactive / overproduction / underproduction of proteins
12. *Ref to* Sickle-cell anemia – Single-base substitution to β-globin gene that causes Hb to crystallize, forming sickle-cell RBC which clogs blood vessels / inefficient O_2 transport
13. *Ref to* Cancer – a result of gain-of-function mutation to **proto-oncogenes** and loss-of-function mutation **tumor-suppressor genes**, leading to **uncontrolled cell division**.

[Why survival also depends on DNA being not *absolutely* stable] – max 2

14. Ref. to role of mutation in natural selection
    a. Mutations allow for **formation for new alleles**
    b. Provides **variation** between individuals in a population to allow the population to **respond to environmental change**
    c. Survival of the fittest to allow population to evolve, hence **prevents extinction** of a species

b) Explain the underlying principles of the polymerase chain reaction (PCR) **and** explain how the specificity of PCR is achieved. [5]

[Underlying principles in PCR] – max 4

1. **Amplify** a segment of DNA from a very **minute amount**

[Denaturation step]

2. Use of **high heat (95°C)** to **denature template DNA** into single-stranded DNA by **breaking hydrogen bonds** between **complementary bases**.

[Annealing step]

3. Use of **DNA primers** to provide a **free 3'-OH end** for *Taq* polymerase in the elongation step.

[Elongation step]

4. Use of **thermostable *Taq* polymerase** which **does not denature at high temperatures**
5. At its optimal temperature at **72°C**, it catalyses the addition of **deoxyribonucleotides** to **3' end of primers** by forming **phosphodiester bond**

6. **Thermostable polymerase** and **excess primers and deoxyribonucleotides** allows PCR to be **automated** over many cycles.

[How the specificity of PCR is achieved] – max 1

7. Sequence of DNA primers is **complementary** to the **3' regions** of the sequence to be amplified

8. Length of primers must be **sufficiently long** (15-25 nucleotides) to ensure it binds only to target region

c) Describe the process of endocytosis.
[5]

[Phagocytosis]

1. The cell surface membrane extends **pseudopodia** / **cytoplasmic extensions** around it the particle.

2. The pseudopodia **fuse** to form a large vacuole around the particle, known as a **phagocytic vesicle**.

[Pinocytosis]

3. Process whereby a cell **invaginates** a region of the cell surface membrane, forming a **vesicle** around a small volume of **extracellular fluid.**

[Receptor-mediated endocytosis]

4. Process by which a cell can acquire **specific** molecules, even those that may be in low concentrations in the extracellular fluid.

5. The specific molecules bind to complementary **protein receptors** embedded on the cell surface membrane.

6. After binding, the receptor proteins cluster in regions of the membrane called **clathrin-coated pits**, which are lined on their cytoplasmic side by a layer of coat proteins

7. Each coated pit forms a **vesicle** containing the ligand molecules.

8. After the ligand molecules are released from the vesicle, the vesicle (and receptors) is then recycled to the cell surface membrane.

QUESTION 6

a) Discuss the importance of hydrogen bonding in ensuring the continuity of life. [10]

[Role of H-bonds between complementary base pairs]

1. Allows **complementary base pairing** to occur in **nucleic acid interactions**

[DNA]

2. Stabilizes two DNA strands to form **double helical** DNA molecule

3. ***Ref. to*** role of DNA (e.g. storing genetic information)

[tRNA]

4. Intra-molecular hydrogen bonding in tRNA allows tRNA to fold into a **clover-leaf structure**

5. ***Ref. to*** role of tRNA – carries amino acids to the ribosome for synthesis of polypeptide

[rRNA]

6. Intra-molecular hydrogen bonding in rRNA allows rRNA to fold into a **precise 3D structure** to **complex with ribosomal proteins** to form ribosome

7. ***Ref. to*** role of ribosome – translation machinery

[During DNA replication]

8. Important in DNA replication, where daughter DNA strand is synthesized via adding **complementary deoxyribonucleotides** to template DNA to ensure **accurate transmission** of genetic information.

[During transcription]

9. Important in transcription, where RNA is synthesized via adding **complementary ribonucleotides** to template DNA

[During translation]

10. Important in translation, where **codons** on mRNA complementary base pair with **anticodon** on tRNA to ensure **correct sequence of amino acids** forms the polypeptide

[Role in maintaining protein structure]

11. ***Ref. to*** maintaining **secondary** structures (**α-helices** and **β-pleated sheets**) in proteins, formed **between peptide regions**.

12. ***Ref. to*** maintaining **tertiary/quaternary** structure of proteins, formed **between R groups**.

13. ***Idea that*** **Shape** of proteins **dictates their specific functions** (e.g. in DNA replication and gene expression)

[Role in enzyme-substrate interaction]

14. ***Ref. to*** allow substrate to bind weakly to the active site of enzyme

[Role in solubility]

15. ***Ref. to*** allows hydrophilic substances to be soluble in aqueous environment to allow reaction to take place

16. ***AVP***

b) Outline the functions of membranes **within** cells. [5]

1. Form compartments (**compartmentalization)** within the cell (i.e. formation of organelles).

2. This allows the maintenance of optimal conditions for **specialized biochemical reactions** to occur.

   a) E.g. nuclear membrane: encloses DNA and allows DNA replication and transcription to occur
   b) E.g. Compartmentalization of lysosome keeps the **lysosomal lumen at pH 5** (optimal pH for lysosomal acid hydrolases).
   c) E.g. RER membrane being site of ribosome attachment for translation to take place and provide correct environment for protein folding
   d) **AVP**

3. **Attachment of specific proteins/enzymes** within organelle membrane allows enzyme-catalysed chemical reactions to take place in a **sequential manner** in a metabolic pathway

   a) E.g. photophosphorylation in the thylakoid membrane of chloroplast
   b) E.g. Oxidative phosphorylation in the inner mitochondrial membrane

4. Membranes are required for the **formation of transport vesicles** during intracellular transport.

   a) E.g. ER vesicles – transport proteins to Golgi for modification
   b) E.g. Golgi vesicles – transport proteins to their destination e.g. secretion, plasma membrane, other organelles.

5. **AVP**

c) With reference to specific examples, discuss the roles of coenzymes in yeast. [5]

[NAD]

1. NAD **oxidizes intermediates** of the **glycolysis**, **Link reaction**, and **Krebs cycle**, forming **NADH**.
2. *[A specific example of oxidation step in glycolysis / Krebs cycle that requires NAD]*

[FAD]

3. FAD **oxidizes intermediates** of the **Krebs cycle**, forming **$FADH_2$**.
4. *[A specific example of oxidation reaction in Krebs Cycle requires FAD]*

[NAD & FAD]

5. **Both NADH and $FADH_2$** acts as **electron donor** in **oxidative phosphorylation**…
6. …where they **donate electrons to the electron transport chain** and is **oxidized to NAD and FAD**.

[Coenzyme A]

7. In **link reaction** of respiration**, coenzyme A** combines with 2C compound/acetyl group to produce **acetyl CoA…**
8. **…** which then enters and is **oxidized** in the **Krebs cycle.**

[Total: 20]

Class Adm No

Candidate Name: ____________________

Class	Adm No

H

millennia institute

2017 Promotional Examination II
Pre-university 2

Biology Higher 1 **8875/01**

18 September 2017

1 hour

Additional Materials: Optical answer sheet

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, Adm No. and class on all the papers you hand in.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Paper 1
There are **thirty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.

Calculators may be used.

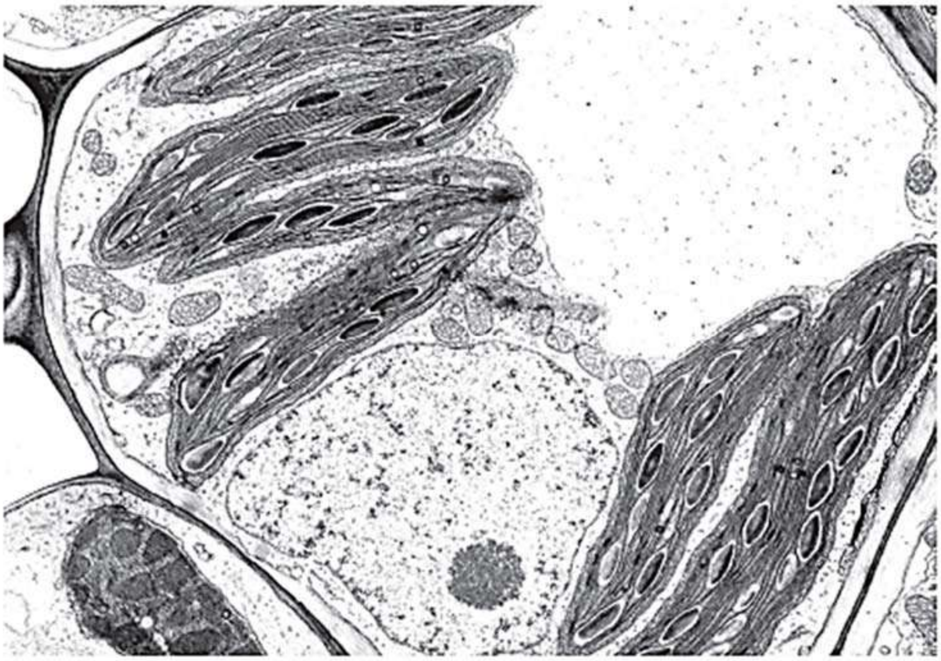
Answer **all** questions

1. A student was tasked to observe a root hair cell using an electron microscope. He was asked to confirm the presence or absence of the cellular structures within the root hair cell.

Which option best describes his observations?

	Structure with a double membrane, inside which are stacks of flattened membranes	Area near the nucleus containing a pair of structures that are composed of microtubules	Structure with a double membrane with inner membrane infolded	Network of tubular-shaped membranous sacs with no ribosomes visible on outer surface of membranes
A	Present	Present	Present	Absent
B	Present	Absent	Absent	Present
C	Absent	Present	Present	Present
D	Absent	Absent	Present	Present

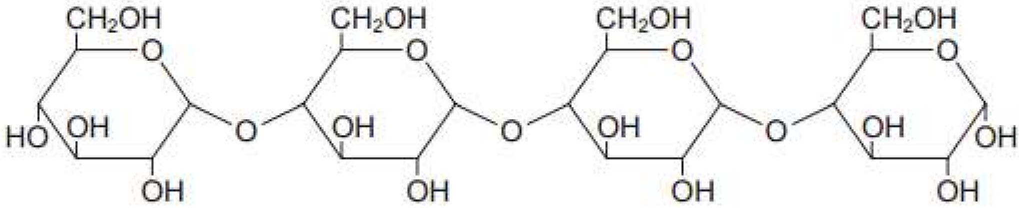
2. The magnification of this electron micrograph is 5000X.



What is the actual size of the nucleolus?

A 0.2 µm
B 0.5 µm
C 2 µm
D 20 µm

3. The diagram shows a section of the starch molecule.

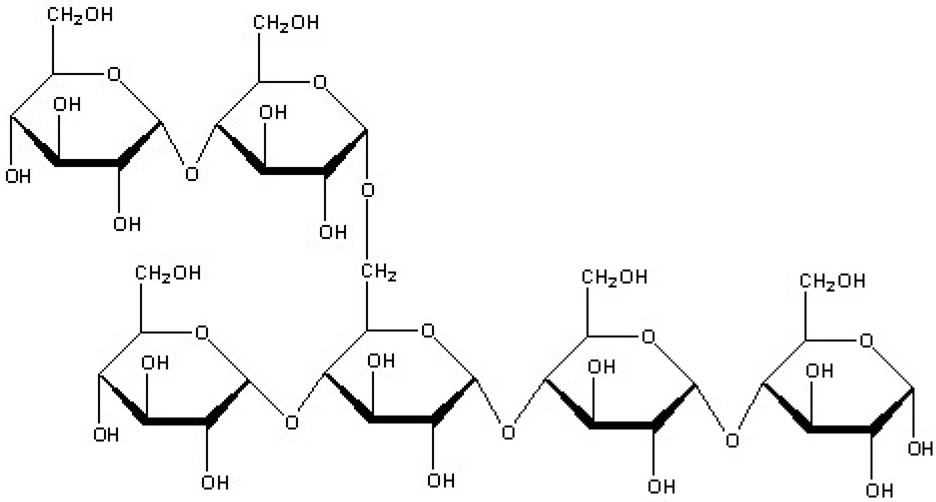


Which of the following procedures could be performed in order to test for the presence of the reducing sugars in amylose?

I add amylase and then heat with Benedict's reagent
II add maltase and then heat with Benedict's reagent
III boil with ethanol and then heat with Benedict's reagent
IV boil with hydrochloric acid, neutralise and then heat with Benedict's reagent

A I and IV only
B II and IV only
C II and III only
D I, II and IV only

4. The diagram shows part of a polysaccharide.



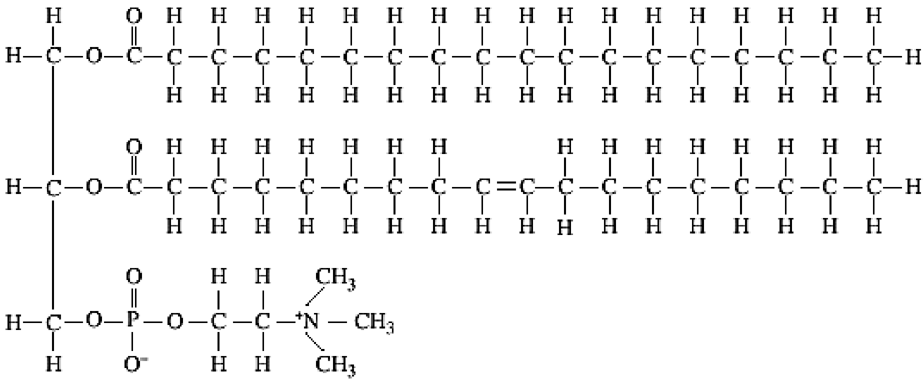
#

If all the glycosidic bonds in this molecule are hydrolysed, how many water molecules will be used and how many separate glucose molecules will be produced?

#

	Number of water molecules used	Number of glucose molecules produced
A	1	0
B	4	5
C	4	6
D	5	6

5. The diagram shows a lipid molecule.

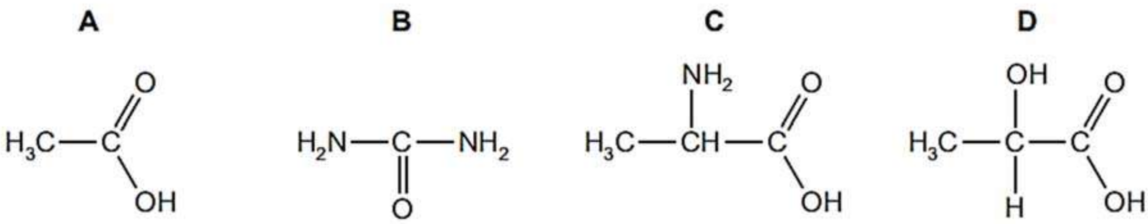


Which option best describes the products of hydrolysis?

A One molecule of glycerol and one molecule of saturated fatty acid
B One molecule of glycerol and two molecules of saturated fatty acid
C One molecule of glycerol, an unsaturated fatty acid molecule and one molecule of saturated fatty acid
D One molecule of glycerol and two unsaturated fatty acid molecules

6. The diagram shows different biomolecules present in a plant cell.

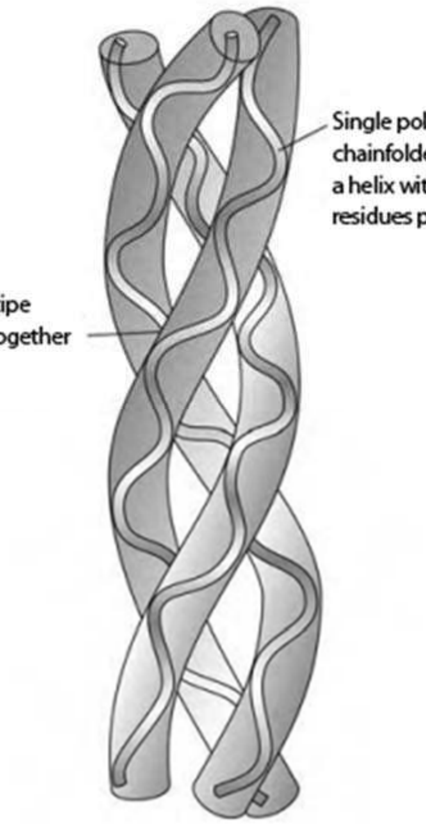
Which molecule is an essential component of Rubisco that are necessary for photosynthesis?



7. How many different types of penta-peptides could be formed using the 20 commonly known amino acids?

A 5^4
B 20^5
C 5^{20}
D 20^4

8. The diagram shows a fibrous protein that is commonly found in connective tissues of mammals.



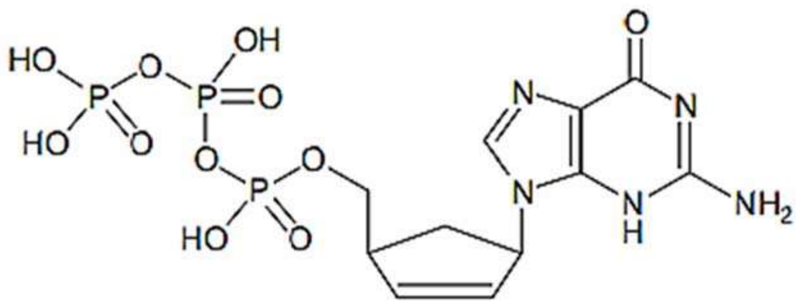
Which statement best describes the fibrous protein?

A The small size of the R-groups of amino acid residues in each chain allows the chains to come close together to form hydrogen bonds.
B Hydroxyl groups projecting in all directions from each chain allow hydrogen bonds to form and result in bundling of the chains to form microfibrils.
C Double bonds present in each chain allow the chains to adopt helical structure.
D Complementary base pairing occurs through the formation of hydrogen bonds between chains.

9. Which statement correctly describes the globular protein that is responsible for the oxygen-carrying capacity of the red blood cells?

A The protein comprises four polypeptide chains and each polypeptide chain contains a prosthetic group of amino acids surrounding an iron ion.
B The protein comprises four polypeptide chains with non-polar R groups of the amino acid residues projected towards the centre within each subunit.
C The protein can carry a total of four oxygen atoms.
D The iron ion in the prosthetic group of each subunit combines irreversibly with oxygen.

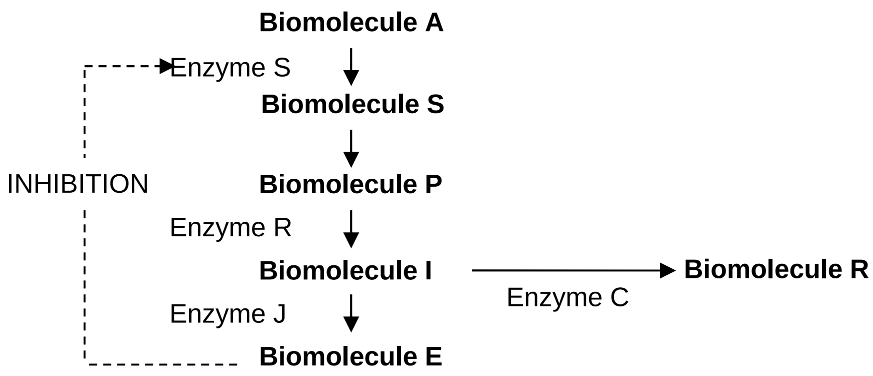
10. The diagram shows the molecular structure of compound X that can inhibit RNA polymerase. It is an analogue of a naturally occurring nucleic acid monomer.



Which statement is true about compound X?

A Compound X is a non-competitive inhibitor.
B Increasing concentration of the naturally occurring monomer cannot reverse the inhibition by compound X.
C The naturally occurring monomer contains a purine base.
D The naturally occurring monomer contains a pyrimidine base.

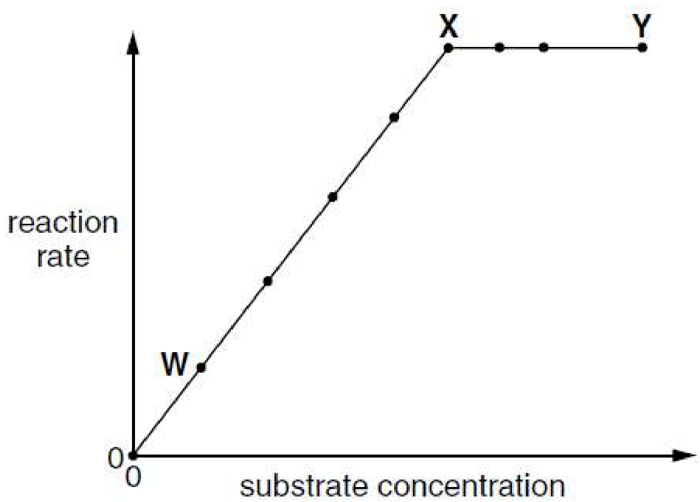
11. A hypothetical metabolic pathway is shown in figure below.



Which changes in enzyme activity will result in the greatest increase in the yield of Biomolecule **R**?

	Enzyme	Change in activity	Enzyme	Change in activity
A	S	Decrease	J	Decrease
B	C	Decrease	R	Increase
C	J	Increase	C	Increase
D	R	Increase	J	Decrease

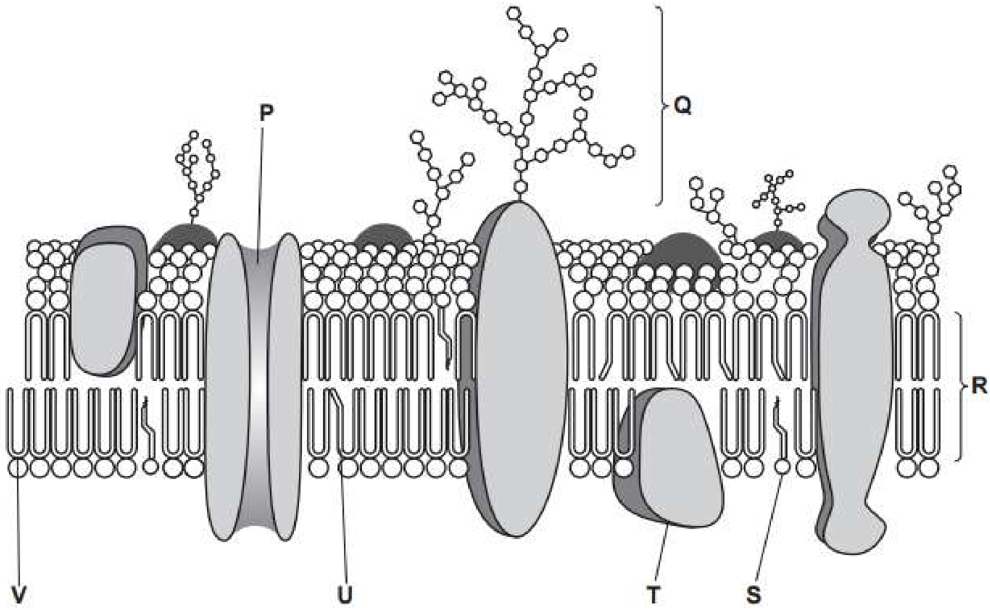
12. The graph shows the effect of substrate concentration on the rate of decomposition of hydrogen peroxide. The catalase concentration is keep constant.



Which statement about the graph is correct?

A Between **X** and **Y**, the number of enzyme molecules is limiting.
B Between **W** and **X**, the number of enzyme molecules is limiting.
C Between **X** and **Y**, the number of substrate molecules is limiting.
D Between **X** and **Y**, the product concentration remains the same.

13. The diagram shows a section through a cell surface membrane from a pancreatic beta cell.



The cell surface membrane of a phagocytic cell has a higher fluidity compared to the pancreatic beta cell.

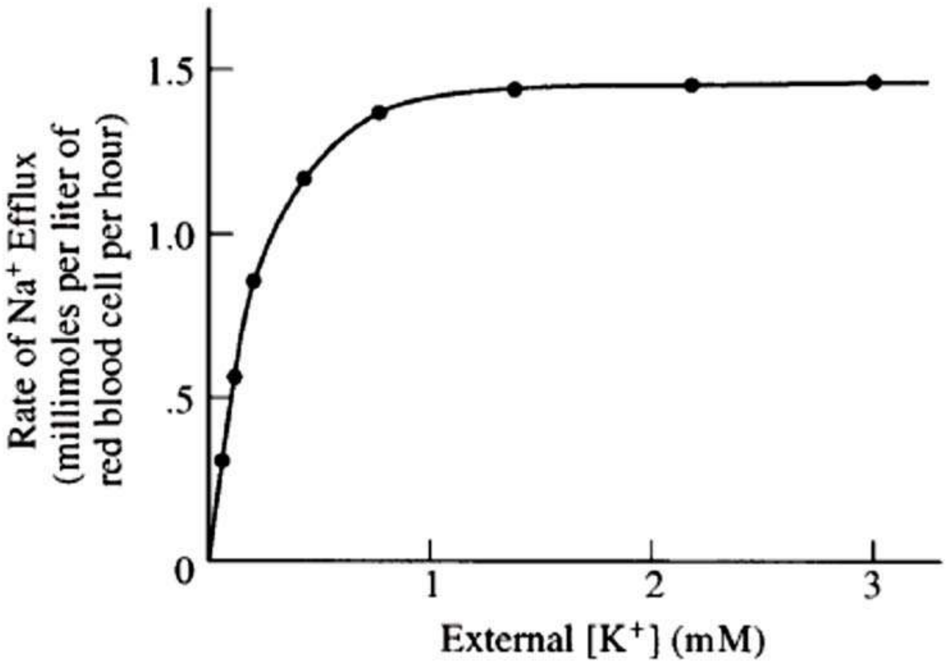
What is the most likely difference that will be observed between a phagocytic cell and pancreatic beta cell?

A Higher proportion of component **U** and a lower proportion of component **V**
B Higher proportion of component **S** and a higher proportion of component **T**
C An increased distance across **R** and a higher proportion of component **V**
D Complete absence of component **Q** and a higher proportion of component **P**

14. A student wanted to investigate the rate of efflux of sodium ions in mammalian cells. A freshly isolated population of mammalian cells was rapidly loaded with radioactive sodium and then subdivided into equally sized samples.

The samples were incubated in isotonic solution containing 10mM sodium chloride and varying concentrations of potassium chloride. The other variables were kept constant throughout this experiment.

The graph depicts the relationship between the rates at which sodium ion left the cells and the extracellular potassium ion concentration.



Which statement best accounts for the plateau in the rate of sodium ion efflux at about 1.0 mM external potassium ion concentration?

A Potassium ions occupy all the potassium-binding sites on the sodium-potassium pumps.
B Potassium ions compete with sodium ions for transport.
C Potassium ions make the membrane impermeable to sodium.
D Potassium ions bind ATP and thereby lowering the substrate concentration.

15. The table below shows the number of chromosomes in each gamete after meiosis and cytokinesis have taken place in two different human germ cells.

Gametes I-IV were formed from human germ cell **X**, whereas gametes V - VIII were formed from human germ cell **Y**.

Human germ cell **X**		Human germ cell **Y**	
Gametes	**Number of chromosomes**	**Gametes**	**Number of chromosomes**
I	22	V	23
II	24	VI	23
III	24	VII	22
IV	22	VIII	24

Which description is consistent with the data shown in the table above?

A Non-disjunction occurs for all 23 pairs of homologous chromosomes in germ cell **X**.

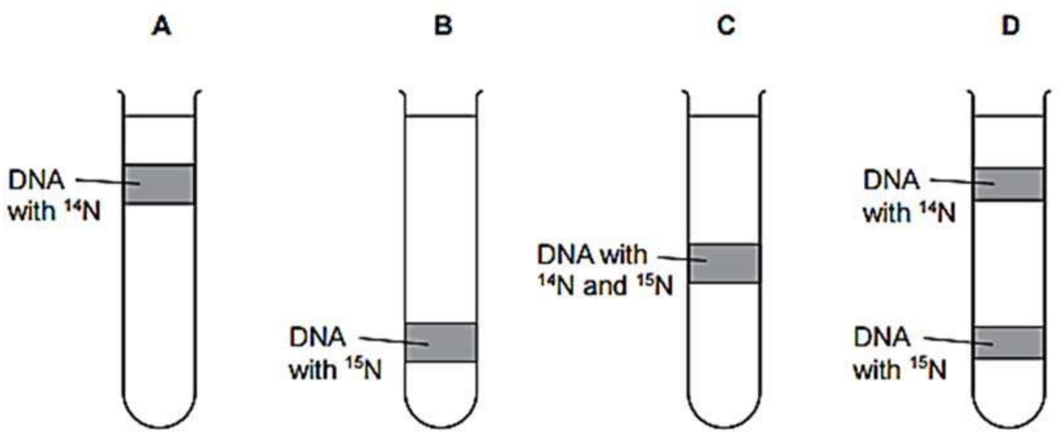
B Non-disjunction occurs for a pair of chromatids during anaphase II in germ cell **X**.

C Centromere of a pair of chromatids failed to divide during anaphase II in germ cell **Y**.

D A pair of homologous chromosomes fail to separate during anaphase I in germ cell **Y**.

16. Escherichia coli were originally grown for many generations in a medium containing a heavy isotope of nitrogen, ^{15}N. They were then transferred to a medium containing the light isotope of nitrogen, ^{14}N.

Which option shows the correct predicted results after the cells are allowed to divide once in the medium with the light isotope?



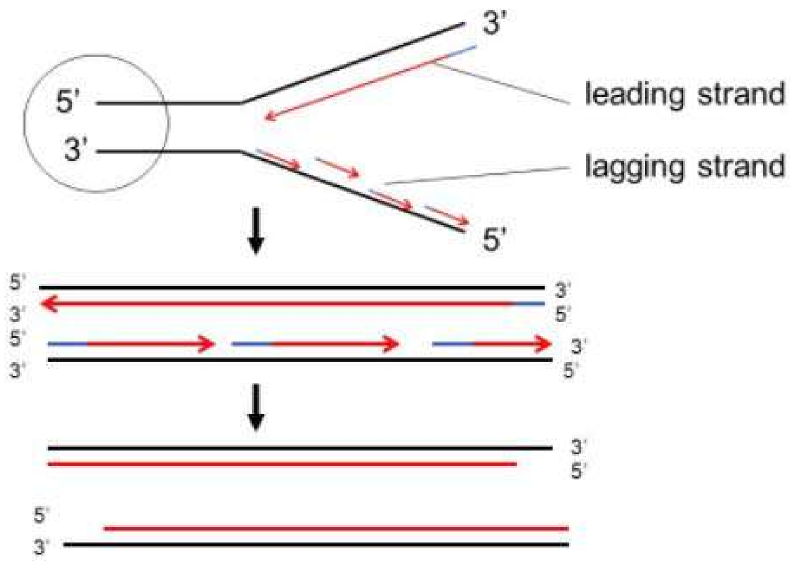
17. The following events occur during transcription.

I Bonds break between complementary bases.
II Bonds form between complementary bases.
III Sugar-phosphate bonds form.
IV Free ribonucleotides pair with complementary nucleotides.

Which events would have occurred twice before the mRNA leaves the nucleus?

A I and II only
B I, III and IV only
C II, III and IV only
D All of the above

18. The diagram illustrates the end-replication problem during DNA replication.



Which statements are **false** about end-replication problem of DNA?

I When a linear DNA molecule replicates, a gap is left at the 3' end of each new strand because DNA polymerase can only add nucleotides to a 5' end.
II Repeated rounds of replication produce shorter and shorter DNA molecules.
III Telomerase prevents the end-replication problem from occurring.
IV Prokaryotes do not have the end-replication problem.

A I and II only

B I and III only

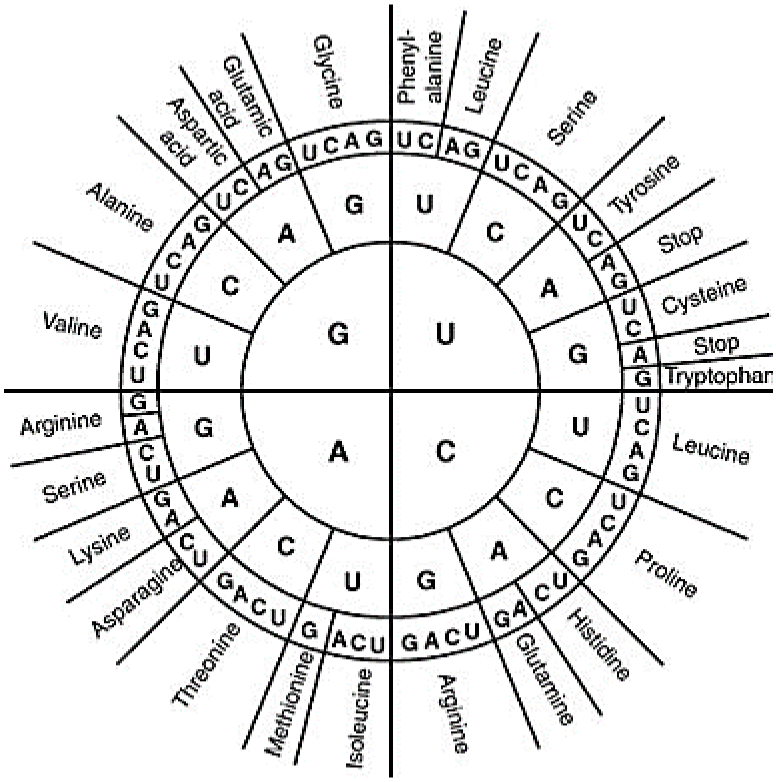
C II and III only

D III and IV only

19. Five different amino acids form the following sequence in a section of the polypeptide chain X:

Aspartic acid--Histidine--Glutamine--Cysteine--Histidine--Lysine--Aspartic acid

The diagram below shows the mRNA codon code.



What is the DNA base sequences in the template strand of the gene coding for the given section of X?

A 3’ CTAGTGGTTACAGTGTTGCTA 5’
B 3’ CTAGTGGTTACAGTGTTCCTA 5’
C 3’ CTAGTGGTTTCTGTGTTGCTA 5’
D 3’ CTAGTGGTTACAGTGTTCCTT 5’

20. The sequence below shows an mRNA segment produced from a gene section bearing one point mutation.

5'-ACCGUAGCAGCU-3'

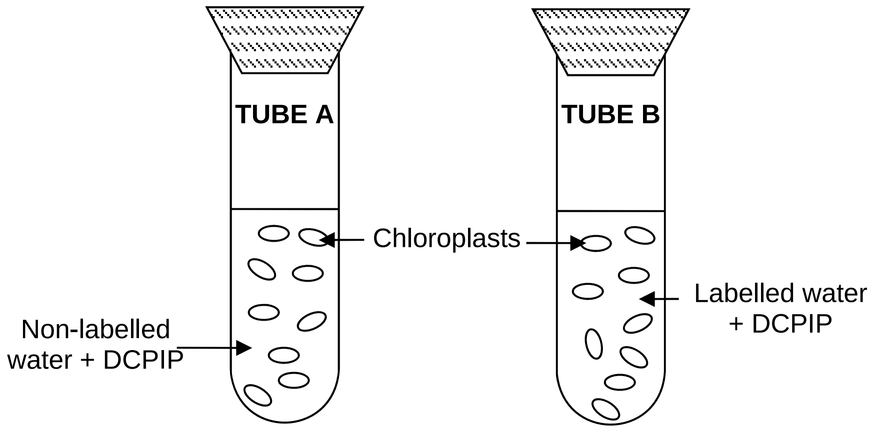
What is the sequence of the corresponding DNA coding strand prior to the mutation?

A 5'-AGCTGCTACGGT-3'
B 5'-ACCGTAGCAGCT-3'
C 5'-ACCGGAGCAGCT-3'
D 5'-AGCTGCTCCGGT-3'

21. The experimental setup below is used to investigate the light-dependent reaction of photosynthesis. Chloroplasts are placed in test tubes containing ^{18}O-labeled water ($H_2{}^{18}O$) and non-labeled water ($H_2{}^{16}O$) respectively.

A few drops of DCPIP, a proton acceptor, are added to each test-tube. DCPIP will decolourise when it is reduced. This colourless DCPIP can be reoxidised to blue.

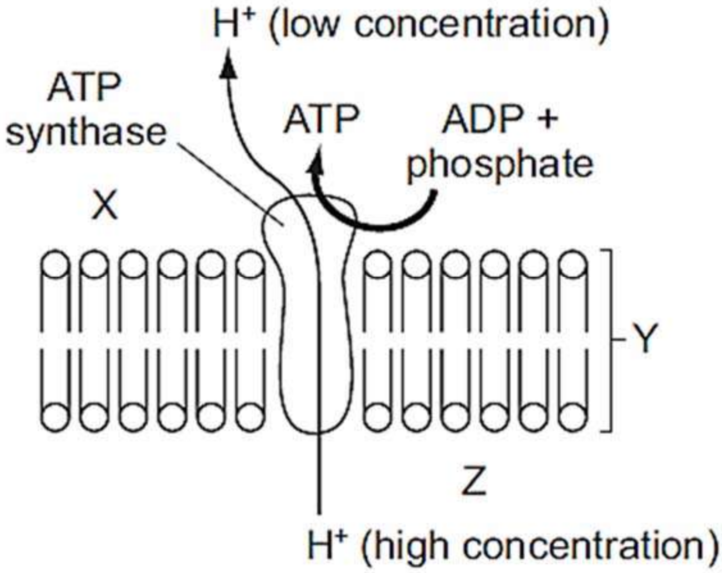
Both test tubes are exposed to light for 20 minutes.



Which row correctly identifies the results of the two test tubes at the end of the experiment?

	TUBE A		TUBE B	
	Gas evolved	**DCPIP colour**	**Gas evolved**	**DCPIP colour**
A	$^{16}O_2$	Colourless	$^{18}O_2$	Colourless
B	$^{16}O_2$	Blue	$^{16}O_2$	Colourless
C	$^{16}O_2$	Colourless	$^{16}O_2$	Colourless
D	$^{16}O_2$	Blue	$^{18}O_2$	Blue

22. The diagram shows a membrane in a eukaryotic cell.



Which statement would be true of the diagram?

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

B Y is the thylakoid membrane, Z is the cytosol and the diagram shows ATP synthesis in a chloroplast.

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

D X is the intermembrane space, Y is the inner mitochondrial membrane and the diagram shows ATP synthesis in a chloroplast.

23. A student set up six different test tubes containing animal tissue preparation to investigate different aspects of respiration. The test tubes are then incubated at optimal conditions.

The set-ups are shown below.

Tube	Contents
1	Glucose + homogenised cells
2	Glucose + mitochondria
3	Glucose + cytoplasm lacking organelles
4	Pyruvate + homogenised cells
5	Pyruvate + mitochondria
6	Pyruvate + cytoplasm lacking organelles

Which test tubes would produce carbon dioxide?

A 1, 2 and 3 only
B 1, 4 and 5 only
C 2, 4 and 6 only
D 4, 5 and 6 only

24. In *Drosophilia melanogaster*, the loci for the recessive allele for curly wings and the recessive allele for hairy bristles are located on different chromosomes.

A pure-breeding fly with wild-type wings and wild-type bristles is crossed with a fly with curly wings and hairy bristles. The F1 generation all had wild-type wings and wild-type bristles. Two of the F1 were crossed and produced 416 offspring.

Which row correctly identifies the numbers of each phenotype in the F2 generation?

	Phenotype			
	Wild-type wings Wild-type bristles	Wild-type wings Hairy bristles	Curly wings Wild-type bristles	Curly wings Hairy bristles
A	226	46	44	100
B	312	0	0	104
C	338	0	0	78
D	232	78	82	24

25. Mr and Mrs Li, who are homozygous for blood type A and blood type B respectively, have a son with blood group AB and haemophilia. Neither parent has haemophilia.

What is the probability that the second child of these parents will be a girl with blood group AB and no haemophilia?

A 1
B 1 in 2
C 1 in 4
D 1 in 8

26. Which statement(s) correctly describe(s) Darwinian evolutionary theory?

I Advantageous traits acquired during the lifetime of an individual is likely to be inherited.

II In competition for survival, the more aggressive animals always survive better.

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

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

A IV only

B II and III only

C III and IV only

D I, II and IV only

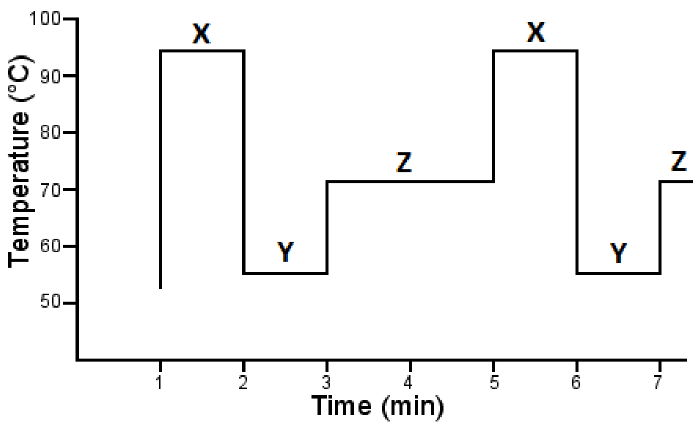
27. Two areas of molecular biology that have received considerable attention in evolutionary studies are the genetic code and cytochrome C. Cytochrome C is an essential component of all respiratory electron transport chains.

Which statements lend evidence to support the ideas that all living organisms are related and there is a single, rather than multiple, origin of life?

I The almost universal nature of the genetic code is a result of evolutionary convergence from multiple lineages.
II The sequence of amino acids in cytochrome C is similar in organisms that are from similar environments or with similar metabolic demands.
III Majority of living organisms on earth have the same, or similar, amino acid sequences for cytochrome C.
IV When transferred into a very dissimilar organism, a gene coding for cytochrome C will lead to the expression of a protein that will function in the other organism.

A I and II only
B II and III only
C III and IV only
D I, III and IV only

28. The diagram below shows the changes in temperature in a thermal cycler over time during polymerase chain reaction.



Which statements are true of the graph shown above?

I Elongation of new strands occurs during **Y**.
II Double stranded DNA template denatures into single strands during **X**.
III Taq polymerase functions optimally at **Z**.
IV DNA primers are annealed to the DNA template during **X**.

A I and IV only
B II and III only
C II and IV only
D I, II and III only

29. The human genome project (HGP) was successfully completed on 14 April 2003. HGP was an international scientific research project with the goal of determining the sequence of nucleotide base pairs that make up human DNA, and of identifying and mapping all of the genes of the human genome from both a physical and a functional standpoint.

Several ethical concerns on HGP were raised by the public and scientific community

Which statement is **not** an ethical concern of the HGP?

A Anxiety may arise in patients when genetic testing is conducted for diseases with no medical treatment currently available.
B If genetic sequences are patented, it will increase the cost of genetic research and treatment.
C Mankind is tampering with nature when the human genome is modified.
D The use of genetic test results may lead to discrimination of individuals by insurance companies and employers.

30. Stem cells are found in many tissues that require frequent tissue replacement such as the skin, the intestine or the blood.

However, within their own environments, a bone marrow cell cannot be induced to produce a skin cell and a skin cell cannot be induced to produce a bone marrow cell.

Which statement explains this?

A Different stem cells have only the genes required for their particular cell line.

B Genes not required for a particular cell line are methylated.

C Genes not required for a particular cell line are removed using restriction enzymes.

D mRNA that is not required for a particular cell line is destroyed.

End of Paper

#

Class Adm No

Candidate Name: ________________________________

H

millennia institute

2017 Promotional Examination II
Pre-university 2

Biology Higher 1 **8875/01**

18 September 2017

1 hour

Additional Materials: Optical answer sheet

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, Adm No. and class on all the papers you hand in.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Paper 1
There are **thirty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.

Calculators may be used.

This question paper consists of 22 printed pages including 1 blank page.

1	D
2	C
3	A
4	D
5	C
6	C
7	B
8	A
9	B
10	C
11	D
12	A
13	A
14	A
15	C
16	C
17	A
18	B
19	B
20	C
21	A
22	C
23	B
24	D
25	B
26	A
27	C
28	B
29	C
30	B

#

Class	Adm No

Candidate Name: ________________________________

H

millennia institute

2017 Promotional Examination II
Pre-University 2

H1 Biology **8875/02**

Paper 2 **12 September 2017**

Additional material: writing papers **2 hours**

READ THESE INSTRUCTIONS FIRST

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

Write your Admission number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the space provided in the question paper.

Section B
Answer **any one** question in the writing papers provided.

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

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
Total	

For Examiner's Use

Answer **all** questions in this section.

1. Measurement of cellular DNA content and the analysis of the cell cycle can be performed by flow cytometry. The DNA content of retinal cells of zebrafish is analysed and Fig. 1.1 show the number of cells at different stages of the cell cycle.

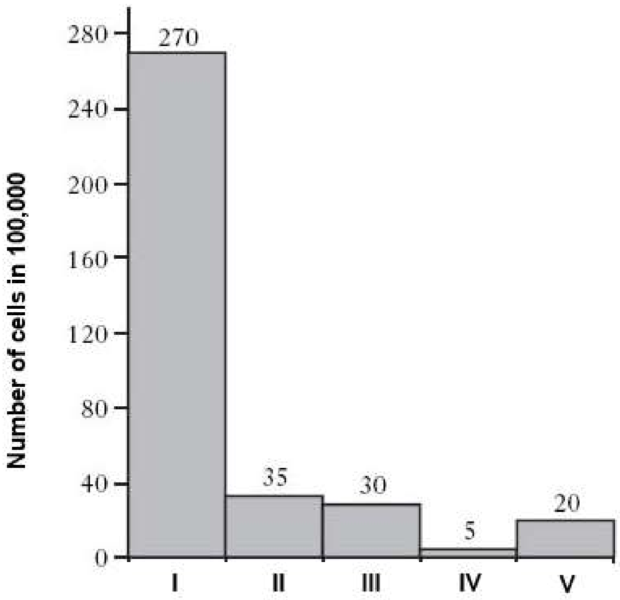


Fig. 1.1

(a)

(i) Identify which stage (**I** to **V**) correspond to interphase.

……………………………………………………………………………………**[1]**

(ii) Suggest a reason for your answer in **(a)(i).**

……………………………………………………………………………………

……………………………………………………………………………………**[1]**

(iii) Explain the importance of DNA replication before mitosis.

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……………………………………………………………………………………**[2]**

Fig. 1.2 shows the electronmicrographs of three zebrafish retinal cells (**A** to **C**). Each cell is undergoing a different stage of mitosis.

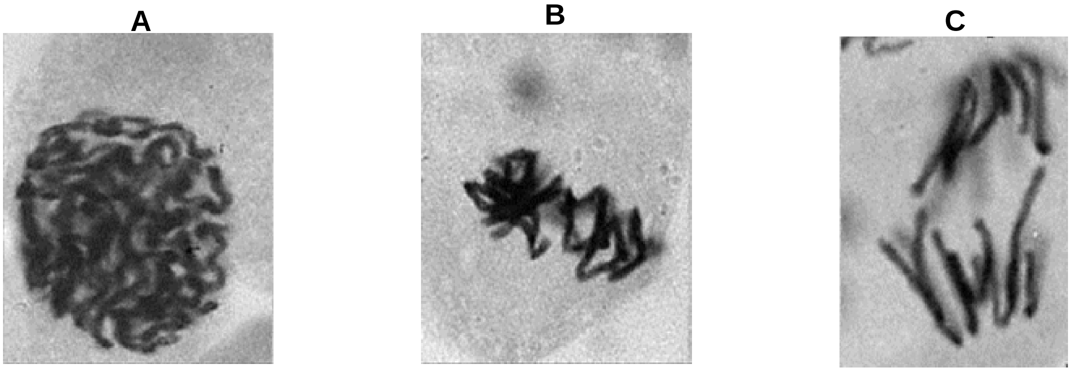

Fig. 1.2

(b)

(i) Identify stages of mitosis that cell **A** and **B** is undergoing.

……………………………………………………………………………………**[1]**

(ii) State the visible features in cell **A** and **B** that enabled your identification in **(b)(i)**.

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……………………………………………………………………………………**[2]**

Fig. 1.3 shows the changes in the DNA amount during the meiotic cell cycle of the germ cells in zebrafish.

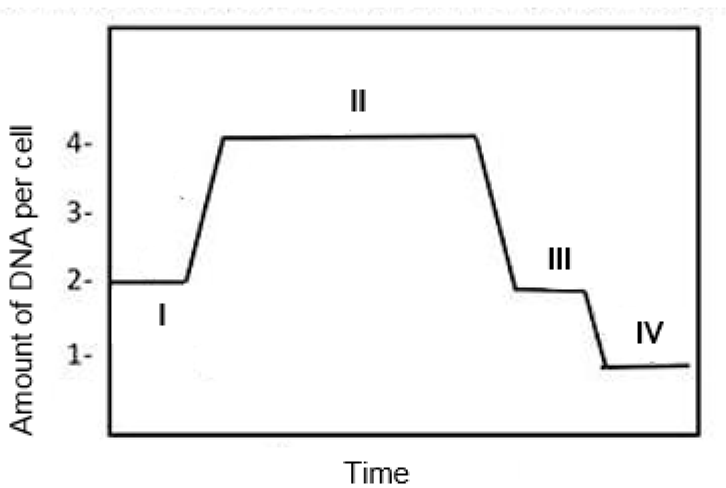

Fig. 1.3

(c) With reference to Fig. 1.3, explain the changes in DNA amount from stage **II** to **IV**.

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…………………………………………………………………………………………….**[3]**

[Total: 10]

2. In recent years, numerous biochemical and genetic studies have demonstrated that peptide signalling plays a greater than anticipated role in various aspects of plant growth and development. A substantial proportion of these plant peptides are secretory and act as local signals mediating cell-to-cell communication.

Fig 2.1 and Fig. 2.2 show two different membrane-bound organelles found in shoot apical meristematic cells.

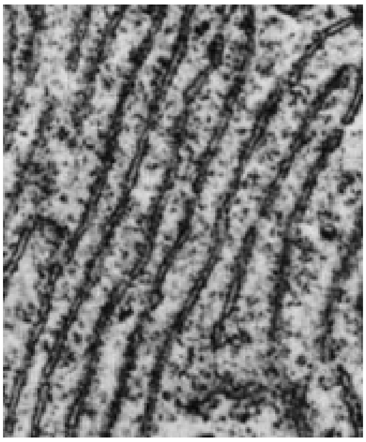

Fig 2.1

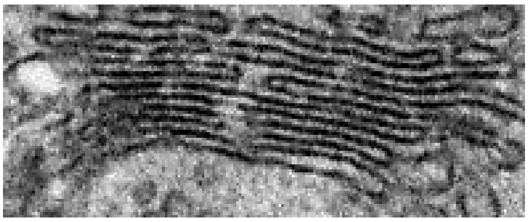

Fig. 2.2

(a) Describe how the two organelles in Fig 2.1 and Fig. 2.2 work together in the production and secretion of plant peptides.

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………………………………………………………………………………………………**[3]**

For Examiner's Use

Fig. 2.3 shows the process of protein synthesis that takes place on the organelle shown in Fig. 2.1.

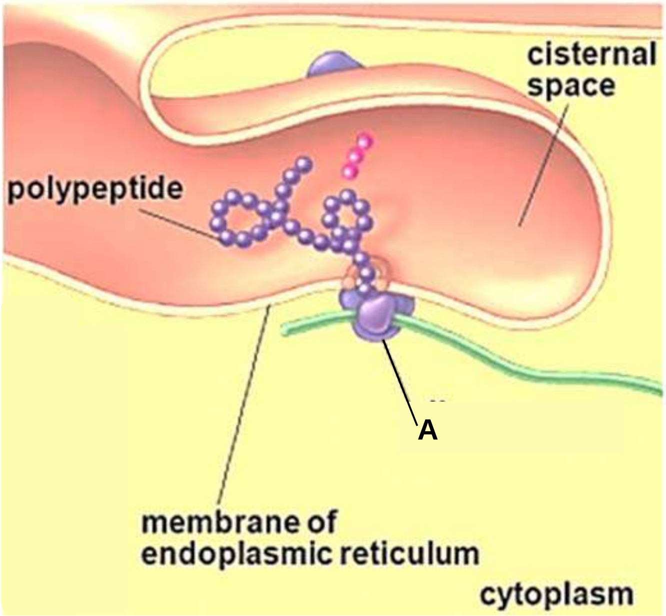

Fig. 2.3

(b) Describe how the structure of **A** is adapted to its role in the process shown in Fig. 2.3.

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……………………………………………………………………………………………**[3]**

Fig. 2.4 shows the role of tRNA in the process of protein translation while Fig. 2.5 shows the genetic code in terms of the mRNA codons sequence.

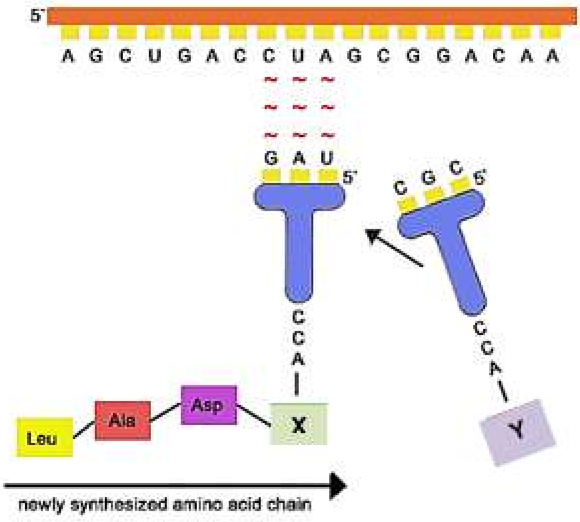

Fig. 2.4

Second Letter

1st letter	U		C		A		G		3rd letter
U	UUU	Phe	UCU		UAU	Tyr	UGU	Cys	U
	UUC		UCC	Ser	UAC		UGC		C
	UUA	Leu	UCA		UAA	Stop	UGA	Stop	A
	UUG		UCG		UAG	Stop	UGG	Trp	G
C	CUU		CCU		CAU	His	CGU		U
	CUC	Leu	CCC	Pro	CAC		CGC	Arg	C
	CUA		CCA		CAA	Gln	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU		ACU		AAU	Asn	AGU	Ser	U
	AUC	Ile	ACC	Thr	AAC		AGC		C
	AUA		ACA		AAA	Lys	AGA	Arg	A
	AUG	Met	ACG		AAG		AGG		G
G	GUU		GCU		GAU	Asp	GGU		U
	GUC	Val	GCC	Ala	GAC		GGC	Gly	C
	GUA		GCA		GAA	Glu	GGA		A
	GUG		GCG		GAG		GGG		G

Fig. 2.5

(c) With reference to Fig. 2.4 and Fig. 2.5, identify amino acid **X** and **Y**.

X: ……………………………

Y: …………………………… **[1]**

[Turn over

For Examiner's Use

The palisade mesophyll cells of plant contain numerous chloroplasts. Fig. 2.6 shows an electron-micrograph of a chloroplast in plant cell.

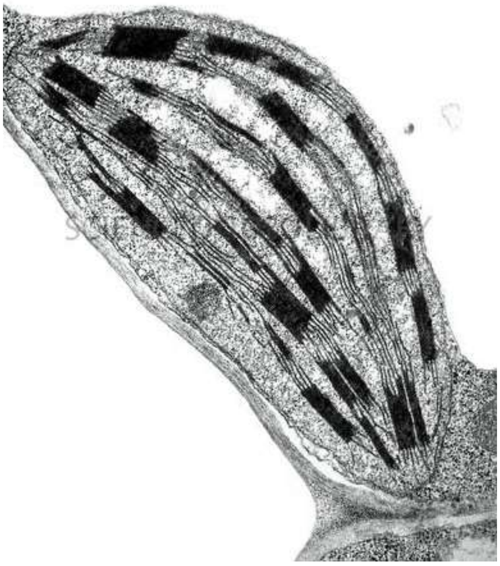

Fig. 2.6

(d) Draw an arrow and label the structure where light-dependent reactions occurs in the chloroplast. **[1]**

The rate of decolourisation of DCPIP in the Hill Reaction is a measure of the rate of the light-dependent stages of photosynthesis. DCPIP, a blue dye, acts as an electron acceptor and becomes colourless when reduced, allowing any reducing agent produced by the chloroplasts to be detected.

A suspension of chloroplasts was made by grinding fresh leaves in buffer solution and centrifuging the mixture. Tubes were then prepared and treated in the following way and the results of this investigation is shown in Table 2.1.

Table 2.1

Tubes	**Content**	**Condition**	**Colour**	
			Start	**After 15 min**
A	3 cm^3 chloroplast suspension 8 cm^3 DCPIP	Illuminated strongly	Blue-green	Green
B	3 cm^3 buffer solution 8 cm^3 DCPIP	Illuminated strongly	Blue	Blue
C	3 cm^3 chloroplast suspension 8 cm^3 DCPIP	Left in the dark	Blue-green	Blue-green

For Examiner's Use

(e) Using your knowledge of light-dependent reactions, account for the results shown in Table 2.1.

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[Total: 12]

For Examiner's Use

3. Haemophilia A, also called factor VIII (FVIII) deficiency or classic haemophilia, is a genetic disorder caused by missing or defective factor VIII, a clotting protein. This genetic disorder is characterised by episodes of internal and external bleeding in affected individuals.

According to the United States Centers for Disease Control and Prevention, haemophilia occurs in approximately 1 in 5,000 live births. There are about 20,000 people with haemophilia in the United States. All races and ethnic groups are affected.

Fig. 3.1 shows a pedigree of a family with history of haemophilia A. The FVIII gene was first isolated from each individual using Polymerase Chain Reaction (PCR). The PCR products were then digested using restriction enzymes and the resulting fragments separated by gel electrophoresis. Fig. 3.2 shows the results of the gel electrophoresis for some of the individuals.

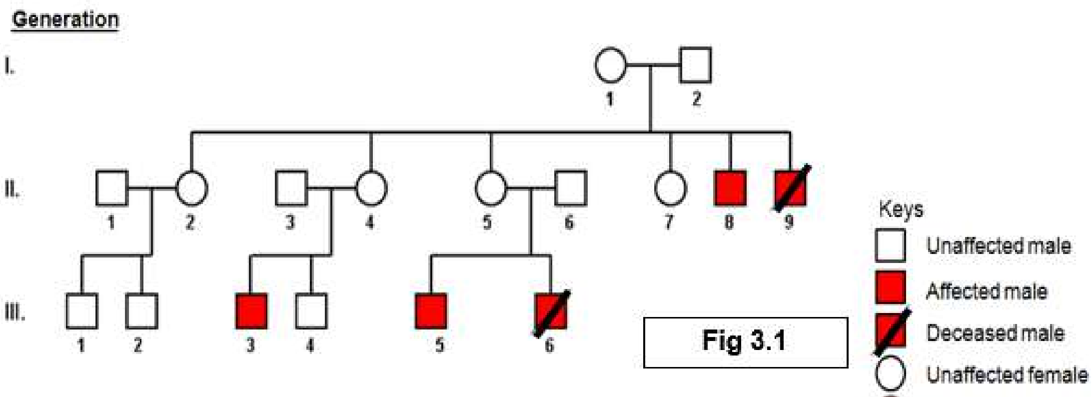

Fig 3.1

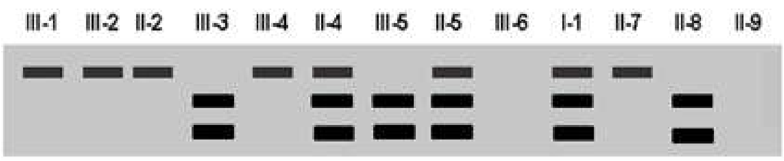

Fig 3.2

(a) With reference to Fig. 3.1 and Fig. 3.2, state two pieces of evidence that confirm that haemophilia A is an X-linked recessive disorder.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

Individual II-3 and II-4 do not exhibit the symptoms of haemophilia A and they are heterozygous for both blood type A and B respectively. III-3, who is the son of II-3 and II-4, suffers from haemophilia A and has a blood type is AB.

(b) With reference to Fig. 3.1 and Fig. 3.2, construct a genetic cross diagram to explain how II-3 and II-4 can result in a child with haemophilia A and blood type AB.

[5]

[Total: 7]

For Examiner's Use

4. MRSA is a variety of *Staphylococcus aureus*. It is difficult to treat infections caused by this type of bacteria because it is resistant to methicillin and to some other antibiotics. As a result, some patients who are already very ill may die if they become infected with MRSA.

(a) Describe how natural selection makes MRSA resistant to the commonly used antibiotics.

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…………………………………………………………………………………………………**[4]**

Antibiotic resistance genes have been employed widely in recombinant DNA technology to produce transgenic bacteria containing human genes.

To produce insulin for medical uses, human insulin genes are transferred into bacteria. Plasmids containing two antibiotic resistance genes, one coding for resistance to tetracycline and one for resistance to ampicillin, are used to carry out this transfer.

Table 4.1 shows the actions of four different restriction enzymes, which might be used in the production of a recombinant DNA molecule, and the source of these enzymes.

Table 4.1

Organisn	Restriction enzyme	Target DNA sequences (cleavage sites shown by arrow linings)
Escherichia coli RY 13	*Eco*RI	5′ G ↑A A T T C 3′ 3′ C T T A A↓ G 5′
Bacillus amyloliquefaciens	*BamH*I	5′ G ↑G A T C C 3′ 3′ C C T A G ↓ G 5′
Providencia stuartii	*Pst*I	5′ C T G C A ↑ G 3′ 3′ G ↓ A C G T C 5′
Haemophilus influenzae	*Hind*II	5′ G T Py ↑ Pu A C 3′ 3′ C A Pu ↓ Py T G 5′

(b) With reference to Table 4.1, explain why *EcoR*I, *BamH*I and *PstI* are more suitable for use in the cloning of human insulin gene than *Hind*II.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

………………………………………………………………………………………………………[2]

For Examiner's Use

After the fragments of human DNA and the cut plasmids were mixed together, several types of plasmid were formed. The different types of plasmid are shown in Fig 4.1.

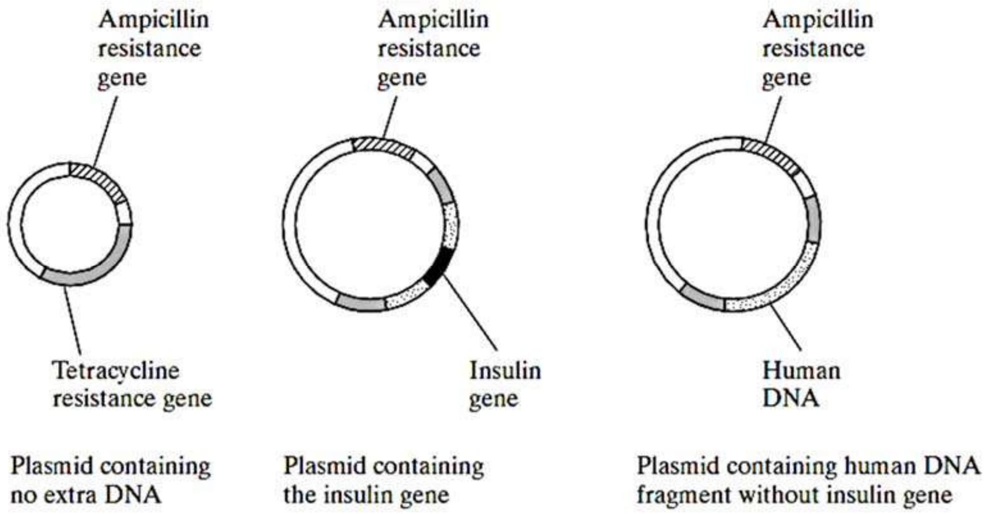

Fig 4.1

(c) State another property of the plasmid not shown in Fig. 4.1 that enables it to be used as a cloning vector.

……………………………………………………………………………………………**[1]**

(d) Explain how it is possible to distinguish between bacteria, which have taken up a plasmid with human DNA and those, which have taken up a plasmid without any extra DNA.

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……………………………………………………………………………………………**[4]**

[Total: 11]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a), (b)** etc., as indicated in the question.

5.

(a) Compare the structure and role of deoxyribonucleic acid and ribonucleic acid. **[6]**

(b) Using named examples, explain how anatomical, embryological and molecular homology supports Darwin's theory of natural selection. **[7]**

(c) Using named examples, discuss the importance of genetic engineering in solving the global demand for food. **[7]**

[Total: 20]

6.

(a) Relate the structure of haemoglobin to its function in animals. **[6]**

(b) Explain the small yield of ATP produced by anaerobic respiration in mammals.**[6]**

(c) Restriction digest is usually performed prior to agarose gel electrophoresis.

With reference to the principles of gel electrophoresis, discuss why the incubation time for restriction digest of the plasmid DNA is important in obtaining accurate results from gel electrophoresis. **[8]**

[Total: 20]

End of Paper

Class	Adm No

Candidate Name: ______________________________

H

millennia institute

2017 Promotional Examination II
Pre-University 2

H1 Biology **8875/02**

Paper 2 **12 September 2017**

2 hours

READ THESE INSTRUCTIONS FIRST

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

Write your Admission number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

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

For Examiner's Use	
Section A	
1	
2	
3	
Section B	
Total	

This question paper consists of 14 printed pages including 1 blank page.

For Examiner's Use

Answer **all** questions in this section.

1. Measurement of cellular DNA content and the analysis of the cell cycle can be performed by flow cytometry. The DNA content of retinal cells of zebrafish is analysed and Fig. 1.1 show the number of cells at different stages of the cell cycle.

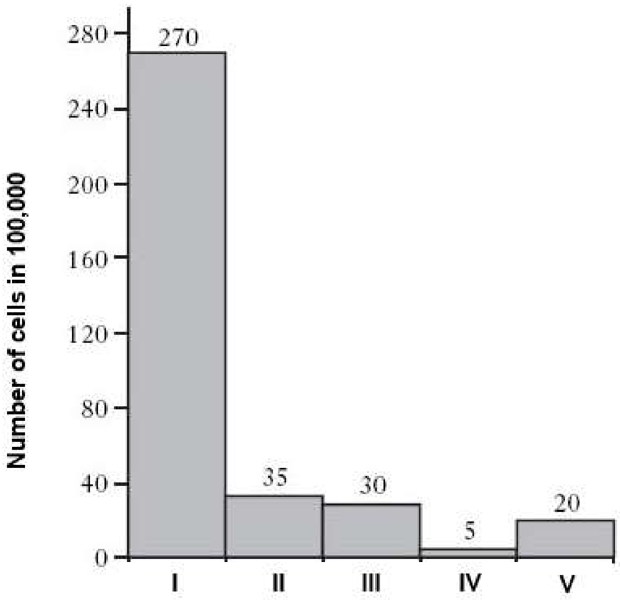

Fig. 1.1

(a)

(i) Identify which stage (**I** to **V**) correspond to interphase.

I

;; for 1 mark, max is 1 mark

]

(ii) Suggest a reason for your answer in **(a)(i).**

Interphase has the longest duration/consist of G1, S and G2 phases, so more cells will be found in the interphase;
; for 1 mark, max is 1 mark

(iii) Explain the importance of DNA replication before mitosis

DNA replication results in each chromosome consists of 2 genetically identical sister chromatids joined at centromere during prophase and metaphase;
The daughter cells are genetically identical because they receive a copy of exact/same DNA molecule/same number and type of chromosomes;
Maintain genetic stability;

; for 1 mark, max is 2 marks

Fig. 1.2 shows the electronmicrographs of three zebrafish retinal cells (**A** to **C**). Each cell is undergoing a different stage of mitosis.

A **B** **C**

Fig. 1.2

(b)

(i) Identify stages of mitosis that cell **A** and **B** is undergoing.

A: prophase;
B: metaphase;

;; for 1 mark, max is 1 mark

(ii) State the visible features in cell **A** and **B** that enabled your identification in **(b)(i).**

Stage A
Chromatin fibres <u>condense</u> to become discrete <u>chromosomes,</u> which are <u>visible;</u>
Absence of <u>nuclear membrane/envelope</u>;

Stage B
Chromosomes start to <u>align</u> in a single row/singly at <u>metaphase plate/equator of the spindle</u>;
;; for 1 mark, max is 2 marks

For Examiner's Use

Fig. 1.3 shows the changes in the DNA amount during the meiotic cell cycle of the germ cells in zebrafish.

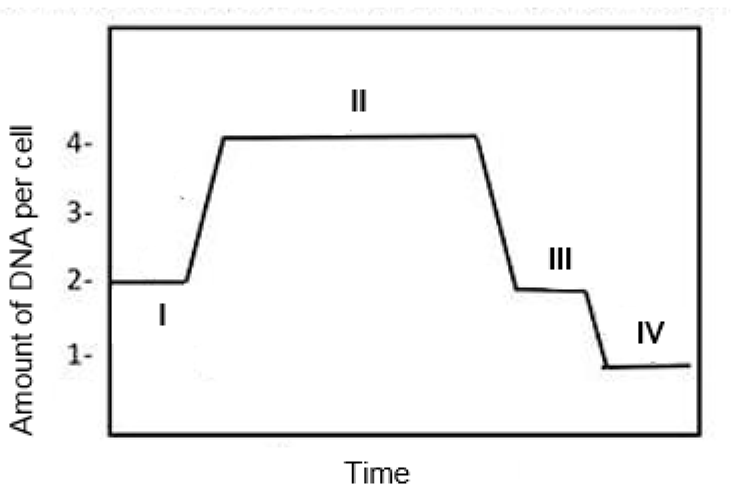

Fig. 1.3

(c) With reference to Fig. 1.3, explain the changes in DNA amount from stage **II** to **IV.**

Stage II correspond to meiosis I while Stage III correspond to meiosis II;
The amount of DNA in each cell remain constant during meiosis I and II because the germ cell has not divided/cytokinesis has not occurred, which occur at the end of meiosis I and II;

; for 1 mark, max is 1 mark

The amount of DNA in each cell is halved at the end of meiosis I due to the separation of the homologous chromosomes during anaphase I;
The amount of DNA in each cell is halved again at the end of meiosis II due to the separation of chromatids during anaphase II;

; for 1 mark, max is 2 marks

[Total: 10]

For Examiner's Use

2. In recent years, numerous biochemical and genetic studies have demonstrated that peptide signalling plays a greater than anticipated role in various aspects of plant growth and development. A substantial proportion of these plant peptides are secretory and act as local signals mediating cell-to-cell communication.

Fig 2.1 and Fig. 2.2 show two different membrane-bound organelles found in shoot apical meristematic cells.

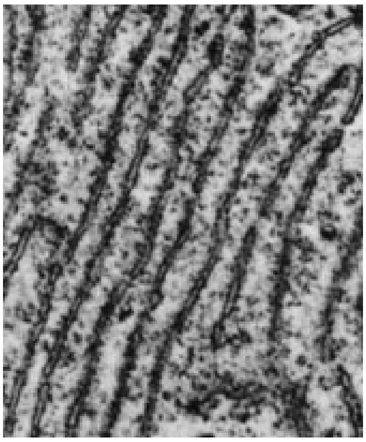

Fig 2.1

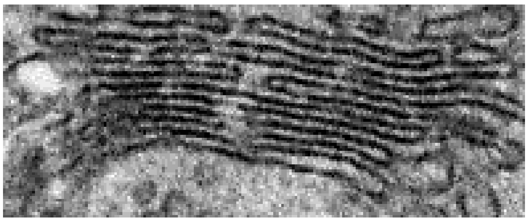

Fig. 2.2

(a) Describe how the two organelles in Fig 2.1 and Fig. 2.2 work together in the production and secretion of plant peptides.

The bound/fixed ribosomes on the rough endoplasmic reticulum synthesise polypeptides/translation, which enters the RER lumen to be modified and folded;
Transport vesicles containing the proteins bud off from the RER and fuse with the cis face of the golgi apparatus;
GA is involved in chemical modification for e.g. glycosylation, sorting and packaging of the proteins;
Secretory vesicles bud off from the trans face of the GA;
Fuse with the cell surface membrane to release the plant peptides via exocytosis;

; for 1 mark, max is 3 marks

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[3]

For Examiner's Use

Fig. 2.3 shows the process of protein synthesis that takes place on the organelle shown in Fig. 2.1.

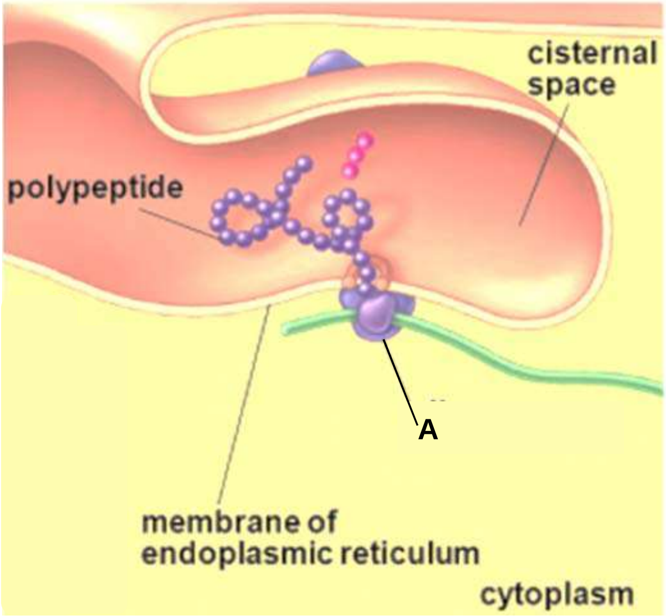

Fig. 2.3

(b) Describe how the structure of **A** is adapted to its role in the process shown in Fig. 2.3.

Small ribosomal subunit able to recognise and bind to 5' end/start codon on mRNA to initiate translation;
Large ribosomal subunit contains A site, P site and E site;
P site contains the initiator tRNA/tRNA with the growing polypeptide chain attached;
A site is for the binding of incoming aminoacyl-tRNA;
E site is for tRNA to be released from ribosome;
Attachment of large ribosomal subunit holds the translation initiation complex in place;
Large ribosomal subunit contains peptidyl transferase + to catalyse formation of peptide bonds between amino acids;

; for 1 mark, max is 3 marks

……………………………………………………………………………………………[3]

Fig. 2.4 shows the role of tRNA in the process of protein translation while Fig. 2.5 shows the genetic code in terms of the mRNA codons sequence.

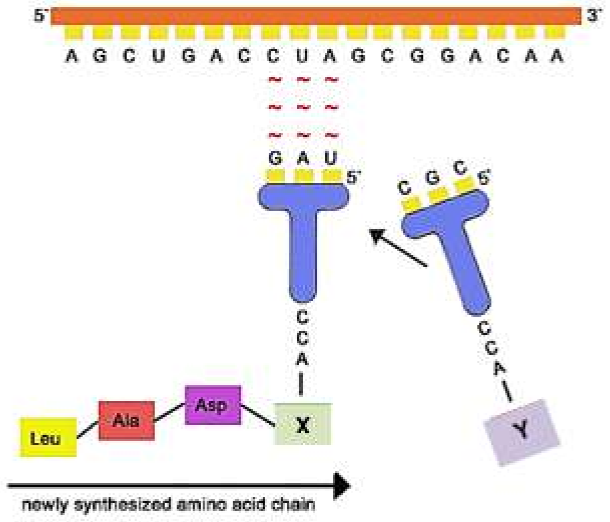

Fig. 2.4

Second Letter

1st letter	U	C	A	G	3rd letter
U	UUU Phe UUC Phe UUA Leu UUG Leu	UCU Ser UCC Ser UCA Ser UCG Ser	UAU Tyr UAC Tyr UAA Stop UAG Stop	UGU Cys UGC Cys UGA Stop UGG Trp	U C A G
C	CUU Leu CUC Leu CUA Leu CUG Leu	CCU Pro CCC Pro CCA Pro CCG Pro	CAU His CAC His CAA Gln CAG Gln	CGU Arg CGC Arg CGA Arg CGG Arg	U C A G
A	AUU Ile AUC Ile AUA Ile AUG Met	ACU Thr ACC Thr ACA Thr ACG Thr	AAU Asn AAC Asn AAA Lys AAG Lys	AGU Ser AGC Ser AGA Arg AGG Arg	U C A G
G	GUU Val GUC Val GUA Val GUG Val	GCU Ala GCC Ala GCA Ala GCG Ala	GAU Asp GAC Asp GAA Glu GAG Glu	GGU Gly GGC Gly GGA Gly GGG Gly	U C A G

Fig. 2.5

(c) With reference to Fig. 2.4 and Fig. 2.5, identify amino acid **X** and **Y**.

X: …

X: leucine;
Y: Alanine;

;; for 1 mark

Y: … **[1]**

The palisade mesophyll cells of plant contain numerous chloroplasts. Fig. 2.6 shows an electron-micograph of a chloroplast in plant cell.

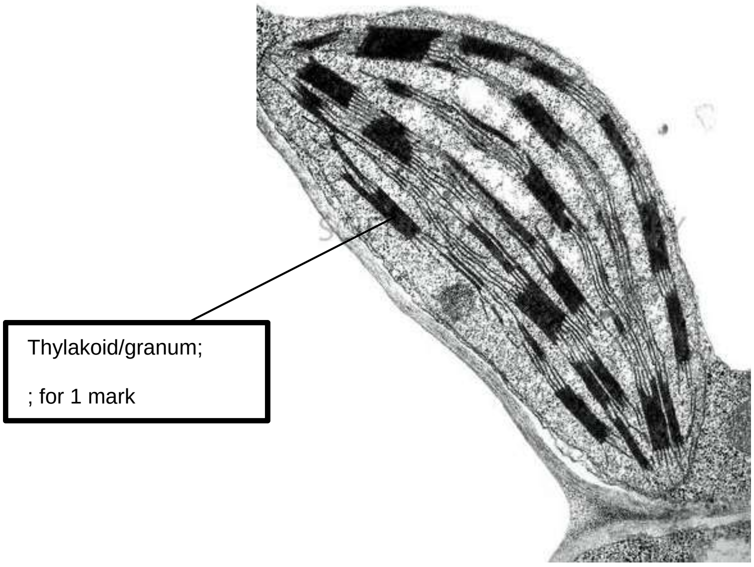

Fig. 2.6

(d) Draw an arrow and labelled the structure where light-dependent reactions occurs in the chloroplast. **[1]**

The rate of decolourisation of DCPIP in the Hill Reaction is a measure of the rate of the light-dependent stages of photosynthesis. DCPIP, a blue dye, acts as an electron acceptor and becomes colourless when reduced, allowing any reducing agent produced by the chloroplasts to be detected.

A suspension of chloroplasts was made by grinding fresh leaves in buffer solution and centrifuging the mixture. Tubes were then prepared and treated in the following way and the results of this investigation is shown in Table 2.1.

Table 2.1

Tubes	**Content**	**Condition**	**Colour**	
			Start	**After 15 min**
A	3 cm^3 chloroplast suspension 8 cm^3 DCPIP	Illuminated strongly	Blue-green	Green
B	3 cm^3 buffer solution 8 cm^3 DCPIP	Illuminated strongly	Blue	Blue
C	3 cm^3 chloroplast suspension 8 cm^3 DCPIP	Left in the dark	Blue-green	Blue-green

For Examiner's Use

(e) Using your knowledge of light-dependent reactions, account for the results shown in Table 2.1.

DCPIP acts like final hydrogen ion/electron acceptor/NADP+ in non-cyclic photophosphorylation/light-dependent reactions;
; for 1 mark, max is 1 mark
Tube A: When light and chloroplast suspension are present, photo-excited electrons from water/PSII/PSI;
Electrons are passed along the electron transport chain to reduce DCPIP;
There is light-dependent reactions + decolourising/changing it from blue to colourless, solution turn green due to the colour of chloroplast/chlorophyll;
; for 1 mark. max is 1 mark

However, when tube C is placed in the dark/absence of light, DCPIP remained blue, indicating that it is not being reduced, thus no photoactivation in the dark;
; for 1 mark. max is 1 mark

Tube B is a control and shows that DCPIP is reduced and decolourised by the photoactivation/non-cyclic photophosphorylation/light-dependent reactions in the chloroplast suspension;
; for 1 mark, max is 1 mark

....

....**[4]**

[Total: 12]

[Turn over

For Examiner's Use

3. Haemophilia A, also called factor VIII (FVIII) deficiency or classic haemophilia, is a genetic disorder caused by missing or defective factor VIII, a clotting protein. This genetic disorder is characterised by episodes of internal and external bleeding in affected individuals.

According to the United States Centers for Disease Control and Prevention, haemophilia occurs in approximately 1 in 5,000 live births. There are about 20,000 people with haemophilia in the United States. All races and ethnic groups are affected.

Fig. 3.1 shows a pedigree of a family with history of haemophilia A. The FVIII gene was first isolated from each individual using Polymerase Chain Reaction (PCR). The PCR products were then digested using restriction enzymes and the resulting fragments separated by gel electrophoresis. Fig. 3.2 shows the results of the gel electrophoresis for some of the individuals.

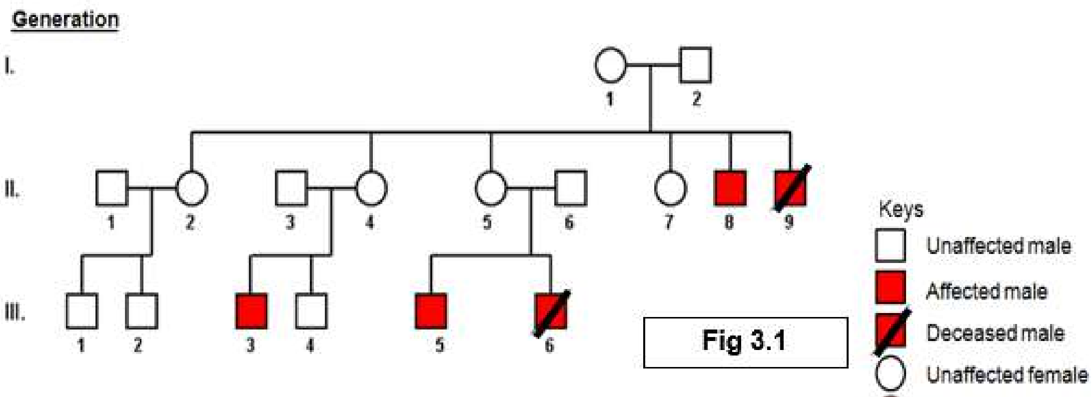

Fig 3.1

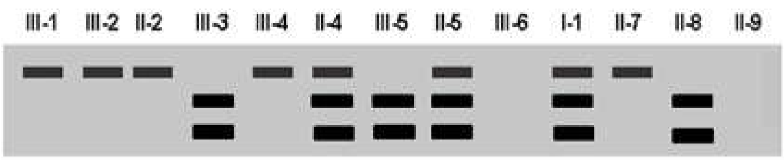

Fig 3.2

(a) With reference to Fig. 3.1 and Fig. 3.2, state two pieces of evidence that confirm that haemophilia A is an X-linked recessive disorder.

X-linked because:
More males affected than females;
Or
Phenotypically normal female/mother unaffected by the disorder/carrier females, only affected sons and daughters not affected + e.g.:
I-1 not affected/carrier/heterozygous, II-8 and II-9 are affected while II-2, II-4, II-5 and II-7 unaffected;
Or
II-4 not affected/carrier/heterozygous, III-3 affected;
Or
II-5 unaffected/carrier/heterozygous but III-5 and III-6 are affected;

; for 1 mark, max is 1 mark

Recessive because:
Identification of which band correspond to mutant and normal allele;
Phenotypically normal parents can produce an affected child + e.g.
I-1 and I-2 gives rise to II-8 and II-9;
II-3 and II-4 gives rise to III-3;
II-5 and II-6 gives rise to III-5 and III-6;
; for 1 mark, max is 1 mark

Individual II-3 and II-4 do not exhibit the symptoms of haemophilia A and they are heterozygous for both blood type A and B respectively. III-3, who is the son of II-3 and II-4, suffers from haemophilia A and has a blood type is AB.

(b) With reference to Fig. 3.1 and Fig. 3.2, construct a genetic cross diagram to explain how II-3 and II-4 can result in a child with haemophilia A and blood type AB.

Let X^H be the allele on the X-chromosome that code for normal blood clotting factor
Let X^h be the allele on the X-chromosome that codes for the defective blood clotting factor
Let I^A be the allele coding for blood type A
Let I^B be the allele coding for blood type B
Let I^O be the allele coding for blood type O

Parental phenotype	Male, unaffected	Female, unaffected
Parental genotype	$X^HYI^AI^O$	$X^HX^h\ I^BI^O$
Gamete	X^HI^A X^HI^O YI^A YI^O	X^HI^B X^HI^O X^hI^B X^hI^O

Punette's square

	X^HI^B	X^HI^o	X^hI^B	X^hI^o
X^HI^A	$X^HX^HI^AI^B$ Female, normal, blood type AB	$X^HX^HI^AI^o$ Female, normal, blood type A	$X^HX^hI^AI^B$ Female, normal, blood type AB	$X^HX^hI^AI^o$ Female, normal, blood type A
X^HI^o	$X^HX^HI^BI^o$ Female, normal, blood type B	$X^HX^HI^oI^o$ Female, normal, blood type O	$X^HX^hI^BI^o$ Female, normal, blood type B	$X^HX^hI^oI^o$ Female, normal, blood type O
YI^A	$X^HYI^AI^B$ Male, normal, blood type AB	$X^HYI^AI^o$ Male, normal, blood type A	$X^hYI^AI^B$ Male, affected, blood type AB	$X^hYI^AI^o$ Male, affected, blood type A
YI^o	$X^HYI^BI^o$ Male, normal, blood type B	$X^HYI^oI^o$ Male, normal, blood type O	$X^hYI^BI^o$ Male, affected, blood type B	$X^hYI^oI^o$ Male, affected, blood type O

F1 genotype	$X^HX^HI^AI^B$, $X^HX^hI^AI^B$	$X^HX^HI^AI^o$, $X^HX^hI^AI^o$,	$X^HX^HI^BI^o$, $X^HX^hI^BI^o$	$X^HX^HI^oI^o$. $X^HX^hI^oI^o$	$X^HYI^AI^B$	$X^HYI^AI^o$	$X^HYI^BI^o$	$X^HYI^oI^o$
F1 phenotype	Female, normal, blood type AB	Female, normal, blood type A	Female, normal, blood type B	Female, normal, blood type O	Male, normal, blood type AB	Male, normal, blood type A	Male, normal, blood type B	Male, normal , blood type O

F1 genotype	$X^hYI^AI^B$	$X^hYI^AI^o$	$X^hYI^BI^o$	$X^hYI^oI^o$
F1 phenotype	Male, affected, blood type AB	Male, affected, blood type A	Male, affected, blood type B	Male, affected, blood type O

Phenotypic ratio	Female, Normal, Blood type AB 2 :	Female, normal, blood type A 2 :	Female, normal, blood type B 2 :	Female, normal, blood type O 2 :	Male, normal, blood type AB 1 :	Male, normal, blood type A 1 :
	Male, normal, blood type B 1 :	Male, normal, blood type O 1 :	Male, affected, blood type AB 1 :	Male, affected, blood type A 1 :	Male, affected, blood type B 1 :	Male, affected, blood type O 1

Correct parental phenotypes and genotypes;
Correct gametes drawn;
Correct punette's square drawn including phenotypes;
Correct F1 phenotypes and genotypes;
Correct phenotypic ratio

[5]

[Total: 7]

For Examiner's Use

4. MRSA is a variety of *Staphylococcus aureus*. It is difficult to treat infections caused by this type of bacteria because it is resistant to methicillin and to some other antibiotics. As a result, some patients who are already very ill may die if they become infected with MRSA.

(a) Describe how natural selection makes MRSA resistant to the commonly used antibiotics.

Pre-existing genetic variations in the bacterial population due to random mutations;
Antibiotic resistant gene / allele already existing in gene pool of bacterial population;
Selection pressure of antibiotic/methicillin being exerted on bacterial population;
Resistant bacteria are at the selective advantage and are able to survive and reproduce to pass down the allele for antibiotic resistance to their offspring;
Or
Non-resistant bacteria are selected against and cannot survive and reproduce to pass down the allele for antibiotic resistance to their offspring;

Over time, frequency of antibiotic resistance allele in the bacterial population increases;
As a result, the population of resistant bacteria increases. Thus, make MRSA resistant to the commonly used antibiotics;

; for 1 mark, max is 4 marks

....

....[4]

Antibiotic resistance genes have been employed widely in recombinant DNA technology to produce transgenic bacteria containing human genes.

To produce insulin for medical uses, human insulin genes are transferred into bacteria. Plasmids containing two antibiotic resistance genes, one coding for resistance to tetracycline and one for resistance to ampicillin, are used to carry out this transfer.

Table 4.1 shows the actions of four different restriction enzymes, which might be used in the production of a recombinant DNA molecule, and the source of these enzymes.

Table 4.1

Organisn	Restriction enzyme	Target DNA sequences (cleavage sites shown by arrow linings)
Escherichia coli RY 13	*Eco*RI	5′ G ↑A A T T C 3′ 3′ C T T A A↓ G 5′
Bacillus amyloliquefaciens	*BamH*I	5′ G ↑G A T C C 3′ 3′ C C T A G ↓ G 5′
Providencia stuartii	*Pst*I	5′ C T G C A ↑ G 3′ 3′ G ↓ A C G T C 5′
Haemophilus influenzae	*Hind*II	5′ G T Py ↑ Pu A C 3′ 3′ C A Pu ↓ Py T G 5′

(b) With reference to Table 4.1, explain why *EcoR*I, *BamH*I and *PstI* are more suitable for use in the cloning of human insulin gene than *Hind*II.

*EcoR*I, *BamH*I and *PstI* make staggered cuts in DNA to produce sticky ends on the human insulin gene and plasmid;
Upon mixing together, the insulin gene and the plasmid can then annealed through complementary base-pairing via hydrogen bond formation;

; for 1 mark, max is 1 mark

*Hind*II produces blunt ends;
Decrease efficiency/require additional steps of producing recombinant DNA molecules as linker DNA must be added for reannealing of the gene of interest and vector;
*Hind*II has restriction site/sequence that is not specific, may cut at multiple sites/another antibiotic resistant gene;

*Hind*II restriction site is not specific hence it may cut the plasmid at multiple locations, the gene of interest could be inserted into multiple locations/sites in the plasmid;

; for 1 mark, max is 1 mark

For Examiner's Use

After the fragments of human DNA and the cut plasmids were mixed together, several types of plasmid were formed. The different types of plasmid are shown in Fig 4.1.

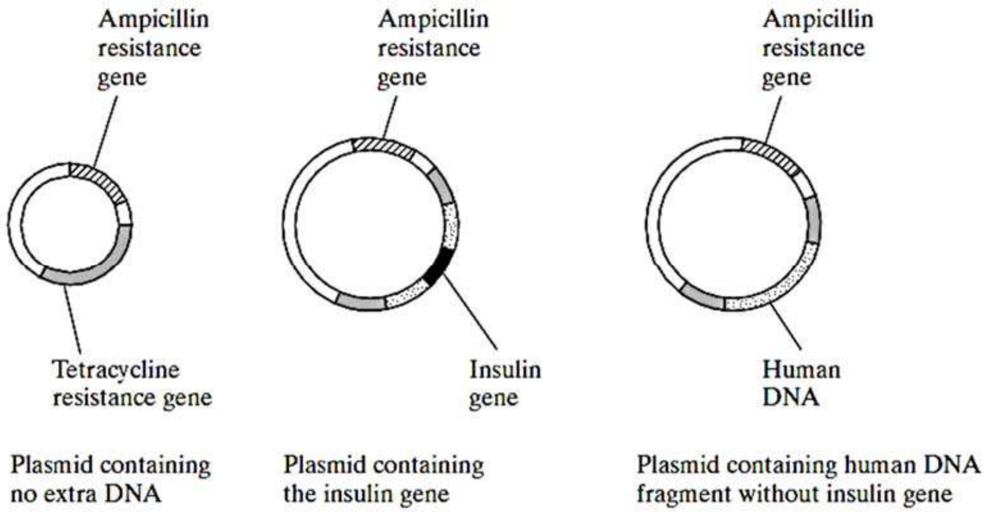

Fig 4.1

(c) State another property of the plasmid not shown in Fig. 4.1 that enables it to be used as a cloning vector.

Origin of replication;
Multiple cloning site/restriction sites;

; for 1 mark, max is 1 mark

[1]

(d) Explain how it is possible to distinguish between bacteria, which have taken up a plasmid with human DNA and those, which have taken up a plasmid without any extra DNA.

Plate the bacteria on nutrient agar plate containing ampicillin;
Only bacteria that have taken up the plasmid/both reannealed and recombinant plasmids can survive due to the presence of ampicillin resistance gene;
Using pad/velvet surface to transfer bacteria via replica plating onto a nutrient agar plate containing tetracycline;
For bacteria with human DNA, tetracycline gene is disrupted by insertion of the human DNA, and is no longer functional;
Comparing the colonies on the agar plate with ampicillin and those colonies growing on agar plate with tetracycline;

; for 1 mark, max is 3 marks

Bacteria with human DNA grow on agar plate with ampicillin but are killed by tetracycline on agar plate containing tetracycline;
Bacteria with no extra DNA in plasmid/reannealed plasmid can survive on agar plate containing tetracycline;

; for 1 mark, max is 1 mark

[Total: 11]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a), (b)** etc., as indicated in the question.

5.

(a) Compare the structure and role of deoxyribonucleic acid and ribonucleic acid. **[6]**

Feature	DNA	RNA
Similarities: • Both contain nucleotide monomers that is made up of nitrogenous base, pentose sugar and a phosphate group; • Both are polynucleotides and can form complementary base pairing between C-G and A-T(DNA) or A-U (RNA); • In complementary base-pairing for both DNA and RNA, same number of H-bonds form between C-G and A-T / A-U; • Same phosphodiester bonds joining the adjacent nucleotides/sugar-phosphate backbone; ; for 1 mark, Max is 2 marks		
Differences:		
Type of nucleotide monomer	Deoxyribonucleotide;	Ribonucleotide;
Type of pentose sugar	Deoxyribose;	Ribose;
Type of nitrogenous bases	Adenine, guanine, cytosine and thymine;	Adenine, guanine, cytosine and uracil;
Ratio of nitrogenous bases	Ratio of adenine to thymine, and cytosine to guanine is 1:1 for all DNA molecules;	Ratio of adenine to uracil, and cytosine to guanine varies/differs from one RNA molecule to another;
Structure	With the exception of the DNA in some viruses, DNA is always double helix/double-stranded/2 polynucleotide chains;	With the exception of the RNA in some viruses, RNA is always single-stranded/one polynucleotide chain;
Types of molecules	There is only one type of DNA;	There are three types of RNA, namely mRNA, rRNA and tRNA;
Size	Large molecule with more nucleotides;	Relatively small molecule with fewer nucleotide;
Role	A template for DNA replication and transcription;	mRNA: A template for protein synthesis/translation; Or tRNA: form complementary base pair with codons on mRNA to bring the corresponding activated amino acids to the ribosome/for translation elongation; Or rRNA: complex with protein to become ribosomal subunits/ribosome;
;; for 1 mark, max is 4 marks		

(b) Using named examples, explain how anatomical, embryological and molecular homology supports Darwin's theory of natural selection. **[7]**

- Anatomy, embryological and molecular homology provide evidences supporting evolution as a process of modifying the characteristics present in an ancestral organism by natural selection in its descendants over time;

Anatomical homology (max 2m)

- An example of an anatomical homology is that of the number and arrangement of bones in the forelimbs of mammals/ pentadactyl limb of mammals;
- The forelimbs of all mammals, including humans, cats, whales and bats, show the same arrangement of bones from the shoulder to the tips of the digits, even though these appendages have very different functions: lifting, walking, swimming and flying;
- Similarity is due to their descent from a common ancestor with the same basic structural plan that has been modified to allow the forelimb to adapt to a certain method of locomotion in a particular environment;
  OR

- Vestigial structures which are reduced or non-functional but shows homology to functioning structures in other species**;**
- such as appendix in human, pelvis and leg bones of snakes;
- Reflect descent with modification from a shared/common ancestor;
- when structure loses function as the selection pressure that selects for it is no longer present;

Embryological homology (max 2m)

- The embryological development of all vertebrates share remarkable similarities;
- All vertebrates embryos share the presence of a post anal tail / pharyngeal pouches / 2-chambered heart/segmented myotomes [mention at least 2 traits];

- Pharyngeal pouches in mammalian embryos are the equivalent/similar to gills in fish embryos at early developmental stages;
- become parts of the ears and throat in humans and other mammals and gills in fishes;

  Or
- 2-chambered heart is retained in fish but develops into 3-chambered heart in amphibians and 4-chambered heart in mammals;
- Similarities during early embryonic development in different vertebrate species can be explained if they descended from a common ancestor /;

Molecular homology (max 2m)

- All forms of life use the same genetic language of DNA and RNA/genetic code is universal. ;
- Likely that all species descended from common ancestors that used the same genetic code;
- Closely related species have more similar DNA/RNA/amino acid sequences in the homologous genes / proteins;
- Differences are a result of accumulated DNA mutations as descendants evolve independently/evolve along different lineages;
- Similarity in nucleotide base sequences is seen in both coding regions but also non-coding region of the DNA genome;

(c) Using named examples, discuss the importance of genetic engineering in solving the global demand for food. **[7]**

- Increase yield by genetically modifying food crops that will result in decreased losses caused by pesticides, fungal infestation, viruses, bacterial infection and pests;

Introduction of genes that code for proteins that confer insecticidal resistance

- Example: Genetically engineered crop plants that express the Bt-toxin gene from the bacteria *Bacillus thuringiensis* produce Bt-toxin protein which kills insect larvae feeding on the plant;

Introduction of genes that code for proteins that confer herbicidal resistance

- Example: Genetically engineered crop plants that are resistant to herbicides by introducing the herbicide/glyphosate resistance gene;
- When herbicide is applied to the field, the weeds are eliminated but not the herbicide resistance crop plants;

Introduction of genes that code for proteins that confer viral resistance;

- E.g., tobacco plant can be made resistant to the tobacco mosaic virus by expressing the coat protein gene of a virus;

Introduction of genes that code for growth hormones;

- Example: The Atlantic salmon has been genetically modified by the addition of a growth hormone gene from a Pacific Chinook salmon and an active promoter from an ocean pout placed upstream of the growth hormone gene;
- The insertion of the growth hormone gene results in faster growth rate and yield of the salmon, thereby increasing the supply of salmon;

Introduction of genes that delayed ripening

- Flavr Savr tomatoes are engineered to include a gene for antisense mRNA to polygalacturonase gene to reduce expression of polygalacturonase;
- This will result in delayed ripening allowing crops to be stored for longer period of time;

AVP;

; for 1 mark, max is 7 marks

6.

(a) Relate the structure of haemoglobin to its function in animals. **[6]**

HAEMOGLOBIN	
Structure	Function
Presence of non-polar amino acids, formation of a hydrophobic cleft, containing a haem binding site/region;	This provides a hydrophobic environment for the haem group to function;
Each subunit/polypeptide bears one haem prosthetic group containing Fe^{2+} ion; Each haem group contains an Fe^{2+} ion within a porphyrin ring;	Fe^{2+} ion is able to bind/combine reversibly to oxygen accounting for the oxygen-transporting ability of haemoglobin;
Each haemoglobin molecule carries 4 prosthetic haem group;	Each molecule can bind to/transport 4 oxygen molecules. This increases the oxygen-carrying capacity of red blood cell;
Amino acid residues found on the surface are generally hydrophilic/polar;	This allows haemoglobin to be a soluble globular protein in aqueous medium;
Binding of oxygen to 1 of the 4 subunits resulting in conformational changes in the remaining subunits/polypeptides;	This allows the other subunits to more readily bind to oxygen; Or Reference to cooperativity;

; for 1 mark, max is 3 marks
Structure and function must be correctly matched to be awarded the mark

(b) Explain the small yield of ATP produced by anaerobic respiration in mammals. **[6]**

Oxygen is the final electron acceptor of electron transport chain;
No oxygen means no movement of electron along ETC, no oxidative phosphorylation, no Krebs cycle and link reactions;
Oxidative phosphorylation produces 34 ATP per glucose molecules;
; for 1 mark, max is 2 marks

Incomplete/partial oxidation of glucose during anaerobic respiration in the absence of oxygen;
During glycolysis, 1 molecule of glucose is broken down to 2 molecules of pyruvate;
Glycolysis produces net yield of 2 ATP only and 2 reduced NAD/NADH per glucose molecule;
ATP production during glycolysis occur via substrate level phosphorylation;
No ATP is produced during lactate fermentation;
During lactate fermentation, pyruvate will be reduced to lactate by lactate dehydrogenase;
Reduced NAD/NADH is needed during lactate fermentation and NAD+ is regenerated so that glycolysis can continue to occur;
; for 1 mark, max is 4 marks

(c) Restriction digest is usually performed prior to agarose gel electrophoresis.

With reference to the principles of gel electrophoresis, discuss why the incubation time for restriction digest of the plasmid DNA is important in obtaining accurate results from gel electrophoresis. **[8]**

- DNA molecules are negatively charged due to the presence of negatively charged phosphate groups;
- When placed in an agarose gel with an electric current passing through it, DNA molecules will move towards the positive electrode/anode;
- Movement/migration of DNA molecules towards the positive electrode is impeded by agarose gel;
- The agarose gel forms a cross-linked matrix and functions as a 'molecular sieve' as the matrix forms little pores through which DNA must travel;
- DNA molecules will be separated into bands according to size/molecular mass and shape;
- Larger DNA molecules have more difficulty/encounter more resistance moving through the pores of the agarose gel;
- The larger DNA molecules move/migrate through the agarose gel at a slower rate/vice versa;
- Supercoiled DNA migrates the fastest, followed by the linear DNA. Circular DNA migrates the slowest;

; for 1 mark, max is 4 marks

- If the duration of restriction digestion is too long, it may result in the restriction enzymes cutting at unspecific sequences of the plasmid other than at the restriction sites;
- This affects the reliability and accuracy of the results as more fragments will be generated and more bands will be observed after gel electrophoresis;
- The fragments will also be smaller in size and will encounter less resistance, thus the band positions will be found closer to the anode;
- If the duration of restriction digestion is too short, it may result in the incomplete restriction digestion of the DNA;
- This affects the reliability and accuracy of the results as the total number of fragments will be lesser than actual, and fewer bands will be observed after gel electrophoresis;
- The plasmid may not be completely cut, resulting in circular DNA with 1 strand cut at 1 place;
- This leads a higher band position than usual as circular DNA encounter more resistance than linear DNA;
- Some plasmids may not be cut at all and may undergo supercoiling;
- This leads to lower band position than usual as supercoiled plasmid encounter the lesser resistance than linear DNA.

; for 1 mark, max is 4 marks

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE NAME

CLASS

BIOLOGY **8875/01**

Paper 1 Multiple Choice **26 September 2017**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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1 A student has drawn a cell structure as seen using a light microscope.

The magnification of the drawing is ×600.

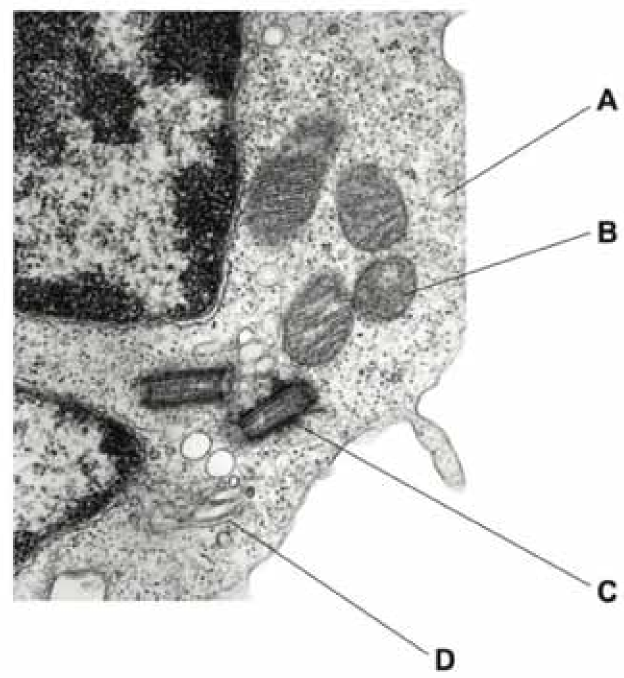
The length of the structure on the drawing is 6mm.

What is the actual length of the cell structure?

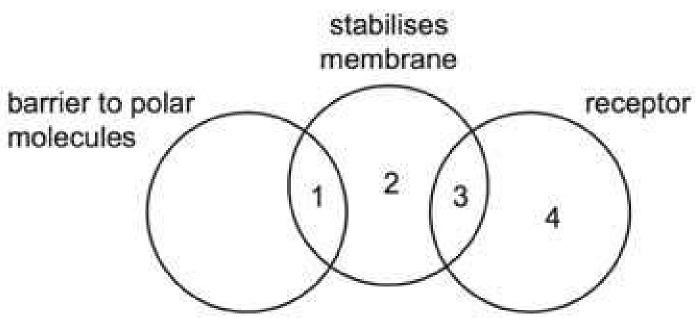
A 1×10^{-1} µm **B** 1×10^{0} µm **C** 1×10^{1} µm **D** 1×10^{2} µm

2 The electron micrograph shows part of a eukaryotic cell.

Which of the labelled organelles is a site of protein synthesis?

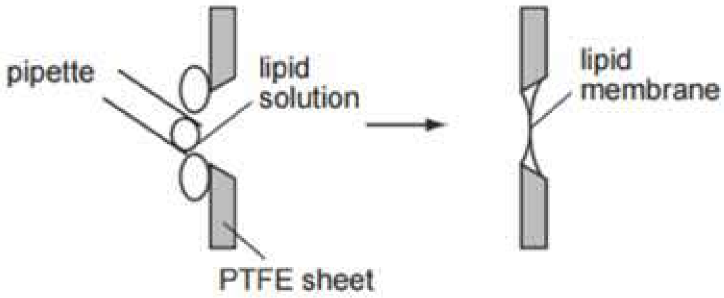


3 Which row correctly links molecules in the cell surface membrane with their roles?



	1	2	3	4
A	glycolipid	cholesterol	glycoprotein	phospholipid
B	glycolipid	glycoprotein	phospholipid	cholesterol
C	glycoprotein	phospholipid	cholesterol	glycolipid
D	phospholipid	cholesterol	glycolipid	glycoprotein

4 Lipid membranes can be formed in the laboratory by painting phospholipids over a PTFE sheet with a hole in it.



Such a lipid membrane is impermeable to water-soluble materials including charged ions such as Na^+ or K^+.

In one experiment with Na^+ ions, no ions flowed across the membrane until a substance called gramicidin was added, at which time the ions flowed.

Which statement is consistent with this information and your knowledge of membrane structure?

Gramicidin becomes incorporated into the membrane and is

A a carbohydrate molecule found only on the outside of the membrane.

B a non-polar lipid which passes all the way through the membrane.

C a protein molecule with both hydrophilic and hydrophobic regions.

D a protein molecule which has only hydrophobic regions.

5 The table shows some information about four carbohydrate polymers.

polymer	α-1,4 glycosidic bonds	α-1,6 glycosidic bonds	shape of molecule
1	✓	✗	helical
2	✗	✓	branched
3	✓	✓	helical
4	✓	✓	branched

key
✓ = present
✗ = absent

Which two polymers form starch?

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

6 When proteins are mixed with some organic solvents, hydrophobic interactions and hydrogen bonding are changed in the protein molecules.

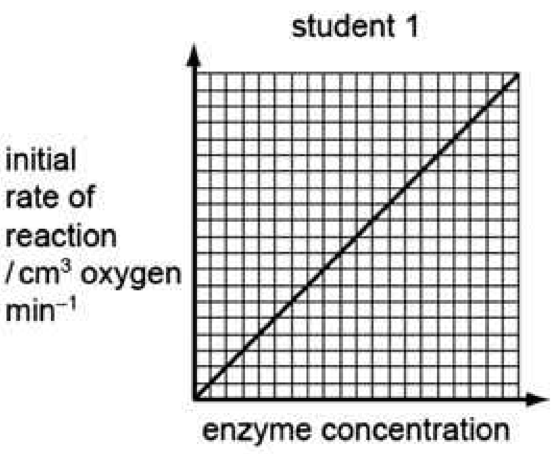
Which levels of protein structure would be affected?

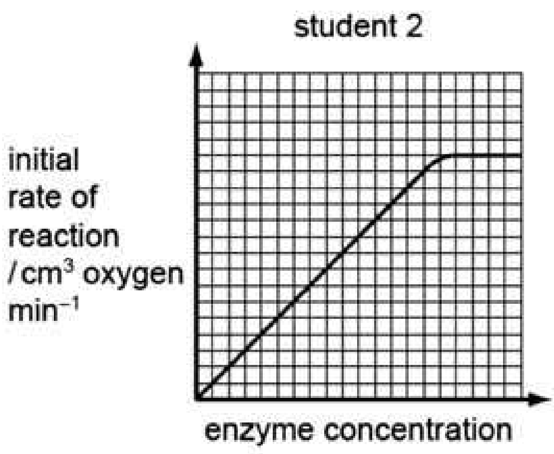
	level of protein structure		
	secondary	tertiary	quaternary
A	✓	✓	✗
B	✓	✗	✓
C	✗	✓	✓
D	✓	✓	✓

key
✓ = affected
✗ = not affected

7 Catalase is an enzyme that catalyses the conversion of hydrogen peroxide into water and oxygen.

Two students investigated the effect of enzyme concentration on the rate of reaction of the enzyme catalase. The students predicted their results would show the same trend. The graphs show the rates obtained by each student.





Which statement explains the different trend shown by student 2's results?

A Student 2 included a competitive inhibitor in the investigation.

B Student 2 performed the investigation at a higher temperature.

C Student 2 performed the investigation at pH6 compared to pH8.

D Student 2 used a lower concentration of substrate in the investigation.

8 The table below shows additional information about the enzymes that catalyse some of the reactions in respiration.

enzyme	information
fructose 1,6-bisphosphate aldolase	• four identical subunits • changes to any one of the subunits means that the enzyme cannot function
hexokinase	• one subunit • active site changes shape to enclose the reactants
phosphofructokinase	• four identical subunits • has allosteric sites in addition to an active site
phosphoglucose isomerase	• two identical subunits • has a cytokine function when secreted into the external medium
pyruvate kinase	• four identical subunits • ATP acts as an inhibitor to regulate glycolysis
triosephosphate isomerase	• two identical subunits • each subunit has 14 alpha helices and 8 beta-pleated sheets

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

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

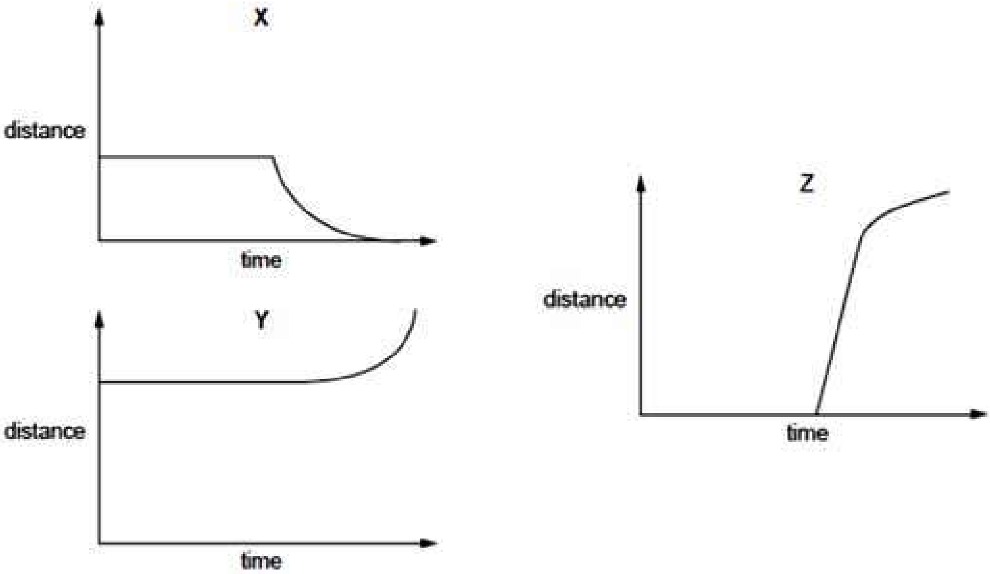
How many of the student's deductions are correct and can be supported using the information provided?

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

9 What are the conditions in a human cell just before the cell enters prophase?

	number of molecules of DNA in nucleus	spindle present	nuclear envelope present
A	46	yes	no
B	46	no	yes
C	92	yes	yes
D	92	no	yes

10 The graphs show various measurements taken from metaphase of mitosis onwards. The graphs are to scale when compared to one another.



Which row correctly describes each graph?

	X	Y	Z
A	Distance between poles of spindle	Distance between sister chromatids	Distance of centromere from pole of spindle
B	Distance between poles of spindle	Distance of centromere from pole of spindle	Distance between sister chromatids
C	Distance of centromere from pole of spindle	Distance between poles of spindle	Distance between sister chromatids
D	Distance of centromere from pole of spindle	Distance between sister chromatids	Distance between poles of spindle

11 DNA is said to replicate in a semi-conservative way.

Results of Meselson and Stahl's experiments gave overwhelming support to this theory. They used E. coli which has a generation time of 20 minutes.

Here are the steps in their experiment but they are in the wrong order.

P All bacteria contain ^{15}N DNA.
Q All bacteria contain hybrid DNA (^{15}N DNA and ^{14}N DNA).
R Bacteria contain either all ^{14}N DNA or hybrid DNA.
S Bacteria grown in a ^{15}N medium for many generations.
T Bacteria transferred to a ^{14}N medium and sampled every 20 minutes.

Which sequence of letters shows the correct order of the steps in the experiment?

A P→Q→R→S→T

B P→S→T→R→Q

C S→P→T→Q→R

D S→P→T→R→Q

12 Polypeptide synthesis is based on sequences of three nucleotides, each specific for an amino acid.

Which row shows the correct nucleotide sequences for an amino acid?

	nucleotide sequence of		
	non-transcribed DNA strand	**mRNA codon**	**tRNA anticodon**
A	GGT	CCA	GGU
B	GGG	CCC	CCC
C	CCG	CCG	GGC
D	CCT	CCU	CCU

13 Which statement(s) about tRNA structure is/are correct?

1 There is a binding site for the attachment of a specific amino acid, as well as a different binding site for the attachment to the ribosome, in order to allow translation to occur.

2 There is a ribose-phosphate backbone with strong covalent phosphodiester bonds and areas within the polynucleotide chain where base-pairing by hydrogen bonding occurs.

3 There is a section known as an anticodon that contains the same triplet of bases as the triplet of DNA bases that has been transcribed to produce the mRNA codon.

A 1 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

14 The following table shows the mRNA codons for six different amino acids.

mRNA codons	amino acid
AAA AAG	lysine
AGA AGG CGG	arginine
GGU GGA GGC GGG	glycine
CCU CCA CCC CCG	proline
UGG	tryptophan
UAU UAC	tyrosine

The base sequence of mRNA coding for part of a polypeptide is shown below.

U	**A**	**U**	**A**	**A**	**G**	**A**	**G**	**G**	**C**	**C**	**U**	**U**	**G**	**G**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

↑
start reading

From the information provided, which of the predictions stated below is **not** true?

A The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13.

B The deletion of a nucleotide at position 5 would result only in an alteration of the second amino acid in the chain.

C The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.

D The substitution of a different nucleotide at position 13 would result in the alteration of one amino acid.

15 The following table shows the chromosome numbers in the hybrids formed between cabbage (*Brassica oleracea*) and radish (*Raphanus sativus*).

type of cell	*no. of chromosomes per cell*
parental cabbage	18
parental radish	18
parental gametes	9
F_1 hybrids	18
F_1 gametes	18
F_2 hybrids	36
F_2 gametes	18
F_3 hybrids	36

During which of the following stages can the occurrence of non-disjunction explain the results?

A formation of the F_1 gametes

B formation of the F_2 gametes

C fusion of the parental gametes

D fusion of the F1 gametes

16 A In horses, there are 3 coat colour patterns, *cremello*(beige), *chestnut* (brown) and *palomino* (golden with pale coloured mane and tail). When 2 *palamino* horses were crossed, they produce 25% *cremello*, 25% *chestnut* and 50% *palomino* horses.

Which of the following statement is true about the cross?

A The *cremello* offspring are all heterozygotes.

B There are 3 alleles involved in the coat colour patterns of the horses.

C All the *palomino* offspring are heterozygotes.

D The allele that code for *chestnut* is recessive to the *cremello.*

17 In mice, the alleles coding for coat pattern is located on the X chromosome. The 'dappled' coat allele is denoted D and its recessive allele for 'plain' coat, d. The alleles coding for 'straight' whiskers (W) and the recessive condition, 'bent' whiskers (w), are found on autosomes.

A male mouse with plain coat and bent whiskers was mated on several occasions to the same female and the large number of offspring consisted of males and females in equal numbers in all combinations of phenotypes, as shown in the table.

Offspring	
dappled, straight whiskers	plain, straight whiskers
dappled, bent whiskers	plain, bent whiskers

If X^D represents an X chromosome carrying the allele for 'dappled' coat and X^d represents an X chromosome carrying the allele for 'plain' coat, what is the genotype of the female parent?

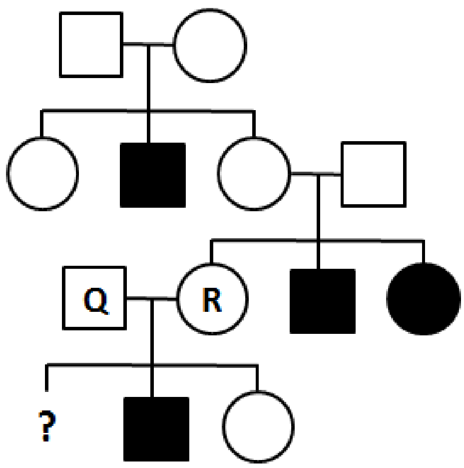
A X^DX^DWW

B X^DX^DWw

C X^DX^dWW

D X^DX^dWw

18 Adducted thumb syndrome is a condition where affected individual will have malformation of the thumb and upper limbs. The figure below show a pedigree chart of a family with the history of adducted thumb syndrome.



If individual Q and R give birth to a son, what is the possibility that their son will be affected by the condition?

A 0.125

B 0.25

C 0.50

D 0.75

19 Which of the following would cause phenotypic variation among organisms of the same genotype?

A continuous variation within the species

B different varieties of the same species

C exposure to different environments

D mutation

20 In a series of experiments, actively photosynthesizing plants were supplied with labelled reactants.

1 water containing ^{18}O isotope

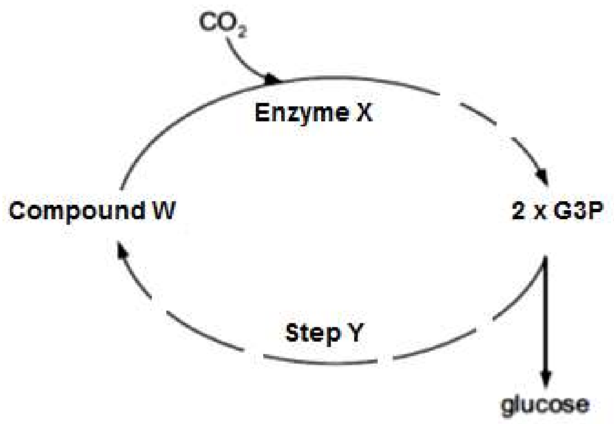
2 carbon dioxide containing ^{17}O isotope

3 carbon dioxide containing ^{13}C isotope

Where in the chloroplast would the products of photosynthesis from these reactants be formed?

	^{18}O	^{17}O	^{13}C
A	stroma	stroma	thylakoids
B	stroma	thylakoids	stroma
C	thylakoids	stroma	stroma
D	thylakoids	stroma	thylakoids

21 The figure below summaries some key reactions which occur in the Calvin cycle. Note that the dashed lines would indicate that there is more than one reaction present.



Using the figure above and your knowledge of Calvin cycle, determine which one of the following statements below is **true**?

A Compound W is expected to accumulate if carbon dioxide concentration increases under low light intensity.

B Enzyme X is expected to accumulate when carbon dioxide concentration decreases.

C Increase in temperature under high light intensity will increase the activity of enzyme X until the optimum temperature.

D ATP from substrate level phosphorylation is required for Step Y to proceed and Compound W to be formed.

22 In an experiment, four tubes were set up as shown in the table below.

tube	contents
1	Glucose + homogenized animal cells
2	Glucose + mitochondria
3	Glucose + cytoplasm lacking organelles
4	Pyruvate + homogenized animal cells

If all other conditions are kept constant, which of the following shows the amount of ATP produced in each tube in **increasing** order?

A 1 – 3 – 4 – 2

B 2 – 3 – 4 – 1

C 4 – 2 – 3 – 1

D 3 – 2 – 1 – 4

23 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

24 Natural selection acts

A directly on an individual's genetic make-up, thereby changing the survival probability of the individual.

B on individuals by changing their genes so they are better able to adapt to their environment.

C on the structures, physiologies and behaviours expressed by individuals in a population to change allele frequencies.

D on phenotypes of individuals so that they change to adapt to their environment and pass on these changes to their offspring.

25 The map shows the distribution (shaded area) of the lizards belonging to the family Iguanidae. Most species of iguana are found in America but a few species inhabit Madagascar and the islands of Fiji and Tonga (arrows at the bottom centre and bottom right of map).

Two observations were made about the different species of iguana:

1 The various American iguana species shared more similar characteristics among themselves than with those iguana species on the island of Fiji.

2 The Madagascar iguana species was only distantly related to other lizard species on the African mainland.

Which observation and explanation best support the Darwinian concept of descent with modification?

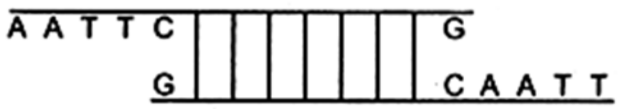
	Observation	**Explanation for the observation**
A	1	The various American iguana species had a more recent common ancestor as compared to those iguana species on the island of Fiji that had diverged a longer time ago.
B	1	The various American iguana species shared more similarities among themselves as the degree of homology in their DNA was higher.
C	2	The Madagascan iguana species was reproductively isolated from the lizard species on the African mainland and thus diverged a long time ago.
D	2	The superficial similarities shared among the Madagascan iguana and the lizards on the African mainland were analogous, not homologous.

26 In genetic engineering, a restriction enzyme is used to cut plasmid DNA at a specific target site. The enzyme recognises a sequence of six bases and forms sticky ends.

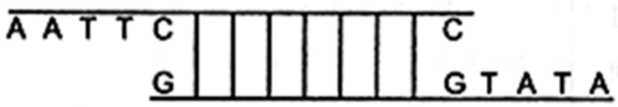
Which diagram of such a cut section of DNA is correct?

A

B



C



D

27 Which one of the following statements regarding polymerase chain reaction is **false**?

A Taq polymerase is chosen for use because of its heat-stable property.

B Amplification of the DNA products requires DNA primers to be added for initiation.

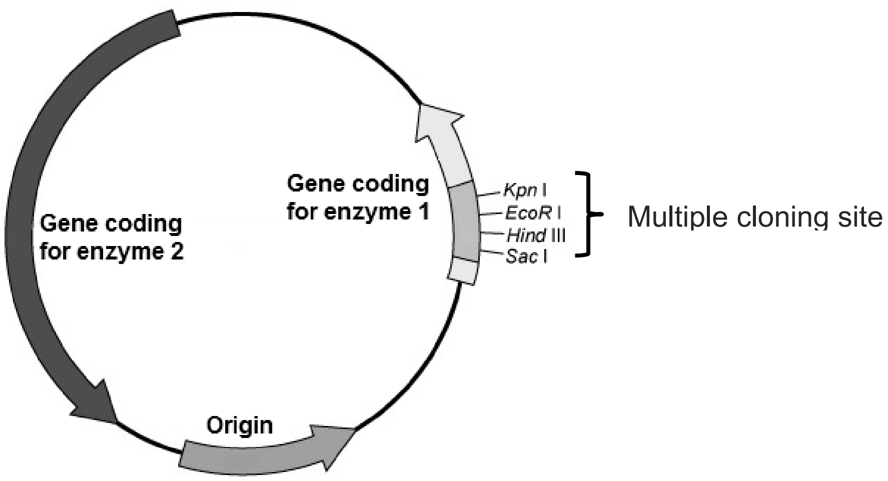
C Initiation of the amplification need not start at the promoter region of the gene.

D The amount of products formed by PCR is not limited by the nucleotides added into reaction mixture.

28 The metabolic pathway shown below is utilised by a species of bacteria to produce substance Z, which is essential for the replication of the bacterial chromosome. When provided with substance X or substance Y, wild-type bacteria are able to synthesise substance Z.

$$\text{Substance X} \xrightarrow{\text{Enzyme 1}} \text{Substance Y} \xrightarrow{\text{Enzyme 2}} \text{Substance Z}$$

Mutant bacteria, lacking the genes coding for both enzyme 1 and 2, were genetically modified to contain the human insulin gene. The following plasmid was used as a vector for transformation.



The transformed cells were plated onto an agar plate containing only substance Y. Which of the following replica plates have to be prepared in order to identify the colony containing recombinant bacteria?

A Replica plate containing substance X only

B Replica plate containing substance X and Y

C Replica plate containing substance Y and Z

D Replica plate containing substance Z only

29 Which is a correct statement about obtaining human embryonic stem cells for research?

A Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.

B The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.

C The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.

D The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

30 Efforts to develop salt-tolerant crop varieties using selective breeding techniques have been unsuccessful. Recently, plant biologists have developed a genetically engineered tomato plant that can thrive in salty water. This genetically modified plant produces significantly higher levels of a naturally occurring transport protein. This transport protein moves salt, in the form of sodium ions into the central vacuoles of leaf cells specifically.

Which statement correctly describes the benefit of genetic engineering of this tomato plant?

A Improving crop yield through maximizing the use of land.

B Improving crop quality since the fruit will be juicy due to influx of water via osmosis.

C Improving crop yield by changing the way the plant uses its energy resources.

D Improving crop quality since the tomato fruit can supplement salt loss to sweating.

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE NAME

CLASS

BIOLOGY 8875/01

Paper 1 Multiple Choice

26 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

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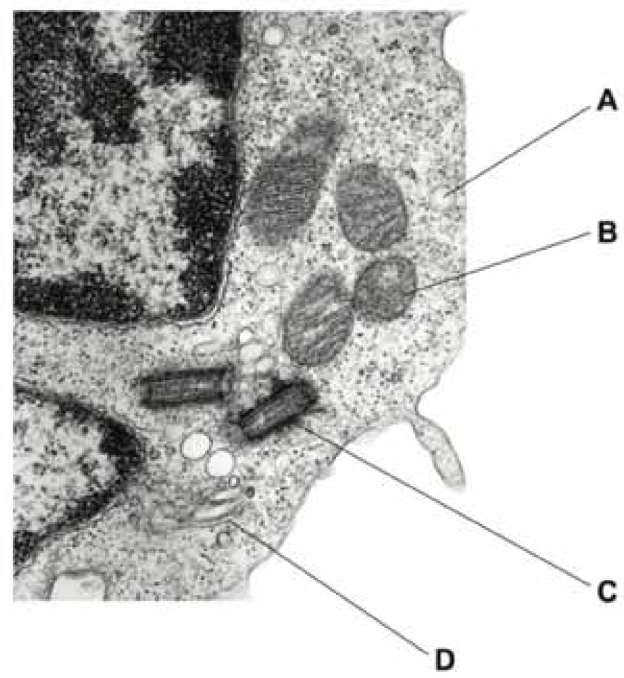
2 The electron micrograph shows part of a eukaryotic cell.

Which of the labelled organelles is a site of protein synthesis? B



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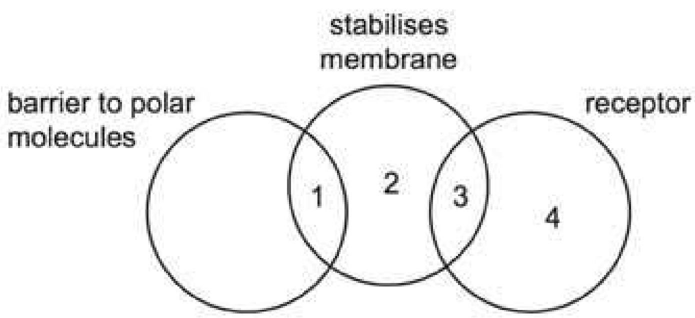
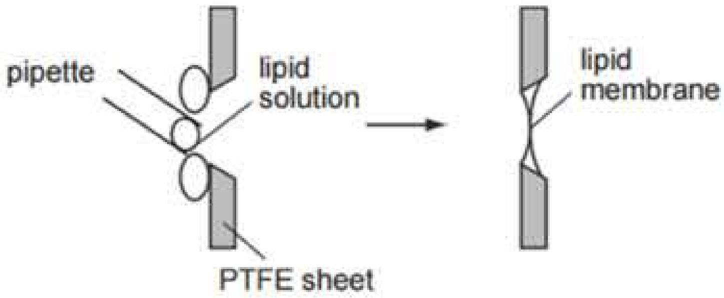


	1	2	3	4
A	glycolipid	cholesterol	glycoprotein	phospholipid
B	glycolipid	glycoprotein	phospholipid	cholesterol
C	glycoprotein	phospholipid	cholesterol	glycolipid
D	phospholipid	cholesterol	glycolipid	glycoprotein

4 Lipid membranes can be formed in the laboratory by painting phospholipids over a PTFE sheet with a hole in it.



Such a lipid membrane is impermeable to water-soluble materials including charged ions such as Na^+ or K^+.

In one experiment with Na^+ ions, no ions flowed across the membrane until a substance called gramicidin was added, at which time the ions flowed.

Which statement is consistent with this information and your knowledge of membrane structure?

Gramicidin becomes incorporated into the membrane and is

A a carbohydrate molecule found only on the outside of the membrane.

B a non-polar lipid which passes all the way through the membrane.

C a protein molecule with both hydrophilic and hydrophobic regions.

D a protein molecule which has only hydrophobic regions.

5 The table shows some information about four carbohydrate polymers.

polymer	α-1,4 glycosidic bonds	α-1,6 glycosidic bonds	shape of molecule
1	✓	✗	helical
2	✗	✓	branched
3	✓	✓	helical
4	✓	✓	branched

key
✓ = present
✗ = absent

Which two polymers form starch?

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

6 When proteins are mixed with some organic solvents, hydrophobic interactions and hydrogen bonding are changed in the protein molecules.

Which levels of protein structure would be affected? D

	level of protein structure		
	secondary	tertiary	quaternary
A	✓	✓	✗
B	✓	✗	✓
C	✗	✓	✓
D	✓	✓	✓

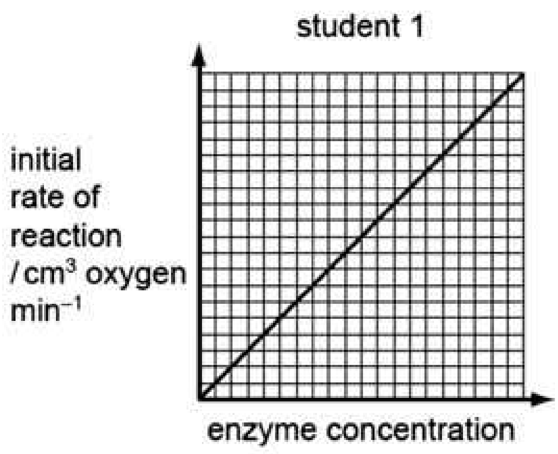
key

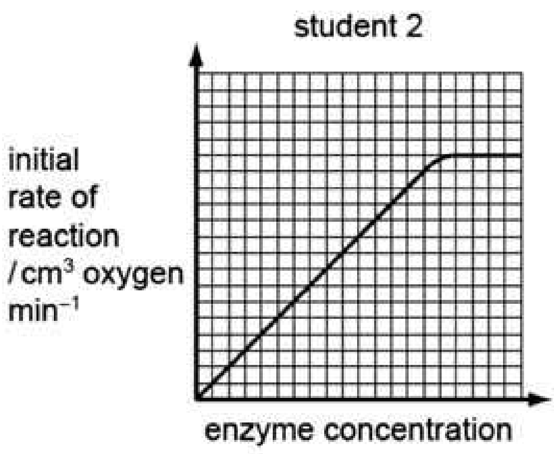
✓ = affected

✗ = not affected

7 Catalase is an enzyme that catalyses the conversion of hydrogen peroxide into water and oxygen.

Two students investigated the effect of enzyme concentration on the rate of reaction of the enzyme catalase. The students predicted their results would show the same trend. The graphs show the rates obtained by each student.





Which statement explains the different trend shown by student 2's results?

A Student 2 included a competitive inhibitor in the investigation.

B Student 2 performed the investigation at a higher temperature.

C Student 2 performed the investigation at pH6 compared to pH8.

D Student 2 used a lower concentration of substrate in the investigation.

8 The table below shows additional information about the enzymes that catalyse some of the reactions in respiration.

enzyme	information
fructose 1,6-bisphosphate aldolase	• four identical subunits • changes to any one of the subunits means that the enzyme cannot function
hexokinase	• one subunit • active site changes shape to enclose the reactants
phosphofructokinase	• four identical subunits • has allosteric sites in addition to an active site
phosphoglucose isomerase	• two identical subunits • has a cytokine function when secreted into the external medium
pyruvate kinase	• four identical subunits • ATP acts as an inhibitor to regulate glycolysis
triosephosphate isomerase	• two identical subunits • each subunit has 14 alpha helices and 8 beta-pleated sheets

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

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

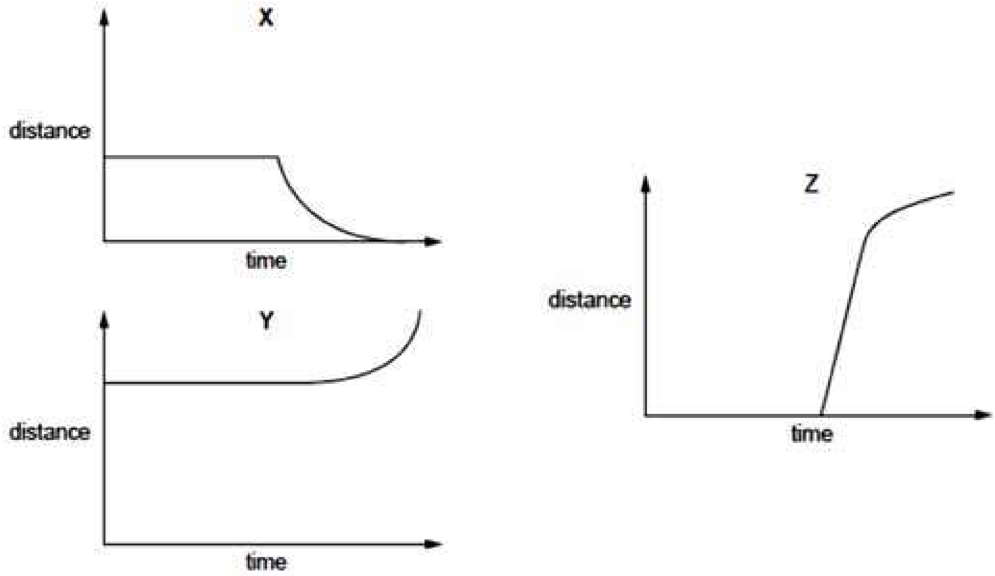
How many of the student's deductions are correct and can be supported using the information provided?

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

9 What are the conditions in a human cell just before the cell enters prophase?

	number of molecules of DNA in nucleus	spindle present	nuclear envelope present
A	46	yes	no
B	46	no	yes
C	92	yes	yes
D	92	no	yes

10 The graphs show various measurements taken from metaphase of mitosis onwards. The graphs are to scale when compared to one another.



Which row correctly describes each graph?

	X	Y	Z
A	Distance between poles of spindle	Distance between sister chromatids	Distance of centromere from pole of spindle
B	Distance between poles of spindle	Distance of centromere from pole of spindle	Distance between sister chromatids
C	Distance of centromere from pole of spindle	Distance between poles of spindle	Distance between sister chromatids
D	Distance of centromere from pole of spindle	Distance between sister chromatids	Distance between poles of spindle

11 DNA is said to replicate in a semi-conservative way.

Results of Meselson and Stahl's experiments gave overwhelming support to this theory. They used E. coli which has a generation time of 20 minutes.

Here are the steps in their experiment but they are in the wrong order.

P All bacteria contain ^{15}N DNA.
Q All bacteria contain hybrid DNA (^{15}N DNA and ^{14}N DNA).
R Bacteria contain either all ^{14}N DNA or hybrid DNA.
S Bacteria grown in a ^{15}N medium for many generations.
T Bacteria transferred to a ^{14}N medium and sampled every 20 minutes.

Which sequence of letters shows the correct order of the steps in the experiment?

A P→Q→R→S→T

B P→S→T→R→Q

C S→P→T→Q→R

D S→P→T→R→Q

12 Polypeptide synthesis is based on sequences of three nucleotides, each specific for an amino acid.

Which row shows the correct nucleotide sequences for an amino acid?

	nucleotide sequence of		
	non-transcribed DNA strand	**mRNA codon**	**tRNA anticodon**
A	GGT	CCA	GGU
B	GGG	CCC	CCC
C	CCG	CCG	GGC
D	CCT	CCU	CCU

13 Which statement(s) about tRNA structure is/are correct?

1 There is a binding site for the attachment of a specific amino acid, as well as a different binding site for the attachment to the ribosome, in order to allow translation to occur.

2 There is a ribose-phosphate backbone with strong covalent phosphodiester bonds and areas within the polynucleotide chain where base-pairing by hydrogen bonding occurs.

3 There is a section known as an anticodon that contains the same triplet of bases as the triplet of DNA bases that has been transcribed to produce the mRNA codon.

A 1 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

14 The following table shows the mRNA codons for six different amino acids.

mRNA codons	amino acid
AAA AAG	lysine
AGA AGG CGG	arginine
GGU GGA GGC GGG	glycine
CCU CCA CCC CCG	proline
UGG	tryptophan
UAU UAC	tyrosine

The base sequence of mRNA coding for part of a polypeptide is shown below.

U	**A**	**U**	**A**	**A**	**G**	**A**	**G**	**G**	**C**	**C**	**U**	**U**	**G**	**G**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

↑
start reading

From the information provided, which of the predictions stated below is **not** true?

A The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13.

B The deletion of a nucleotide at position 5 would result only in an alteration of the second amino acid in the chain.

C The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.

D The substitution of a different nucleotide at position 13 would result in the alteration of one amino acid.

15 The following table shows the chromosome numbers in the hybrids formed between cabbage (*Brassica oleracea*) and radish (*Raphanus sativus*).

type of cell	*no. of chromosomes per cell*
parental cabbage	18
parental radish	18
parental gametes	9
F_1 hybrids	18
F_1 gametes	18
F_2 hybrids	36
F_2 gametes	18
F_3 hybrids	36

During which of the following stages can the occurrence of non-disjunction explain the results?

A formation of the F_1 gametes

B formation of the F_2 gametes

C fusion of the parental gametes

D fusion of the F1 gametes

16 A In horses, there are 3 coat colour patterns, *cremello*(beige), *chestnut* (brown) and *palomino* (golden with pale coloured mane and tail). When 2 *palamino* horses were crossed, they produce 25% *cremello*, 25% *chestnut* and 50% *palomino* horses.

Which of the following statement is true about the cross?

A The *cremello* offspring are all heterozygotes.

B There are 3 alleles involved in the coat colour patterns of the horses.

C All the *palomino* offspring are heterozygotes.

D The allele that code for *chestnut* is recessive to the *cremello.*

17 In mice, the alleles coding for coat pattern is located on the X chromosome. The ‘dappled’ coat allele is denoted D and its recessive allele for ‘plain’ coat, d. The alleles coding for ‘straight’ whiskers (W) and the recessive condition, ‘bent’ whiskers (w), are found on autosomes.

A male mouse with plain coat and bent whiskers was mated on several occasions to the same female and the large number of offspring consisted of males and females in equal numbers in all combinations of phenotypes, as shown in the table.

Offspring	
dappled, straight whiskers	plain, straight whiskers
dappled, bent whiskers	plain, bent whiskers

If X^D represents an X chromosome carrying the allele for ‘dappled’ coat and X^d represents an X chromosome carrying the allele for ‘plain’ coat, what is the genotype of the female parent?

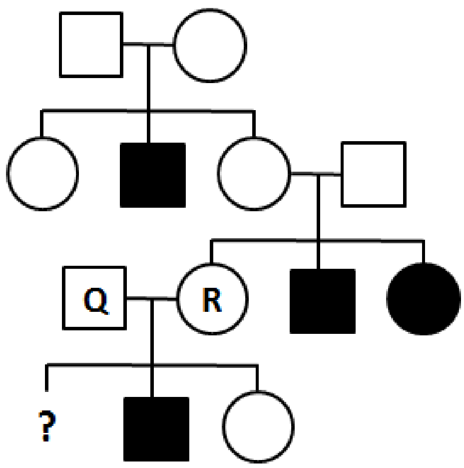
A X^DX^DWW

B X^DX^DWw

C X^DX^dWW

D X^DX^dWw

18 Adducted thumb syndrome is a condition where affected individual will have malformation of the thumb and upper limbs. The figure below show a pedigree chart of a family with the history of adducted thumb syndrome.



If individual Q and R give birth to a son, what is the possibility that their son will be affected by the condition?

A 0.125

B 0.25

C 0.50

D 0.75

19 Which of the following would cause phenotypic variation among organisms of the same genotype?

A continuous variation within the species

B different varieties of the same species

C exposure to different environments

D mutation

20 In a series of experiments, actively photosynthesizing plants were supplied with labelled reactants.

1 water containing ^{18}O isotope

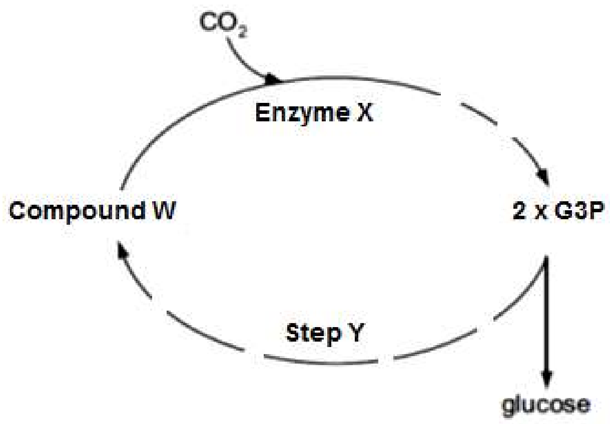
2 carbon dioxide containing ^{17}O isotope

3 carbon dioxide containing ^{13}C isotope

Where in the chloroplast would the products of photosynthesis from these reactants be formed?

	^{18}O	^{17}O	^{13}C
A	stroma	stroma	thylakoids
B	stroma	thylakoids	stroma
C	thylakoids	stroma	stroma
D	thylakoids	stroma	thylakoids

21 The figure below summaries some key reactions which occur in the Calvin cycle. Note that the dashed lines would indicate that there is more than one reaction present.



Using the figure above and your knowledge of Calvin cycle, determine which one of the following statements below is **true**?

A Compound W is expected to accumulate if carbon dioxide concentration increases under low light intensity.

B Enzyme X is expected to accumulate when carbon dioxide concentration decreases.

C Increase in temperature under high light intensity will increase the activity of enzyme X until the optimum temperature.

D ATP from substrate level phosphorylation is required for Step Y to proceed and Compound W to be formed.

22 In an experiment, four tubes were set up as shown in the table below.

tube	contents
1	Glucose + homogenized animal cells
2	Glucose + mitochondria
3	Glucose + cytoplasm lacking organelles
4	Pyruvate + homogenized animal cells

If all other conditions are kept constant, which of the following shows the amount of ATP produced in each tube in **increasing** order?

A 1 – 3 – 4 – 2

B 2 – 3 – 4 – 1

C 4 – 2 – 3 – 1

D 3 – 2 – 1 – 4

23 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? D

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

24 Natural selection acts

A directly on an individual's genetic make-up, thereby changing the survival probability of the individual.

B on individuals by changing their genes so they are better able to adapt to their environment.

C on the structures, physiologies and behaviours expressed by individuals in a population to change allele frequencies.

D on phenotypes of individuals so that they change to adapt to their environment and pass on these changes to their offspring.

25 The map shows the distribution (shaded area) of the lizards belonging to the family Iguanidae. Most species of iguana are found in America but a few species inhabit Madagascar and the islands of Fiji and Tonga (arrows at the bottom centre and bottom right of map).

Two observations were made about the different species of iguana:

1 The various American iguana species shared more similar characteristics among themselves than with those iguana species on the island of Fiji.

2 The Madagascar iguana species was only distantly related to other lizard species on the African mainland.

Which observation and explanation best support the Darwinian concept of descent with modification?

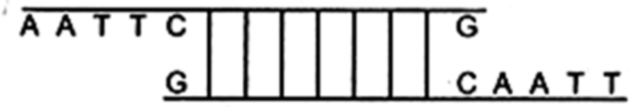
	Observation	**Explanation for the observation**
A	1	The various American iguana species had a more recent common ancestor as compared to those iguana species on the island of Fiji that had diverged a longer time ago.
B	1	The various American iguana species shared more similarities among themselves as the degree of homology in their DNA was higher.
C	2	The Madagascan iguana species was reproductively isolated from the lizard species on the African mainland and thus diverged a long time ago.
D	2	The superficial similarities shared among the Madagascan iguana and the lizards on the African mainland were analogous, not homologous.

26 In genetic engineering, a restriction enzyme is used to cut plasmid DNA at a specific target site. The enzyme recognises a sequence of six bases and forms sticky ends.

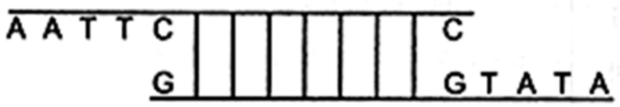
Which diagram of such a cut section of DNA is correct? AAAAAAAAAAAAAAAAAAA

A

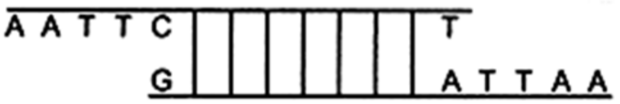
B



C



D



27 Which one of the following statements regarding polymerase chain reaction is **false**?

A Taq polymerase is chosen for use because of its heat-stable property.

B Amplification of the DNA products requires DNA primers to be added for initiation.

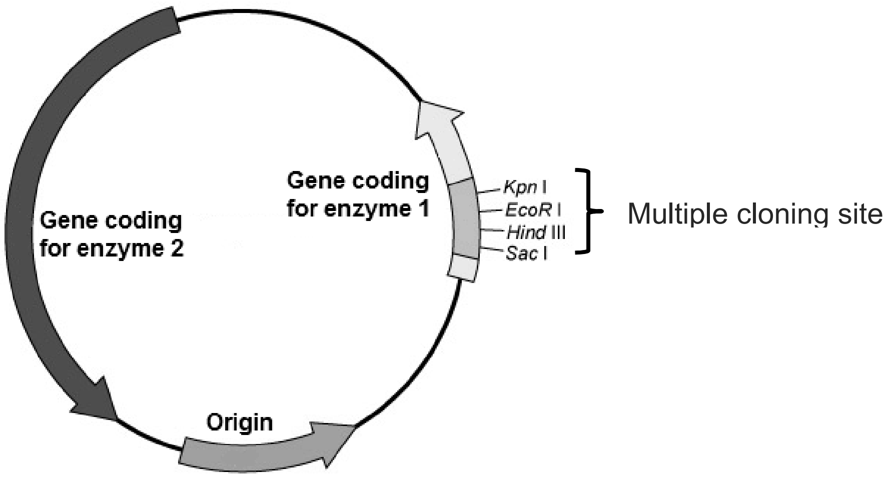
C Initiation of the amplification need not start at the promoter region of the gene.

D The amount of products formed by PCR is not limited by the nucleotides added into reaction mixture.

28 The metabolic pathway shown below is utilised by a species of bacteria to produce substance Z, which is essential for the replication of the bacterial chromosome. When provided with substance X or substance Y, wild-type bacteria are able to synthesise substance Z.

$$\text{Substance X} \xrightarrow{\text{Enzyme 1}} \text{Substance Y} \xrightarrow{\text{Enzyme 2}} \text{Substance Z}$$

Mutant bacteria, lacking the genes coding for both enzyme 1 and 2, were genetically modified to contain the human insulin gene. The following plasmid was used as a vector for transformation.



The transformed cells were plated onto an agar plate containing only substance Y. Which of the following replica plates have to be prepared in order to identify the colony containing recombinant bacteria?

A Replica plate containing substance X only
B Replica plate containing substance X and Y
C Replica plate containing substance Y and Z
D Replica plate containing substance Z only

29 Which is a correct statement about obtaining human embryonic stem cells for research?

A Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.

B The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.

C The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.

D The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

30 Efforts to develop salt-tolerant crop varieties using selective breeding techniques have been unsuccessful. Recently, plant biologists have developed a genetically engineered tomato plant that can thrive in salty water. This genetically modified plant produces significantly higher levels of a naturally occurring transport protein. This transport protein moves salt, in the form of sodium ions into the central vacuoles of leaf cells specifically.

Which statement correctly describes the benefit of genetic engineering of this tomato plant?

A Improving crop yield through maximizing the use of land.

B Improving crop quality since the fruit will be juicy due to influx of water via osmosis.

C Improving crop yield by changing the way the plant uses its energy resources.

D Improving crop quality since the tomato fruit can supplement salt loss to sweating.

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE NAME

CLASS

BIOLOGY

8875/02

Paper 2 Structured Questions

14 September 2017

Additional Materials: Answer Paper

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do no use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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 no use appropriate units.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
Total	

This document consists of **10** printed pages.

[Turn over

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

1 **Table 1.1** shows some features of four biological molecules that are all polymers.

(a) Complete Table 1.1 by using a tick (✓) to indicate the features that apply to each polymer.

Table 1.1

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				
contains glycosidic bonds				
polymer is branched				
contains nitrogen				
can be found in both animal and plant cells				

[4]

(b) **Fig. 1.1** is a simple diagram of a phospholipid molecule.

Explain how the structure of a phospholipid molecule makes it suitable for its function in cell membranes. You may label and annotate **Fig. 1.1** as part of your answer.

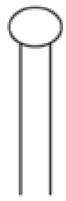


Fig. 1.1

....

....

....

....

....

.... [3]

(c) State two components of a cell surface membrane other than phospholipid molecules and describe their function.

....

....

....

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....

....

.... [4]

[Total: 11]

2 Fig. 2.1 below shows a diagram of a cell. The parts of a diagram are not drawn to scale.

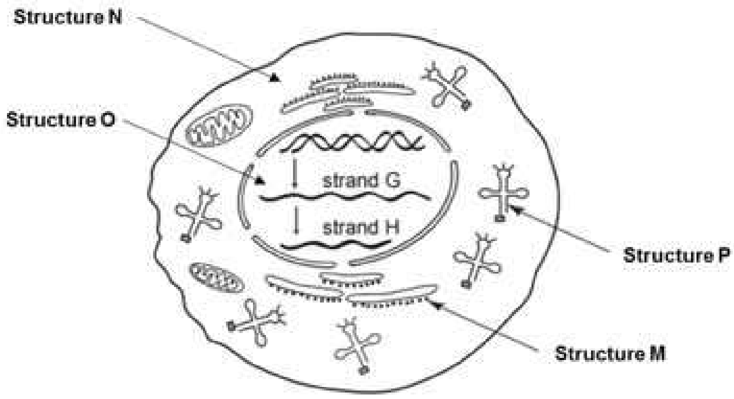


Fig. 2.1

(a) (i) In which structure would RNA polymerase be found?

.... [1]

(ii) Explain the mode of action of RNA polymerase.

[4]

(b) Strand H is shorter than strand G. Describe the process that results in this shortening, using appropriate names for both strands.

[2]

(c) Name strand H and structures P and M. Explain how each contributes to protein synthesis.

Strand H:

Structure P:

Structure M:

[3]

[Total: 10]

3 **(a)** Sometimes a gene has more than two alleles, termed *multiple alleles*.

The ABO blood group system in humans is controlled by a gene with three alleles, I^A, I^B and I^o. Alleles I^A and I^B are codominant and I^o is recessive to both.

The blood group **AB** is the result of codominance.

Explain what is meant by *codominance* in this context.

....

....

....

....

....

....
[3]

(b) In humans, a gene that codes for the production of a protein, called factor VIII, is located on the X chromosome. The dominant allele for this gene produces factor VIII, but the recessive allele does not produce factor VIII.

A person who is unable to make factor VIII has haemophilia in which the blood fails to clot properly.

Explain why a man with haemophilia cannot pass haemophilia to his son but may pass haemophilia to his grandson.

....

....

....

....

....

....
[3]

(c) A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black (**C^B**) and splashed-white (**C^W**). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

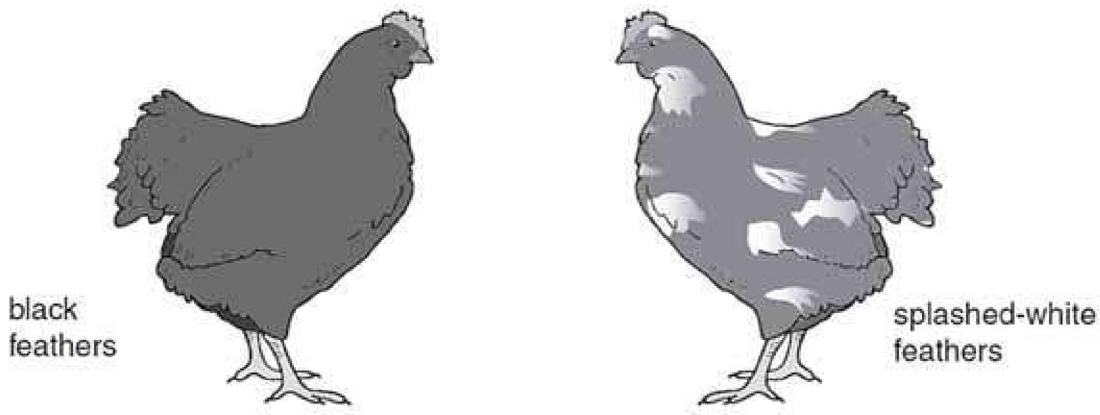


Fig. 3.1

Another gene may cause stripes on feathers (barred feathers). This gene is carried on the X chromosome. The allele for barred feathers (**X^A**) is dominant to the allele for nonbarred feathers (**X^a**).

In chickens, the male is homogametic and has two X chromosomes while the female is heterogametic and has one X chromosome and one Y chromosome.

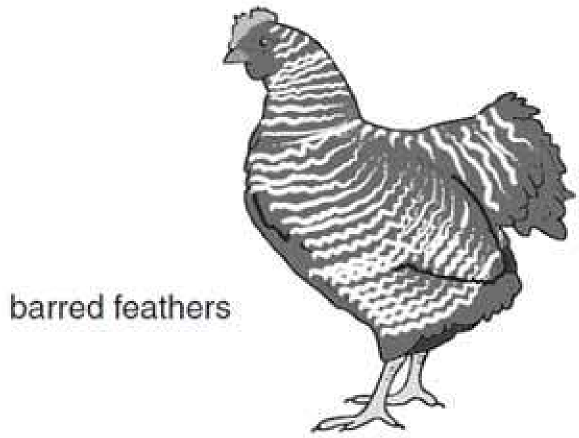


Fig. 3.2

(i) A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

Using the symbols given above draw a genetic diagram to show this cross.

[3]

(ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

....

....

....

....

....

....

[3]

[Total: 12]

4 Genetic information in humans can be obtained by DNA profiling.
In DNA profiling, the polymerase chain reaction is used by a scientist to amplify a particular sequence of DNA.

(a) Briefly describe the steps of polymerase chain reaction.

....

....

....

....

....

....

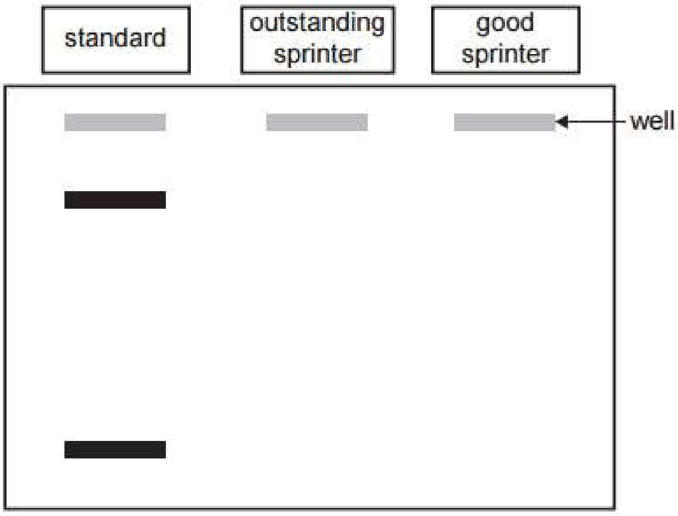
....

.... [4]

Scientists investigating the performance of athletes found that one gene contributing to the performance of sprinters is the ACTN3 gene. There are two alleles of the gene, the 577R allele and the 577X allele. The 577X allele codes for a very short protein fragment in muscle fibres due to a stop codon mutation. The table below summarises the athletic potential for the three possible genotypes for the ACTN3 gene.

ACTN3 genotype	Athletic potential
577R / 577R	outstanding sprinter
577R / 577X	good sprinter or long-distance runner
577X / 577X	very good long-distance runner

(b) A scientist tested sprinters to see if they possessed the 577R allele. Samples were obtained from athletes' muscle fibres. A standard containing proteins of the same lengths as the proteins coded for by both alleles 577X and 577R was used as a comparison. The standard and the samples were exposed to gel electrophoresis. In gel electrophoresis, protein molecules separate according to size and charge in the same way as DNA molecules. The result for the standard is shown below.



(i) On the diagram of the gel above, draw the bands expected for an outstanding sprinter and for a good sprinter. [1]

(ii) Explain why you have placed the bands in these positions.

....

....

....

.... [2]

[Total: 7]

Section B

Answer EITHER 4 or 5.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

Either

5 **(a)** Describe the structures of chloroplasts and mitochondria. [6]

(b) State the similarities between ATP production in chloroplasts and mitochondria and suggest why these similarities exist. [6]

(c) Distinguish between the processes of Krebs cycle and Calvin cycle. [8]

Or

6 **(a)** A guppy *(Poecilia reticulate)* is a species of small fish which originates in the freshwater mountain streams of the islands of Trinidad and Tobago.

It was observed in one stream, the guppies have bright and colorful rainbow markings, while in another nearby stream they would be less brightly colored.

Describe how natural selection may bring about the evolution of the less brightly colored guppies in the other stream. [5]

(b) Explain how variation could arise in a sexually-reproducing population. [7]

(c) Describe the unique features of stem cells and with reference to **named examples**, outline the normal functions of stem cells in a living organism. [8]

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE NAME: ANSWERS

CLASS:

BIOLOGY

8875/02

Paper 2 Structured Questions

14 September 2017

Additional Materials: Answer Paper

2 hours

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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 no use appropriate units.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
Section A	**40**
1	**11**
2	**10**
3	**12**
4	**7**
Section B	**20**
Total	**60**

This document consists of **5** printed pages and **1** blank page.

[Turn over

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

1 **Table 1.1** shows some features of four biological molecules that are all polymers.

(a) Complete Table 1.1 by using a tick (✓) to indicate the features that apply to each polymer.

Table 1.1

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				
contains glycosidic bonds				
polymer is branched				
contains nitrogen				
can be found in both animal and plant cells				

[4]

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				✓
contains glycosidic bonds	✓	✓		
polymer is branched	✓			
contains nitrogen			✓	✓
can be found in both animal and plant cells	;	;	✓ ;	✓ ;

(b) **Fig. 1.1** is a simple diagram of a phospholipid molecule.

Explain how the structure of a phospholipid molecule makes it suitable for its function in cell membranes. You may label and annotate **Fig. 1.1** as part of your answer.

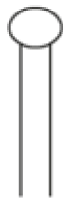


Fig. 1.1

Structure: Hydrophilic / polar, phosphate, head / group and hydrophobic / non polar, hydrocarbon / fatty acid, tails / chains; **R** *if labelled correctly but incorrectly described in the text*

Structure: Phosphate heads faces aqueous medium and fatty acid tails faces each other / inwards / interior of the cell membrane, forming the phospholipid bilayer ;

Function: resulting in partially / selectively permeability **R** *semi-permeable* / ability to act as a barrier to, hydrophilic substances / water soluble substances / polar substances / ions / AW ;

Structure + function: Presence of unsaturated hydrocarbon tails in phospholipid results in kinks, preventing the close packing of phospholipids, thus regulating fluidity of membrane;

Max 3m

[3]

(c) State two components of a cell surface membrane other than phospholipid molecules and describe their function.

max two components, one mark each
one mark for function to match the stated component

Glycolipid / glycoprotein; **R** *oligosaccharide*
Receptors for cell signalling / cell-cell recognition / cell-cell adhesion;

Cholesterol;
Regulate membrane fluidity / in low temperatures increases fluidity / in high temperatures decreases fluidity / provides mechanical stability to membranes ;

Protein; **Ignore** *any qualification of component e.g. channel / carrier / transport*
Receptor for cell signalling / enzyme / channel protein / provides hydrophilic pore / channel / carrier protein / provides specific binding site for facilitated diffusion / active transport / transport of hydrophilic / polar / charged molecules ;

max two components, one mark each
one mark for function to match the stated component

[4]

[Total: 11]

2 Fig. 2.1 below shows a diagram of a cell. The parts of a diagram are not drawn to scale.

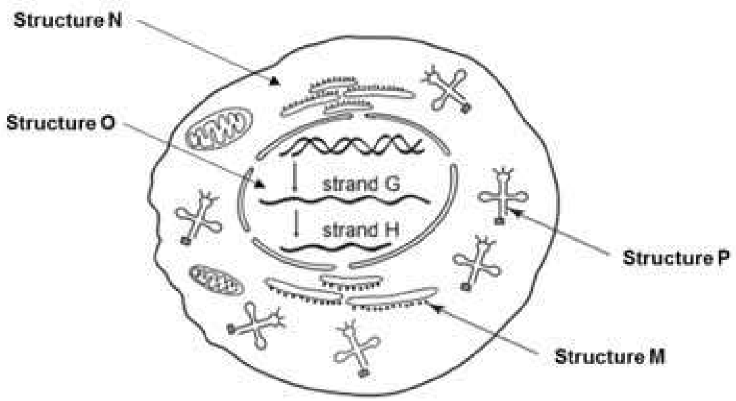


Fig. 2.1

(a) (i) In which structure would RNA polymerase be found?

Structure O which is the nucleus ;

[1]

(ii) Explain the mode of action of RNA polymerase.

Catalyses the formation of phosphodiester bond between incoming ribonucleotide and 3'OH end of the growing RNA strand ;

RNA polymerase has an active site that is complementary to the ribonucleotides in terms of shape, size, charge and orientation ;

Binding of incoming ribonucleotides to active site leads to formation of enzyme-substrate complex, which is a transition state;

Lowers the activation energy as it provides an alternative pathway for the reaction ;

[4]

(b) Strand H is shorter than strand G. Describe the process that results in this shortening, using appropriate names for both strands.

Strand G is pre-messenger ribonucleic acid while strand H is mature ribonucleic acid, after post-transcriptional modification;

Strand H is shortened due to RNA splicing as introns are removed;

[2]

(c) Name strand H and structures P and M. Explain how each contributes to protein synthesis.

Strand H: mature ribonucleic acid. It contains genetic information from the DNA in nucleus to the ribosomes in cytoplasm and acts as a template for protein synthesis ;

Structure P: transfer ribonucleic acid (tRNA). It carries the correct amino acid to the ribosomes during translation ;

Structure M: Ribosome. Contains peptidyl transferase that catalyses the formation of peptide bonds between adjacent amino acids ;

[3]

[Total: 10]

3 **(a)** Sometimes a gene has more than two alleles, termed *multiple alleles*.

The ABO blood group system in humans is controlled by a gene with three alleles, I^A, I^B and I^o. Alleles I^A and I^B are codominant and I^o is recessive to both.

The blood group **AB** is the result of codominance.

Explain what is meant by *codominance* in this context.

I^A allele codes for A antigen and I^B allele codes for B antigen;

Individual with genotype I^AI^B will have both A and B antigens and therefore, AB blood group;

Phenotype of heterozygote different from either homozygote whereby I^AI^A gives A blood group and I^BI^B gives B blood group;

Ref. more than 2 phenotypes possible;

[3]

(b) In humans, a gene that codes for the production of a protein, called factor VIII, is located on the X chromosome. The dominant allele for this gene produces factor VIII, but the recessive allele does not produce factor VIII.

A person who is unable to make factor VIII has haemophilia in which the blood fails to clot properly.

Explain why a man with haemophilia cannot pass haemophilia to his son but may pass haemophilia to his grandson.

son receives Y chromosome from father / did not inherit X chromosome containing haemophilia allele from father ;

father will pass haemophilia allele to daughter(s) ;

daughter may pass allele to, her son / his grandson ;

[3]

(c) A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black (**C**^{B}) and splashed-white (**C**^{W}). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

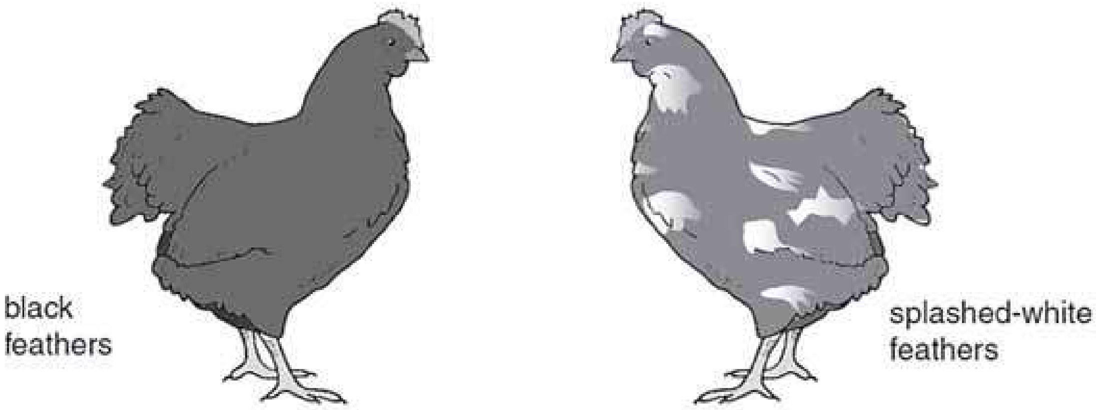


Fig. 3.1

Another gene may cause stripes on feathers (barred feathers). This gene is carried on the X chromosome. The allele for barred feathers (**X^A**) is dominant to the allele for nonbarred feathers (**X^a**).

In chickens, the male is homogametic and has two X chromosomes while the female is heterogametic and has one X chromosome and one Y chromosome.

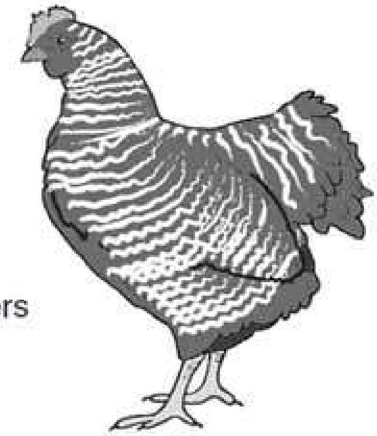


Fig. 3.2

(i) A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

Using the symbols given above draw a genetic diagram to show this cross.

(c) (i) (male) $C^BC^BX^aX^a$; x (female) $C^WC^WX^AY$;

(gametes) C^BX^a C^WX^A or C^WY ;

$C^BC^WX^AX^a$; (male, blue, barred) $C^BC^WX^aY$; (female, blue, non-barred)

accept other symbols but only with key
if male XY and female XX then mark gametes and offspring genotypes to max 2
if other symbols used but no key then mark to max 2

1 mark for parental genotype;
1 mark for gametes;
1 mark for offspring genotype and matching;

[3]

(ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

with non-barred female (X^aY);

if all offspring barred, must be X^AX^A / homozygous ;

if some offspring non-barred, must be X^AX^A / heterozygous ;

[3]

[Total: 12]

4 Genetic information in humans can be obtained by DNA profiling.
In DNA profiling, the polymerase chain reaction is used by a scientist to amplify a particular sequence of DNA.

(a) Briefly describe the steps of polymerase chain reaction.

Denaturation of double-stranded DNA to single-stranded DNA at 95^0C by breaking hydrogen bonds;

Annealing of primers via complementary base pairing between primers and flanking sequence of the target DNA when temp is lowered to $50\text{-}60^0C$;

During elongation stage, temp increased to about 72^0C where Taq polymerase catalyse the addition of deoxyribonucleotides to the 3'OH end of primers ;

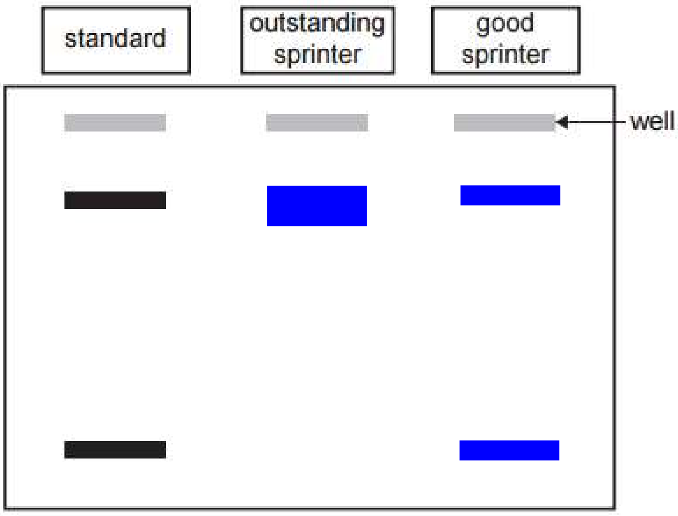
The sequential process of denaturation-annealing-elongation is repeated many times. This is called a chain reaction as the products of the previous reaction are used as reactants in the next cycle.

[4]

Scientists investigating the performance of athletes found that one gene contributing to the performance of sprinters is the ACTN3 gene. There are two alleles of the gene, the 577R allele and the 577X allele. The 577X allele codes for a very short protein fragment in muscle fibres due to a stop codon mutation. The table below summarises the athletic potential for the three possible genotypes for the ACTN3 gene.

ACTN3 genotype	Athletic potential
577R / 577R	outstanding sprinter
577R / 577X	good sprinter or long-distance runner
577X / 577X	very good long-distance runner

(b) A scientist tested sprinters to see if they possessed the 577R allele. Samples were obtained from athletes' muscle fibres. A standard containing proteins of the same lengths as the proteins coded for by both alleles 577X and 577R was used as a comparison. The standard and the samples were exposed to gel electrophoresis. In gel electrophoresis, protein molecules separate according to size and charge in the same way as DNA molecules. The result for the standard is shown below.



(i) On the diagram of the gel above, draw the bands expected for an outstanding sprinter and for a good sprinter. [1]

(ii) Explain why you have placed the bands in these positions.

Outstanding sprinter only has one band as only one allele is present, thicker band due to the presence of two copies of the same allele / homozygous;

Good sprinter has two bands due to two different alleles / heterozygous;

[2]
[Total: 7]

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Section B

Answer EITHER 4 or 5.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

Either

5 **(a)** Explain how ATP is produced in living organisms. [8]

1. Source of energy for synthesis of ATP: Photophosphorylation in chloroplast comes from light while oxidative phosphorylation in mitochondria comes from oxidation of glucose;
2. Electron transport chain are found in thylakoid membrane in chloroplasts and inner membrane in mitochondria;
3. Electrons are passed along the electron transport chain from one electron carrier to the next, each with an energy level lower than the one preceding it;
4. Energy is used to pump protons from matrix of the mitochondrion into the intermembrane space + from stroma of chloroplast into thylakoid space;
5. This produces a high concentration of H^+ due to impermeable nature of membranes to protons, generating a steep electrochemical proton gradient;
6. Stalked particles containing ATP synthases ® ATPase are embedded on inner mitochondria membrane / thylakoid membrane;
7. Protons diffuse through them, synthesizing ATP by the phosphorylation of ADP with inorganic phosphate (P_i);
8. Substrate-level phosphorylation in glycolysis: synthesis of ATP using phosphate groups from glycolytic intermediates;
9. Substrate-level phosphorylation in Krebs cycle: synthesis of ATP using phosphate group from GTP;

(b) Describe the structure of chloroplast and distinguish it from the mitochondria. [7]

Structure of chloroplast:

1. Organelle bounded by a double membrane;
2. Contains 70S ribosomes and circular DNA;
3. Contains series of electron carriers forming the electron transport chain and stalked particles containing ATP synthase embedded on the thylakoid membrane;
4. Thylakoid membrane extensively folded;
5. Cylindrical in shape / rod-shaped;

Structural differences:

6. Chloroplast contains photosynthetic pigments such as chlorophyll/carotenoids but mitochondria do not;
7. Chloroplast contains starch grains while mitochondria contain glycogen granules;
8. Orientation of the stalked particles in chloroplast is such that the ATP synthase faces the stroma while that in mitochondria faces the mitochondrial matrix;

9. Inner membrane of chloroplast is thylakoid while that of mitochondria is cristae / inner mitochondrial membrane;
10. Mitochondrial matrix in mitochondria vs stroma in chloroplast;

(c) Describe, with examples, how the environment may affect the phenotype [5]

1 Genetically identical zygote can be different due to wide range of environment effects;
2 The expression of genotype may be influenced by environment factors like nutrients, light, or temperature;
3 E.g. Fur colour in Himalayan rabbits is affected by a temperature-sensitive enzyme involved in pigment synthesis;
4 Low temperature can results in active enzyme that result in black pigment formation. Thus, Himalayan rabbit are black extreme parts of the body;
5 E.g. Phenotypes of honey bee (drones, queen or workers) are determined by the diet of larvae during development;
6 Royal jelly diet will give rise a queen bee;
7 Spontaneous somatic mutation may occur due to exposure to harmful radiation or carcinogens and cause different phenotypes;

[Total:20]

Or

6 (a) Explain how variation could arise in a sexually-reproducing population. [8]

1. Meiosis is an important step for sexual reproduction as haploid gametes are produced;
2. Meiosis results in genetic variation as the reduction division allows the combining of genetic materials from two parents / individuals;
3. Due to crossing over of non-sister chromatids of homologous chromosomes, at the chiasmata, during prophase I;
4. Thus allowing corresponding sections to be exchanged, separating linked genes / creating new combination of alleles in each chromatid;
5. Due to independent assortment of chromosomes during metaphase I, whereby the orientation of homologous pair of chromosomes along the metaphase plate is independent of other bivalents;
6. This is followed by independent segregation during anaphase I, resulting in numerous possible chromosomal combinations in a gamete, i.e. 2n, where n = number of homologous pairs of chromosomes;
7. In addition, during fertilization, random fusion of gametes occurs, resulting in numerous combinations of a zygote;

Maximum 2 marks on mutation;;

8. (Spontaneous) gene mutation: change in DNA sequence of a gene / change in one or a few nucleotides, giving rise to new alleles;
9. Chromosomal aberrations: change in structure of chromosomes due to translocation / deletion / duplication of chromosomal fragment + elaboration;
10. Chromosomal aberration: change in number of chromosome i.e aneuploidy / polyploidy – extra / lack of one chromosome or sets of chromosomes + elaboration;

(b) Describe how natural selection may bring about the evolution of the Galapagos finches.

1. Selection pressure: limited / different food source which led to the variety of beaks in different species of Galapagos finches
2. Idea of adaptive radiation: development of a variety of species from a single ancestral form (idea of descent with modification)
3. Variation in terms of beak size and shape exist between individuals within the Galapagos finches population
4. Individual finches who are better adapted to obtaining the food source will survive till maturity and produce fertile, viable offspring compared to the others
5. Ref to passing down of beneficial alleles to the offspring, accumulate genetic differences over long periods of time, leading to evolution of the finches

[5]

(c) Describe the unique features of stem cells and with reference to named examples, distinguish between pluripotent and multipotent stem cells.

Unique features of stem cells:

1. Stem cells are unspecialised cells ;
2. During a single division, they can divide into one genetically identical daughter cell and another more specialised daughter cell which can undergo further differentiation ;
3. They are capable of dividing and renewing themselves for long periods ;
4. They can give rise to specialised cell types according to internal / external signals ;

Differences:

5. Pluripotent stem cells such as embryonic stem cells can differentiate into almost any cell **type** to form any organ or any cell type ;
6. While multipotent stem cells such as blood / haematopoetic stem cells can differentiate into a limited range of cell **type**, usually of a closely-related family of cells;
7. Embryonic stem cells can give rise to the three primary germ layers: ectoderm, endoderm and mesoderm (which subsequently give rise to the multiple specialised cell types that form the heart, lungs, skin and other tissue) while blood / haematopoietic stem cells can differentiate into red blood cells, white blood cells, platelets etc. (for cell replacement / tissue repair) ;
8. Pluripotent stem cells like ESCs are not totipotent but are multipotent ;
9. Pluripotent stem cells like ESCs are obtained from the blastocyst in an embryo while multipotent stem cells like blood / haematopoietic stem cells are adult stem cells that can be found in organs / tissues such as the brain, bone marrow, skeletal muscle, skin or liver;

[7]

[Total:20]

NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 1

CANDIDATE NAME

BIOLOGY CLASS 2bi1A

REGISTRATION NUMBER

BIOLOGY

8875/01

Paper 1 Multiple Choice

13 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your Biology class, registration number and name above and on the Answer Sheet provided.

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

Read the instructions on the Answer Sheet very carefully.

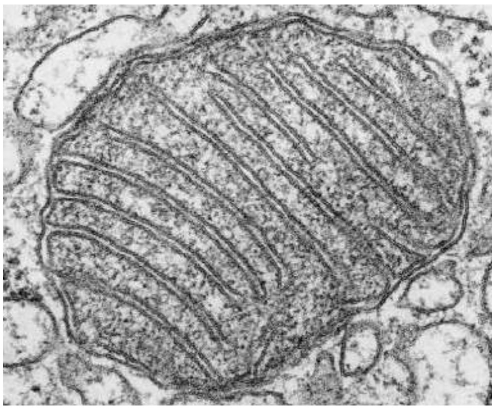
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

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

[Turn over

1 The electron micrographs, which are taken at different magnifications, show four different organelles that can be found in different eukaryotic cells.

1



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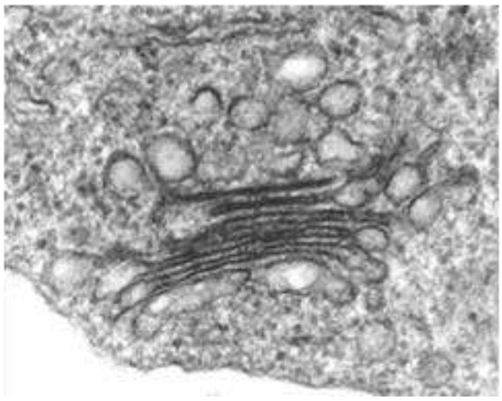

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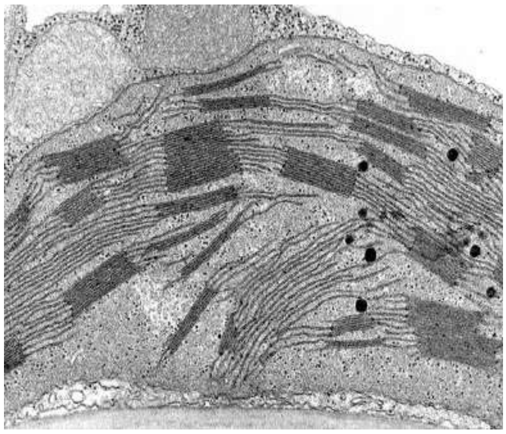
4



Which organelle(s) contain(s) nucleic acids?

A 4 only

B 1 and 4 only

C 1, 3 and 4 only

D 1, 2, 3 and 4

2 Which statements about membrane fluidity are correct?

1 The less unsaturated the fatty acid chains of the phospholipids, the more fluid the membrane is.

2 The greater the amount of cholesterol in the membrane, the less fluid the membrane is at high temperatures.

3 The longer the hydrocarbon tails of the phospholipids, the more fluid the membrane is.

4 The lower the temperature, the less fluid the membrane is.

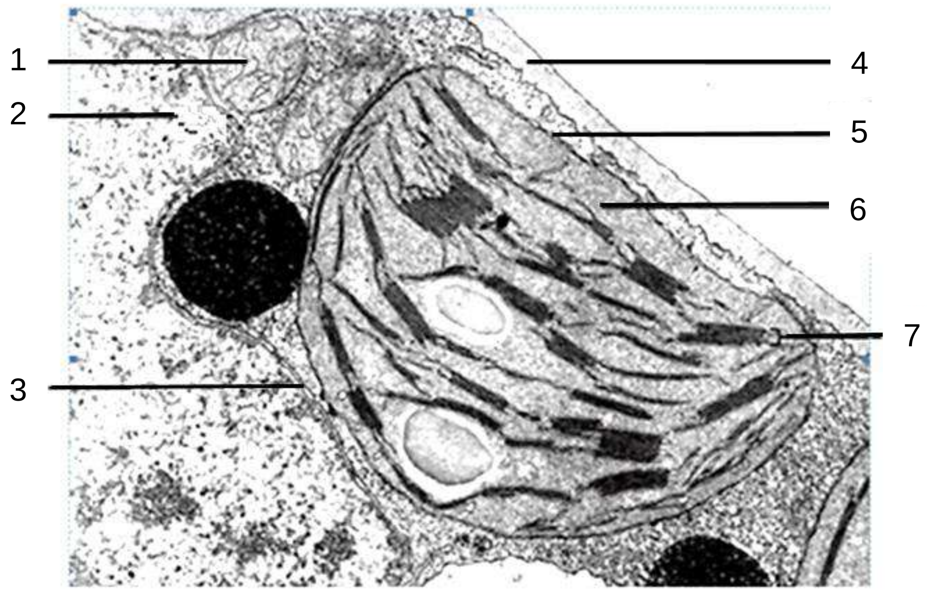
A 1 and 3

B 2 and 4

C 1, 2 and 3

D 2, 3 and 4

3 The diagram shows part of a eukaryotic cell.



Which row is correct?

	composed of two membranes	site of Calvin cycle	composed of cellulose	stack of membrane bound structures	site of ATP synthesis
A	3	6	4	7	1
B	3	4	6	5	1
C	5	6	4	7	2

D	5	6	3	I	2

4 The following statements describe three orders of structure of the insulin molecule.

1 The molecule consists of two polypeptide chains joined and folded around one another.

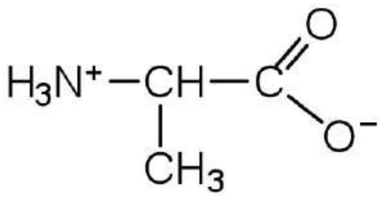
2 The sequence and number of amino acids in each polypeptide chain are known.

3 The amino acids in each chain are coiled into a helix and held in position by hydrogen bonds.

Which order is described by each statement?

	1	2	3
A	primary	secondary	tertiary
B	quaternary	primary	secondary
C	quaternary	primary	tertiary
D	secondary	tertiary	primary

5 The diagram shows the structure of an amino acid.



What is true about this amino acid?

1 It has a hydrophobic R group.

2 It is amphoteric.

3 It is insoluble in water.

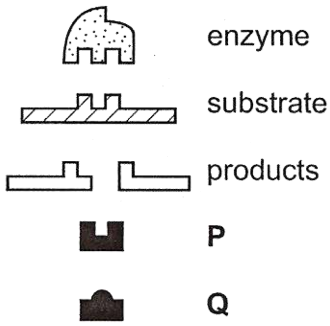
A 1 only

B 3 only

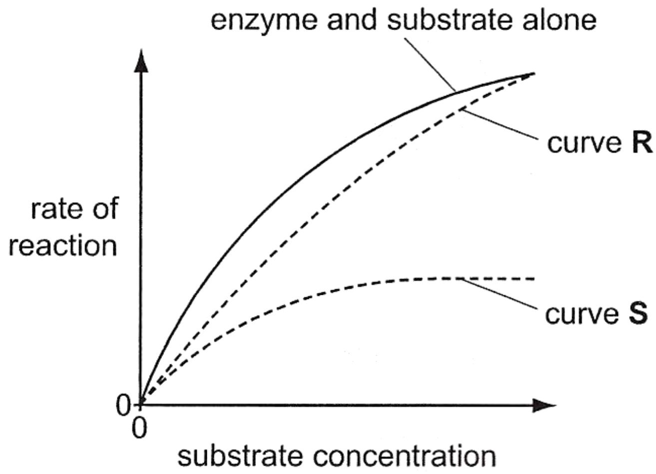
C 1 and 2 only

D 1, 2 and 3

6 The diagram shows an enzyme molecule with its normal substrate and products. P and Q are other molecules that can bind to the enzyme.



The graph shows the effect of P and Q on the rate of reaction of the enzyme at different substrate concentrations.



Which statement correctly describes the activity of the enzyme?

A P is a competitive inhibitor that binds to the active site, resulting in curve R.

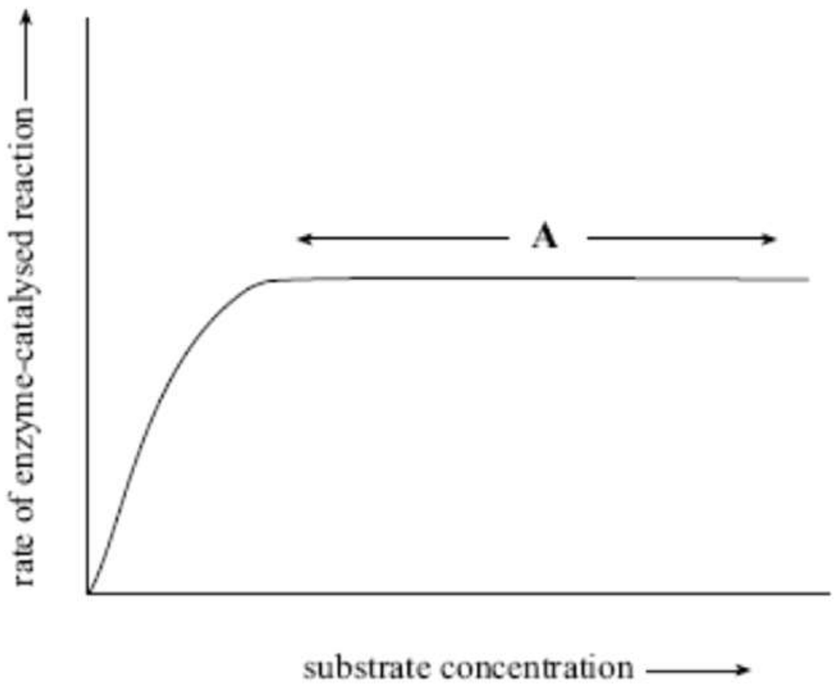
B P is a non-competitive inhibitor that distorts the shape of the enzyme, resulting in curve S.

C Q is a competitive inhibitor that distorts the shape of the enzyme, resulting in curve R.

D Q is a non-competitive inhibitor that binds to the active site, resulting in curve S.

7 The graph shows the results of an experiment to determine the effect of varying substrate concentrations on the rate of an enzyme-catalysed reaction.

The experiment was conducted at the optimum pH for the enzyme and in the presence of an inhibitor.



What would result in a higher rate of the enzyme-catalysed reaction in the section labelled A on the graph?

A decreased enzyme concentration

B decreased inhibitor concentration

C increased pH

D increased substrate concentration

8 How does the second meiotic division differ from mitosis?

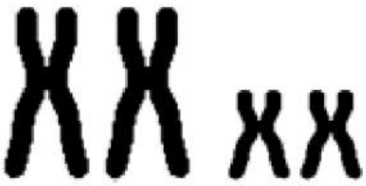
A Chiasmata form between the chromatids of a bivalent in the second meiotic division but not in mitosis.

B Each chromosome replicates to form two chromatids during metaphase in the second meiotic division but not in mitosis.

C Exchange of genetic material occurs between chromatids in the second meiotic division but not in mitosis.

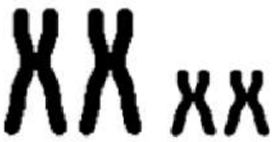
D The separating chromatids of a pair differ genetically in the second meiotic division but not in mitosis.

9 The diagram shows the chromosomes of a cell just before the metaphase stage of mitosis.



What will be the appearance of the chromosomes at telophase?

A



B

C

D

10 Suppose a cell with 14 chromosomes divides mitotically and one of the two new cells has 13 chromosomes and the other has 15 chromosomes.

At which phase of the cell cycle could an error have occurred and resulted in the unequal number of chromosomes in the two new cells?

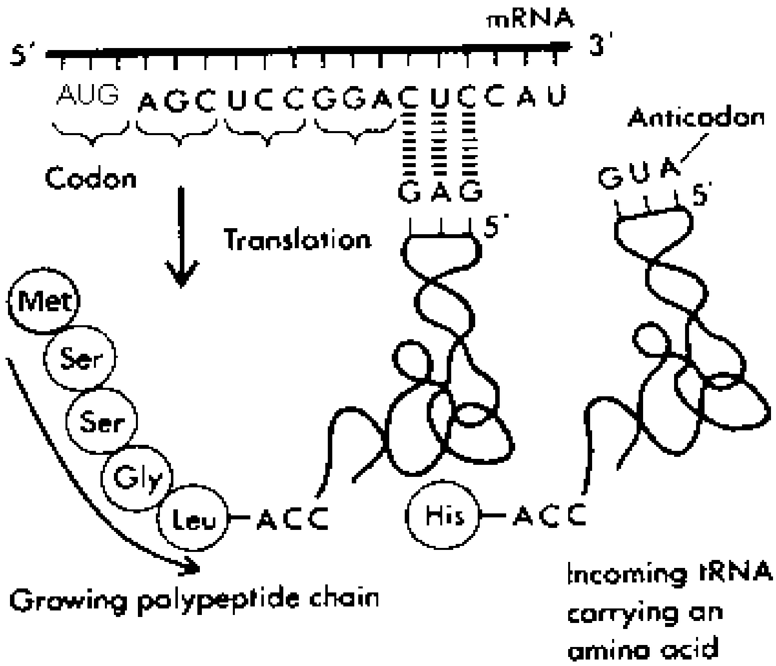
A anaphase

B interphase

C prophase

D telophase

11 The diagram shows the process of translation.



Which pair of statements is correct?

1. The ribosome is translocating from right to left.
2. The diagram shows degeneracy of the genetic code.
3. The polypeptide would be attached to the tRNA after histidine was added.
4. The number of hydrogen bonds formed between the respective codons and anticodons is the same for the two tRNAs.

A 1 and 3

B 1 and 4

C 2 and 3

D 2 and 4

12 The following DNA sequence of the coding strand, which is complementary to the mRNA, is taken randomly from a bacterial genome.

3’ TTACGCTTCGAAATAGGAATATCATAGGCT 5’

This DNA sequence is cloned into a plasmid, which is introduced into a suitable host.

The table shows the mRNA codons for some amino acids.

arg	CGA, CGG, AGA, AGG	leu	CUU, CUC, CUA, CUG
asp	GAU, GAC	lys	AAA, AAG
ile	AUU, AUC, AUA	phe	UUU, UUC
met	AUG	ser	UCA, UCG, AGU, AGC
stop	UAG, UGA, UAA	tyr	UAU, UAC

What are the first four amino acids of the polypeptide generated from this DNA sequence?

A met-arg-ser-lys

B met-arg-ser-phe

C met-ile-phe-leu

D met-tyr-lys-asp

13 Which is not a characteristic of a cancer cell?

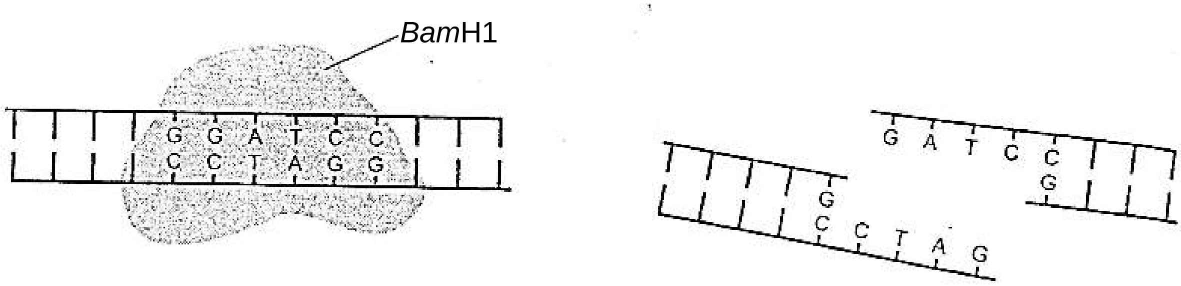
A It grows and divides without stimulation by a growth factor.

B It releases factors that cause nearby cells to become cancerous.

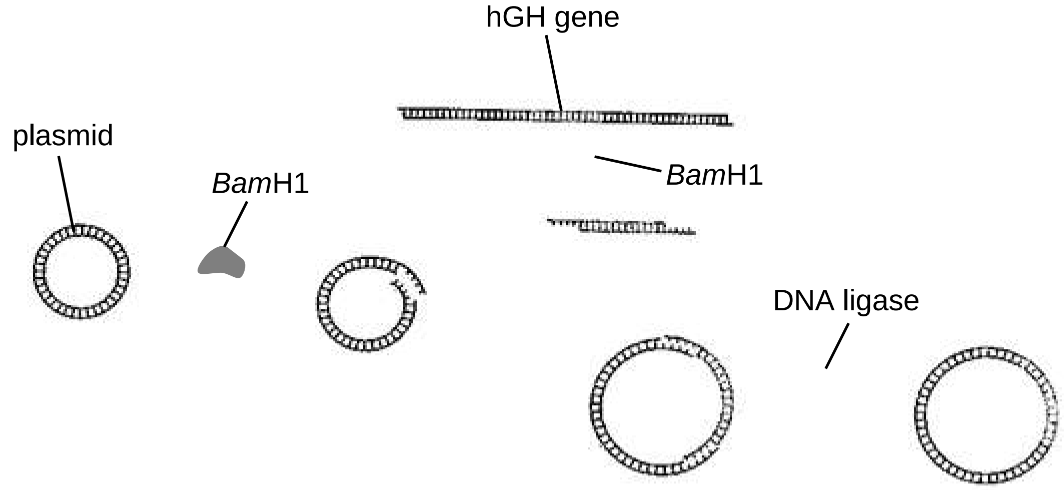
C It replicates an unlimited number of times.

D Its DNA damage does not halt cell division or stimulate apoptosis.

14 *Bam*H1 is a restriction enzyme that cuts DNA as shown in the diagram.



The diagram shows part of the procedure for producing *E.coli* that will synthesise human growth hormone, hGH.



At the end of this process, many plasmids do not contain the hGH gene.

What could explain this?

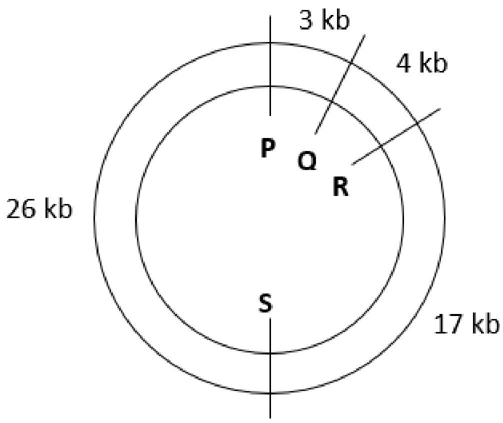
A Different alleles of the hGH gene have different sticky ends.

B Not all of the plasmids cut by BamH1 have sticky ends.

C Some of the plasmids are cut at more than one position.

D The sticky ends of some of the plasmids rejoin with each other.

15 The diagram shows a plasmid with the positions of four restriction sites P to S indicated.



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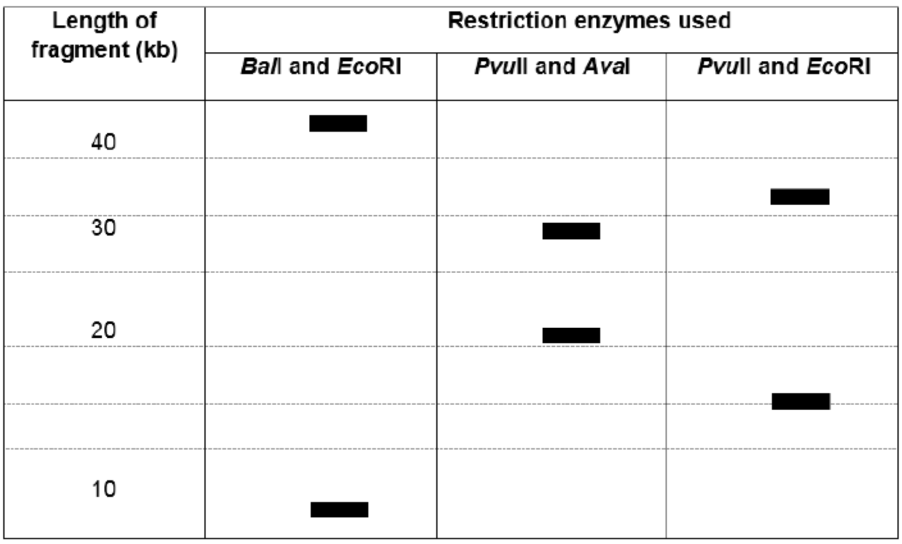

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Which of the following statements cannot account for the difference in the number of bands seen on the gel?

1 The two enzymes have active sites that are of different shapes.

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3 Ethidium bromide binds with greater affinity to double stranded DNA than single stranded DNA.

A 1 only

B 1 and 3 only

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17 Which combination correctly describes the light-dependent reactions of photosynthesis?

	site of reaction in chloroplast	ATP	NADP
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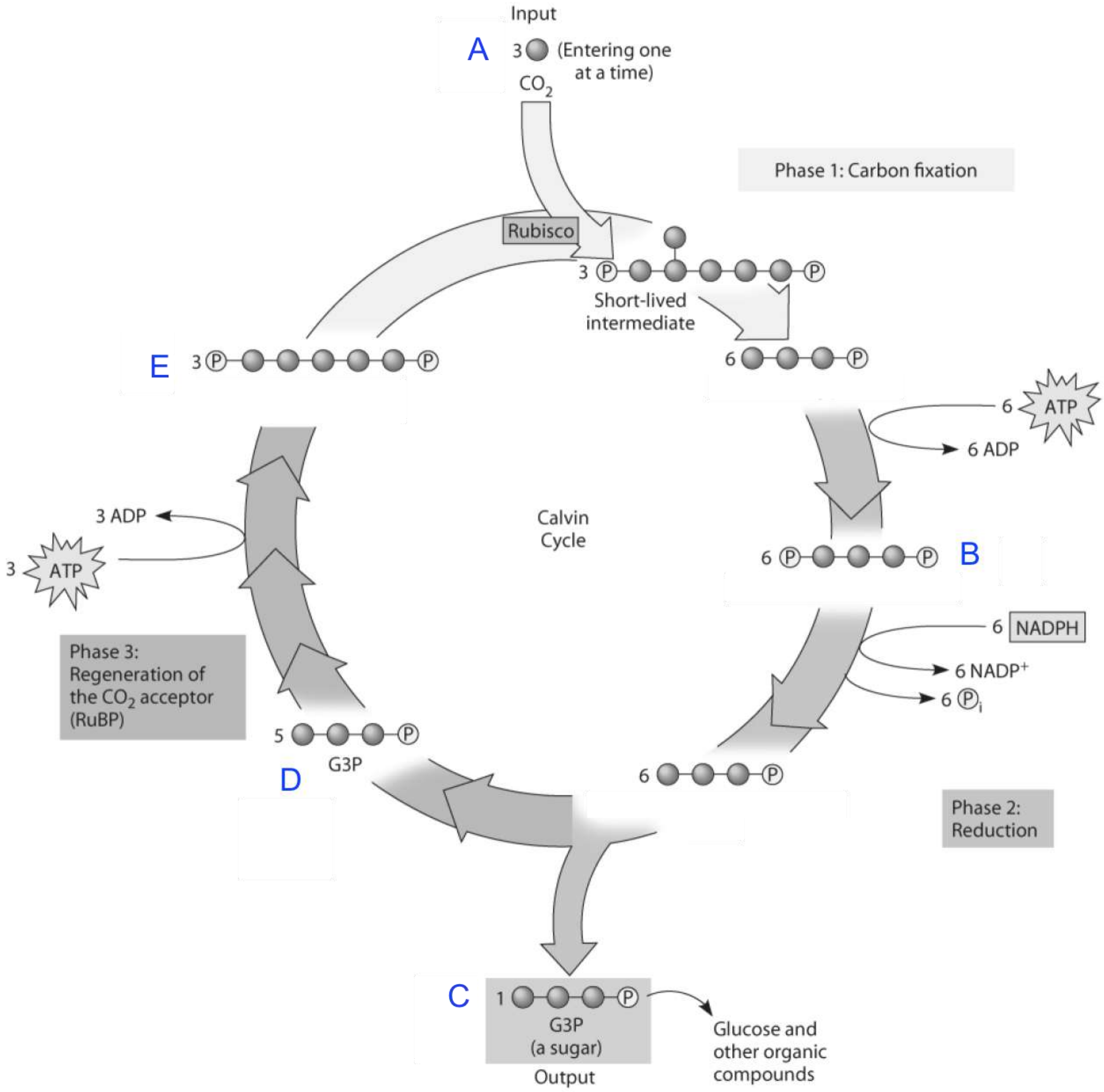

If ATP used by a plant is labelled with radioactive phosphorus, in which molecules would the radioactivity be measurable after one "turn" of the Calvin cycle?

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A Oxygen is used to oxidise the acetyl group carbons of acetyl-CoA in the Krebs cycle.

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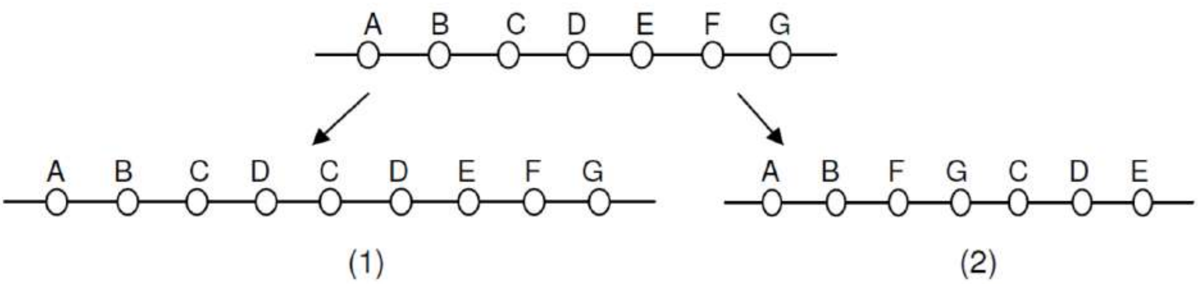

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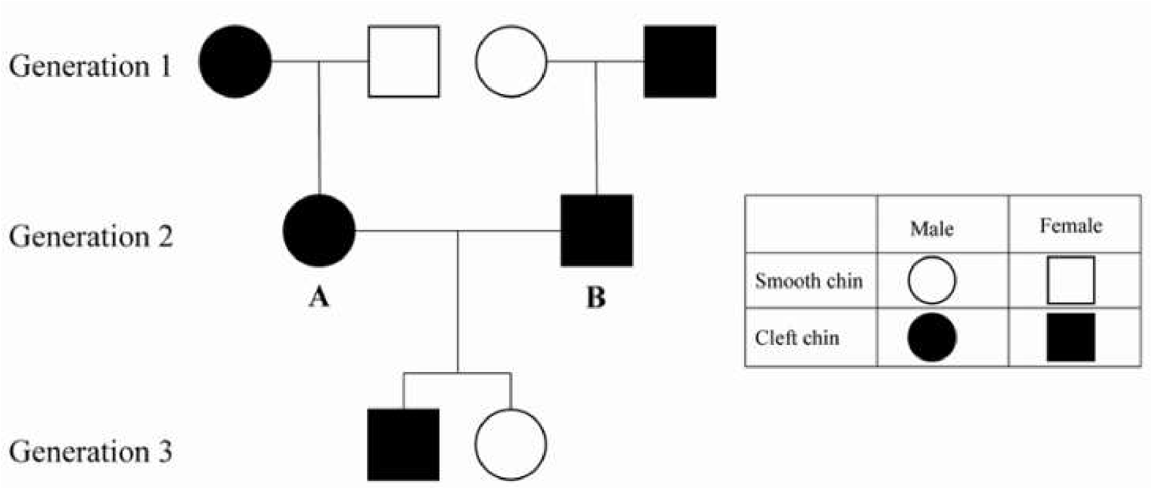

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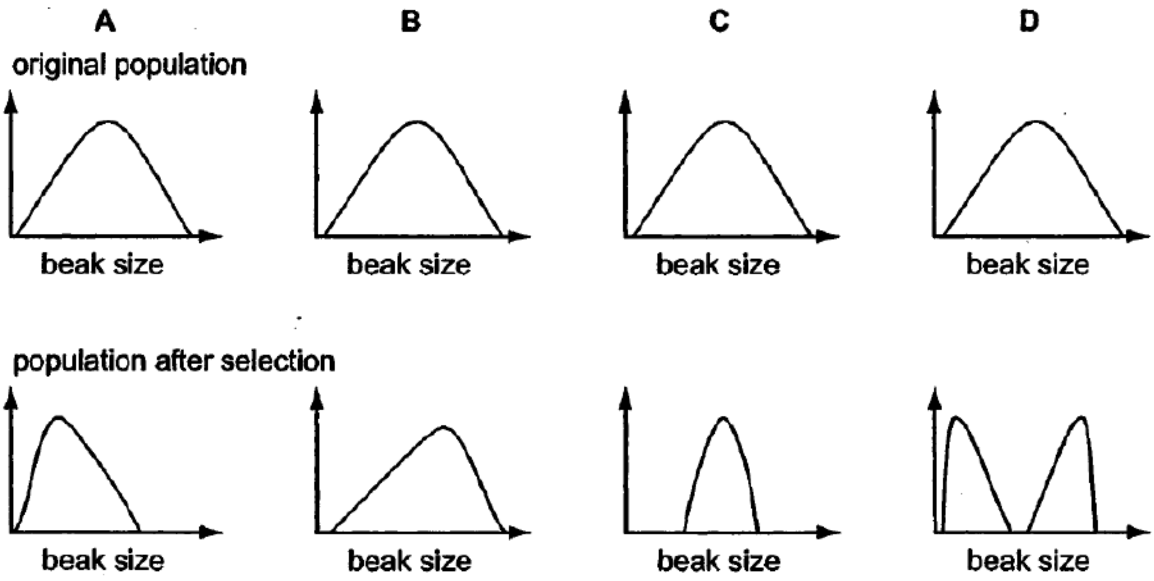

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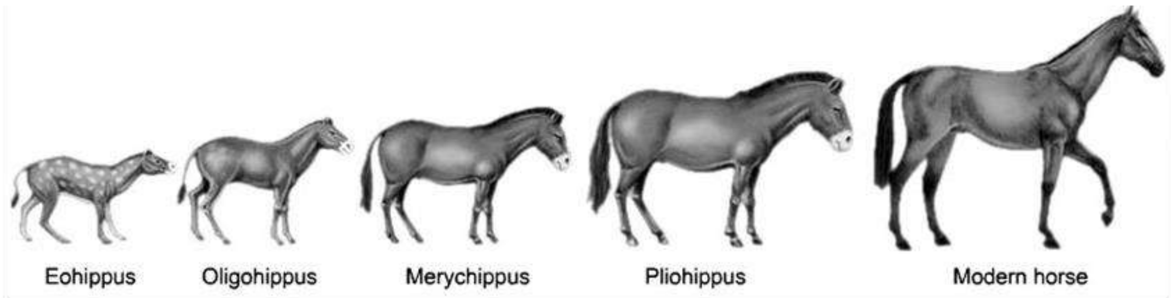

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NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 1

CANDIDATE NAME	

BIOLOGY CLASS	2bi1A	REGISTRATION NUMBER	

BIOLOGY

8875/01

Paper 1 Multiple Choice

13 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your Biology class, registration number and name above and on the Answer Sheet provided.

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

Read the instructions on the Answer Sheet very carefully.

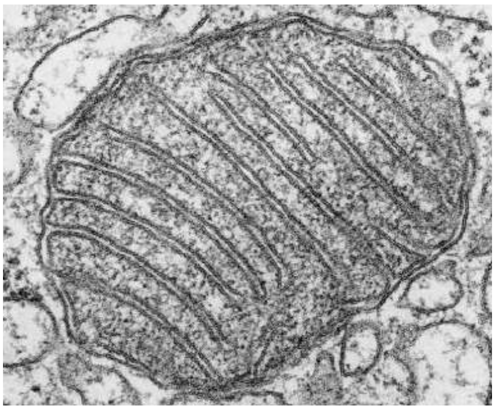
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

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

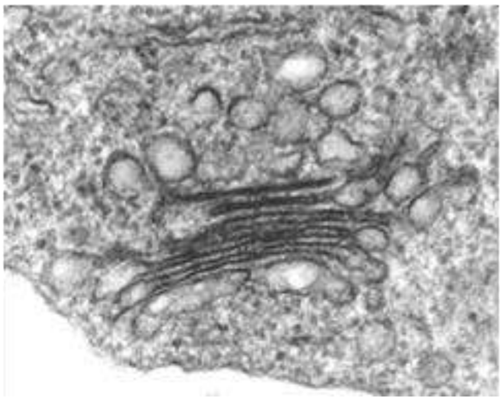
[Turn over

1 The electron micrographs, which are taken at different magnifications, show four different organelles that can be found in different eukaryotic cells.

1



2



3

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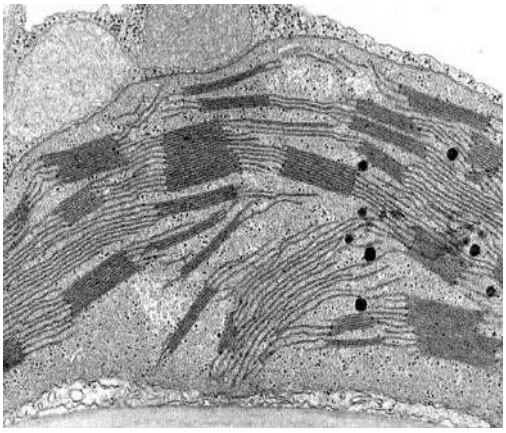


Which organelle(s) contain(s) nucleic acids?

A 4 only

B 1 and 4 only

C 1, 3 and 4 only

D 1, 2, 3 and 4

2 Which statements about membrane fluidity are correct?

1 The less unsaturated the fatty acid chains of the phospholipids, the more fluid the membrane is.

2 The greater the amount of cholesterol in the membrane, the less fluid the membrane is at high temperatures.

3 The longer the hydrocarbon tails of the phospholipids, the more fluid the membrane is.

4 The lower the temperature, the less fluid the membrane is.

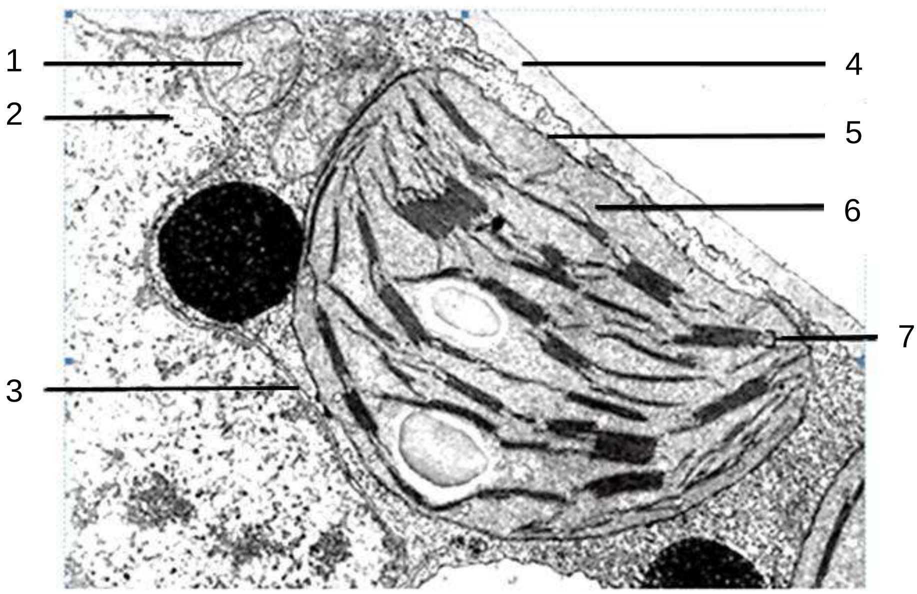
A 1 and 3

B 2 and 4

C 1, 2 and 3

D 2, 3 and 4

3 The diagram shows part of a eukaryotic cell.



Which row is correct?

	composed of two membranes	site of Calvin cycle	composed of cellulose	stack of membrane bound structures	site of ATP synthesis
A	3	6	4	7	1
B	3	4	6	5	1
C	5	6	4	7	2
D	5	6	3	I	2

4 The following statements describe three orders of structure of the insulin molecule.

1 The molecule consists of two polypeptide chains joined and folded around one another.

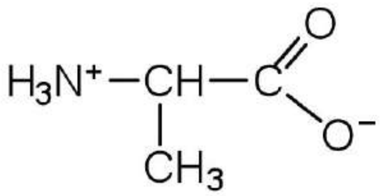
2 The sequence and number of amino acids in each polypeptide chain are known.

3 The amino acids in each chain are coiled into a helix and held in position by hydrogen bonds.

Which order is described by each statement?

	1	2	3
A	primary	secondary	tertiary
B	quaternary	primary	secondary
C	quaternary	primary	tertiary
D	secondary	tertiary	primary

5 The diagram shows the structure of an amino acid.



What is true about this amino acid?

1 It has a hydrophobic R group.

2 It is amphoteric.

3 It is insoluble in water.

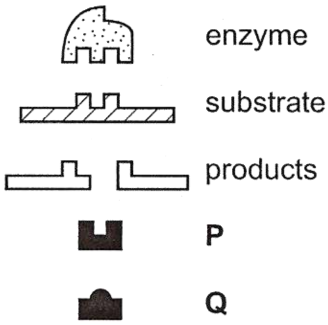
A 1 only

B 3 only

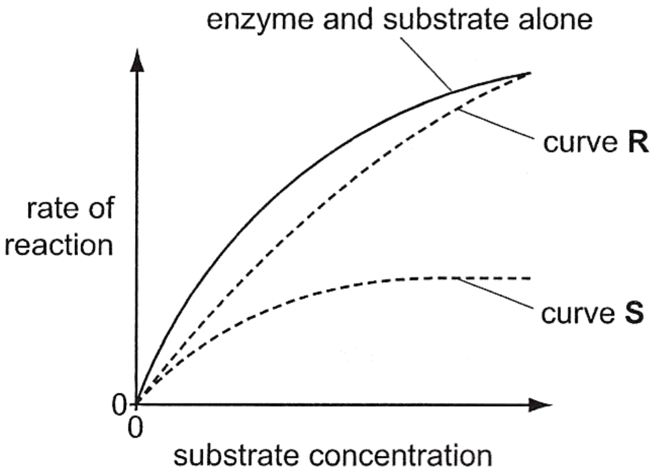
C 1 and 2 only

D 1, 2 and 3

6 The diagram shows an enzyme molecule with its normal substrate and products. P and Q are other molecules that can bind to the enzyme.



The graph shows the effect of P and Q on the rate of reaction of the enzyme at different substrate concentrations.



Which statement correctly describes the activity of the enzyme?

A P is a competitive inhibitor that binds to the active site, resulting in curve R.

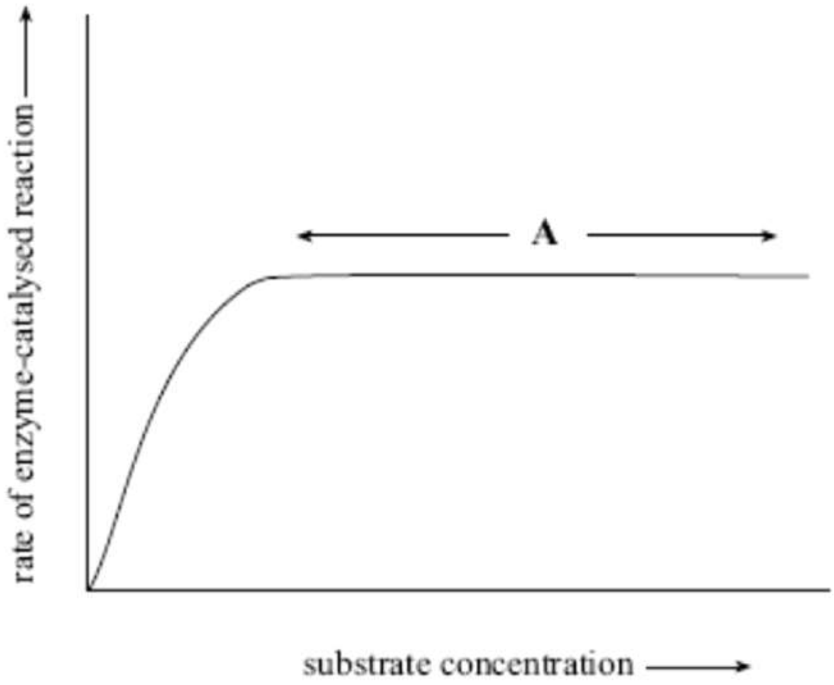
B P is a non-competitive inhibitor that distorts the shape of the enzyme, resulting in curve S.

C Q is a competitive inhibitor that distorts the shape of the enzyme, resulting in curve R.

D Q is a non-competitive inhibitor that binds to the active site, resulting in curve S.

7 The graph shows the results of an experiment to determine the effect of varying substrate concentrations on the rate of an enzyme-catalysed reaction.

The experiment was conducted at the optimum pH for the enzyme and in the presence of an inhibitor.



What would result in a higher rate of the enzyme-catalysed reaction in the section labelled A on the graph?

A decreased enzyme concentration

B decreased inhibitor concentration

C increased pH

D increased substrate concentration

8 How does the second meiotic division differ from mitosis?

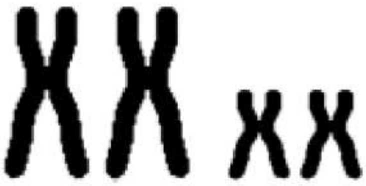
A Chiasmata form between the chromatids of a bivalent in the second meiotic division but not in mitosis.

B Each chromosome replicates to form two chromatids during metaphase in the second meiotic division but not in mitosis.

C Exchange of genetic material occurs between chromatids in the second meiotic division but not in mitosis.

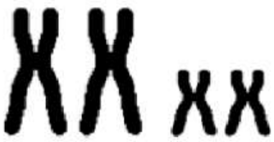
D The separating chromatids of a pair differ genetically in the second meiotic division but not in mitosis.

9 The diagram shows the chromosomes of a cell just before the metaphase stage of mitosis.



What will be the appearance of the chromosomes at telophase?

A



B

C

D

10 Suppose a cell with 14 chromosomes divides mitotically and one of the two new cells has 13 chromosomes and the other has 15 chromosomes.

At which phase of the cell cycle could an error have occurred and resulted in the unequal number of chromosomes in the two new cells?

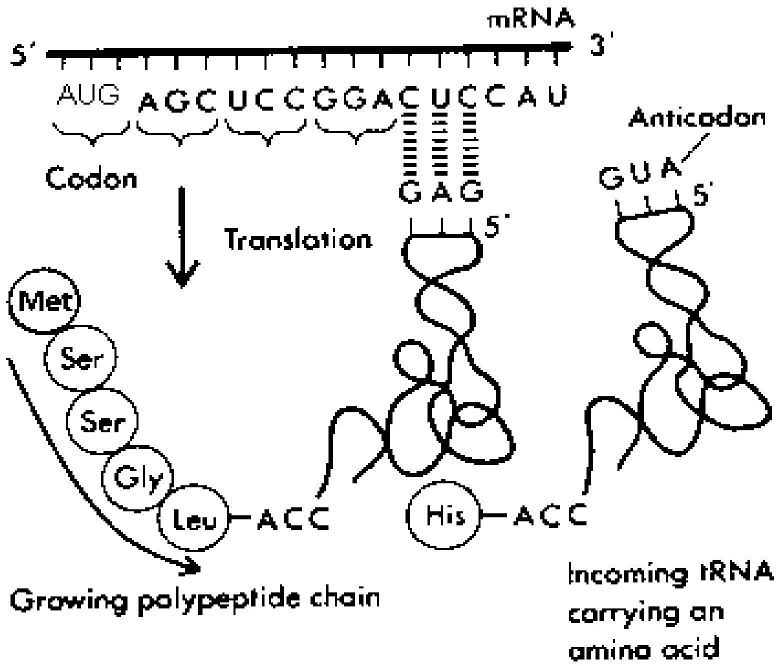
A anaphase

B interphase

C prophase

D telophase

11 The diagram shows the process of translation.



Which pair of statements is correct?

1. The ribosome is translocating from right to left.
2. The diagram shows degeneracy of the genetic code.
3. The polypeptide would be attached to the tRNA after histidine was added.
4. The number of hydrogen bonds formed between the respective codons and anticodons is the same for the two tRNAs.

A 1 and 3

B 1 and 4

C 2 and 3

D 2 and 4

12 The following DNA sequence of the coding strand, which is complementary to the mRNA, is taken randomly from a bacterial genome.

3' TTACGCTTCGAAATAGGAATATCATAGGCT 5'

This DNA sequence is cloned into a plasmid, which is introduced into a suitable host.

The table shows the mRNA codons for some amino acids.

arg	CGA, CGG, AGA, AGG	leu	CUU, CUC, CUA, CUG
asp	GAU, GAC	lys	AAA, AAG
ile	AUU, AUC, AUA	phe	UUU, UUC
met	AUG	ser	UCA, UCG, AGU, AGC
stop	UAG, UGA, UAA	tyr	UAU, UAC

What are the first four amino acids of the polypeptide generated from this DNA sequence?

A met-arg-ser-lys

B met-arg-ser-phe

C met-ile-phe-leu

D met-tyr-lys-asp

13 Which is not a characteristic of a cancer cell?

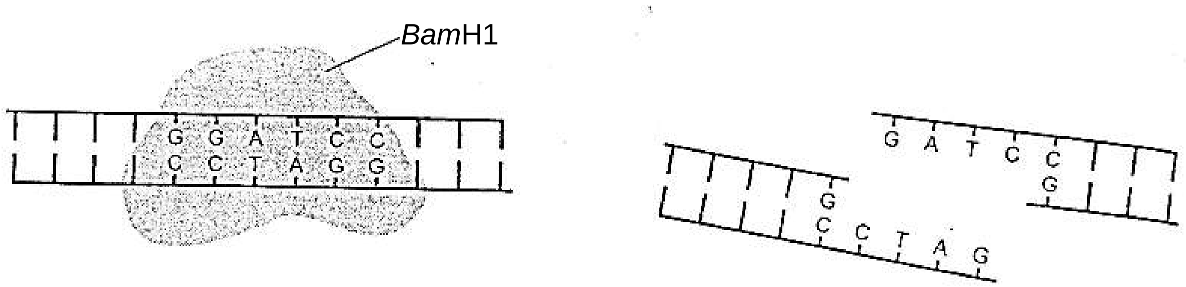
A It grows and divides without stimulation by a growth factor.

B It releases factors that cause nearby cells to become cancerous.

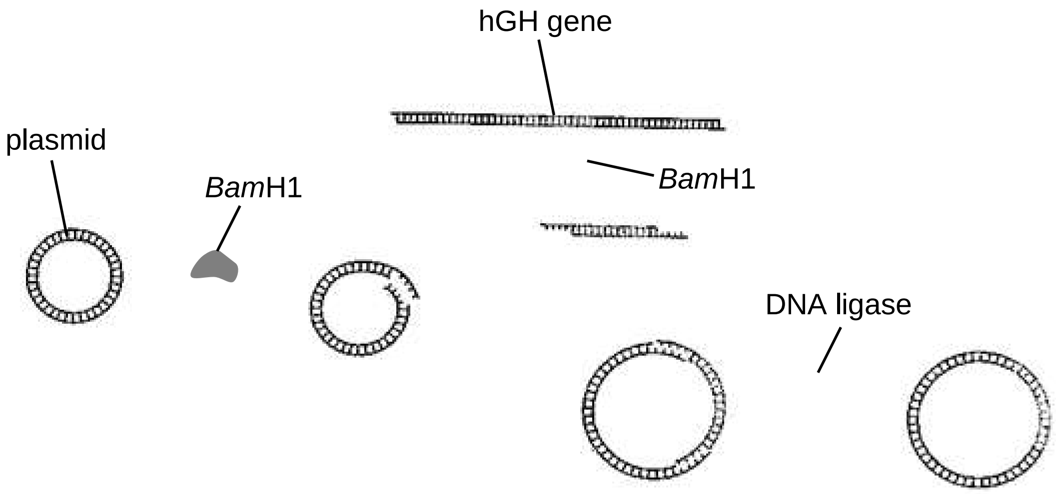
C It replicates an unlimited number of times.

D Its DNA damage does not halt cell division or stimulate apoptosis.

14 *Bam*H1 is a restriction enzyme that cuts DNA as shown in the diagram.



The diagram shows part of the procedure for producing *E.coli* that will synthesise human growth hormone, hGH.



At the end of this process, many plasmids do not contain the hGH gene.

What could explain this?

A Different alleles of the hGH gene have different sticky ends.

B Not all of the plasmids cut by BamH1 have sticky ends.

C Some of the plasmids are cut at more than one position.

D The sticky ends of some of the plasmids rejoin with each other.

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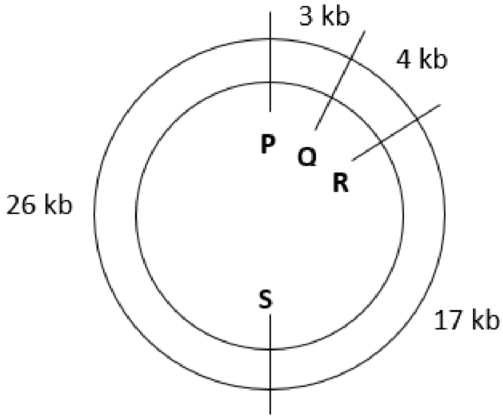

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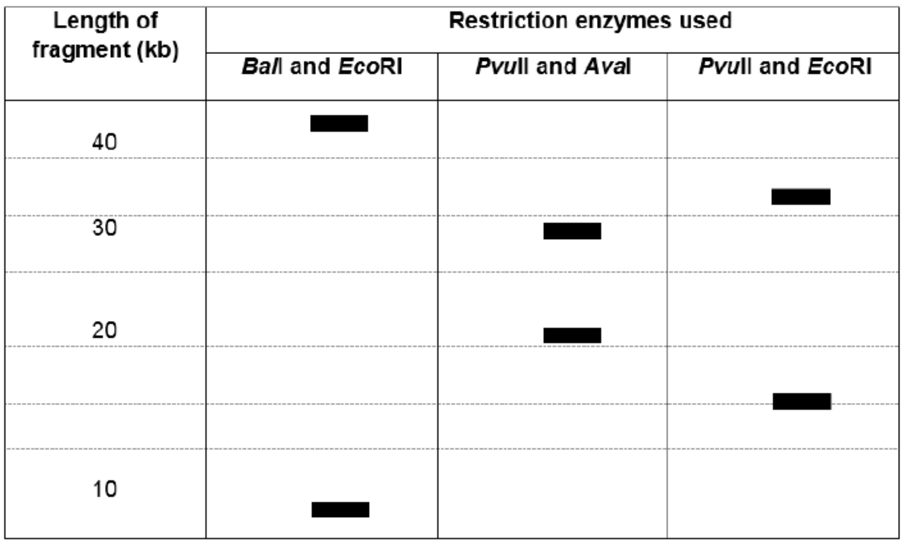

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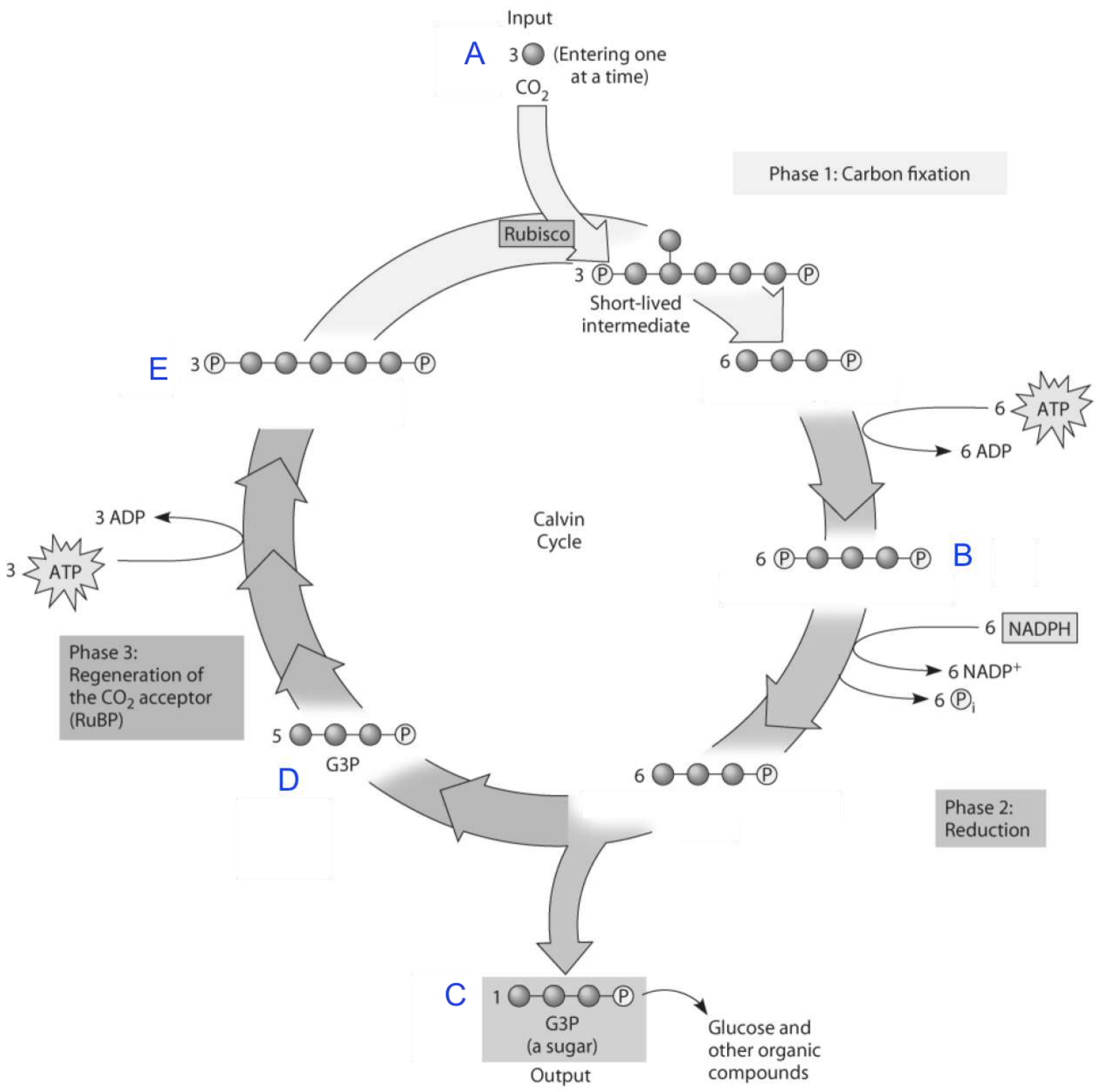

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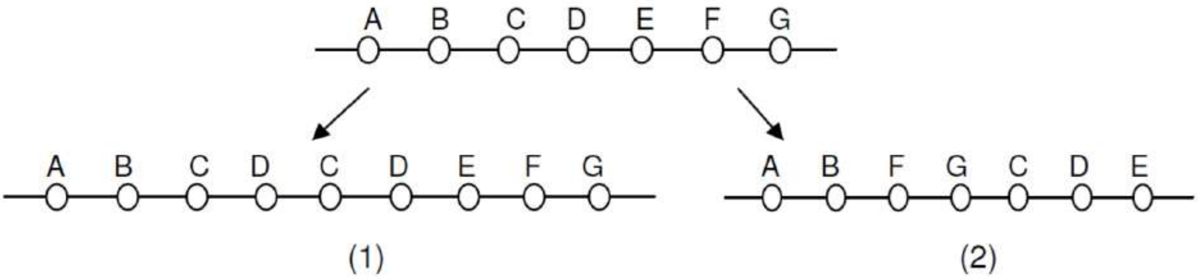

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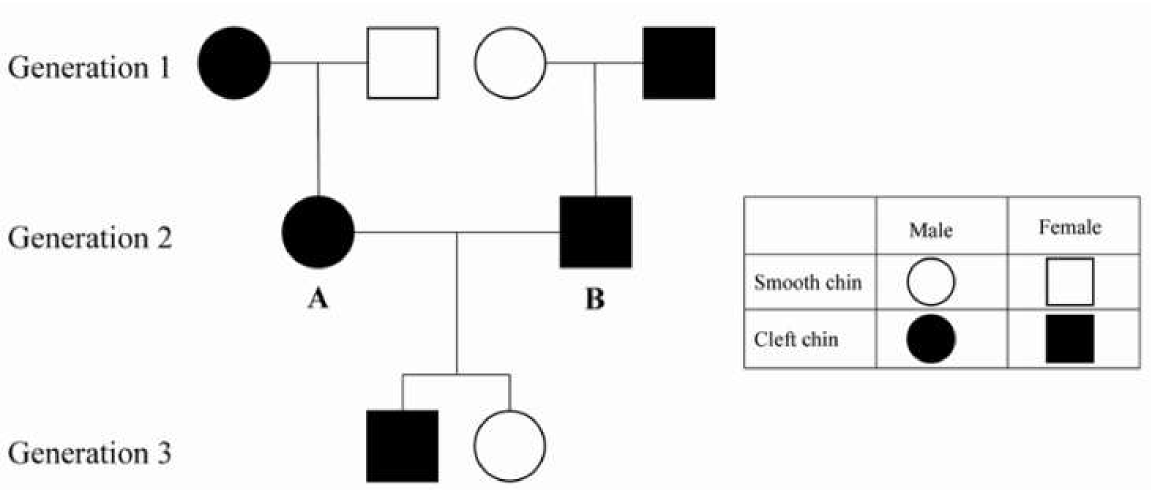

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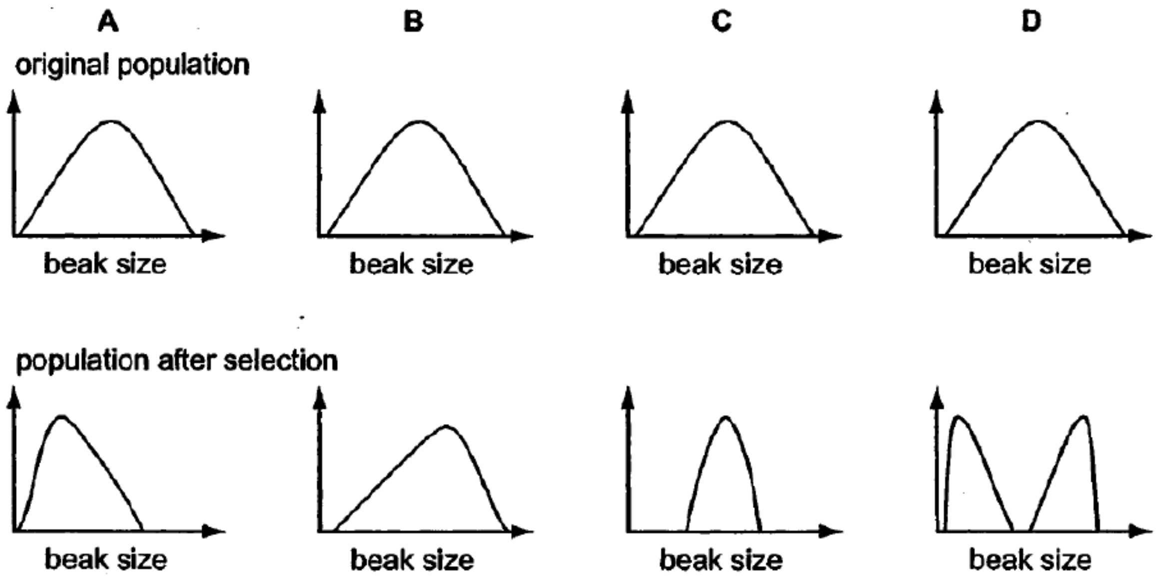

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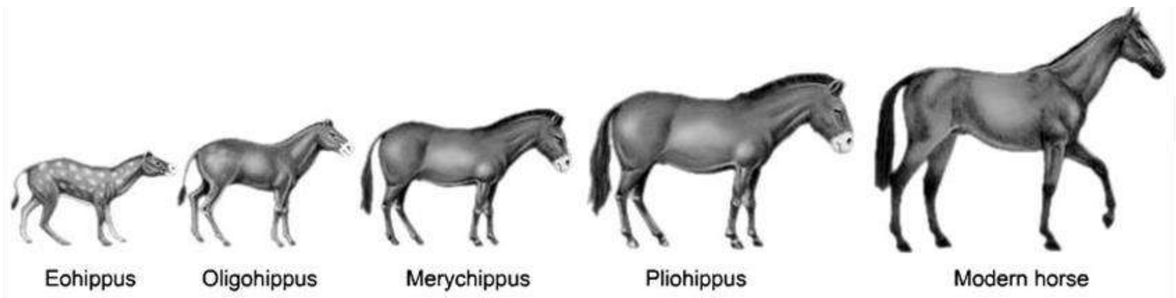

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2016 NJC SH2 H1 Biology Prelim Exam Paper 1 Answers

No	Answer	No	Answer	No	Answer
1	C	11	C	21	B
2	B	12	B	22	D
3	A	13	B	23	C
4	B	14	C	24	B
5	C	15	B	25	B
6	A	16	C	26	B
7	B	17	A	27	A
8	D	18	D	28	C
9	C	19	D	29	D
10	A	20	B	30	C

NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 1

CANDIDATE NAME	
BIOLOGY CLASS	2bi2____ / 2IPbi2__
REGISTRATION NUMBER	

BIOLOGY 8875/02

Paper 2

25 August 2017

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** the questions.

Section B
Answer **one** question.

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

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

For Examiner's Use	
Section A	(Total: 40)
1	/ 12
2	/ 12
3	/ 7
4	/ 9
Section B	(Total: 20)
5 or 6	/ 20
Total	**/ 100**

This document consists of **15** printed pages.

Section A

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

1 Fig. 1.1 shows the main steps involved in the synthesis of preproinsulin to insulin in the pancreatic β-cell. The preproinsulin is synthesised into the lumen of organelle **A** as proinsulin.

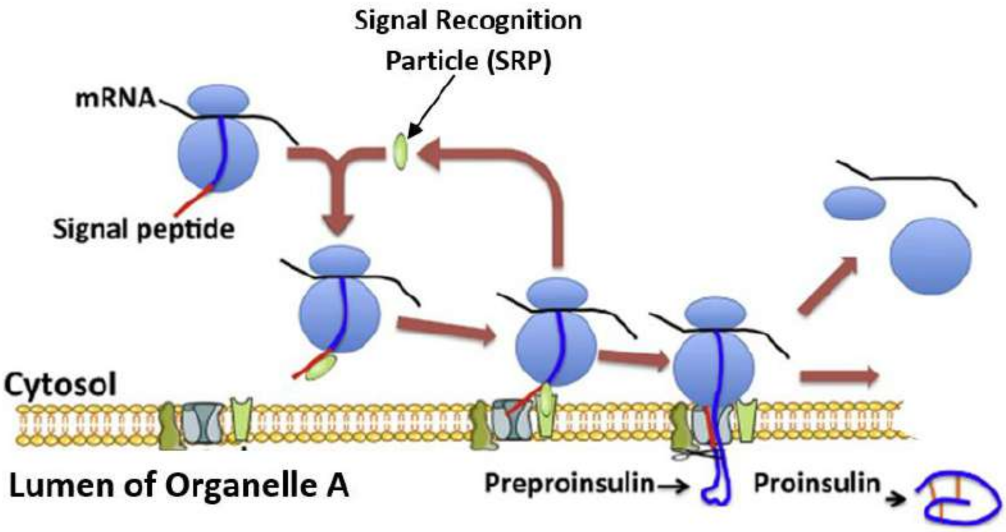

Fig. 1.1

The proinsulin is then be transported to organelle **B** where it is further processed to form insulin.

Fig. 1.2 shows the conversion of proinsulin to insulin in organelle **B**.

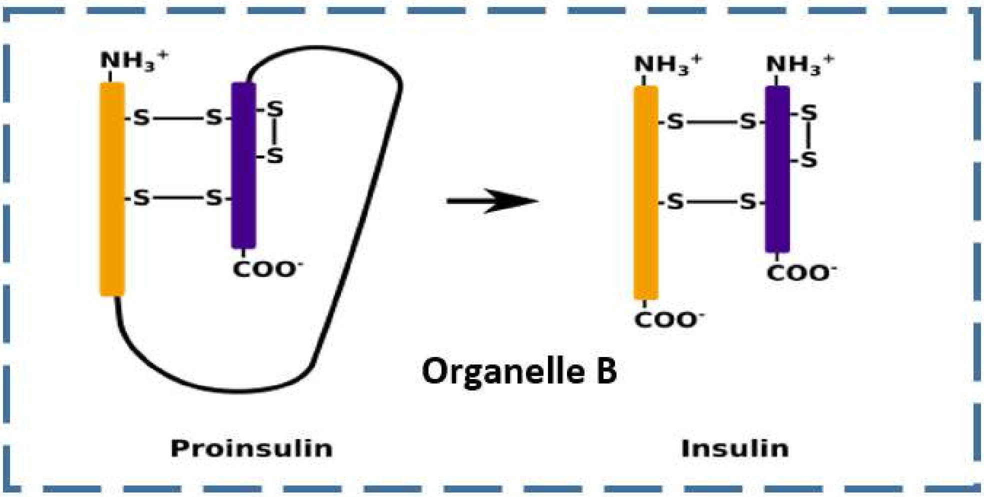

Fig. 1.2

(a) Name the organelles labelled **A** and **B**.

organelle **A:** ....

organelle **B:** .... [1]

(b) State the role of rRNA in insulin protein synthesis

....

....

....

....

.... [2]

(c) Insulin is released by pancreatic β-cell. Outline the route taken by proinsulin.

....

....

....

....

.... [2]

Fig. 1.3 shows the structure of small sections of DNA and messenger RNA (mRNA) in the nucleus of pancreatic β-cell during transcription of the gene coding for insulin.

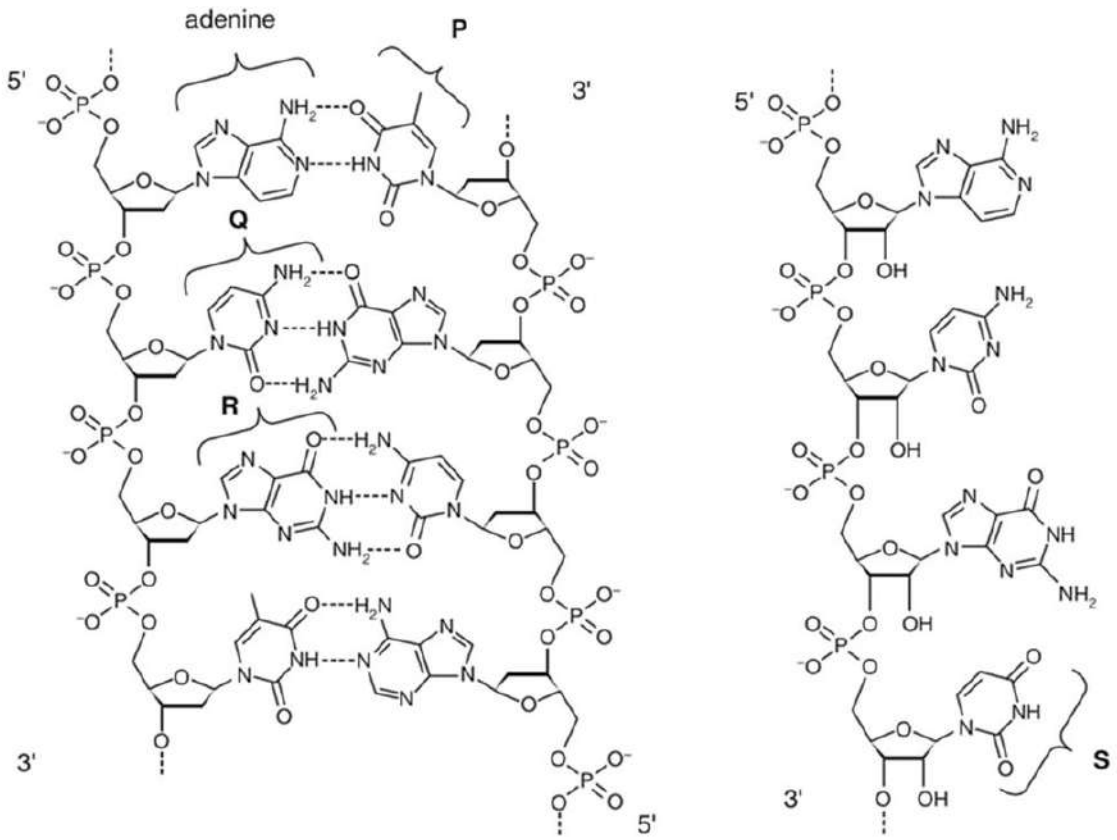

Fig. 1.3

(d) Name the bases **P** to **S**.

P: ....

Q: ....

R: ....

S: .... [2]

(e) Describe how messenger RNA coding for insulin is synthesised in pancreatic β-cell.

....

....

....

....

....

.... [3]

(f) Explain why gene mutations do not always produce mutated insulin protein whereas mutations of the splicing sites involved in RNA splicing will produce mutated insulin.

....

....

....

....

.... [2]

[Total: 12]

2 Clover is an important crop plant grown as food for sheep and cattle. It is a leguminous plant and its root nodules contain nitrogen-fixing bacteria.

Some clover plants can produce hydrogen cyanide when their tissues are damaged. This is a poisonous compound which will prevent herbivores such as slugs from feeding on the plant. Cyanide is also poisonous to the plants that produce them. Those plants that can produce cyanide are called cyanogenic; those that cannot are called acyanogenic.

Fig. 2.1 shows how the production of cyanide in a species of European clover is genetically controlled.

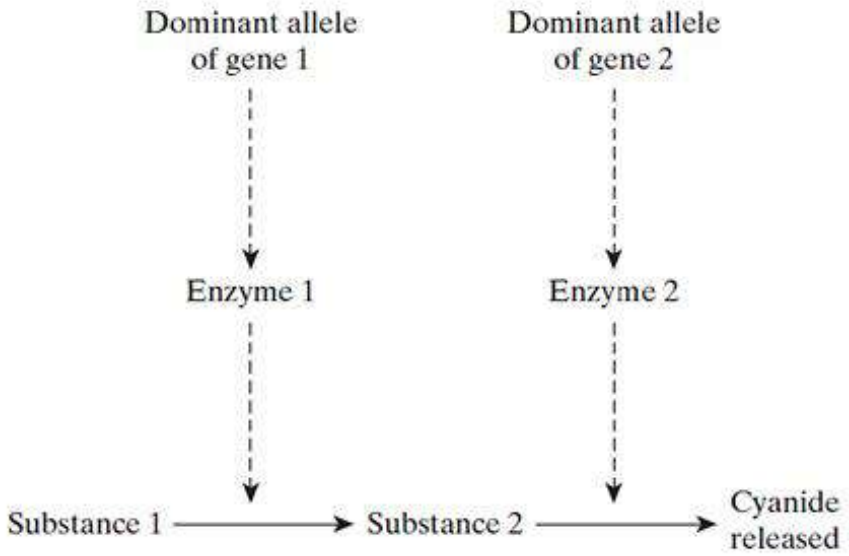

Fig. 2.1

(a) Distinguish between gene and alleles.

....

....

....

.... [2]

(b) Using appropriate symbols, show by means of a genetic diagram, the different genotypes and phenotypes obtained when two plants that are heterozygous at both the gene loci are crossed.

[4]

When the leaves of cyanogenic plants are damaged by slugs, or exposed to low temperatures, membranes within the cells are broken. This causes the release of the enzymes that control the reactions that produce cyanide.

Fig. 2.2 shows the proportions of cyanogenic and acyanogenic plants in clover populations in different parts of Europe and the mean minimum winter temperatures. It also shows isotherms, which are lines joining places with the same mean January temperature. Slugs are not usually active at temperatures below 0°C.

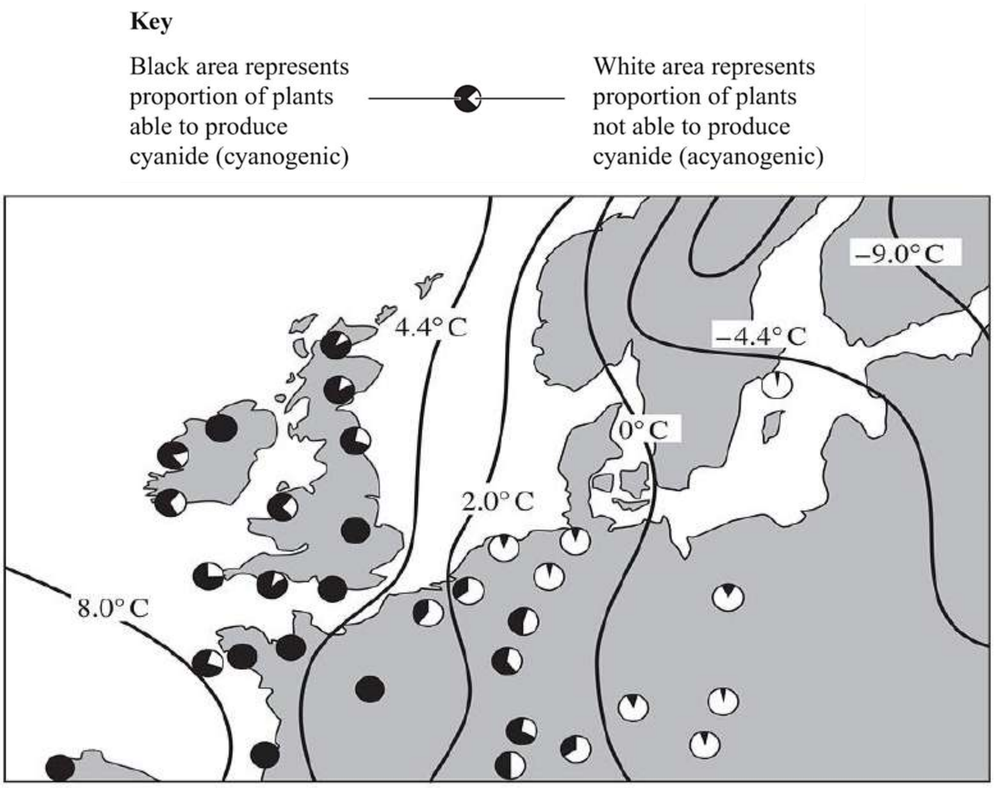

Fig. 2.2

(c) Explain how different proportions of cyanogenic and acyanogenic plants may have evolved in populations in different parts of Europe.

....

....

....

....

....

....

....

.... [4]

(d) Explain using an example, how homology supports Darwin's theory of natural selection.

....

....

....

....

.... [2]

[Total: 12]

3 **(a)** Human newborns and hibernating mammals contain large amounts of brown adipose tissue ('body fat').

Fig. 3.1 shows the electron micrograph of a brown adipocyte. Brown adipocytes are characterised by presence of numerous vacuoles and organelle X throughout the cell.

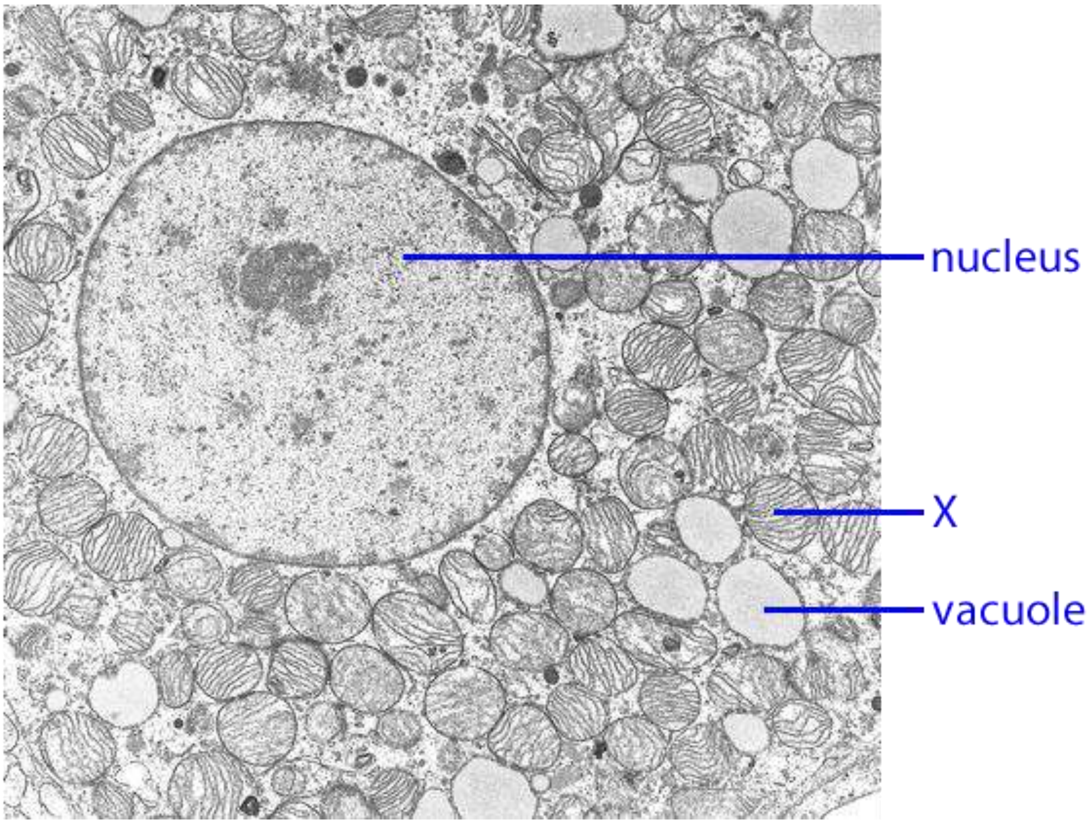

Fig. 3.1

(i) Identify organelle **X**.

.... [1]

(ii) Suggest the role of the numerous vacuoles found in brown adipocytes.

.... [1]

(b) Fig. 3.2 shows the schematic representation of a series of protein complexes found on the inner membrane of organelle **X**.

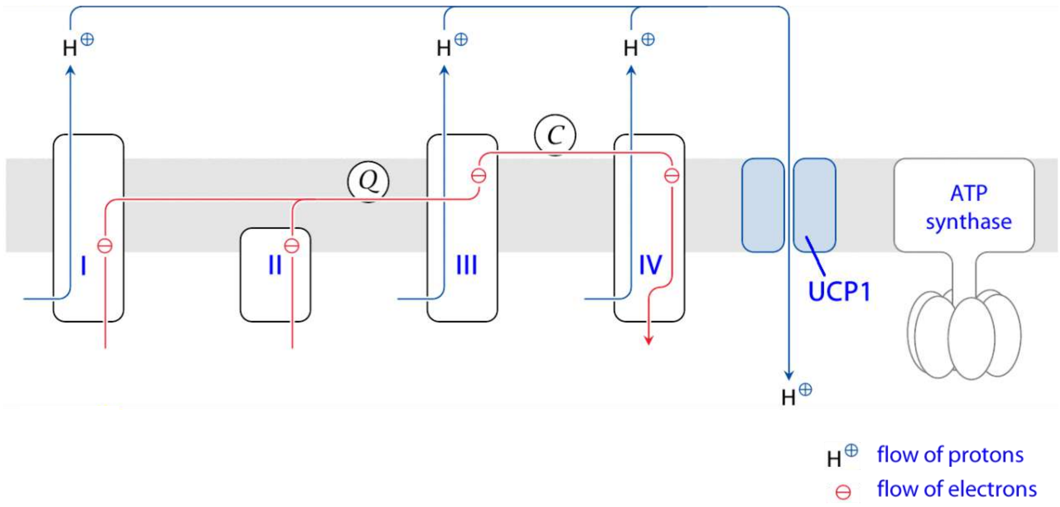

Fig. 3.2

(i) Oxygen is required to sustain the process illustrated in Fig. 3.2.

With reference to the Fig. 3.2, describe the role played by oxygen.

....

.... [1]

(ii) Brown adipocytes contain a unique protein, UCP1, which is not found in organelle **X** in any other cell type.

Evaluate the impact of UCP1 on the normal functioning of the process illustrated in Fig. 3.2 and suggest the physiological significance of brown adipose tissue.

....

....

....

.... [2]

(c) In other cell types, NADH and $FADH_2$ are used to drive ATP synthesis by ATP synthase.

Using relevant information from Fig. 3.2, suggest and explain why more ATP is produced from NADH.

-- [2]

[Total: 7]

4 Fig. 4.1 shows the life cycle of a water flea.

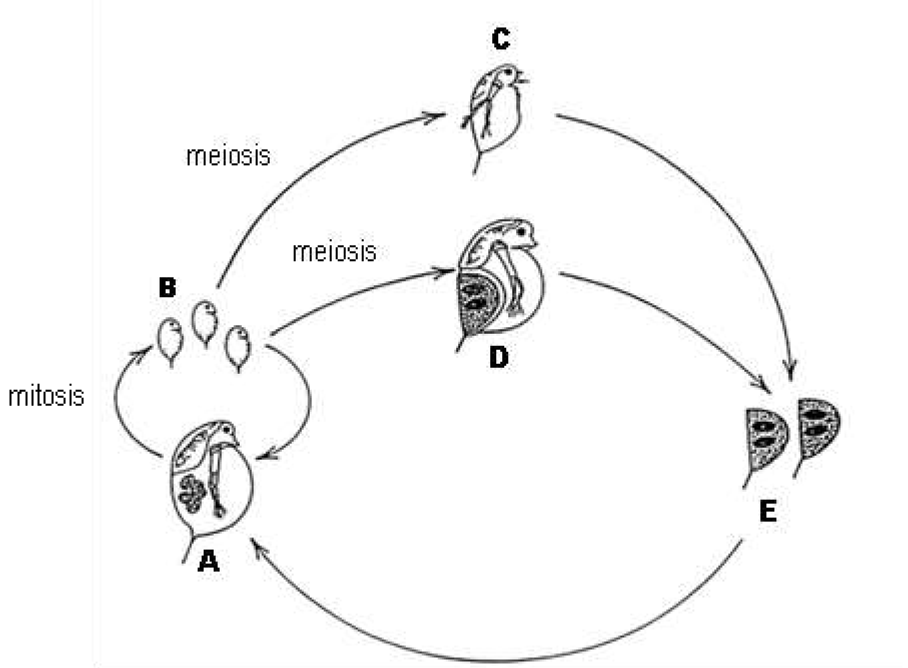

Fig. 4.1

In favourable conditions, all the animals in a population are females (**A**). These females produce eggs by mitosis, which develop into young females (**B**) without being fertilized. In unfavourable conditions, eggs produced by meiosis develop directly without fertilization into either males (**C**) or females (**D**). The eggs produced by the females (**D**) are fertilized by the sperms from the males (**C**), then released in protective egg cases (**E**) which enable them to survive unfavourable conditions. When favourable conditions return, these eggs develop back into females (**A**).

(a) The females at stage **A** of the life cycle have 18 chromosomes.

Complete the table to show the number of chromosomes at the other stages of the life cycle.

stage of life cycle	chromosome number
A	18
B	
C	
D	
E	

[1]

(b) Explain why the eggs from **D** and the sperms from **C** must be produced by mitosis.

[2]

(c) Explain why females **A**, developed from fertilized eggs **E**, are genetically different from each other.

[3]

(d) Give an example of a favourable condition in which females will develop from eggs formed via mitosis.

[1]

(e) The eggs of the water flea are produced by stem cells in the ovary.

Explain what makes a stem cell unique from a normal adult cell in the water flea.

[2]

[Total: 9]

Section B

Answer EITHER 5 OR 6.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

Either

5 **(a)** Describe how the molecular structure of phospholipids is related to their function in the plasma membrane. [6]

(b) Explain the mode of action of enzymes in terms of specificity and activation energy. [8]

(c) Explain the effects of competitive and non-competitive inhibitors on the rate of enzymatic activity. [6]

[Total: 20]

Or

6 **(a)** Describe the polymerase chain reaction and explain the advantages and limitations of this procedure. [8]

(b) Explain the significance of genetic engineering in improving the quality and yield of crop plants and animals and also in solving the demand for food in the world (e.g. Bt corn, golden rice and GM salmon). [6]

(c) Describe the natural functions of restriction enzymes and explain how they can be used in the process of gene cloning. [6]

[Total: 20]

- End of paper -

NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 1

CANDIDATE NAME	
BIOLOGY CLASS	2bi2____ / 2IPbi2__
REGISTRATION NUMBER	

BIOLOGY

8875/02

Paper 2

25 August 2017

2 hours

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Section A

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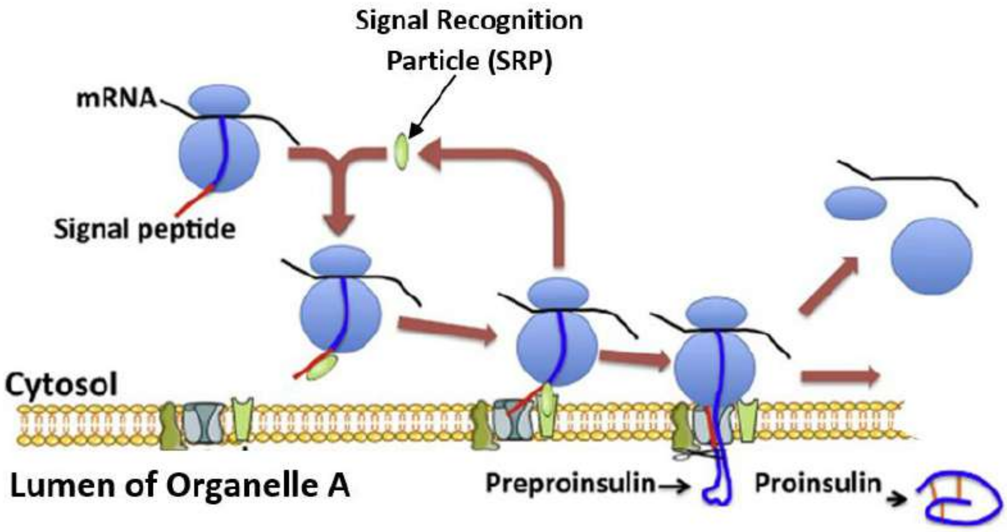


Fig. 1.1

The proinsulin is then be transported to organelle **B** where it is further processed to form insulin.

Fig. 1.2 shows the conversion of proinsulin to insulin in organelle **B**.

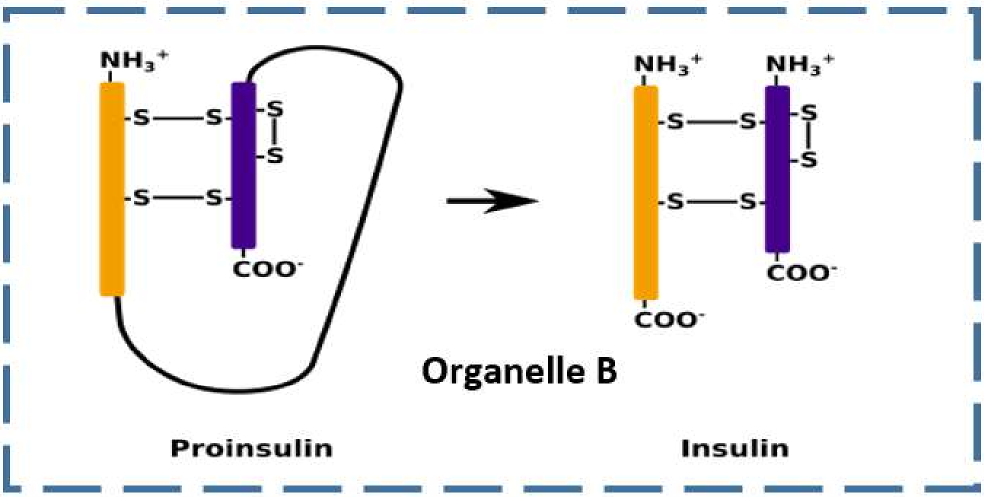


Fig. 1.2

(a) Name the organelles labelled **A** and **B**.

Organelle A: **Rough Endoplasmic reticulum (Must spell in FULL)**

Organelle B: **Golgi apparatus / Golgi body** [1]

(b) State the role of rRNA in insulin protein synthesis

1. **rRNA along with ribosomal proteins forms the structural component of ribosome (large and small sub-unit)**
2. **rRNA is responsible for catalytic function of ribosome in the formation of peptide bond between amino acids (found at the large sub-unit)**
3. **rRNA in the small ribosomal subunit binds to 5' end of mRNA sequence during protein translation**
4. **rRNA at the A site binds to the amino-acyl tRNA while the rRNA at the P site binds to the peptidyl-tRNA**

OWTTE

*** Any 2 of the above**

[2]

Examiner's Comments:
Most students were able to get this part of this question right. It is crucial to use the key words when describing the catalytic sites found in the large ribosomal sub-unit. It was common to see among weaker students describing the process of protein synthesis without making reference to the role of rRNA.

(c) Insulin is released by pancreatic β-cell. Outline the route taken by proinsulin.

1. **From Rough ER, a transport vesicle takes the Proinsulin to the Golgi apparatus (GA).**
2. **After chemical modification and packaging, a secretory vesicle pinched/buds off from GA.**
3. **The transport of secretory vesicles (aided by microtubules-the cytoskeletal elements) in the cytoplasm, until they fuse to the plasma membrane.**
4. **Secretory vesicle fuses with the cell surface membrane before releasing insulin by exocytosis.**

*** 3 points to get 2 marks. Pt 4 is crucial to talk about.**

[2]

Examiner's comments:
Most students obtained partial mark for this question. In order to get full mark, they will need to mention that secretory vesicles are involved in releasing the insulin via exocytosis outside the pancreatic β-cell.

Fig. 1.3 shows the structure of small sections of DNA and messenger RNA (mRNA) in the nucleus of pancreatic β-cell during transcription of the gene coding for insulin.

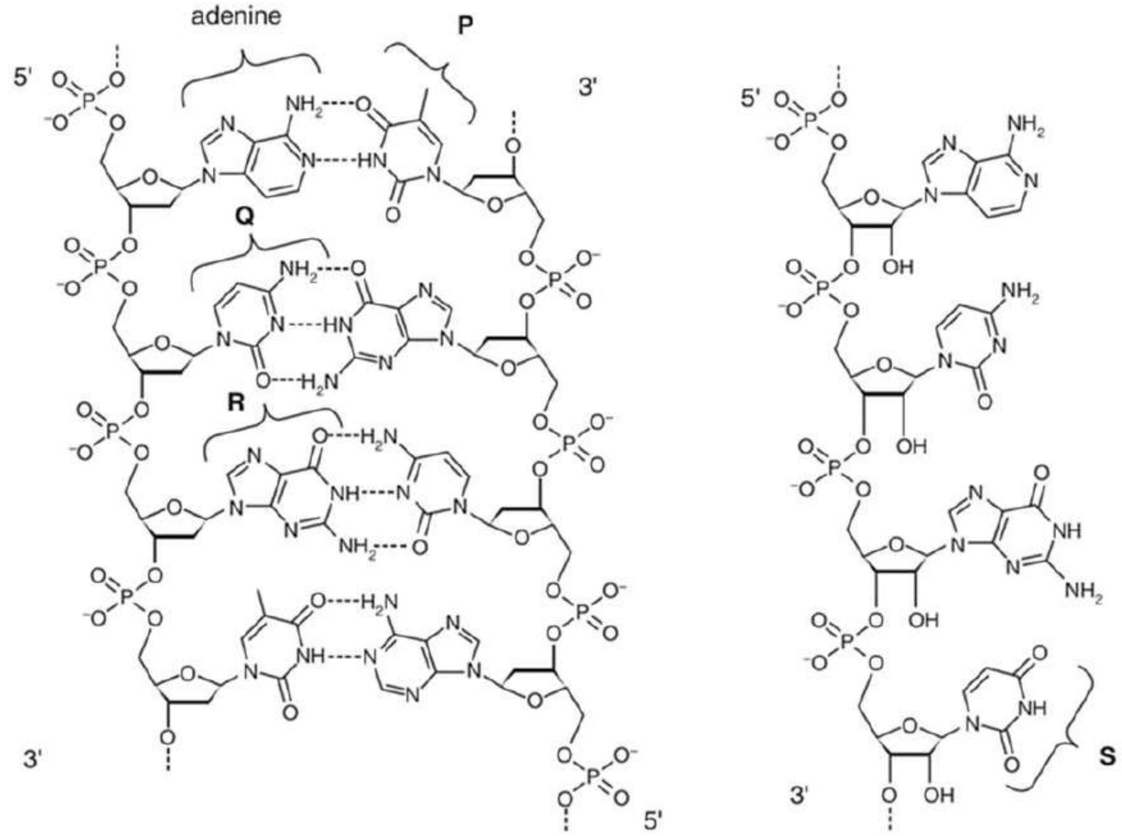


Fig. 1.3

(d) Name the bases **P** to **S**.

P: **Thymine** , **Q:** **Cytosine** , **R:** **Guanine** , **S:** **Uracil** [2]

(all 4 correct – 2 marks, 2-3 correct – 1 mark)

(e) Describe how messenger RNA coding for insulin is synthesised in pancreatic β-cell.

1. **RNA polymerase recognises and binds to the promoter of the gene causing the DNA double helix to unwind / uncoil and separate.**
2. **One of the two DNA strands serves as template strand.**
3. **Free ribonucleoside triphosphates formed complementary base pairing (A,T,G,C) with ribonucleotides on the template DNA strand.**
4. **RNA polymerase catalyses formation of phosphodiester bonds between ribonucleotides through condensation reaction.**
5. **Transcription proceeds until after the RNA polymerase transcribes a termination sequence.** [3]

(f) Explain why gene mutations do not always produce mutated insulin protein whereas mutations of the splicing sites involved in RNA splicing will produce mutated insulin.

Why gene mutations do not always produce mutated insulin: [1]

1. **Gene mutations that involve substitution may result in the same amino acid being coded for and due to the Degenerate code/ same amino acid can be coded for by different codons.**
2. **Gene mutation could occur at the intro region instead of exons.**

Why mutations at RNA Splicing sites will produce mutated insulin: [1]

Mutation at the Splice site will affect the binding of spliceosome, and will affect the removal of introns & exons, hence giving rise to a mutated protein with loss of function.

Example of the kind of mutations at RNA splicing sites and the outcome:

An example of mutation at RNA splicing sites *(any one)*	Effect of such mutation (i.e. production of mutated collagen) *(any one)*
Different combinations of exons being produced	**Different primary sequences of amino acids resulting in different protein (mutated protein)**
An exon is lost / wrong excision of exons	**Large number of bases and hence amino acids is lost/ as above**
Introns not removed by spliceosome	**Introns translated and became additional amino acids, this will lead to change the protein structure**

[2]

Examiner's comments:
Most students were able to get this question right. Do note that incorrect splicing (due to mutation at the splice sites) do not need to frame shift mutation.

[Total: 12]

2 Clover is an important crop plant grown as food for sheep and cattle. It is a leguminous plant and its root nodules contain nitrogen-fixing bacteria.

Some clover plants can produce hydrogen cyanide when their tissues are damaged. This is a poisonous compound which will prevent herbivores such as slugs from feeding on the plant. Cyanide is also poisonous to the plants that produce them. Those plants that can produce cyanide are called cyanogenic; those that cannot are called acyanogenic.

Fig. 2.1 shows how the production of cyanide in a species of European clover is genetically controlled.

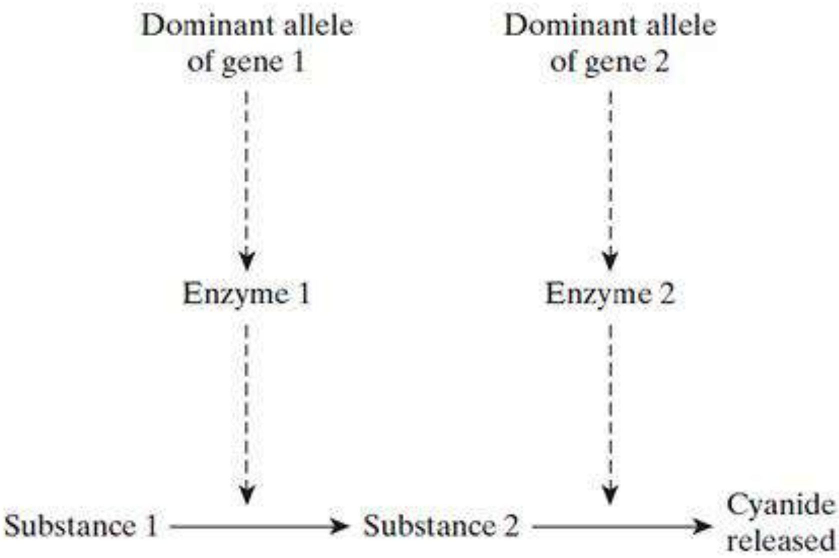


Fig. 2.1

(a) Distinguish between gene and alleles.

- **Gene – sequence of bases that codes for a polypeptide/product**
- **Alleles –alternative forms of a gene / Have slightly different base sequences**
  - **Occupies the same gene loci**
  - **Codes for different products**

[2]

Examiner's Comments:
Students were not able to recall the full definition. Only partial definitions were given by students.

(b) Using appropriate symbols, show by means of a genetic diagram, the different genotypes and phenotypes obtained when two plants that are heterozygous at both the gene loci are crossed.

Let A = allele that codes for enzyme 1
Let a = allele that does not code for enzyme
Let B = allele that codes for enzyme 2
Let b = allele that does not code for enzyme 2

A and B are completely dominant over a and b respectively.

Parents	AaBb	X	AaBb	*1m correct genotypes*
	↓ meiosis		↓ meiosis	
Gametes	AB Ab aB ab		AB Ab aB ab	*1m correct gametes (all or none)*

Gametes	**AB**	**Ab**	**aB**	**ab**
AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
aB	AaBB	AaBb	aaBB	aaBb
Ab	AaBb	Aabb	aaBb	aabb

Genotypes: A_B_ = Cyanogenic = 9/16
A_bb = acyanogenic
aaB_ = acyanogenic } **= 7/16**
aabb = acyanogenic

1 m for correct genotypes and phenotypes (4 max)

[4]

Examiner's Comments:
*Poorly done by almost all students for this questions. It was common to observe students drawing a monohybrid cross, where clearly it is not. (It was even stated in the question that "…two plants that are heterozygous at **both the gene loci** are crossed."*
It was surprised to see that students were not able to relate part (a) of the questions when formulating the solution for this part.

When the leaves of cyanogenic plants are damaged by slugs, or exposed to low temperatures, membranes within the cells are broken. This causes the release of the enzymes that control the reactions that produce cyanide.

Fig. 2.2 shows the proportions of cyanogenic and acyanogenic plants in clover populations in different parts of Europe and the mean minimum winter temperatures. It also shows isotherms, which are lines joining places with the same mean January temperature. Slugs are not usually active at temperatures below 0^{o}C.

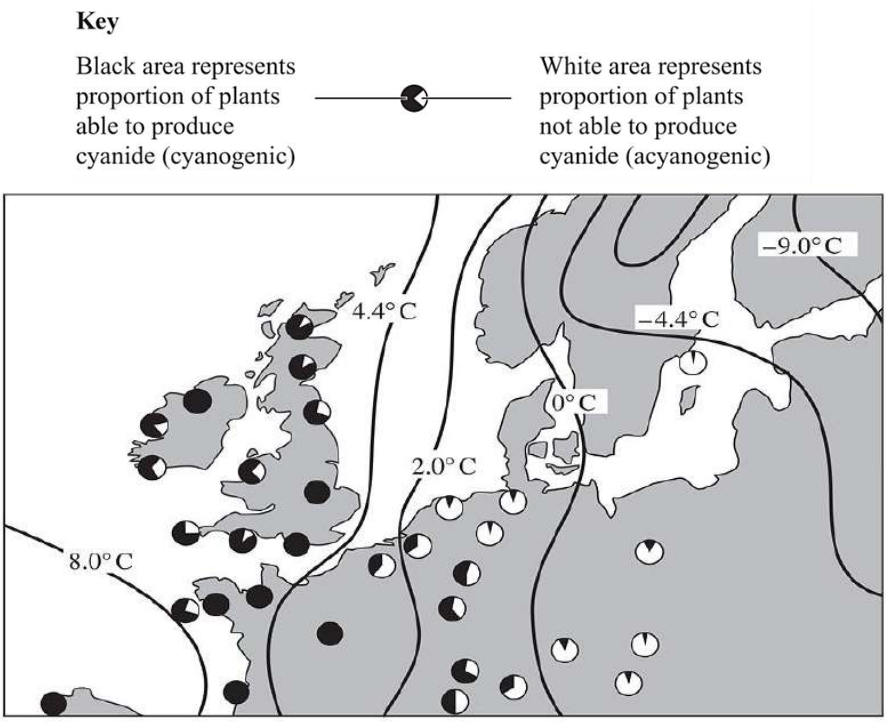


Fig. 2.2

(c) Explain how different proportions of cyanogenic and acyanogenic plants may have evolved in populations in different parts of Europe.

- **<u>Genetic variations/variation in gene/allele(s)</u> are present in populations for cyanide production among these plants; [impt key point]**

- **<u>Different environments</u> (due to temp differences) have <u>different selection pressure</u>;**
  - **Cold areas, plants are acyanogenic: Selective advantage is <u>not to produce cyanide</u> releasing cyanide will kill itself! (Slugs are also not active at 0^{o}C)**
  - **Warmer areas, plants are cyanogenic: <u>Slugs present</u> as selective pressure; cyanide production will kill slugs!**

- **<u>At colder/below 0^{o}C areas</u>, cyanogenic plants die while non-cyanogenic survive; non-cyanogenic allele/gene passed on more often;** [4]

- **At Warmer areas, cyanogenic plants at selective advantage, because of less herbivore feeding; so cyanogenic have a higher probability of surviving and reproducing to pass on the advantageous cyanogenic allele/gene.**

- **The proportion of each population with advantageous alleles, altering allele frequencies. Proportion of the population exhibiting favourable traits will increase.**

Examiner's Comments:
This question was generally well answered. It is important to mention that the presence of genetic variation already existed in the population so that different proportion of cyanogenic and acyanogenic plants could have evolved is crucial here. This was often left out by many students. Similarly, the use of keywords such as "selective pressure, selective advantage" were also left out.

(d) Explain using an example, how homology supports Darwin's theory of natural selection.

- **Homology / similarity in characteristics resulting from shared/common ancestry even though they may have different functions.**
  - **E.g. Flipper of dolphin, forelimb of human, wings of bat, etc.**

Example of various types of homology:

- **Analogical structures with similar functions but based on vastly different structures, and organisms do not share common ancestry.**
  - **E.g. Fish fin and dolphin flipper.**
- **Anatomical homology sharing common ancestry in aspect of morphology in form and structure.**
- **Embryological homology common ancestry based on similarity of developmental pathways (anatomical characteristics in embryos).**
  - **e.g. (comparative embryology) - all vertebrate embryos have gill pouches on sides of throat.**
- **Molecular homology common ancestry in molecular (DNA, amino acid sequences) makeup of related species.**
  - **Ref. to amino acids sequences of cytochrome C / haemoglobin;**

- **Conclusion: *Such homology* in very different organisms suggests a possible common ancestor**
- **Only descent with modification results due to differential survival and reproduction of organisms based on their environment with different selection pressure→ natural selection** [2]

Examiner's Comments:
Generally well answered. Students need to draw the connection between homology (with examples) and how that supports Darwin's theory of natural selection.

[Total: 12]

Note and other information (For your reference)

- **Biogeography – study of past and present distribution of individual species/ entire communities.**
  - **e.g. island biogeography & sugar gliders vs. flying squirrels.**
  - **many species are endemic to islands, most island species closely related to species from neighbouring islands / island hopping is the rise of new species when populations spread out.**
  - **species tend to be closely related to other species from same area than to others with same way of life in other areas / sugar gliders (Australia), flying squirrels (North America) are species with similar characteristics due to environmental factors but are not closely related (convergent evolution/ analogy).**
  - **By studying distribution of organisms/how they disperse, this determines if they are homologous and traces evolutionary pathway.**
- **Fossil Records – support evolution by showing succession of organisms shown within layers.**
- **Deeper stratum (Rocks) – older organism, transitional forms, also show depopulation / immigrations/ mass extinctions, but are often incomplete.**

3 **(a)** Human newborns and hibernating mammals contain large amounts of brown adipose tissue (‘body fat’).

Fig. 3.1 shows the electron micrograph of a brown adipocyte. Brown adipocytes are characterised by presence of numerous vacuoles and organelle X throughout the cell.

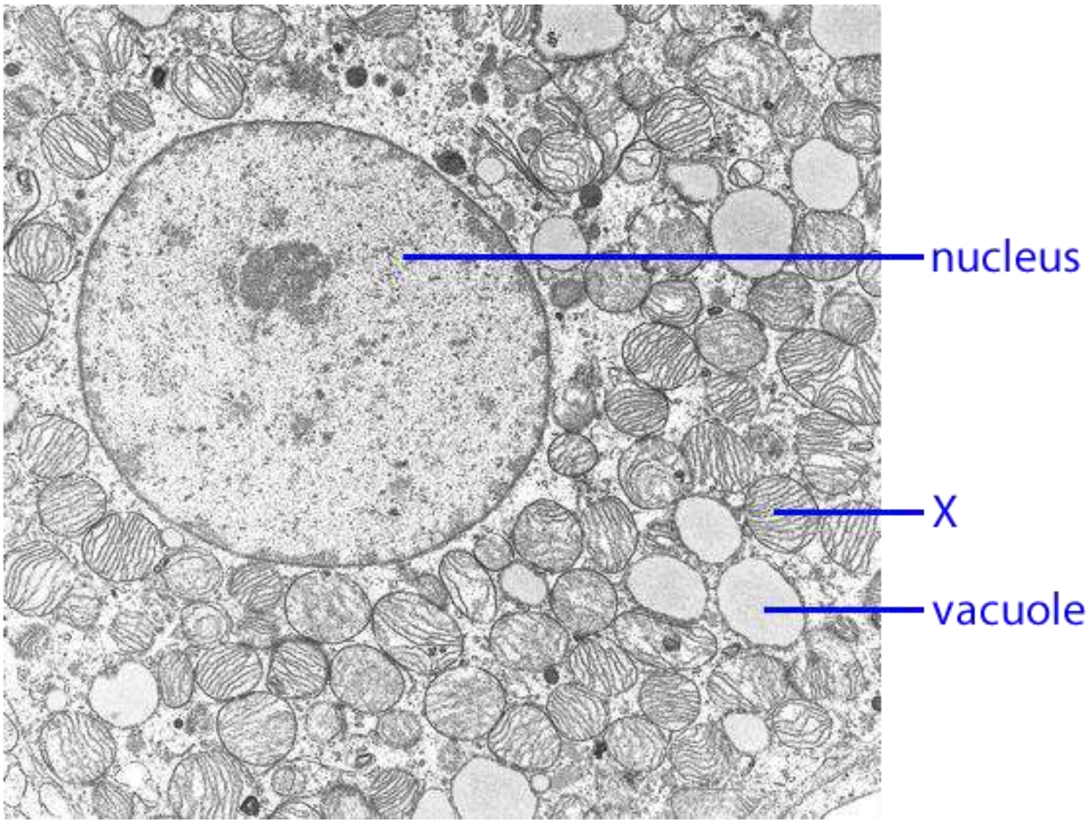


Fig. 3.1

(i) Identify organelle **X**.

mitochondrion [1]

Examiner’s comments:
Majority of the students wrote “mitochondria” as the answer even when the line in Fig. 6.1 clearly pointed to one mitochondrion only. Students were not penalized this time. They should pay attention to singular / plural forms of naming when answering such questions next time.

(ii) Suggest the role of the numerous vacuoles found in brown adipocytes.

They store lipids / triglycerides / fats. [1]

Examiner’s comments:
Students who were mindful that the question context is about brown adipocytes were more likely to make a correct guess. Wrong answers were plentiful and varied.

(b) Fig. 3.2 shows the schematic representation of a series of protein complexes found on the inner membrane of organelle **X**.

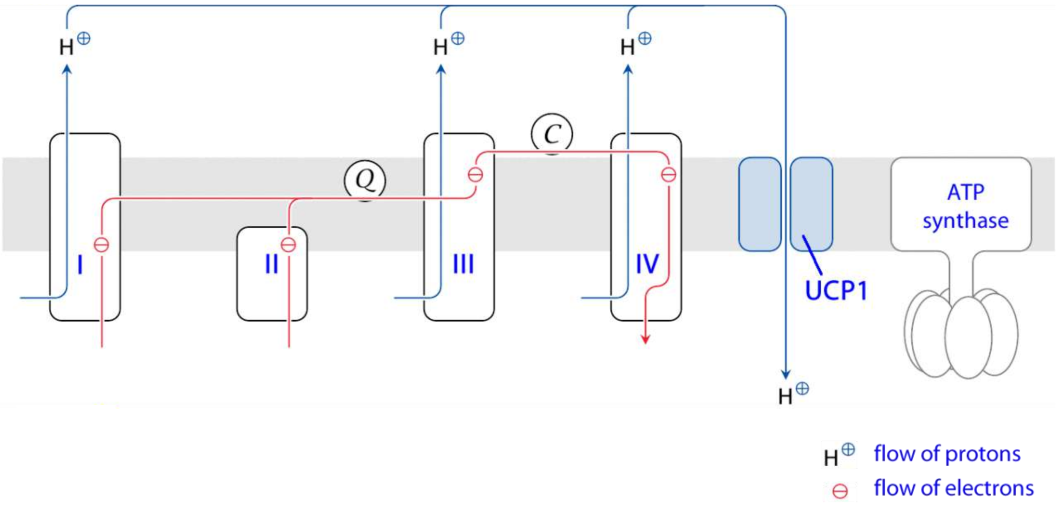


Fig. 3.2

(i) Oxygen is required to sustain the process illustrated in Fig. 3.2.

With reference to the Fig. 3.2, describe the role played by oxygen.

Oxygen serves as the final electron acceptor, receiving electrons from complex IV to form water. [1]

Examiner's comments:
Majority of the students were familiar with the role of oxygen in aerobic respiration. However, many did not get the mark as they failed to make explicit reference (e.g. quote "IV") to Fig. 6.2 and only described in general terms.

(ii) Brown adipocytes contain a unique protein, UCP1, which is not found in organelle **X** in any other cell type.

Evaluate the impact of UCP1 on the normal functioning of the process illustrated in Fig. 3.2 and suggest the physiological significance of brown adipose tissue.

1. **As UCP1 allows protons to leak back into the matrix without passing through the ATP synthase, no ATP will be synthesized from the NADH and $FADH_2$.**

2. **The energy released from the spontaneous flow of protons through UCP1 is lost as heat, which helps to keep the organisms warm.** [2]

Examiner's comments:

Many students could get Point 1, but failed to suggest the correct physiological significance of brown adipose tissue (i.e. Point 2). No ATP synthesis does not mean that the respiratory substrates would be reserved for use during hibernation. So long as oxygen is present, the first three stages of aerobic respiration will still occur to produce NADH and $FADH_2$ for electron transport to occur at the inner mitochondrial membrane. The lipids in brown adipose tissue will still be broken down, not for ATP synthesis but for non-shivering thermogenesis (heat production), which is important for regulating body temperature of human newborns and hibernating mammals.

(c) In other cell types, NADH and $FADH_2$ are used to drive ATP synthesis by ATP synthase.

Using relevant information from Fig. 3.2, suggest and explain why more ATP is produced from NADH.

1. **NADH and $FADH_2$ donates electrons to complex I and II respectively, the energy released from transfer of electrons through the complexes is used to pump protons across the inner membrane.**

2. **Because NADH started with Complex I, it had more chances to pumps more protons across the gradient, which powers the ATP synthase and gives us 3 ATP per molecule of NADH, while $FADH_2$ produces 2 ATP during the ETC because it gives up its electron to complex II, bypassing complex I.** [2]

[Total: 7]

4 Fig. 4.1 shows the life cycle of a water flea.

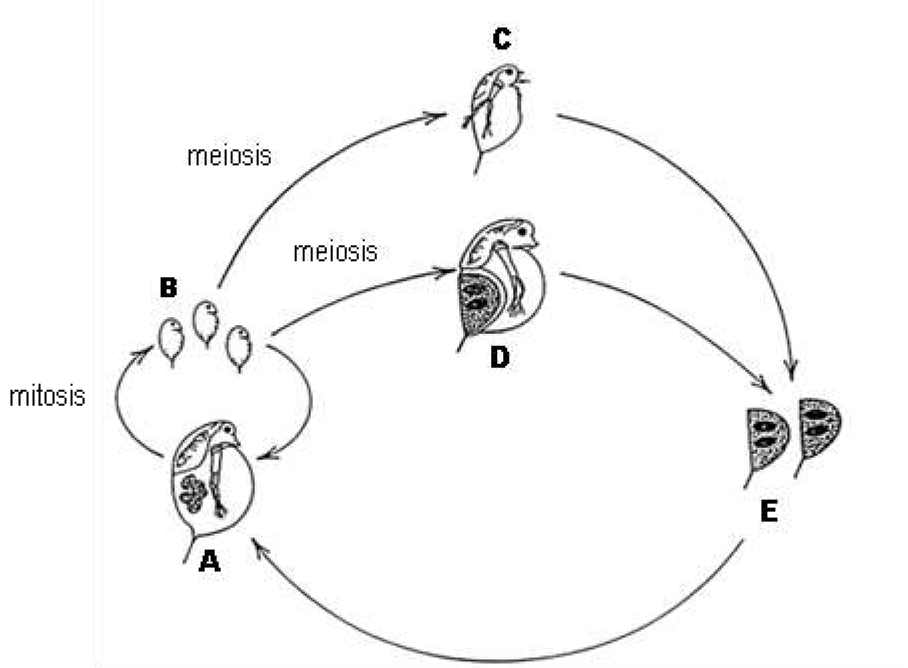


Fig. 4.1

In favourable conditions, all the animals in a population are females (**A**). These females produce eggs by mitosis, which develop into young females (**B**) without being fertilized. In unfavourable conditions, eggs produced by meiosis develop directly without fertilization into either males (**C**) or females (**D**). The eggs produced by the females (**D**) are fertilized by the sperms from the males (**C**), then released in protective egg cases (**E**) which enable them to survive unfavourable conditions. When favourable conditions return, these eggs develop back into females (**A**).

(a) The females at stage **A** of the life cycle have 18 chromosomes.

Complete the table to show the number of chromosomes at the other stages of the life cycle.

stage of life cycle	chromosome number
A	18
B	**18**
C	**9**
D	**9**
E	**18**

[1]

Examiner's comments:
Weaker students gave all kinds of answers. They should read the paragraph below Fig. 3.1 very carefully before filling up the table.

(b) Explain why the eggs from **D** and the sperms from **C** must be produced by mitosis.

1. **Since C and D (developed from unfertilised eggs from B) are haploid, mitosis ensures that the haploid chromosome number is preserved / the eggs and sperms are haploid.**

2. **Thus, when the haploid sperm and haploid egg fuse, the original diploid chromosome number is restored.** [2]

Examiner's comments:
On the whole, the question was interpreted correctly by majority of the students. To score Point 1, it should be clear in the answer that both C and D are haploid to begin with. It is irrelevant to state the general definition or roles of mitosis. Some students showed critical thought by explaining that it is not possible for a haploid cell to undergo meiosis as there is only one copy of each type of chromosome (pairing of homologous chromosomes is not possible). Weaker students mistook "the eggs from D and the sperms from C" as "the eggs produced by meiosis in B that developed into C and D" and wrote answers that went off tangent.

(c) Explain why females **A**, developed from fertilized eggs **E**, are genetically different from each other.

(Any 3)

1. **C and D developed from eggs that are produced by meiosis in B.**

2. **Crossing over between non-sister chromatids of homologous chromosomes at prophase 1 of meiosis**

3. **Independent assortment of homologous chromosomes at metaphase 1 of meiosis**

4. **Independent assortment of non-identical chromatids at metaphase 2 of meiosis**

5. **Random mating between C and D**

6. **Mutations can occur at any time.** [3]

Examiner's comments:
Students who did well knew that this question was about how genetic variation could be produced in water fleas. Weaker students mainly lost marks due to careless reading of the paragraph below Fig. 3.1 or incorrect use of key words related to meiosis. Some students misinterpreted the question as why A is genetically different from E. They failed to realize that A and E should be genetically identical since each fertilized egg E would develop into a female A (just like how your first cell developed into the present multicellular you). They should be explaining why females A are genetically different from each other. It should also be noted that random fertilization or random fusion of gametes from C and D would not produce further genetic variation in this case as the gametes from C and D are produced by mitosis.

(d) Give an example of a favourable condition in which females will develop from eggs formed via mitosis.

(Any 1)

- **Presence of water in a previously dry pond**
- **Reasonably high temperature (~20ºC)**
- **Abundant food source**
- **Lack of competition**
- **Stable environment**
- **Few or no predators**
- **Appropriate photoperiod**
- **Water of optimal pH**
- **Suitable salinity**
- **(any other valid point)**

[1]

Examiner's comments:
This question was generally well done with "abundant food source" and "few or no predators" as the most common answers.

(e) The eggs of the water flea are produced by stem cells in the ovary.

Explain what makes a stem cell unique from a normal adult cell in the water flea.

(Any 2)

1. **capable of indefinite self-renewal**

2. **unspecialised / undifferentiated**

3. **can give rise to specialised cells through differentiation** [2]

Examiner's comments:
Most students are familiar with the unique properties of a stem cell. However, some students wrote that "stem cell could give rise to any type of cells" without realizing that only totipotent stem cells can do that. Do note that this question requires unique properties that apply to ALL types of stem cells.

[Total: 9]

Section B

Answer EITHER 5 OR 6.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

5 **(a)** Describe how the molecular structure of phospholipids is related to their function in the plasma membrane. [6]

(Any 6)

- **[1F1] Each phospholipid consists of a phosphate group, a glycerol backbone and two fatty acid chains.**
- **[1F2] Each phospholipid is amphipathic / contains both a hydrophilic region and a hydrophobic region within the same molecule.**
- **[1F3] Hydrophilic phosphate heads are on the outside of the bilayer, in contact with the surrounding aqueous medium.**
- **[1F4] Hydrophobic fatty acid chains point towards the interior of the bilayer, away from the surrounding aqueous medium.**
- **[1F] Major component of the plasma membrane / Form a bilayer**
- **[2F] Selectively permeable to solutes due to presence of hydrophobic core in the bilayer**
- **[3F] Determine the fluidity of membrane**
- **[3F1] The more unsaturated fatty acid chains are, the more fluid the membrane is.**
- **[3F2] Kinks in unsaturated fatty acid chains prevent close packing of the phospholipids and decrease the interaction between adjacent fatty acid chains.**
- **[3F3] Phospholipids with shorter fatty acid chains are more fluid.**
- **[3F4] Shorter chain length reduces the tendency of the hydrocarbon tails to interact with one another.**
- **[4F] Some types of phospholipid can be split to produce products that function as second messengers in signal transduction.**

Examiner's comments:
Students who did well kept their answers to the scope of the structure-function relationship of phospholipids. Some students went off tangent by writing about the structure-function relationship of plasma membrane and even the role of cholesterol in regulating membrane fluidity.

(b) Explain the mode of action of enzymes in terms of specificity and activation energy. [8]

Specificity:

- **[S1] catalyse only one particular reaction**
- **[S2] act on molecules that have specific functional groups / act on particular type of chemical bonds / act on a particular stereo or optical isomer**

- **[S3] lock and key hypothesis**
- **[S4] enzyme's active site is the "lock" while substrate is the "key"**
- **[S5] shape of substrates must be complementary to that of the enzyme active site**

OR

- **[S6] induced fit hypothesis**
- **[S7] substrates enter the active site, induces a conformational change in the enzyme, substrates fit more snugly into the active site**
- **[S8] shape of the active site of enzyme may not be exactly complementary to that of substrate**

Activation Energy:

- **[E1] definition: the energy barrier that has to be overcome before a reaction can take place to form products**
- **[E2] enzymes lower the activation energy**
- **[E3] substrate molecules bind to the enzyme molecule at the active site to form enzyme-substrate complexes**
- **[E4] the enzyme molecule holds the different substrate molecules in an arrangement that forces them closer together in the correct orientation**
- **[E5] the proximity of the substrates within the enzyme-substrate complex greatly increases the probability of a reaction occurring**
- **[E6] certain bonds in the substrate molecule may be placed under physical stress**
- **[E7] the R-group of amino acid residues at the active site can change the charge on the substrate which will increase the reactivity of the substrate**

Examiner's comments:
Insufficient elaboration and inappropriate phrasing are the two key reasons why students lost marks for this question.

(c) Explain the effects of competitive and non-competitive inhibitors on the rate of enzymatic activity. [6]

(Max 3m for Competitive Inhibitors)

- **[C1] inhibitor is similar in shape / structure with the substrate**
- **[C2] competes for and binds at / occupies the active site of the enzyme**
- **[C3] thus blocking the substrate from binding with the enzyme**
- **[C4] number of enzyme-substrate complexes formed per unit time decreases**
- **[C5] effect of inhibition can be overcome by increasing substrate concentration**
- **[C6] V_{max} of uninhibited reaction can be reached**

(Max 3m for Non-competitive Inhibitors)

- **[N1] inhibitor has no structural similarity to the substrate**
- **[N2] does not compete with substrate for binding to active site**
- **[N3] binds to a site away from the active site on enzyme**
- **[N4] Enzyme is still able to bind with the substrate at the active site but catalysis is unable to take place.**
- **[N5] effect of inhibition cannot be overcome by increasing substrate concentration**
- **[N6] V_{max} of uninhibited reaction can only be reached with an increase in enzyme concentration while keeping inhibitor concentration constant.**

Examiner's comments:
Students could score high or even full marks for this question if not for careless mix-up of where each type of inhibitor binds to.

[Total: 20]

6 (a) Describe the polymerase chain reaction and explain the advantages and limitations of this procedure. [8]

Procedure of PCR [4]

Purpose of PCR:

- **PCR allows for the amplification of a specified segment of DNA in vitro.**
- **5 Components required for PCR are Template DNA, primers (DNA in nature), Taq polymerase, dNTPs (Nucleotides- A;T;G;C) and buffer**

Procedure of PCR [4]

1. **There are 3 main steps in PCR: Denaturation, Primer annealing and Extension step**

2. **Denaturation Step: [1]**
   - **Heat treatment (up to 95^{0}C) to break the hydrogen bonds holding double stranded DNA together to form 2 separate strands of DNA**
   - **Each strand will act as a template for the synthesis of its complementary strand (daughter strand)**

3. **Primer annealing Step: [1]**
   - **subsequent cooling of DNA (55 ^{0}C - 64^{0}C) in the presence of excess DNA primers allows their specific attachment to their complementary DNA.**
   - **Two types of DNA primers are used, the forward and reverse primers which will bind to 3' end of the target DNA sequence to be amplified.**

4. **Elongation or Extension step: [1]**
   - **Taq polymerase performs synthesis of the complementary DNA strand at up to 72^{0}C, the optimal temperature of this enzyme**
   - **Taq polymerase catalyzes the synthesis of the new complementary stand by addition of free deoxynucleotides to the 3' end of the primer**
   - **The primers provide free 3'OH for DNA polymerase to add new dNTPs to elongate the newly synthesised strand.**

5. **Repeat the 3 steps all over again for another 25-30 cycles: Each denaturation – hybridization - synthesis cycle results in a doubling in number of the DNA sequence being replicated**

Advantages [2]

1. **The amount of desired sequences increase exponentially, e.g. n cycles will yield 2^n strands of target DNA.**
2. **Fast and efficient way to amplify. This technique is also fully automated within the thermocycler, thus it is a convenient way to amplify DNA.**
3. **PCR is highly sensitive such that a target sequence can be amplified even when a minute amount of DNA source is available**
4. **The large amount of desired DNA sequence can be used in clinical diagnosis e.g. genetic screening of cystic fibrosis and early detection of HIV**
5. **Amplified DNA samples can be used for forensic analysis, archaeology and palaeontology**

Limitations [2]

1. **Not so accurate: Tag polymerase lacks 3' to 5' proofreading ability and this makes it impossible for the polymerase to check if the base inserted is the correct one**
2. **Success of PCR requires knowledge of the sequences flanking the target region to be amplified. If the flanking sequences of a gene of interest are unknown, no proper primers can be synthesized, and PCR cannot be used.**
3. **Limited length of DNA fragments which can be amplified. DNA fragments to be amplified are limited to about 3kb. (3000 base pairs)**

Examiner's Comments:

This question was well answered. Students were aware of the main stages involved in PCR. Some minor details such as the purpose of the respective steps were left out in weaker students.

(b) Explain the significance of genetic engineering in improving the quality and yield of crop plants and animals and also in solving the demand for food in the world (e.g. Bt corn, golden rice and GM salmon). [6]

***Define genetic engineering* - the application of recombinant DNA technology to introduce genetic material/ foreign genes in order to alter the hereditary traits/ genetic makeup of a cell, organism, or population [1]**

State one example from both Quality & Yield + explain how it is significance. [5 marks]

<u>**Improved yield e.g. Bt corn [2]**</u>

- **The gene of interest is derived from the soil bacterium, *Bacillus thuringiensis*. The bacteria produces a protein called Bt toxin (Cry proteins) that kills European corn borer.**
- **This gene codes for Cry proteins is inserted into corn plant to form BT corn.**
- **This Cry protein acts as insect stomach poisons that must be eaten to kill the insect. Once eaten, the insect's own digestive enzymes activate the toxic form of the protein. The Cry proteins bind to specific receptors on the intestinal lining and rupture the cells. Within hours, the gut wall breaks down and normal gut bacteria invade the body cavity where they multiply and cause sepsis and subsequent death of the organism within 2 or 3 days.**
- **Genetically modified Bt maize has revolutionized pest control and many farmers have benefited financially.**
- **As this toxin is lethal to the pest but harmless to other animals, this Bt corn allows farmers to control pest infestations in order to reduce crop losses.**
- **Growers creates Bt corn as an alternative to spraying insecticides for control corn borer.**

Improved quality e.g. golden rice [2]

- **Vitamin A deficiency is the leading cause of preventable blindness in children.**
- **Rice grain, which serves as a food staple for much of the world do not contain vitamin A naturally.**
- **It was discovered that geranyl geranyl diphosphate (GGPP) found in rice seed can be a precursor to carotenoid production. Beta-carotene and other carotenes (the red, yellow, and orange pigments found in carrots and other vegetables) are natural precursors (inactive form) of vitamin A.**
- **Thus it is possible to genetically engineer a new breed of rice variety, golden rice which can express the enzymes necessary for the conversion of GGPP to beta-carotene.**

- **To engineer golden rice, genes coding for phytoene synthase (isolated from plant) and phytoene desaturase (isolated from bacteria) must be introduced into the rice plant cells. These enzyme-coding genes catalyze the biosynthesis of beta-carotene from precursor GGPP in the endosperm (edible part of the grain)**

- **A bacterium, *Agrobacterium tumefaciens*, containing a Ti plasmid, was used to introduce all the enzyme-coding genes necessary for the complete biochemical pathway for beta-carotene production. OR another way of introducing DNA into plant cells is through DNA coated particles that are literally shot through the cell wall using a modified gun. This is commonly referred to as the use of a 'gene gun'.**

Improved yield e.g. GM salmon [2]

- **Recombinant DNA composed of an antifreeze promoter from an ocean pout and a growth hormone gene from a Pacific Chinook salmon is synthesized.**
- **Fusing of a strong gene promoter such as the ocean pout antifreeze promoter leads to enhancement in the expression of the gene construct.**
- **The recombinant DNA is then introduced into fertilized eggs of Atlantic salmon. Subsequent selection and breeding led to development of the genetically modified salmon.**
- **Due to the year-round production of growth hormone (due to the antifreeze promoter), this allows for continuous feeding and growth of the GM salmon.**
- **The GM salmon is able to grow quicker in size while feeding more efficiently (less feed is consumed to reach a larger size).**

Examiner's Comments:

This question was generally well answered. Students generally knew what the examples were. The stronger candidates were able elaborate and provide the details for each examples.

(c) Describe the natural functions of restriction enzymes and explain how they can be used in the process of gene cloning. [6]

Natural functions of Res [1]

1. **REs are naturally found in and isolated from bacteria and its natural function is to provide a protective mechanism to help bacteria resist attack from bacteriophages**
2. **REs work by recognizing specific sequences in the phage DNA and cleaving those sequences thereby degrading the incoming viral DNA**
3. **thus preventing / restricting the bacteriophage from succeeding in causing a full-blown bacterial infection**

How REs can be used in gene cloning [5]

1. **REs each binds to a double-stranded DNA molecule at a specific DNA sequence / restriction site and makes a double-stranded cut at or near that sequence [1]**

Choice of RE for extracting Gene of interest / Cut a vector [2]

2. **A chosen RE is used to cleave the gene donor / chromosome / cDNA library to isolate the gene of interest**
3. **The same RE is used to cleave the cloning vector / plasmid making the plasmid DNA linear to facilitate subsequent insertion of the excised gene of interest into plasmid**

Types of Ends Created [2]

4. **Usually, the chosen RE will cleave the DNA in a staggered manner resulting in short single-stranded overhangs / sticky / cohesive ends at each end of the molecule**
5. **sticky-ended fragments of gene of interest are incubated with complementary sticky-ended linearized vector fragments under conditions that favour annealing so as to facilitate the formation of a recombinant plasmid by DNA ligase**
6. **If the chosen RE make a cut in the middle of the recognition sequence resulting in blunt / flush ends. For blunt ends, adaptors will have to be ligated by DNA ligase to the ends of gene of interest and plasmid fragments to generate sticky-ended fragments**

Examiner's comments:
This question is generally well answered. The natural functions of restriction enzymes were often left out among the students.

[Total: 20]

RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

H1 BIOLOGY 8875

PAPER 1
22 SEP 2017
1 HOUR

CANDIDATE NAME	

CENTRE NUMBER	S					INDEX NUMBER					

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and index number on the Answer Sheet in the spaces provided.
DO **NOT** WRITE IN ANY BARCODES.

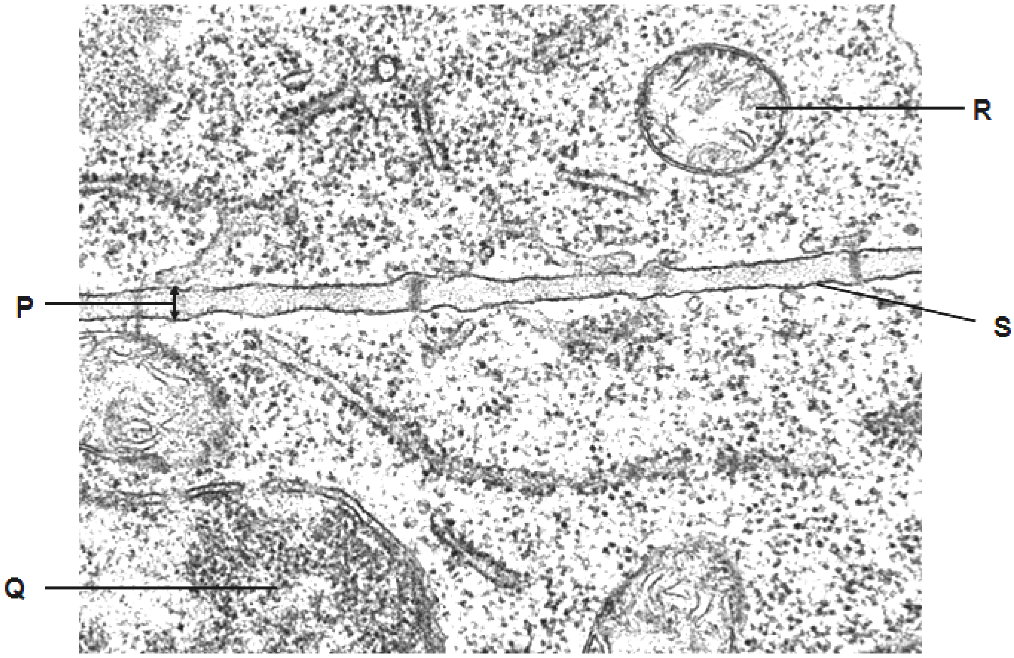
There are **thirty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

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

This Question Paper consists of **20** printed pages.

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



Peter v. Sengbusch - b-online@botanik.uni-hamburg.de

Which of the following statements correctly describe the labelled structures?

1 **R** contains circular DNA and is found in both prokaryotic and eukaryotic cells.

2 **P** has a fluid mosaic structure and regulates the movement of substances between the two plant cells.

3 **S** acts as a selective permeable barrier.

4 **Q** contains enzymes which play an important role in cell specialisation.

A 1 and 3

B 3 and 4

C 1, 2 and 3

D All of the above

2 A student prepared three solutions of sugars, **X**, **Y** and **Z**, and diluted them to varying concentrations. A sample of each was heated with Benedict's reagent, with or without prior acid hydrolysis. The results are shown below.

	concentration of solution / moldm^{-3}					
	0.0001		0.001		0.01	
	no acid	with acid	no acid	with acid	no acid	with acid
X	blue solution	blue solution	green mixture	green mixture	orange mixture	orange mixture
Y	blue solution	green mixture	blue solution	green mixture	blue mixture	orange mixture
Z	blue solution	green mixture	green mixture	green mixture	orange mixture	orange mixture

Based on the results, which of the following conclusions are not correct?

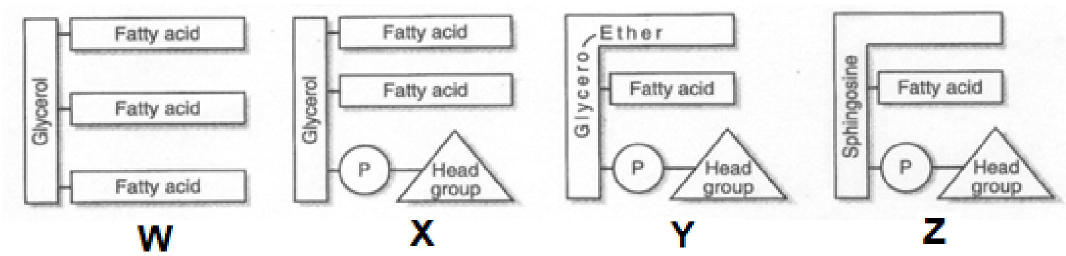
A Solution **Y** does not consist of monosaccharides.

B Solution **X** and solution **Y** consists of disaccharides only.

C Solution **X** consists of monosaccharides only.

D Solution **Z** contains disaccharides.

3 The diagram below shows the components of different types of lipids.



Which statement(s) correctly describes the four lipid molecules?

1 All molecules are made by condensation reactions.

2 The hydrocarbon chains of **W** are always from saturated fatty acids.

3 The hydrocarbon chains of molecules **W** and **Y** may be from saturated or unsaturated fatty acids.

4 The hydrocarbon chains of **X** are always of the same length.

A 1 only

B 1 and 4

C 1 and 3

D 2 and 4

4 The R groups of two amino acids are shown below.

amino acid	R group
serine	$-CH_2-OH$
alanine	$-CH_3$

When placed in aqueous medium, where in a globular protein will these amino acids be found?

A Both serine and alanine will be found in the interior of the globular protein.

B Both serine and alanine will be found on the exterior of the globular protein.

C Alanine will be found in the interior, and serine on the exterior of the globular protein.

D Alanine will be found on the exterior, and serine in the interior of the globular protein.

5 The pathways below show the relationship between an enzyme (**E**) and its substrate (**S**), product (**P**) and an inhibitor (**I**).

Pathway **A**: **E** + **S** → **E** + **P**

Pathway **B**: **E** + **S** + **I** → **E** + **S** + **I**

In the above reactions, assume that

- increasing the concentration of **S** increases the activity of the enzyme,
- at low substrate concentrations the presence of **I** reduces rate of reaction velocity, and
- the same maximum rate of reaction can be reached in the presence or absence of **I**.

Which mechanism is operating in pathway **B**?

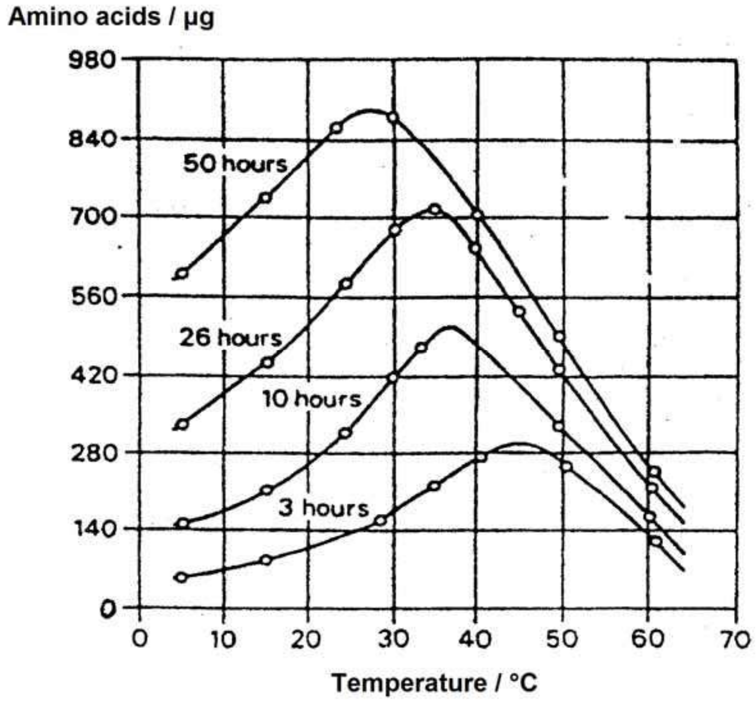
A Positive feedback

B Negative feedback

C Competitive inhibition

D Non-competitive inhibition

6 The graph below shows the effect of temperature on the activity of a proteolytic enzyme incubated at varying durations.



Which of the following can be deduced from the graph?

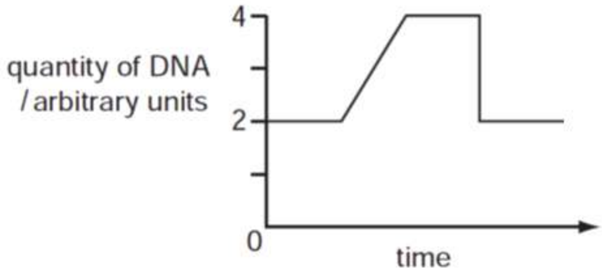
A The optimum temperature of the proteolytic enzyme is 27°C.

B The proteolytic enzyme undergoes denaturation at 27°C.

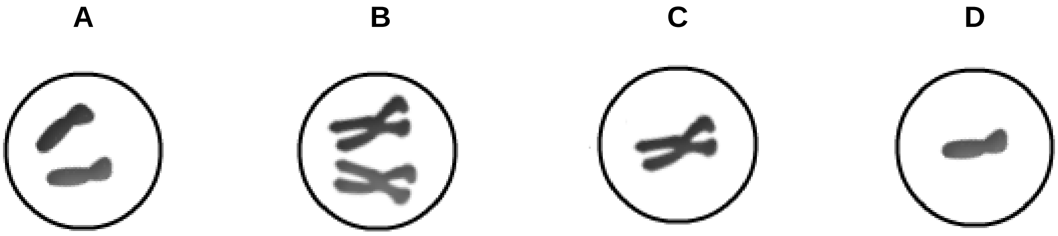
C The optimum temperature of the proteolytic enzyme decreases as the incubation time increases, due to time for breaking of covalent bonds.

D The optimum temperature of the proteolytic enzyme increases with incubation time, causing the hydrolysis to last longer.

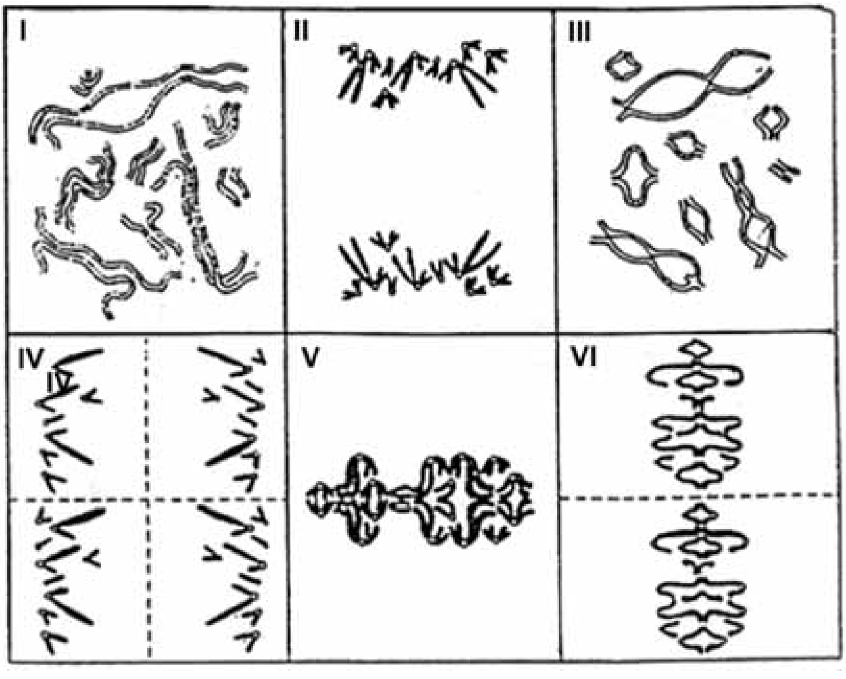
7 The graph shows the change in the quantity of DNA in a cell with one pair of chromosomes during a cell division.



Which nucleus is formed as a result of this division?



8 The diagram depicts the behaviour of chromosomes at various stages of meiosis of the same cell.



Which of the following shows the correct order of the stages?

A **III → V → II → VI → IV → I**

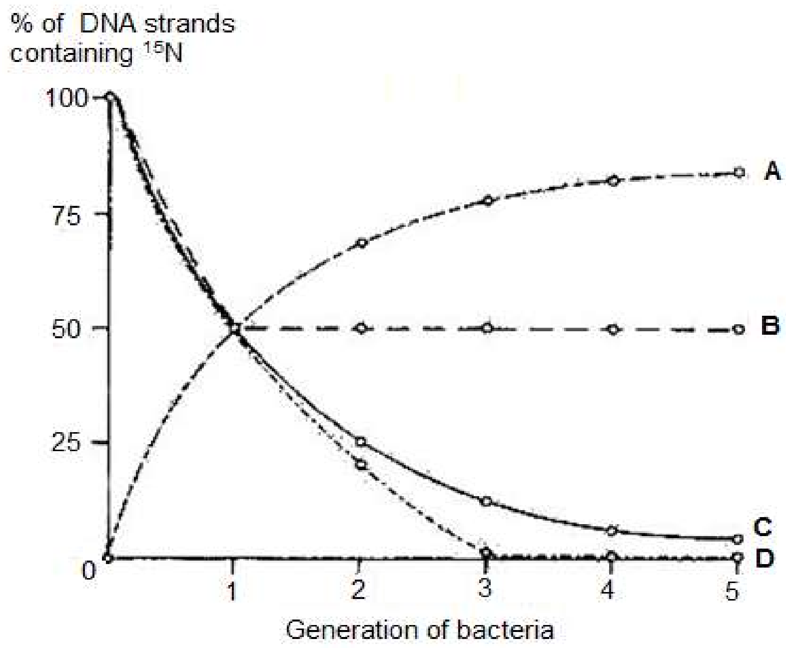
B **III → I → V → II → VI → IV**

C **II → III → I → V → VI → IV**

D **I → III → V → II → VI → IV**

9 Bacteria were cultured in a medium containing heavy nitrogen (^{15}N) until all their DNA were labelled. These bacteria were then grown in a medium containing only light nitrogen (^{14}N) for five generations. The percentage of DNA strands containing ^{15}N in each generation was estimated.

Which curve provides evidence that each daughter DNA molecule produced consists of a parental strand and a newly synthesised daughter strand?



10 A student obtained a sample of DNA from which mRNA was transcribed. He then separated the two strands of DNA by adding NaOH. While doing so, he accidentally contaminated the DNA-mRNA mixture with another DNA sample. The base composition of each DNA strand and that of the mRNA were analysed. The results of the analysis are shown in the table below.

	A	G	C	T	U
DNA strand 1	19.1	26.0	31.0	23.9	0.0
DNA strand 2	24.2	30.8	25.7	19.3	0.0
DNA strand 3	20.5	25.2	29.8	24.5	0.0
DNA strand 4	25.1	24.2	18.8	29.9	0.0
mRNA	19.0	25.9	30.8	0.0	24.3

Which strand of DNA was used as a template for the synthesis of mRNA?

A DNA strand 1

B DNA strand 2

C DNA strand 3

D DNA strand 4

11 Part of the amino acid sequence in β-globin chains of normal and mutant haemoglobin are shown.

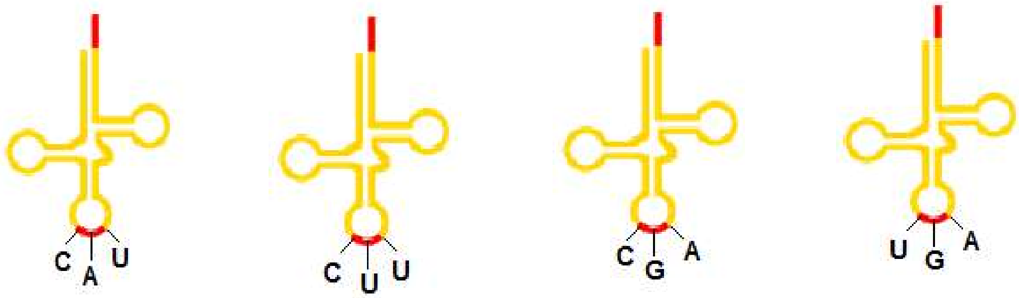
normal haemoglobin	thr-pro-glu-glu
mutant haemoglobin	thr-pro-val-glu

Possible mRNA codons for these amino acids are shown below.

glutamine (glu)	GAA GAG
threonine (thr)	ACU ACC
proline (pro)	CCU CCC
valine (val)	GUA GUG

Which tRNA molecule is not involved in the formation of this part of amino acid sequence in mutant haemoglobin?

A **B** **C** **D**



12 A black-haired female rabbit was crossed with a white-haired male rabbit. Eight offspring were born. Two were white-haired males, two were white-haired females and all the others were black-haired females.

Which statement is correct, from this evidence, about the inheritance of hair colour in rabbits?

A Hair colour is sex-linked in rabbits.

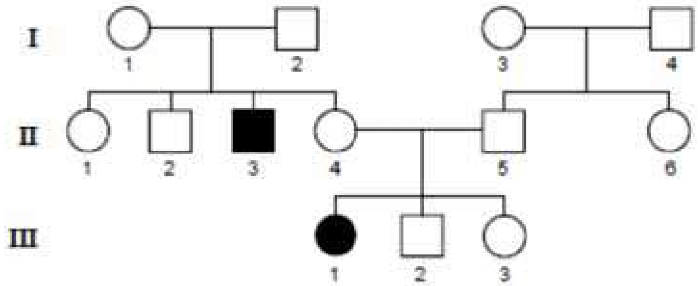
B The allele for black hair is dominant to the allele for white hair.

C The allele for white hair is dominant to the allele for black hair.

D The results of this cross are inconclusive.

13 Phenylketonuria (PKU) is a condition in which affected individuals fail to produce the enzyme phenylalanine hydroxylase. PKU is inherited as an autosomal recessive condition.

The following pedigree shows a family in which two members have PKU.



In the pedigree shown, individuals that must be heterozygous for PKU include

A I–2 **B** I–4 **C** II–1 **D** II–6

14 Tay-Sachs disease is characterised by abnormal accumulation of lipid-related compounds, which results in deterioration of cognitive and motor abilities.

It is caused by an autosomal recessive mutation in the allele coding for hexosaminidase A (HEXA), an enzyme that regulates the metabolism of phospholipids.

The base triplets in part of the coding DNA sequences for a normal HEXA allele and a mutant Tay-Sachs allele, as well as their corresponding amino acids are shown.

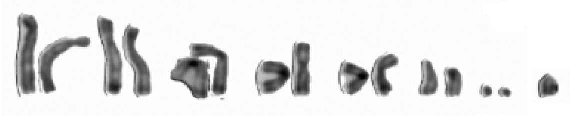
Normal HEXA allele	CGT Arg	ATA Ile	TCC Ser	TAT Tyr	GCC Gly	CCT Pro	GAC… Asp	
Tay-Sachs allele	CGT Arg	ATA Ile	TCT Ser	ATC Ile	CTA Leu	TGC Cys	CCC Pro	TGA… Thr

Which combination correctly describes the nature of mutation that results in the Tay-Sachs allele?

	changes to nucleotide sequences	alteration of reading frame	length of polypeptide
A	deletion of 2 bases	yes	shorter
B	insertion of 2 bases	yes	longer
C	substitution of 4 bases	no	unchanged
D	insertion of 4 bases	yes	longer

15 The figures below show the complete karyotypes of two rodents of the same species. In this species of rodent, males are the heterogametic sex, where they have two different sex chromosomes.

Rodent **A** (Male)



Rodent **B** (Female)

Which of the following observations is not true?

A A chromosomal aberration occurred in the ovary of the mother of rodent **B**

B Rodent **A** is diploid and 2n = 16.

C Rodent **B** has 1 missing chromosome.

D Non-disjunction of autosomes occurred in rodent **B**.

16 Which of the following statements are true about non-cyclic photophosphorylation?

1 $NADP^+$ is oxidized in non-cyclic phosphorylation.

2 P_{680} and P_{700} are reduced after the electrons are excited to higher energy levels.

3 ATP is synthesised in non-cyclic photophosphorylation.

4 The products of non-cyclic phosphorylation are $NADPH/H^+$, ATP and oxygen.

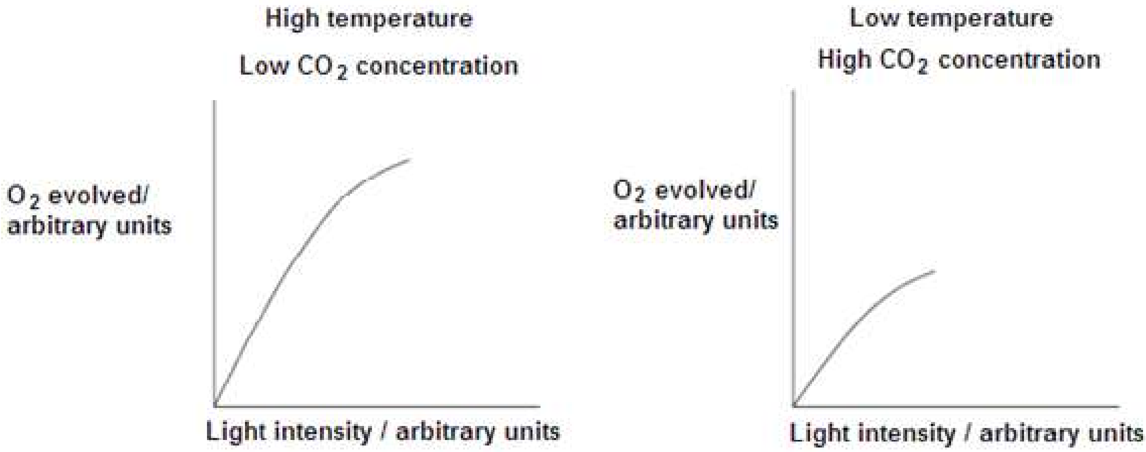
A 1 and 2

B 3 and 4

C 1, 2 and 3

D 2, 3 and 4

17 Students investigated the rate of photosynthesis by measuring the rate of oxygen evolved from an aquatic plant. The results of two experiments that they set up are shown below.



Which conclusion can be drawn from this data?

A Temperature does not affect the rate of photosynthesis.

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18 The common isotope of oxygen is ^{16}O. Air containing $^{16}O_2$ and $^{18}O_2$ was bubbled through a suspension of algae for a limited period. After this, the concentration of these two isotopes of oxygen in the water was monitored for the next 50 minutes whilst the algae were subjected to periods of dark and light. The results are shown in the diagram.

What is the best explanation for these results?

A Both isotopes of oxygen are used by the algae in the dark in respiration, but in the light oxygen is produced from water in photorespiration.

B The algae can distinguish chemically between the two isotopes.

C The algae produce oxygen from the water which is used in photosynthesis, but only in the light.

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19 After vigorous exercise, changes occur in the muscle tissue. Compared with 'at rest' conditions what will be changes be?

	ATP	lactate	pH
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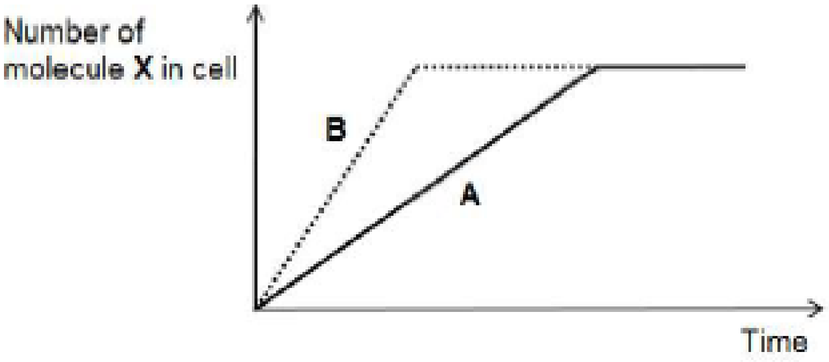
D	increased	decreased	decreased

20 Graph **A** shows the transport of molecule **X**, with the help of carrier proteins, into a cell over time.



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

	transport process	alteration resulting in graph B
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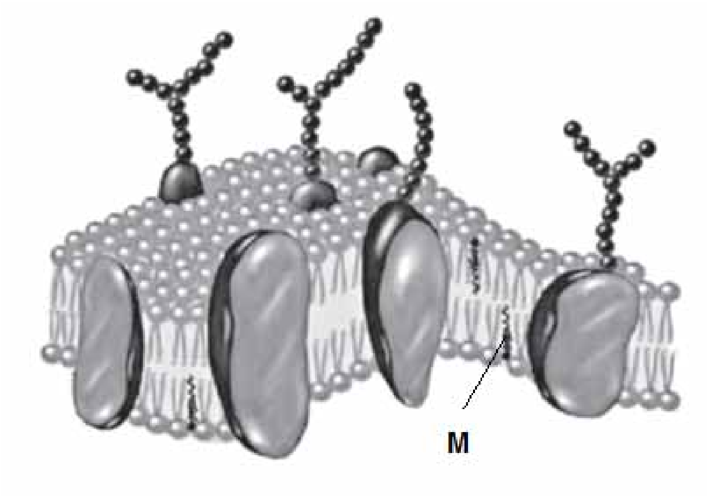

Which of the following correctly describes the function of molecule **M**?

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2 enhances membrane fluidity

3 limits membrane permeability

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A 1 and 2 only

B 1, 2 and 3 only

C 1, 2, 3 and 4 only

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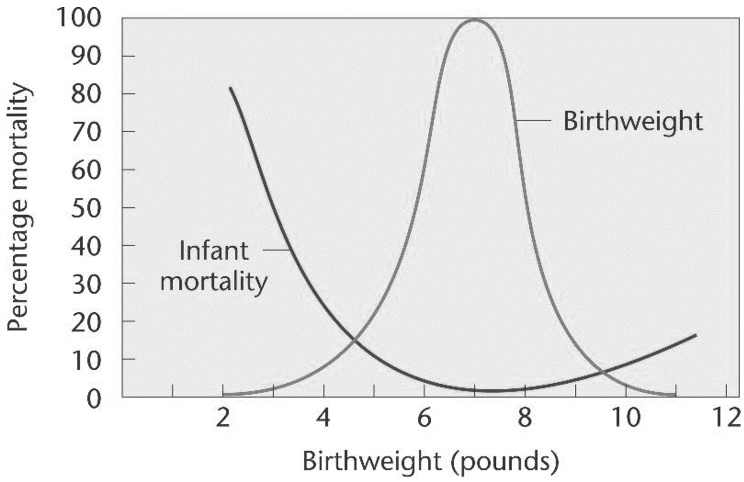
22 The graph below shows the relationship between birthweight and infant mortality in humans.



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23 The formation of the Isthmus of Panama around 3 *Mya* led to the separation of the Pacific and Atlantic oceans. Pistol shrimps of the *Alpheus* genus can be found in both oceans, surrounding the Isthmus. *Alpheus nuttingi* resides in the Atlantic ocean and *Alpheus millsae* resides in the Pacific ocean.

Despite being physically separated, *A. nuttingi* and *A. millsae* are morphologically and genetically very similar. The two species have also been shown to be capable of interbreeding in captivity. Which of the following statements are likely to be true?

1 *A. nuttingi* and *A. millsae* are derived from a common ancestral species.

2 The formation of the Isthmus resulted in geographical isolation of the two species 3 *Mya*.

3 *A. nuttingi* and *A. millsae* are two separate species because they are geographically isolated.

4 Similar environmental conditions around the Isthmus exerted similar selection pressures, leading to convergent evolution between *A. nuttingi* and *A. millsae*.

A 1 only

B 1 and 3

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24 Myxomatosis is a viral disease of rabbits. It spreads rapidly and most rabbits die within 14 days of being infected. Myxomatosis has been deliberately used to reduce the number of rabbits in countries where they are a significant crop pest.

The initial release of the virus caused populations to fall by over 90%. Resistance to myxomatosis increased in the 70 years following initial release, so at the present time up to 50% of infected rabbits are able to survive.

Which of the following statements could explain the increasing frequency of resistance to myxomatosis in the years following release of the virus?

1 In populations with high incidences of myxomatosis, mutations leading to resistance are more likely to occur.

2 Infected rabbits die quickly, hence the alleles that code for myxomatosis are eliminated from the population.

3 The initial release of the virus led to death of large number of rabbits, greatly altering the frequency of alleles in rabbit populations.

4 During disease outbreaks there is greater food availability for the surviving rabbits, increasing the probability that they survive.

A 4 only

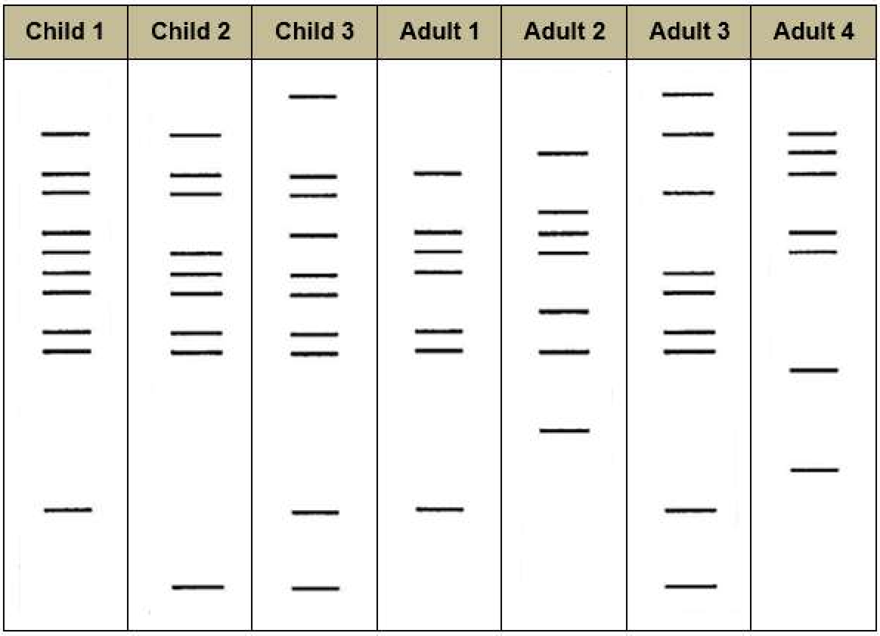
B 1 and 2 only

C 2 and 4 only

D 2, 3 and 4 only

25 Seven skeletons were found in an unidentified grave. To establish the relationship between these seven individuals, DNA were isolated from these skeletons and then analysed using gel electrophoresis.

The results obtained from the skeletons, three children and four adults, are shown below.



Other analysis showed that all three children have the same parents. Which two adults may be the parents of these children?

A Adults 1 and 2

B Adults 1 and 3

C Adults 2 and 3

D Adults 2 and 4

26 Which of the following statements about polymerase chain reaction are true?

1 Copy fragments of DNA
2 Amplify fragments of DNA
3 Translate fragments of DNA
4 Requires an excess of RNA primers
5 Requires DNA-dependent DNA polymerase

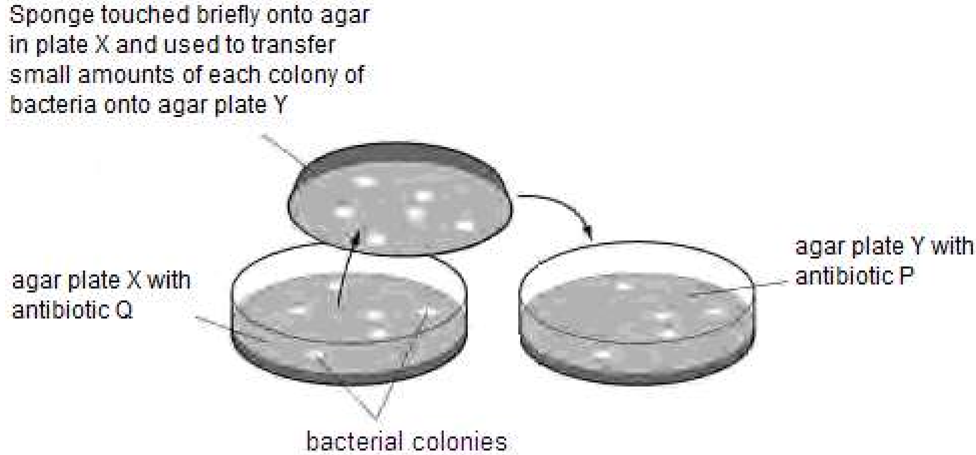
A 1 and 2

B 2 and 5

C 1, 2 and 4

D 1, 2 and 5

27 The diagram shows a method used to detect bacteria colonies which are successfully transformed during genetic engineering.



Which explains why other methods for detecting successful transformation are now preferred?

1 Incorporating heavy-metal resistance genes along with the desired genes means that you can easily kill cells that have not been transformed.

2 Presence or absence of non-toxic fluorescent markers is easy to detect using ultra-violet light.

3 The antibiotic resistance genes previously used as markers might have escaped into the environment.

4 The antibiotic resistance genes previously used as markers killed the transformed cells so they were difficult to use.

A 1 and 3

B 2 and 4

C 1, 2 and 3

D 1, 2, 3 and 4

28 Which of the following best explains why a genome project is not finished when the sequence has been completed?

A Genomes change too fast and must constantly be updated.

B Without knowing the number, the function, and the location of genes within a genome, the sequence is not very useful.

C Individuals within a species are so unique that having a single sequence is insufficient to characterise a species' genome.

D Many sections of a genome are too difficult to sequence and have not actually been included in 'complete' genomes.

29 Which of the following statements regarding stem cells are **not** correct?

1 Stem cells are present within various organs of the adult body.

2 Stem cells can develop into a whole organism when implanted into the womb.

3 Stem cells can be grown indefinitely in culture under appropriate culture conditions.

4 Stems cells isolated from a 3-5 day old human embryo can differentiate into only one kind of cells.

A 1 and 3 only

B 2 and 4 only

C 1, 2 and 3

D 2, 3 and 4

30 Maize varieties with leaves that produce protein toxic to insects are being developed. The DNA coding for these toxic proteins was inserted into a maize chromosome via a bacterial plasmid. Many people oppose to this process.

Which objection is **not** biologically valid?

A Beneficial insects may be killed if they eat genetically modified maize.

B Genes for antibiotic resistance are present in plasmids and these genes may be passed to harmful bacteria.

C Hybridisation may transfer the bacterial genes from maize to weeds, giving the weed species new and harmful characteristics.

D Mutations may be caused in cattle or humans that eat the genetically modified maize.

RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

H1 BIOLOGY 8875

PAPER 1
22 SEP 2017
1 HOUR

CANDIDATE NAME										
CENTRE NUMBER	S					INDEX NUMBER				

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and index number on the Answer Sheet in the spaces provided.
DO **NOT** WRITE IN ANY BARCODES.

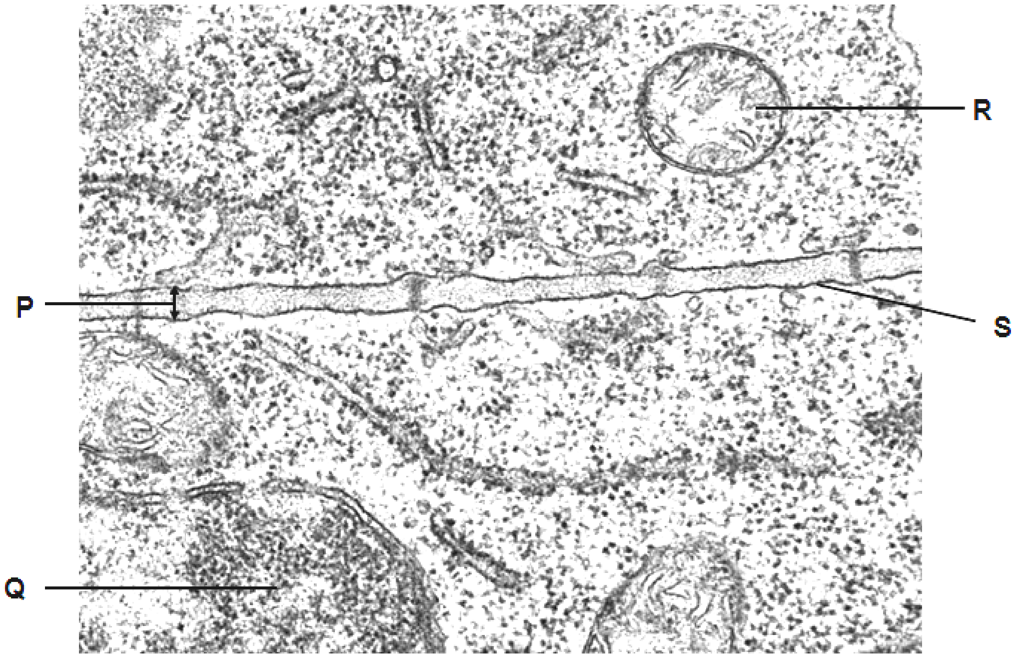
There are **thirty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

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

This Question Paper consists of **20** printed pages.

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



Peter v. Sengbusch - b-online@botanik.uni-hamburg.de

Which of the following statements correctly describe the labelled structures?

1 **R** contains circular DNA and is found in both prokaryotic and eukaryotic cells.

2 **P** has a fluid mosaic structure and regulates the movement of substances between the two plant cells.

3 **S** acts as a selective permeable barrier.

4 **Q** contains enzymes which play an important role in cell specialisation.

A 1 and 3

B 3 and 4

C 1, 2 and 3

D All of the above

2 A student prepared three solutions of sugars, **X**, **Y** and **Z**, and diluted them to varying concentrations. A sample of each was heated with Benedict's reagent, with or without prior acid hydrolysis. The results are shown below.

	concentration of solution / moldm^{-3}					
	0.0001		**0.001**		**0.01**	
	no acid	**with acid**	**no acid**	**with acid**	**no acid**	**with acid**
X	blue solution	blue solution	green mixture	green mixture	orange mixture	orange mixture
Y	blue solution	green mixture	blue solution	green mixture	blue mixture	orange mixture
Z	blue solution	green mixture	green mixture	green mixture	orange mixture	orange mixture

Based on the results, which of the following conclusions are not correct?

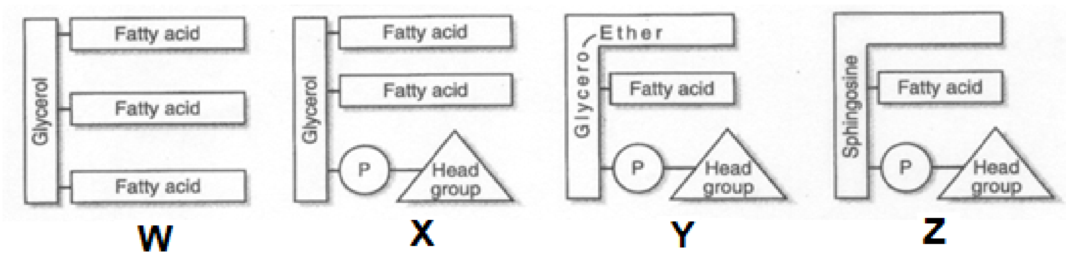
A Solution **Y** does not consist of monosaccharides.

B Solution **X** and solution **Y** consists of disaccharides only.

C Solution **X** consists of monosaccharides only.

D Solution **Z** contains disaccharides.

3 The diagram below shows the components of different types of lipids.



Which statement(s) correctly describes the four lipid molecules?

1 All molecules are made by condensation reactions.

2 The hydrocarbon chains of **W** are always from saturated fatty acids.

3 The hydrocarbon chains of molecules **W** and **Y** may be from saturated or unsaturated fatty acids.

4 The hydrocarbon chains of **X** are always of the same length.

A 1 only

B 1 and 4

C 1 and 3

D 2 and 4

4 The R groups of two amino acids are shown below.

amino acid	R group
serine	$-CH_2-OH$
alanine	$-CH_3$

When placed in aqueous medium, where in a globular protein will these amino acids be found?

A Both serine and alanine will be found in the interior of the globular protein.

B Both serine and alanine will be found on the exterior of the globular protein.

C Alanine will be found in the interior, and serine on the exterior of the globular protein.

D Alanine will be found on the exterior, and serine in the interior of the globular protein.

5 The pathways below show the relationship between an enzyme (**E**) and its substrate (**S**), product (**P**) and an inhibitor (**I**).

Pathway **A**: **E** + **S** → **E** + **P**

Pathway **B**: **E** + **S** + **I** → **E** + **S** + **I**

In the above reactions, assume that

- increasing the concentration of **S** increases the activity of the enzyme,
- at low substrate concentrations the presence of **I** reduces rate of reaction velocity, and
- the same maximum rate of reaction can be reached in the presence or absence of **I**.

Which mechanism is operating in pathway **B**?

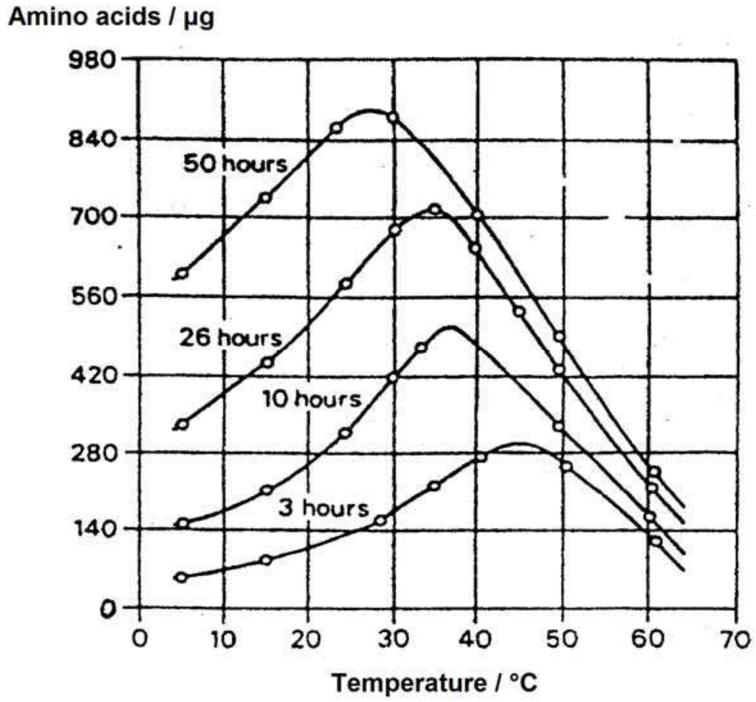
A Positive feedback

B Negative feedback

C Competitive inhibition

D Non-competitive inhibition

6 The graph below shows the effect of temperature on the activity of a proteolytic enzyme incubated at varying durations.



Which of the following can be deduced from the graph?

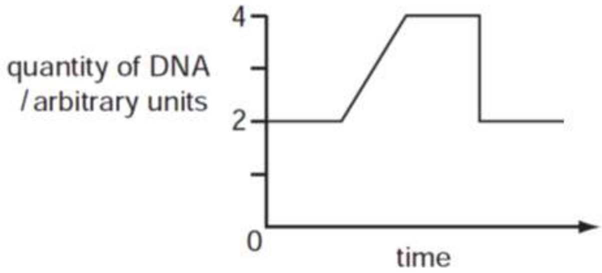
A The optimum temperature of the proteolytic enzyme is 27°C.

B The proteolytic enzyme undergoes denaturation at 27°C.

C The optimum temperature of the proteolytic enzyme decreases as the incubation time increases, due to time for breaking of covalent bonds.

D The optimum temperature of the proteolytic enzyme increases with incubation time, causing the hydrolysis to last longer.

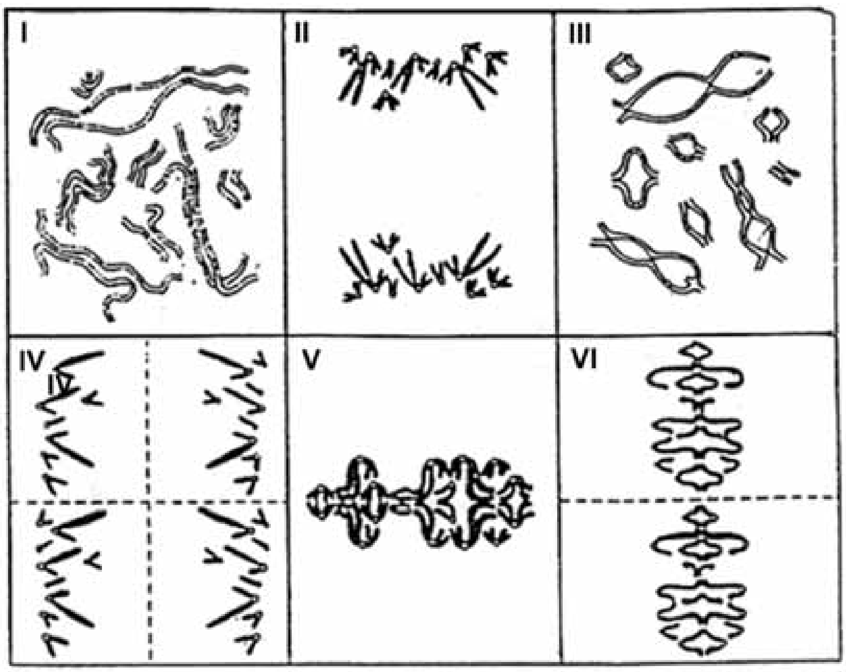
7 The graph shows the change in the quantity of DNA in a cell with one pair of chromosomes during a cell division.



Which nucleus is formed as a result of this division?

A	B	C	D
			

8 The diagram depicts the behaviour of chromosomes at various stages of meiosis of the same cell.



Which of the following shows the correct order of the stages?

A **III → V → II → VI → IV → I**

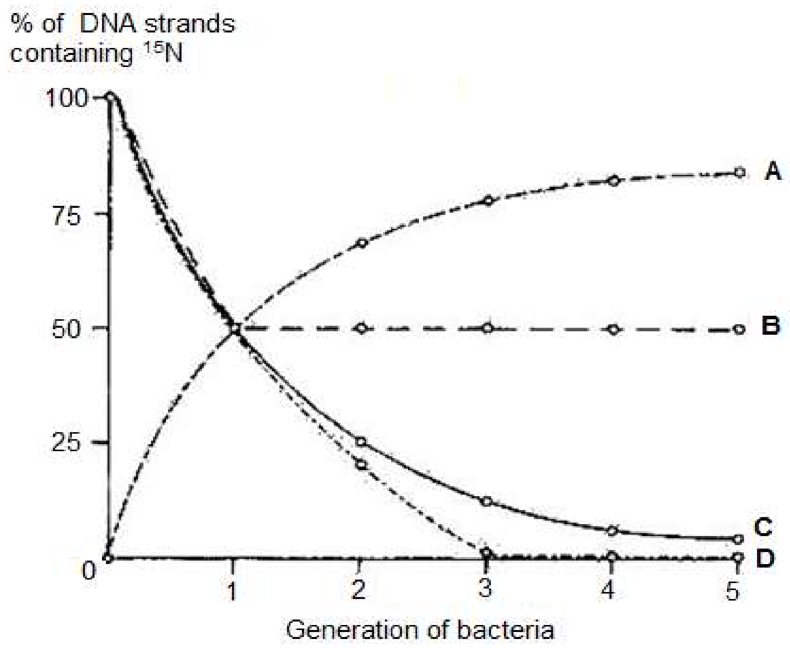
B **III → I → V → II → VI → IV**

C **II → III → I → V → VI → IV**

D **I → III → V → II → VI → IV**

9 Bacteria were cultured in a medium containing heavy nitrogen (^{15}N) until all their DNA were labelled. These bacteria were then grown in a medium containing only light nitrogen (^{14}N) for five generations. The percentage of DNA strands containing ^{15}N in each generation was estimated.

Which curve provides evidence that each daughter DNA molecule produced consists of a parental strand and a newly synthesised daughter strand? Answer: C



10 A student obtained a sample of DNA from which mRNA was transcribed. He then separated the two strands of DNA by adding NaOH. While doing so, he accidentally contaminated the DNA-mRNA mixture with another DNA sample. The base composition of each DNA strand and that of the mRNA were analysed. The results of the analysis are shown in the table below.

	A	G	C	T	U
DNA strand 1	19.1	26.0	31.0	23.9	0.0
DNA strand 2	24.2	30.8	25.7	19.3	0.0
DNA strand 3	20.5	25.2	29.8	24.5	0.0
DNA strand 4	25.1	24.2	18.8	29.9	0.0
mRNA	19.0	25.9	30.8	0.0	24.3

Which strand of DNA was used as a template for the synthesis of mRNA?

A DNA strand 1

B DNA strand 2

C DNA strand 3

D DNA strand 4

11 Part of the amino acid sequence in β-globin chains of normal and mutant haemoglobin are shown.

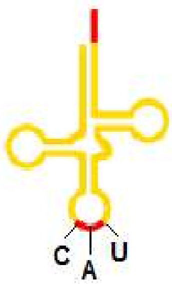
normal haemoglobin	thr-pro-glu-glu
mutant haemoglobin	thr-pro-val-glu

Possible mRNA codons for these amino acids are shown below.

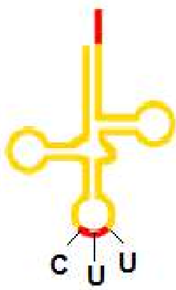
glutamine (glu)	GAA GAG
threonine (thr)	ACU ACC
proline (pro)	CCU CCC
valine (val)	GUA GUG

Which tRNA molecule is not involved in the formation of this part of amino acid sequence in mutant haemoglobin?

A



B



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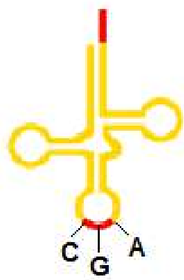
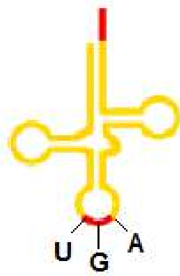


D



12 A black-haired female rabbit was crossed with a white-haired male rabbit. Eight offspring were born. Two were white-haired males, two were white-haired females and all the others were black-haired females.

Which statement is correct, from this evidence, about the inheritance of hair colour in rabbits?

A Hair colour is sex-linked in rabbits.

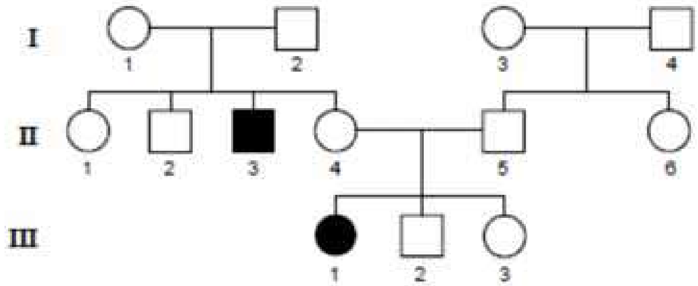
B The allele for black hair is dominant to the allele for white hair.

C The allele for white hair is dominant to the allele for black hair.

D The results of this cross are inconclusive.

13 Phenylketonuria (PKU) is a condition in which affected individuals fail to produce the enzyme phenylalanine hydroxylase. PKU is inherited as an autosomal recessive condition.

The following pedigree shows a family in which two members have PKU.



In the pedigree shown, individuals that must be heterozygous for PKU include

A I–2 **B** I–4 **C** II–1 **D** II–6

14 Tay-Sachs disease is characterised by abnormal accumulation of lipid-related compounds, which results in deterioration of cognitive and motor abilities.

It is caused by an autosomal recessive mutation in the allele coding for hexosaminidase A (HEXA), an enzyme that regulates the metabolism of phospholipids.

The base triplets in part of the coding DNA sequences for a normal HEXA allele and a mutant Tay-Sachs allele, as well as their corresponding amino acids are shown.

Normal HEXA allele	CGT Arg	ATA Ile	TCC Ser	TAT Tyr	GCC Gly	CCT Pro	GAC… Asp	
Tay-Sachs allele	CGT Arg	ATA Ile	TCT Ser	ATC Ile	CTA Leu	TGC Cys	CCC Pro	TGA… Thr

Which combination correctly describes the nature of mutation that results in the Tay-Sachs allele?

	changes to nucleotide sequences	alteration of reading frame	length of polypeptide
A	deletion of 2 bases	yes	shorter
B	insertion of 2 bases	yes	longer
C	substitution of 4 bases	no	unchanged
D	insertion of 4 bases	yes	longer

15 The figures below show the complete karyotypes of two rodents of the same species. In this species of rodent, males are the heterogametic sex, where they have two different sex chromosomes.

Rodent **A** (Male)

Rodent **B** (Female)

Which of the following observations is not true?

A A chromosomal aberration occurred in the ovary of the mother of rodent **B**

B Rodent **A** is diploid and 2n = 16.

C Rodent **B** has 1 missing chromosome.

D Non-disjunction of autosomes occurred in rodent **B**.

16 Which of the following statements are true about non-cyclic photophosphorylation?

1 $NADP^+$ is oxidized in non-cyclic phosphorylation.

2 P_{680} and P_{700} are reduced after the electrons are excited to higher energy levels.

3 ATP is synthesised in non-cyclic photophosphorylation.

4 The products of non-cyclic phosphorylation are $NADPH/H^+$, ATP and oxygen.

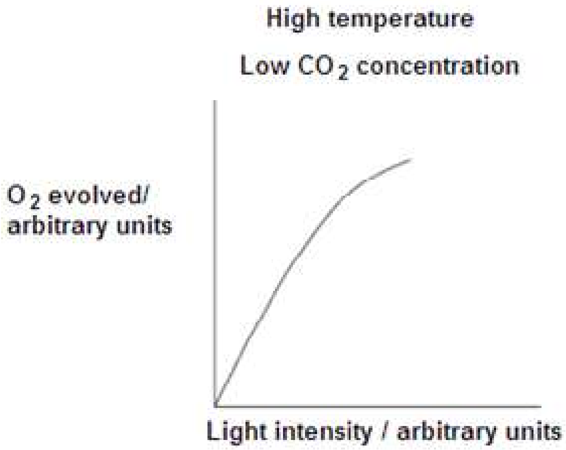
A 1 and 2

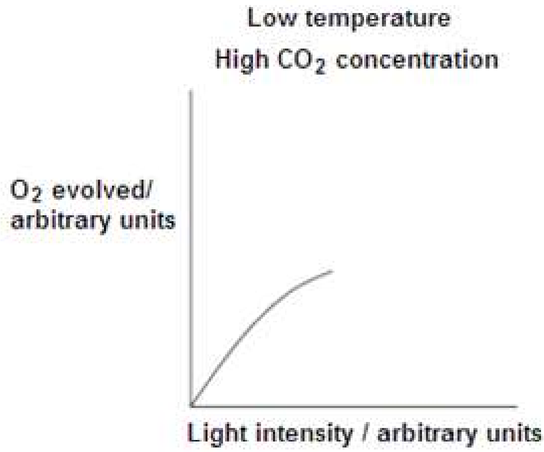
B 3 and 4

C 1, 2 and 3

D 2, 3 and 4

17 Students investigated the rate of photosynthesis by measuring the rate of oxygen evolved from an aquatic plant. The results of two experiments that they set up are shown below.





Which conclusion can be drawn from this data?

A Temperature does not affect the rate of photosynthesis.

B High concentrations of CO_2 reduce the rate of photosynthesis.

C Temperature and CO_2 concentration are both limiting factors.

D The greater the light intensity the greater the rate of photosynthesis.

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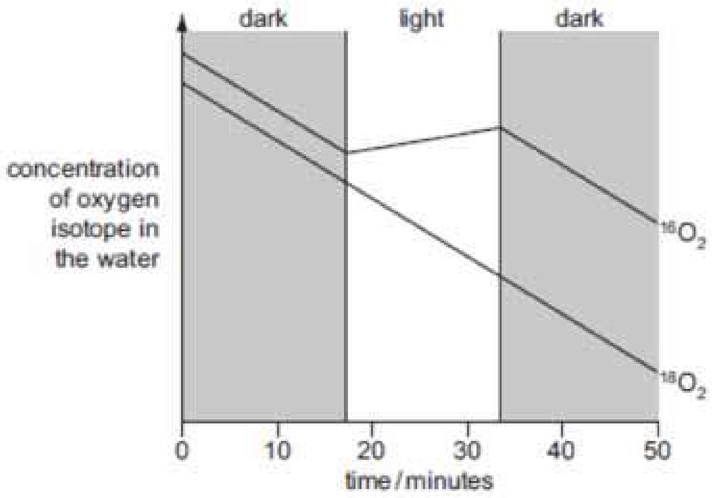

What is the best explanation for these results?

A Both isotopes of oxygen are used by the algae in the dark in respiration, but in the light oxygen is produced from water in photorespiration.

B The algae can distinguish chemically between the two isotopes.

C The algae produce oxygen from the water which is used in photosynthesis, but only in the light.

D The two isotopes have different rates of diffusion.

19 After vigorous exercise, changes occur in the muscle tissue. Compared with 'at rest' conditions what will be changes be?

	ATP	lactate	pH
A	decreased	increased	decreased
B	increased	increased	increased
C	decreased	decreased	increased
D	increased	decreased	decreased

20 Graph **A** shows the transport of molecule **X**, with the help of carrier proteins, into a cell over time.

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

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

	transport process	alteration resulting in graph **B**
A	facilitated diffusion	increase in environmental temperature to 90 °C
B	active transport	increase in concentration of **X** in cell
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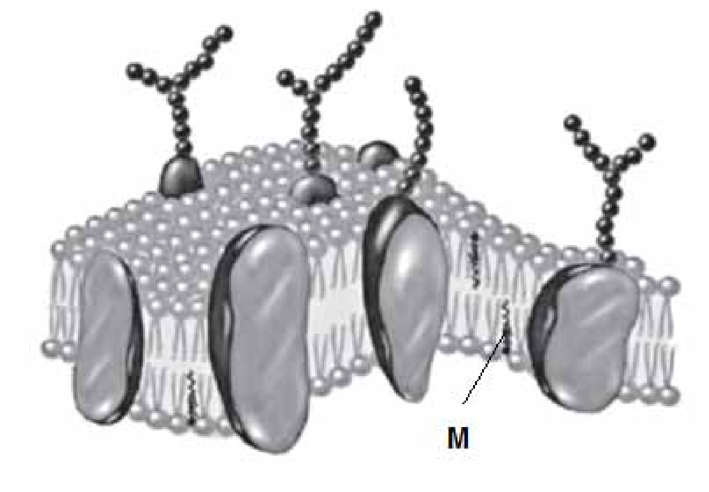

Which of the following correctly describes the function of molecule **M**?

1 limits membrane fluidity

2 enhances membrane fluidity

3 limits membrane permeability

4 enhances membrane permeability

5 allows for cell-cell adhesion

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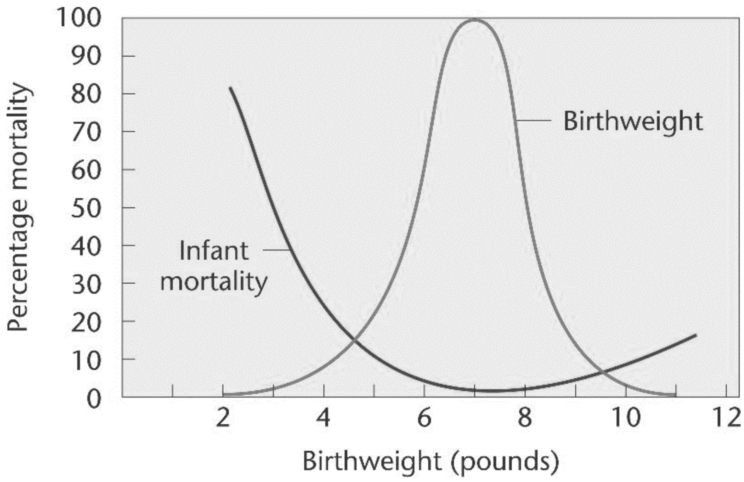
22 The graph below shows the relationship between birthweight and infant mortality in humans.



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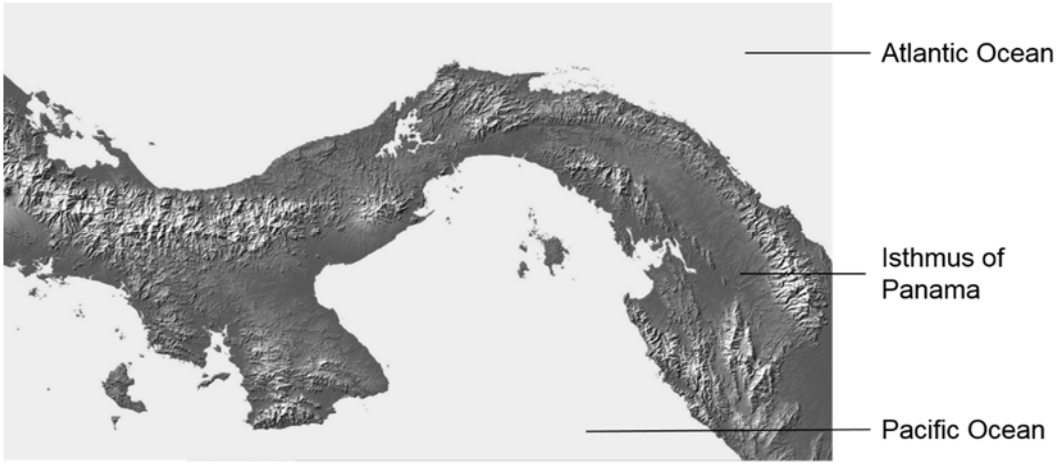

Despite being physically separated, *A. nuttingi* and *A. millsae* are morphologically and genetically very similar. The two species have also been shown to be capable of interbreeding in captivity. Which of the following statements are likely to be true?

1 *A. nuttingi* and *A. millsae* are derived from a common ancestral species.

2 The formation of the Isthmus resulted in geographical isolation of the two species 3 *Mya*.

3 *A. nuttingi* and *A. millsae* are two separate species because they are geographically isolated.

4 Similar environmental conditions around the Isthmus exerted similar selection pressures, leading to convergent evolution between *A. nuttingi* and *A. millsae*.

A 1 only

B 1 and 3

C 2 and 3

D 3 and 4

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The initial release of the virus caused populations to fall by over 90%. Resistance to myxomatosis increased in the 70 years following initial release, so at the present time up to 50% of infected rabbits are able to survive.

Which of the following statements could explain the increasing frequency of resistance to myxomatosis in the years following release of the virus?

1 In populations with high incidences of myxomatosis, mutations leading to resistance are more likely to occur.

2 Infected rabbits die quickly, hence the alleles that code for myxomatosis are eliminated from the population.

3 The initial release of the virus led to death of large number of rabbits, greatly altering the frequency of alleles in rabbit populations.

4 During disease outbreaks there is greater food availability for the surviving rabbits, increasing the probability that they survive.

A 4 only

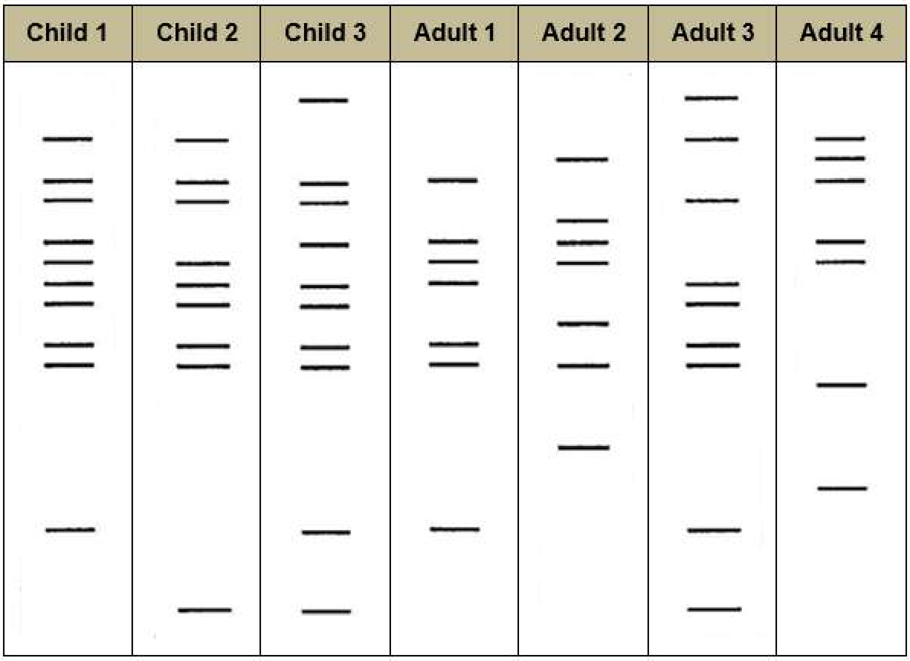
B 1 and 2 only

C 2 and 4 only

D 2, 3 and 4 only

25 Seven skeletons were found in an unidentified grave. To establish the relationship between these seven individuals, DNA were isolated from these skeletons and then analysed using gel electrophoresis.

The results obtained from the skeletons, three children and four adults, are shown below.



Other analysis showed that all three children have the same parents. Which two adults may be the parents of these children?

A Adults 1 and 2

B Adults 1 and 3

C Adults 2 and 3

D Adults 2 and 4

26 Which of the following statements about polymerase chain reaction are true?

1 Copy fragments of DNA
2 Amplify fragments of DNA
3 Translate fragments of DNA
4 Requires an excess of RNA primers
5 Requires DNA-dependent DNA polymerase

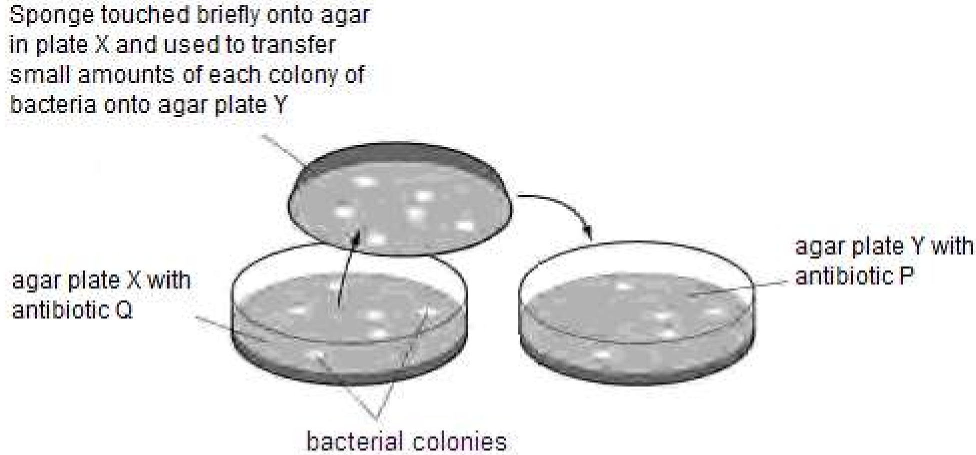
A 1 and 2

B 2 and 5

C 1, 2 and 4

D 1, 2 and 5

27 The diagram shows a method used to detect bacteria colonies which are successfully transformed during genetic engineering.



Which explains why other methods for detecting successful transformation are now preferred?

1 Incorporating heavy-metal esistance genes along with the desired genes means that you can easily kill cells that have not been transformed.

2 Presence or absence of non-toxic fluorescent markers is easy to detect using ultra-violet light.

3 The antibiotic resistance genes previously used as markers might have escaped into the environment.

4 The antibiotic resistance genes previously used as markers killed the transformed cells so they were difficult to use.

A 1 and 3

B 2 and 4

C 1, 2 and 3

D 1, 2, 3 and 4

28 Which of the following best explains why a genome project is not finished when the sequence has been completed?

A Genomes change too fast and must constantly be updated.

B Without knowing the number, the function, and the location of genes within a genome, the sequence is not very useful.

C Individuals within a species are so unique that having a single sequence is insufficient to characterise a species' genome.

D Many sections of a genome are too difficult to sequence and have not actually been included in 'complete' genomes.

29 Which of the following statements regarding stem cells are **not** correct?

1 Stem cells are present within various organs of the adult body.

2 Stem cells can develop into a whole organism when implanted into the womb.

3 Stem cells can be grown indefinitely in culture under appropriate culture conditions.

4 Stems cells isolated from a 3-5 day old human embryo can differentiate into only one kind of cells.

A 1 and 3 only

B 2 and 4 only

C 1, 2 and 3

D 2, 3 and 4

30 Maize varieties with leaves that produce protein toxic to insects are being developed. The DNA coding for these toxic proteins was inserted into a maize chromosome via a bacterial plasmid. Many people oppose to this process.

Which objection is **not** biologically valid?

A Beneficial insects may be killed if they eat genetically modified maize.

B Genes for antibiotic resistance are present in plasmids and these genes may be passed to harmful bacteria.

C Hybridisation may transfer the bacterial genes from maize to weeds, giving the weed species new and harmful characteristics.

D Mutations may be caused in cattle or humans that eat the genetically modified maize.

RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

CANDIDATE NAME	

CENTRE NUMBER	S					CLASS		INDEX NUMBER						

H1 BIOLOGY **8875/02**

Paper 2 Core Paper **11 Sep 2017**

2 hours

Additional Materials: Answer Paper

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.
Circle the question attempted on the cover page.

The use of an approved scientific calculator is expected, where appropriate.

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

For Examiner's Use	
Section A	
1	**/ 8**
2	**/ 12**
3	**/ 9**
4	**/ 11**
Section B	
5 or 6	**/ 20**
Total	**/ 60**

This Question Paper consists of **12** printed pages.

SECTION A

Answer **all** questions.

1 Fig. 1.1 represents the molecular structure of a type of phospholipid.

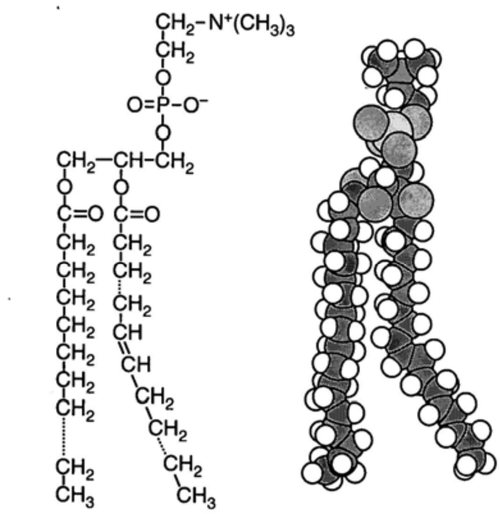


Fig. 1.1

(a) (i) Describe the arrangement of phopsholipids in cell membranes. [2]

____

____

____

____

(ii) Explain how the structure of phospholipids is related to this arrangement in cell membranes. [2]

____

____

____

____

Fig 1.2 shows a channel protein, aquaporin, which is necessary for the bulk flow of water molecules.

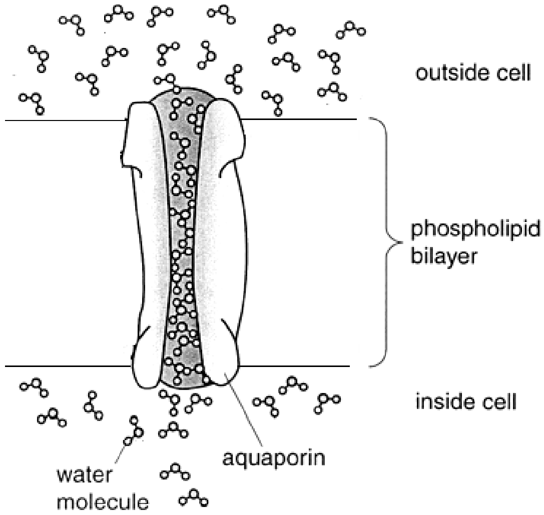


Fig 1.2

(b) With reference to Fig. 1.2, describe how water molecules move across a membrane. [2]

Diabetes insipidus is a condition characterised by large amounts of diluted urine. Fluid is not reabsorbed by the cells in the kidney due to changes in permeability of their surface membrane. Reduction of fluid intake by patients has little effect on the concentration of urine.

Diabetes insipidus is a result of mutation in the gene coding for aquaporin channels.

A clinician studied the surface membrane of kidney cells involved in reabsorption of fluid in individuals with diabetes insipidus and found that aquaporin channels are absent.

(c) Suggest how mutant aquaporin channels leads to diluted urine in individuals with diabetes insipidus. [2]

[Total: 8]

2 Fig. 2.1 is an electron micrograph of a mitochondrion.

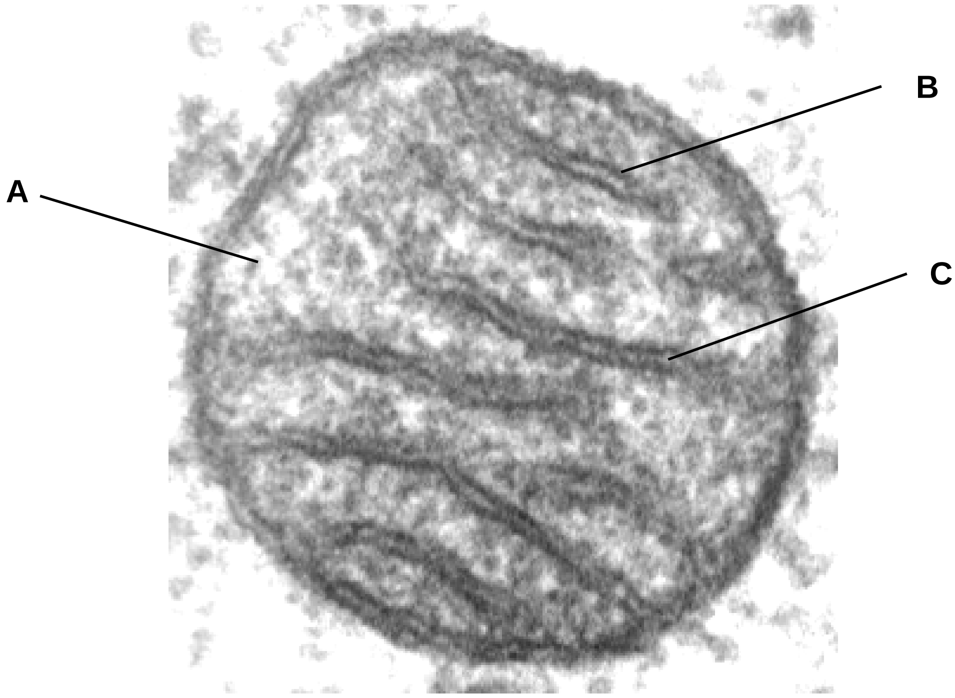


Fig. 2.1

(a) **(i)** Identify structures **A** and **B**. [2]

A ____

B ____

(ii) Describe how structure **A** is adapted to its function. [1]

____

____

(b) **(i)** State the role of high concentration of protons at **C**. [1]

____

____

(ii) Explain how the high concentration of protons is generated at **C**. [3]

In an investigation to determine the effect of chemical **M** on respiration, mitochondria were incubated in four ways:

1. with glucose
2. with pyruvate
3. with glucose and chemical **M**
4. with pyruvate and chemical **M**

After incubation, the results are summarised in Table 1.1.

Table 1.1

	CO_2 evolution	O_2 consumption	ATP production by oxidative phosphorylation
Glucose	x	x	x
Pyruvate	✓	✓	✓
Glucose + chemical **M**	x	x	x
Pyruvate + chemical **M**	✓	✓	x

(c) **(i)** Explain why carbon dioxide is produced when mitochondria are incubated with pyruvate but not when incubated with glucose. [3]

(ii) Suggest why when mitochondria are incubated with chemical **M**, oxygen consumption occurs but not ATP production. [2]

[Total: 12]

3 In lizard, a recessive mutant allele leads to black body colour as opposed to the normal brown body colour. A second recessive mutant allele at a separate locus leads to grey spots as opposed to normal white spots on the body.

A test cross was conducted for these loci. This test cross took F1 females from a standard dihybrid cross and crossed them with a male pure breeding for black body with grey spots. The following offspring were produced:

Brown body with white spots	160
Brown body with grey spots	155
Black body with white spots	156
Black body with grey spots	162

(a) Define the term *locus*. [1]

(b) Draw a genetic diagram to explain the observed results of this test cross. [4]

(b) A mutation occurs to the gene locus determining body colour and a new body colour red appeared in the population of lizards.

Table 3.1 shows the change in the frequency of the three different phenotypes.

Table 3.1

	Initial Population	Generation 10	Generation 20	Generation 30
Brown colour	80%	80%	70%	40%
Red colour	10%	0%	0%	0%
Black colour	10%	20%	30%	60%

Using Table 3.1 and your knowledge of natural selection, explains the results. [4]

[Total: 9]

4 Genetically modified maize was widely grown in the maize-growing areas of the USA. One of the genetically modified varieties of maize contains a gene (*Bt*) from a bacterium, *Bacillus thuringiensis*. The gene codes for a toxin, which is expressed in the leaves and acts as an insecticide.

In USA, milkweed frequently grows around the edge of maize fields and is fed upon by caterpillars of the Monarch butterfly. In an investigation on the environmental effects of *Bt* maize, leaves of milkweed were divided into three groups, **A**, **B** and **C**, and treated as shown in Table 4.1.

Table 4.1

Treatment group	**Treatment**
A	dusted with pollen from genetically modified maize carrying the *Bt* gene;
B	dusted with pollen from maize that had not been genetically modified;
C	not dusted with pollen.

Monarch caterpillars were then placed on the leaves and the survival of the caterpillars was measured over four days. The results of the experiment are shown in Fig. 4.1.

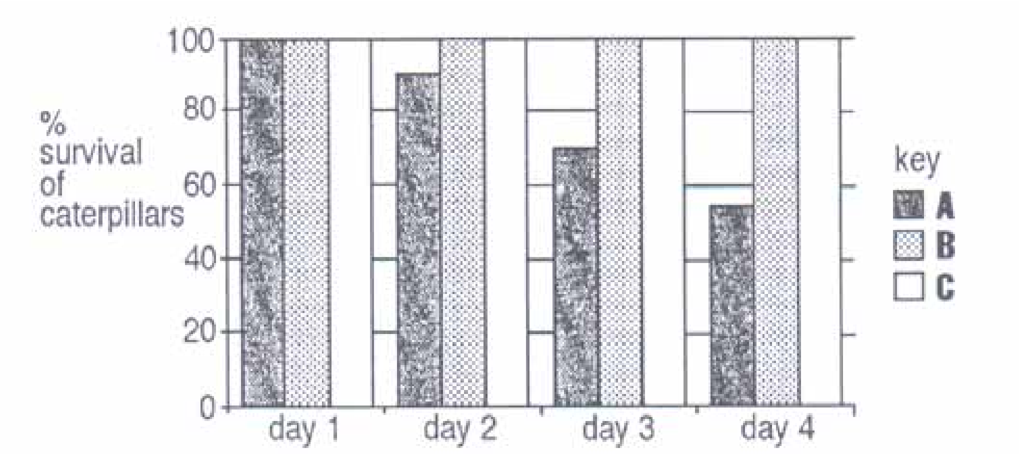


Fig. 4.1

(a) Explain why farmers in the USA grow maize carrying the *Bt* gene. [2]

(b) With reference to Fig. 4.1, comment on the effect of eating pollen from different maize plants on the survival of Monarch butterfly caterpillars. [2]

Plasmids are small circles of DNA, found in many bacteria, which can be used for genetic engineering of crop plants such as *Bt* corn.

(c) State and explain which **one** feature of plasmids means that they may be used for intermediate steps in gene cloning involving **any** species of organism. [2]

Fig. 4.2 shows a length of DNA from *Bt* maize. The DNA is cut with restriction enzyme, *Hae*III.

Bt gene

1kb	TTCGGGGCCG	2kb	GGCCGGAATTCGGCATACAATTCACTGGCCG	0.5kb
1kb	AAGCCGGCCC	2kb	CCGGCCTTAAGCCGTATGTTAAGTGACCGGC	0.5kb

Fig. 4.2

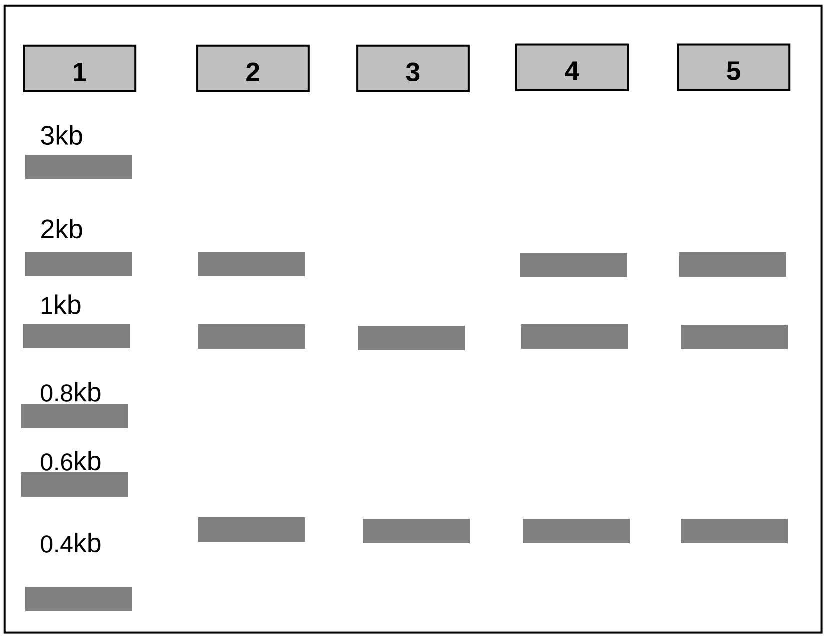
Target site of *Hae*III

GGCC
CCGG

(d) Explain what is meant by a restriction enzyme. [2]

(e) With reference to Fig. 4.2, state how many fragments of DNA are produced after digestion with *Hae*III. [1]

Some companies claimed they have successfully introduced the *Bt* gene into the maize that they sell to the farmers. DNA from the maize plants were analysed using restriction enzymes *Hae*III and electrophoresis as shown in Fig. 4.3.



1: Marker

2: *Bt* maize

3: maize from company **X**

4: maize from company **Y**

5: maize from company **Z**

Fig. 4.3

(f) Identify and explain which company is likely to have sold non-genetically modified maize. [2]

[Total: 11]

SECTION B

Answer EITHER 5 or 6.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

Either

5 **(a)** Using a named example, describe how a gene mutation can lead to a disease phenotype. [7]

(b) Explain how temperature affects the rate of an enzyme-catalysed reaction. [7]

(c) Describe the main ways in which an enzyme differs from DNA. [6]

[Total: 20]

Or

6 **(a)** Describe how mitosis maintains genetic stability and its importance in growth, repair and asexual reproduction. [7]

(b) Describe the structure of an amino acid and how a peptide bond is formed with another amino acid. [6]

(c) Compare transcription and translation. [7]

[Total: 20]

RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION II

CANDIDATE NAME	

CENTRE NUMBER	S					CLASS		INDEX NUMBER					

H1 BIOLOGY **8875/02**

Paper 2 Core Paper **11 Sep 2017**

2 hours

Additional Materials: Answer Paper

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For Examiner's Use	
Section A	
1	**/ 12**
2	**/ 8**
3	**/ 9**
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Section B	
5 or 6*	**/ 20**
Total	**/ 60**

This Question Paper consists of **12** printed pages.

SECTION A

Answer **all** questions.

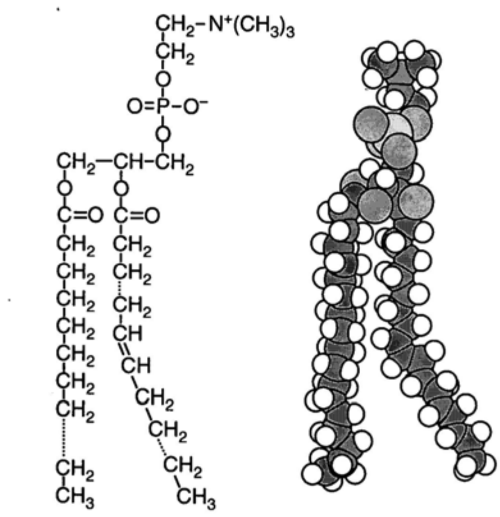
1	Fig. 1.1 represents the molecular structure of a type of phospholipid.  **Fig. 1.1**			
	(a)	**(i)**	Describe the arrangement of phopsholipids in cell membranes.	[2]
			1. Phospholipids arranged into a bilayer;; **2. The (hydrophilic) phosphate heads of the phospholipids face outwards on both sides of the membrane;** **3. The (non-polar, hydrophobic) hydrocarbon tails face inwards;**	
		(ii)	Explain how the structure of phospholipids is related to this arrangement in cell membranes.	[2]
			1. Phospholipid is amphipathic; **2. The hydrophilic phosphate group of the phospholipid molecule; interact with the aqueous environment on both sides of membrane;;** **3. The non-polar/hydrophobic hydrocarbon chains/tail of the phospholipid molecule shielded from the aqueous medium;;**	

Fig 1.1 shows a channel protein, aquaporin, which is necessary for the bulk flow of water molecules.

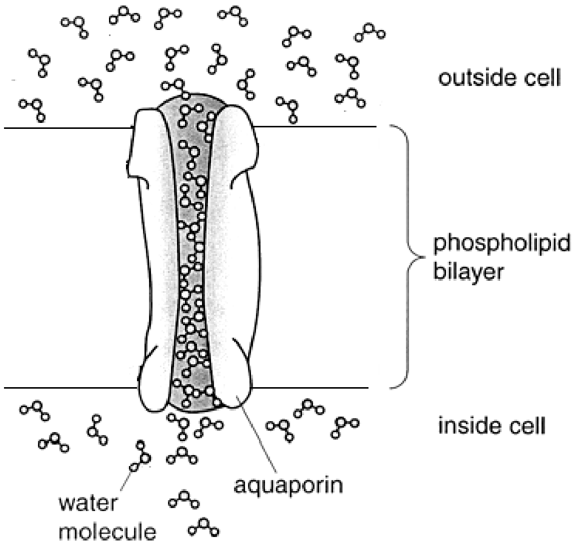


Fig 1.1

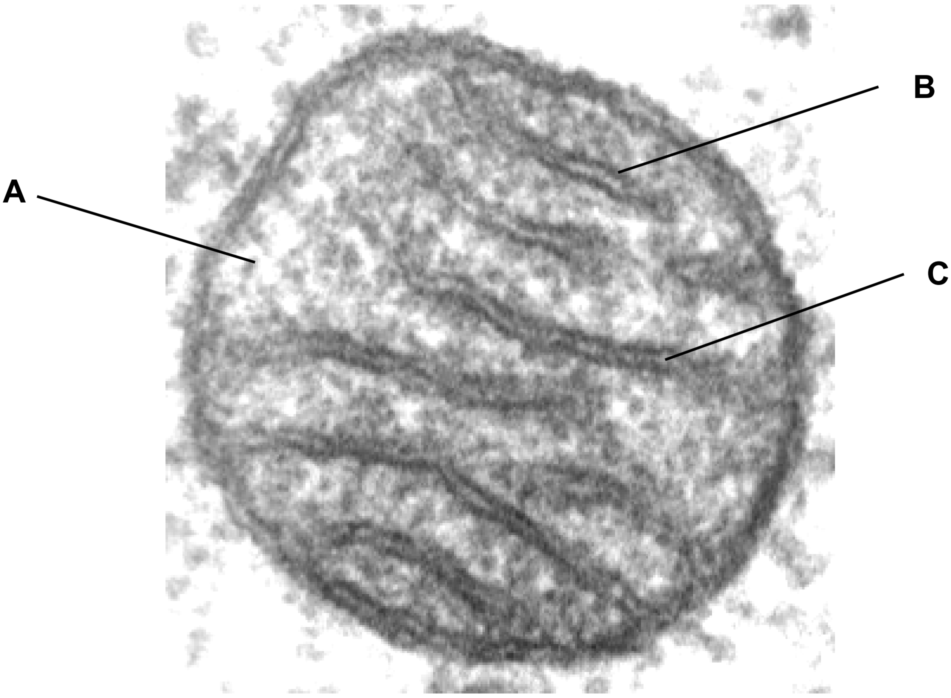
(b)	With reference to Fig. 1.1, describe how water molecules move across a membrane.	[2]
	1. As the cell has a more negative water potential compared to the surrounding water; ***Reject: concentration of water*** **2. water molecules from the surrounding move into the cell;** **3. through aquaporin channels;** **4. down water potential gradient;**	

Diabetes insipidus is a condition characterised by large amounts of diluted urine. Fluid is not reabsorbed by the cells in the kidney due to changes in permeability of their surface membrane. Reduction of fluid intake by patients has little effect on the concentration of urine.

Diabetes insipidus is a result of mutation in the gene coding for aquaporin channels.

A clinician studied the surface membrane of kidney cells involved in reabsorption of fluid in individuals with diabetes insipidus and found that aquaporin channels are absent.

(c)	Suggest how mutant aquaporin channels leads to diluted urine in individuals with diabetes insipidus.	[2]
	1. Mutation leads to change in three-dimensional conformation of aquaporin protein;; **2. Aquaporin not embedded in cell membrane;** **3. Water not reabsorbed into kidney cells;**	
	[Total: 8]	

2	Fig. 2.1 is an electron micrograph of a mitochondrion.  **Fig. 2.1**				
	(a)	**(i)**	Identify structures **A** and **B**.		[2]
			A	**(mitochondrial) Matrix;;**	
			B	**Cristae / inner membrane;;**	
		(ii)	Describe how structure **A** is adapted to its function.		[1]
			Matrix contains enzymes of Krebs cycle;;		
	(b)	**(i)**	State the role of high concentration of protons at **C**.		[1]
			proton gradient as a <u>source of potential energy for the synthesis of ATP</u>;;		
		(ii)	Explain how the high concentration of protons is generated at **C**.		[3]
			1. electrons from NADH / $FADH_2$; **2. passes along a chain of electron carriers (releasing energy in a series of small steps);** **3. <u>free</u> energy released;** **4. is used to pump protons;** **5. from matrix into intermembrane space;**		

6. **inner mitochondrial membrane is impermeable to ions;**

In an investigation to determine the effect of chemical **M** on respiration, mitochondria were incubated in four ways:

1. with glucose
2. with pyruvate
3. with glucose and chemical **M**
4. with pyruvate and chemical **M**

After incubation, the results are summarised in Table 1.1.

Table 1.1

	CO_2 evolution	O_2 consumption	ATP production by oxidative phosphorylation
Glucose	x	x	x
Pyruvate	✓	✓	✓
Glucose + chemical **M**	x	x	x
Pyruvate + chemical **M**	✓	✓	x

(c) (i) Explain why carbon dioxide is produced when mitochondria are incubated with pyruvate but not when incubated with glucose. [3]

1. **no glycolytic enzymes in mitochondria;**
2. **glycolysis does not occur in the mitochondria / glycolysis can only occur in the cytosol;**
3. **glucose cannot be oxidised to form pyruvate;**
4. **pyruvate can enter mitochondria but glucose cannot;**
5. **CO_2 produced by decarboxylation in link reaction;**
6. **and Krebs cycle;**

(ii) Suggest why when mitochondria are incubated with chemical **M**, oxygen consumption occurs but not ATP production. [2]

1. **Chemical M only block ATP synthase so no phosphorylation of ADP/no flow of H^+ down concentration gradient (through ATP synthase);;**
2. **Chemical M does not affect ETC to transfer electrons to oxygen;;**

[Total: 12]

3 In lizard, a recessive mutant allele leads to black body colour as opposed to the normal brown body colour. A second recessive mutant allele at a separate locus leads to grey spots as opposed to normal white spots on the body.

A test cross was conducted for these loci. This test cross took F1 females from a standard dihybrid cross and crossed them with a male pure breeding for black body with grey spots. The following offspring were produced:

Brown body with white spots	160
Brown body with grey spots	155
Black body with white spots	156
Black body with grey spots	162

(a) Define the term *locus*. [1]

Locus refers to the <u>position of a gene/allele on a chromosome</u> or within a DNA molecule;;

(b) Draw a genetic diagram to explain the observed results of this test cross. [4]

F1 Parental phenotype	**Brown body white spots**		**x**	**Black body grey spots**	
F1 Parental genotypes	**BbWw**		**x**	**bbww**	**;;**
Gametes	**BW**	**bW**	**x**	**bw**	**;**
	Bw	**bw**			

	BW	**Bw**	**bW**	**bw**
bw	**BbWw** **Brown body white spots**	**Bbww** **Brown body grey spots**	**bbWw** **black body white spots**	**bbww** **brown body grey spots**

Correct genotype;;
Correct corresponding phenotypes;;

F2 phenotypic ratio **1 Brown body white spots: 1 Brown body grey spots: black body white spots: 1 brown body grey spots ;**

(b) A mutation occurs to the gene locus determining body colour and a new body colour red appeared in the population of lizards.

Table 3.1 shows the change in the frequency of the three different phenotypes.

	Initial Population	Generation 10	Generation 20	Generation 30
Brown colour	80%	80%	70%	40%
Red colour	10%	0%	0%	0%
Black colour	10%	20%	30%	60%

Using Table 3.1 and your knowledge of natural selection, explains the results. [4]

1. **Mutations leads to variations;**
2. **appearance of red phenotype;**
3. **Red phenotype and brown phenotypes are selected against;**
4. **Red phenotype disappeared after 10 generations;**
5. **Brown phenotype decreased in frequency;**
6. **Black phenotype is favoured;**
7. **Survive and reproduce;**
8. **Pass on the allele to the offspring;**
9. **Population size of black phenotype greater than brown phenotype after 30 generations;**
10. **Quote values: 60% black phenotype vs 40% brown phenotypes;**

[Total: 9]

4 Genetically modified maize was widely grown in the maize-growing areas of the USA. One of the genetically modified varieties of maize contains a gene (*Bt*) from a bacterium, *Bacillus thuringiensis*. The gene codes for a toxin, which is expressed in the leaves and acts as an insecticide.

In USA, milkweed frequently grows around the edge of maize fields and is fed upon by caterpillars of the Monarch butterfly. In an investigation on the environmental effects of *Bt* maize, leaves of milkweed were divided into three groups, **A**, **B** and **C**, and treated as shown in **Table 4.1**.

Table 4.1

Treatment group	Treatment
A	dusted with pollen from genetically modified maize carrying the *Bt* gene;
B	dusted with pollen from maize that had not been genetically modified;
C	not dusted with pollen.

Monarch caterpillars were then placed on the leaves and the survival of the caterpillars was measured over four days. The results of the experiment are shown in Fig. 4.1.

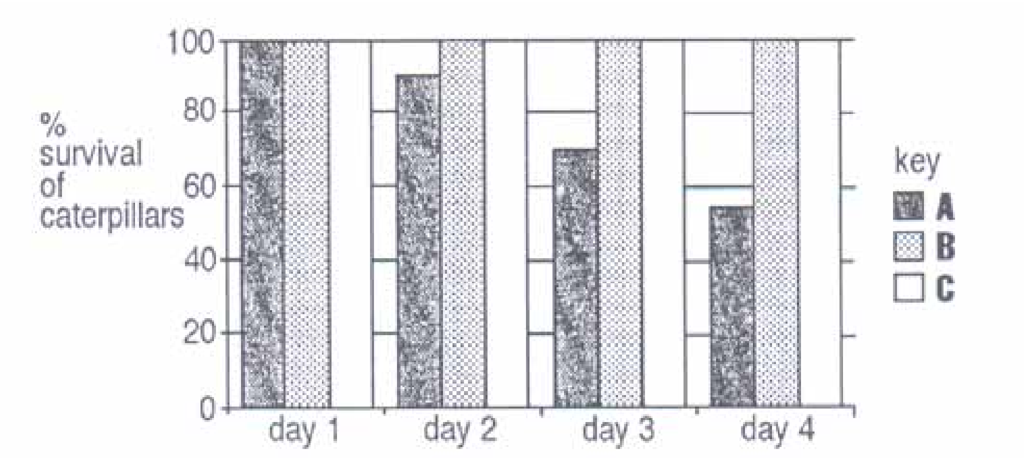


Fig. 4.1

(a) Explain why farmers in the USA grow maize carrying the *Bt* gene. [2]

1. **maize carrying *Bt* gene produces a toxin in its leaves which kills insects that attack them;;**
2. **reduce use of insecticides which are harmful to humans / environment;**
3. **higher yield of crop;**

	(b)	With reference to Fig. 4.1, comment on the effect of eating pollen from different maize plants on the survival of Monarch butterfly caterpillars.	[2]
		1. caterpillars that consumed pollens from non-genetically modified and leaves without pollen were unaffected; **2. 100% survival of caterpillars throughout the 4 days;** **3. caterpillars that consumed pollens from *Bt* maize decreased with time;** **4. % survival of caterpillars decreased from 100% to 55%;**	
	Plasmids are small circles of DNA, found in many bacteria, which can be used for genetic engineering of crop plants such as *Bt* corn.		
	(c)	State and explain which **one** feature of plasmids means that they may be used for intermediate steps in gene cloning involving **any** species of organism.	[2]
		1. Plasmids have <u>multiple</u> restriction sites; **2. that can be recognized and <u>cleaved</u> by <u>different</u> restriction enzymes;** **3. a wide range of DNA fragment isolated from any species by restriction digestion;** **4. can be inserted into the plasmid if cut with the same restriction enzyme;**	

Fig. 4.2 shows a length of DNA from *Bt* maize. The DNA is cut with restriction enzyme, *Hae*III.

Bt gene

```
|1kb| TTCGGGGCCG |2kb| GGCCGGAATTCGGCATACAATTCACTGGCCG |0.5kb|
|1kb| AAGCCGGCCC |2kb| CCGGCCTTAAGCCGTATGTTAAGTGACCGGC |0.5kb|
```

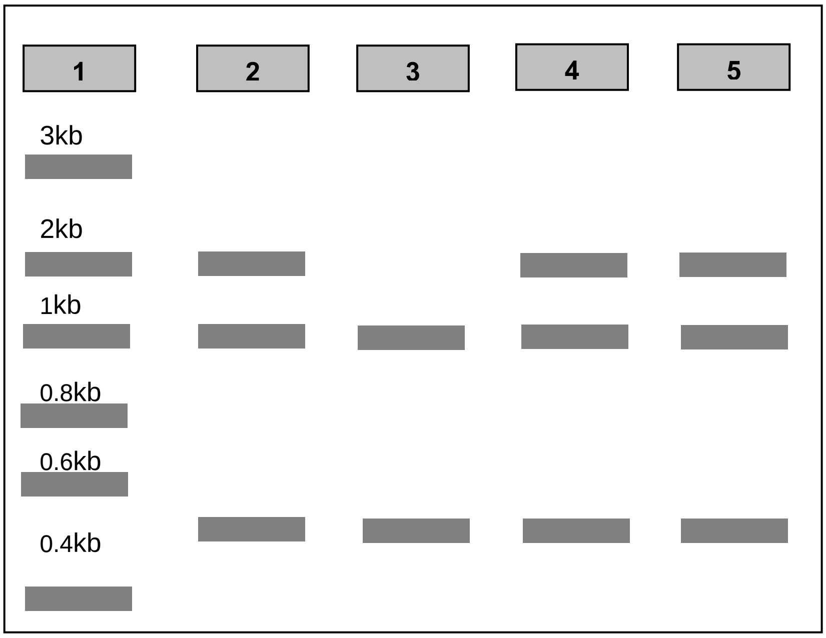
Fig. 4.2

Target site of *Hae*III

GGCC
CCGG

	(d)	Explain what is meant by a restriction enzyme.	[2]
		A restriction enzyme: **1. recognises and binds a specific palindromic DNA base sequence / restriction site;;** **2. cuts double-stranded DNA molecules by breaking internal phosphoester bonds;;**	
	(e)	With reference to Fig. 4.2, state how many fragments of DNA are produced after digestion with *Hae*III.	[1]
		4;;	

Some companies claimed they have successfully introduced the *Bt* gene into the maize that they sell to the farmers. DNA from the maize plants were analysed using restriction enzymes *Hae*III and electrophoresis as shown in Fig. 4.3.



1: Marker
2: *Bt* maize
3: maize from company **X**
4: maize from company **Y**
5: maize from company **Z**

Fig. 4.3

	(f)	Identify and explain which company is likely to have sold non-genetically modified maize.	[2]
		1. Company X;; **2. 2kb band is missing which means the *Bt* gene is not incorporated into the DNA of the maize;;**	
		[Total: 11]	

SECTION B

Answer EITHER 5 or 6.

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Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

5	**(a)**	Using a named example, describe how a gene mutation can lead to a disease phenotype.	[7]
		1. Sickle cell anemia;; **2. Base pair substitution;** **3. thymine replaced by adenine;** **4. of β globin gene;** **5. This changes codon 6 on mRNA;** **6. GAA to GUA;** **7. resulting in missense mutation;** **8. that changes glutamic acid to valine;** **9. from a negatively charged/hydrophilic amino acid;** **10. to a neutral/hydrophobic amino acid;** **11. This changes the folding / three dimensional conformation of haemoglobin / β globin;** **12. generating a sticky patch;** **13. on the surface of haemoglobin;** **14. The deoxygenated form of mutant haemoglobin;** **15. is insoluble in red blood cells;** **16. forming crystalline arrays;** **17. This causes red blood cells to form a sickle shape;** **18. Sickle-shaped red blood cells are rigid;**	
	(b)	Explain how temperature affects the rate of an enzyme-catalysed reaction.	[7]
		1. at low temperature, enzyme is inactive; **2. the rate of reaction increases with temperature until the optimum temperature is reached;** **3. the rate of reaction is doubled for every increase of 10°C;** **4. increasing temperature increases the kinetic energy of the enzyme and substrate molecules;**	

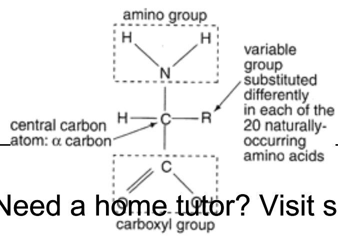
5. increase in the frequency of effective collisions between the enzyme and substrate molecules;
6. more enzyme/substrate complexes are formed per unit time, rate of reaction increases;
7. optimum temperature is the temperature at which the enzyme is functioning at its maximum rate;
8. above optimum temperature, the rate of reaction decreases rapidly
9. the enzyme are denatured;
10. atoms which make up the enzyme molecule vibrate vigorously;
11. bonds (hydrogen and hydrophobic interactions) holding the enzyme molecule in its precise shape begin to break;
12. change in active site conformation;
13. substrate unable to fit into the active site of the enzyme;
14. less successful enzyme-substrate complexes formed per unit time;
15. graph;

(c) Describe the main ways in which an enzyme differs from DNA. [6]

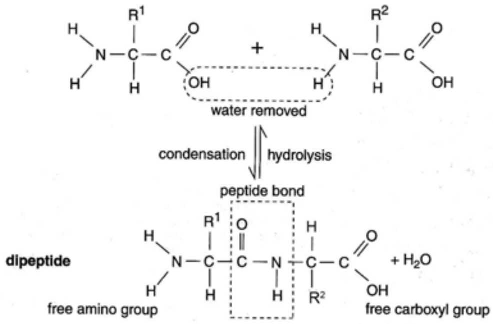
	Features	Enzyme	DNA
1	Monomer	Amino acid	Deoxyribonucleotide
2	Choice of monomers	Twenty types, dependent on R-groups	Four types, dependent on nitrogenous bases
3	Links between monomers	Peptide linkage	Phosphoester linkage
4	Secondary structure	Single polypeptide chain	Double polynucleotide chains
5	Higher order structures	Folding of single polypeptide chain Conjugation of various polypeptide chains	Coiling of double helix around histones
6	Bonds responsible	Hydrogen, disulphide, ionic bonds, hydrophobic interactions	Hydrogen bonds between complementary bases
7	Location of synthesis	Cytoplasm	Nucleus, chloroplast, mitochondria
8	Function	Catalysis of reaction	Transmission of genetic information

		[Total: 20]	

6	**(a)**	Describe how mitosis maintains genetic stability and its importance in growth, repair and asexual reproduction.	[7]
		1. Mitosis forms 2 daughter nuclei ; **2. Which are <u>genetically identical</u> to the parent cell;** **3. With the <u>same number of chromosomes</u> as the parent cell;** **4. S phase of interphase ;** **5. amount of DNA is doubled;** **6. <u>Semi-conservative replication</u> ensures that all genetic information is retained;** **7. Crossing over or pairing up of homologous chromosomes do not occur;** **8. Ensures that there is no genetic variation / maintains genetic stability;** **<u>Growth</u>** **9. Mitosis plays a role in the <u>growth</u> in tissues;** **10. <u>Increase in cell numbers;</u>** **11. results in increase in size of organisms (growth) in multicellular organisms;** **12. New cells are <u>identical</u> with existing cells so that they carry out the <u>same function</u>;** **<u>Repair</u>** **13. Mitosis is important for the <u>repair / replacement of worn-out parts</u> of the body;** **14. Important for tissues that replaced damaged cells with <u>exact copies of the original cells</u> in order for the tissue to <u>function properly</u>;** **<u>Asexual reproduction</u>** **15. Mitosis forms the basis of <u>asexual reproduction</u> as the separated cells / plant parts become new offspring;** **16. Forms clones that are genetically identical with parents facilitates <u>successful colonization of habitats</u> by species;**	
	(b)	Describe the structure of an amino acid and how a peptide bond is formed with another amino acid.	[6]
		1. reference to a <u>central carbon atom</u> (i.e. the <u>α-carbon atom</u>); to which is bonded: **2. an <u>amino group</u> ($-NH_2$);** **3. a <u>carboxyl group</u> ($-COOH$);**	



4. a hydrogen atom; and
5. an R-group (or side chain);
6. which is variable amongst the 20 different amino acids; occurring in nature.
7. Show the structure of an amino acid;
8. a condensation reaction occurs;
9. between the carboxyl group of one amino acid;
10. and the amino group of another;
11. a molecule of water is removed in the condensation reaction;
12. condensation reaction is catalysed by peptidyltransferase;
13. a component of the large ribosomal subunit;
14. show how 2 amino acids are joined together;;



	(c)	Compare the transcription and translation.	[7]

Similarity

1. Both processes require a template;;
2. Both processes are catalysed by enzymes;;
3. Both processes involve complementary base-pairing;;
4. Ref to modification of products with elaboration;;

Differences (max 5)

	Feature	Transcription	Translation
1	location	In nucleus	Ribosomes
2	Template	DNA template	mRNA
3	Enzyme	RNA polymerase catalyses formation of phosphoester bond between adjacent ribonucleotides	Peptidyl transferase catalyses the formation of peptide bond
4	Bond between	Bond is formed between the	Bond is formed between carboxyl

	monomers	phosphate group of one nucleotide and carbon atom 3 of ribose of the next nucleotide	group of one amino acid and the amino group of the next amino acid
5	Reading of genetic message	RNA polymerase moves along DNA template	Ribosome moves along mRNA
6	Involved of tRNA	Not involved	tRNA carries amino acids to ribosomes
7	Raw materials	Free ribonucleotides	Amino acids attached to tRNA
8	Products	mRNA, rRNA and tRNA	polypeptide
9	Fate of products	Products exit nucleus and migrate to the cytoplasm	Polypeptide chain remain in the cytoplasm or secreted out of the cell
10	AVP: Involvement of ribosome	Not involved	Ribosome is the binding site for mRNA and amino acid tRNA complex

1 mark for each comparative statement

[Total: 20]

CANDIDATE NAME: ____________________________________ INDEX NUMBER _________

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SERANGOON JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2017

BIOLOGY 8875
Higher 1

PAPER 1

Thursday
21 September 2017

1 hour

Additional materials:
Optical Mark Sheet

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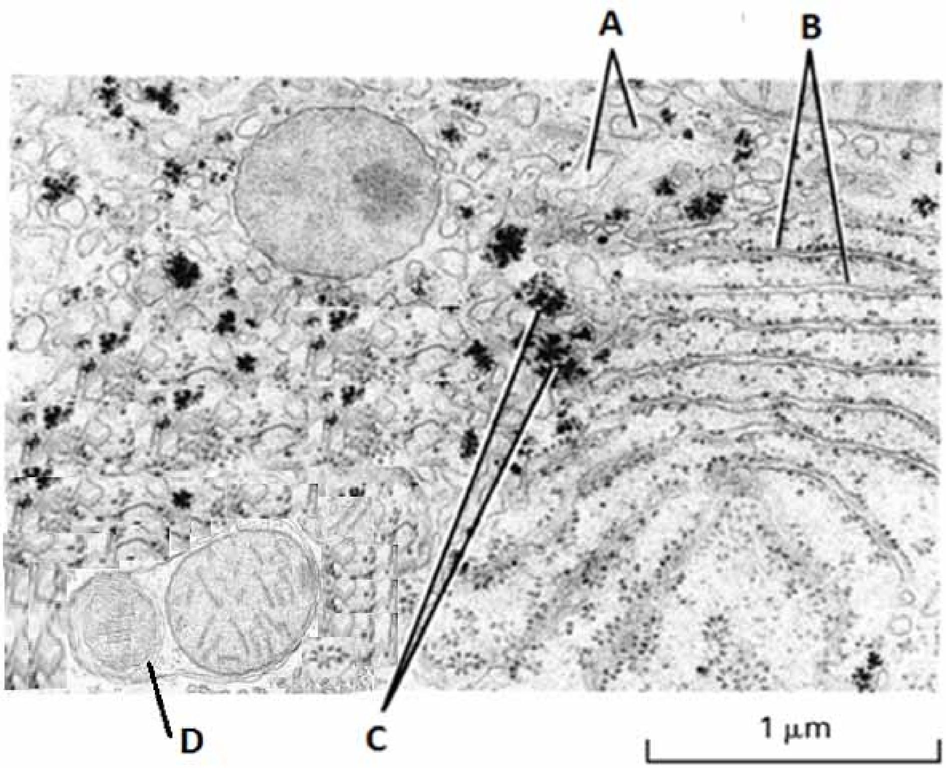

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4 The process shown in structure **D** is autolysis.

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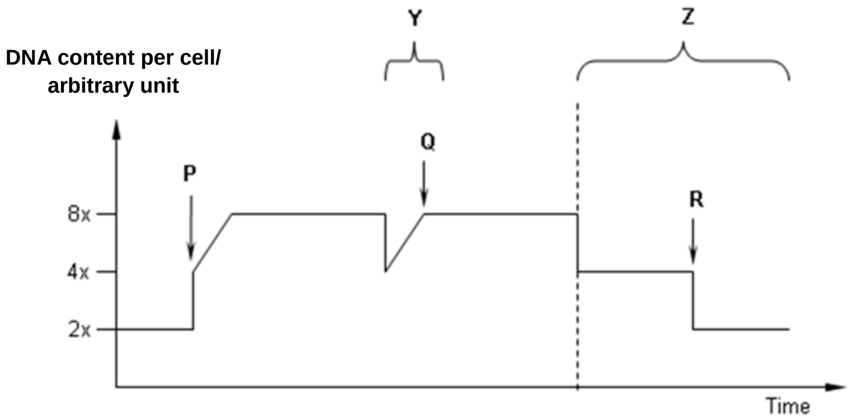
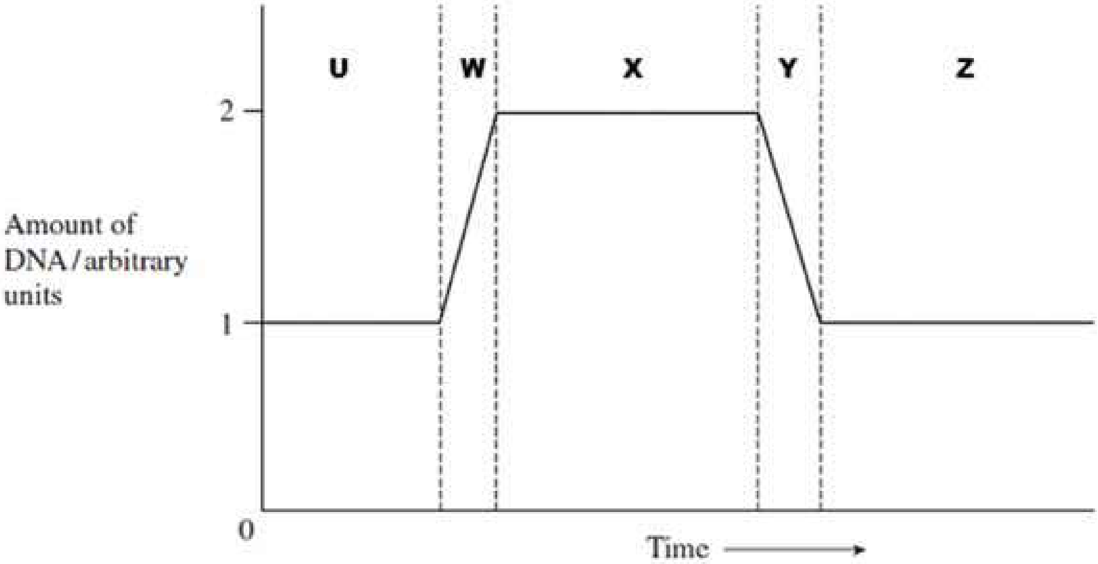
4 The graph represents the changes in the DNA content within a cell at different stages in the cell cycle.



Name the events occurring at **P**, **Q** and **R**, and identify the stage where meiosis is occurring.

	P	Q	R	Meiosis occurring at
A	S phase	Fertilisation	Cytokinesis	**Y**
B	Fertilisation	Interphase	Cytokinesis	**Z**
C	S phase	Prophase	Telophase	**Y**
D	Fertilisation	Metaphase	Telophase	**Z**

5 The graph shows changes in the amount of DNA in a cell during one cell cycle. The letters U – Z marks out the different phases in the cell cycle.



Many drugs that are used to treat cancer work at different time periods during the cell cycle.

(i) Cisplatin binds to DNA and stops free DNA nucleotides from joining together.

(ii) Drug B stops spindle fibres from shortening.

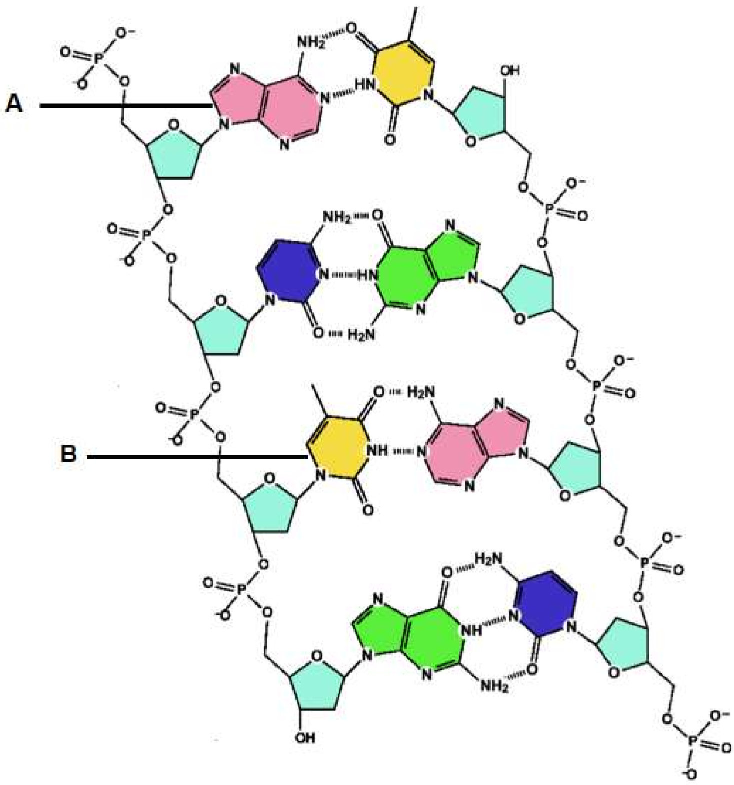
With reference to the cell cycle above, determine where these 2 drugs work.

	Cisplatin	Drug B
A	**W**	**X**
B	**W**	**Y**
C	**U**	**X**
D	**U**	**Z**

6 During the production of fruit juice, enzymes are used to break down the components of cell walls. Which carbohydrate will be produced by this hydrolysis?

A Sucrose
B Maltose
C α - glucose
D β - glucose

7 The figure below shows a DNA molecule.



Which statement(s) correctly describe the polynucleotide?

1 The structure labelled **A** corresponds to that of a purine, while the structure labelled **B** corresponds to that of a pyrimidine.

2 The antiparallel nature of DNA double helix allows phosphodiester bonds to form between the nitrogenous bases of opposite strands.

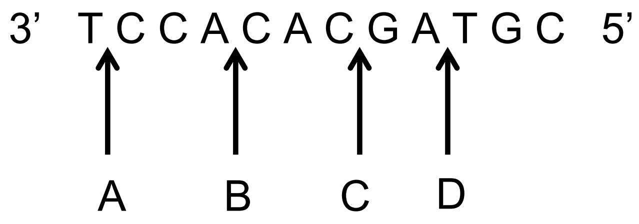
3 Distance between adjacent deoxyribonucleotides is 3.4 Å and one turn consists of 10 deoxyribonucleotides. (Note: 10 Å = 1 nm)

4 The wound DNA double helix consists of alternating major grooves and minor grooves along its axis which are essential for the binding with proteins.

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

8 The RNA triplet UAG acts as a stop codon terminating the synthesis of a polypeptide. The diagram shows a template strand of DNA which codes for four amino acids.

Where would a mutation, introducing a thymine nucleotide, result in the termination of translation?



9 The non-template strand of a gene is analyzed and 20% of its bases are found to be adenine and 30% of its bases are cytosine. The corresponding template DNA strand of this gene has 10% cytosine.

What is the ratio of purine to pyrimidine found in pre-mRNA transcribed from this gene?

A 1 : 1

B 2 : 3

C 3 : 2

D 3 : 7

10 Which of the following statement(s) about cancer is / are true?

I Individuals who inherit one mutant tumour suppressor gene are more likely to develop cancer than individuals with two non-mutant copies.

II Cancer is a result of increased cell division which promotes the mutation of a proto-oncogene.

III Mutagenic activation of a single oncogene is sufficient to cause a normal cell to develop into a cancerous cell.

A I only

B I and II only

C I and III only

D I, II and III

11 Which of the following statements correctly compares oxidative phosphorylation and non-cyclic photophosphorylation?

A Both types of phosphorylation produce ATP and oxygen as end products.

B Both types of phosphorylation produce ATP and the reduced form of a redox reagent.

C Oxidative phosphorylation is involved in the conversion of one form of chemical energy to another while non-cyclic photophosphorylation is involved in converting light energy to chemical energy.

D Water is an electron donor in non-cyclic photophosphorylation while it is an electron acceptor in oxidative phosphorylation.

12 What happens to most of the reduced NAD molecules in cell metabolism?

A They act as oxidising agents in glycolysis.

B They are oxidised in inner mitochondrial membrane for ATP formation.

C They are oxidised in the Calvin cycle.

D They combine with succinic acid as part of Krebs cycle.

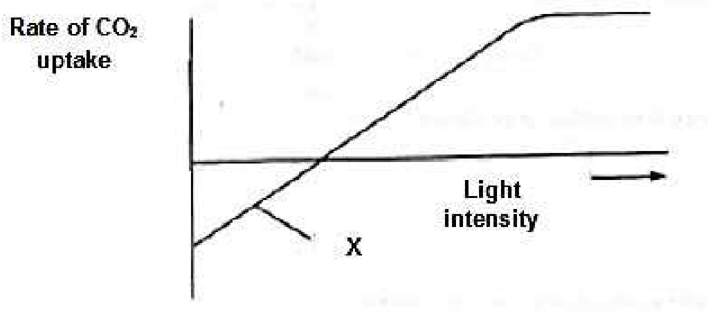
13 Rotene and oligomycin are two metabolic poisons which affect cellular respiration. The effects of rotene and oligomycin on aerobic respiration are summarised in the table.

	Ability to use glucose	**Ability to use oxygen**	**ATP yield**
Rotene	Yes	No	Decreases
Oligomycin	Yes	Yes	Decreases

Which of the following correctly identifies the specific functions of these two metabolic poisons?

	Rotene	**Oligomycin**
A	Electron transport inhibitor	Inhibits ATP synthase
B	Inhibits ATP synthase	Electron transport inhibitor
C	Dissipate proton gradient	Inhibits ATP synthase
D	Inhibits ATP synthase	Dissipate proton gradient

14 In the graph below, the rate of CO_2 uptake by plant cells is shown to vary with increasing light intensity.



Which of the following is true at point **X**?

A The plant is photosynthesizing.

B Rate of respiration equals rate of photosynthesis.

C CO_2 is a limiting factor.

D There is not enough light for photosynthesis to have commenced.

15 Which sequence of events correctly describes evolution?

1 Differential reproduction of the spiders occurs.

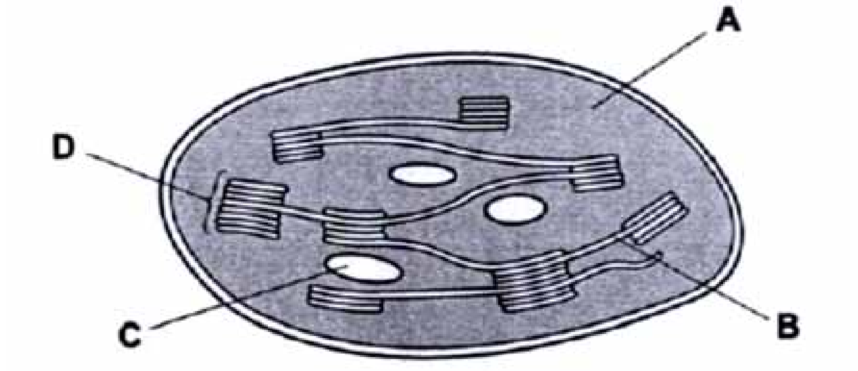
2 A new selection pressure occurs.

3 Allele frequencies within the spider population change.

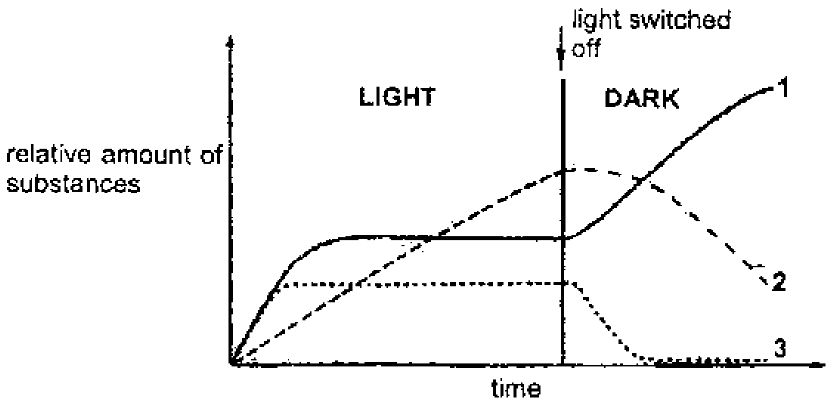
4 Poorly adapted spiders have decreased survivorship.

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

16 The diagram shows a section through a chloroplast. Where would the products of photophosphorylation be used?



17 ^{14}C-labelled carbon dioxide was supplied to photosynthesising algae. The relative amounts of three organic compounds were measured. The diagram shows the results.



Which of the following are correct explanations for the graph above?

I *GP* level falls as shown in graph 2 due to the absence of reduced NADP when light is are switched off.

II *GP* level rises as shown in graph 1 due to the absence of ATP when light is switched off.

III Levels of RuBP and GP are constant during periods of light as they serve as intermediates in the Calvin cycle.

IV RuBP level falls as carboxylation of RuBP is independent of light as shown in graph 3.

V Sucrose level falls as shown in graph 3 due to the absence of ATP and reduced NADP.

A **I**, **II** and **V** only

B **I**, **II** and **III** only

C **II**, **III** and **IV** only

D **III**, **IV** and **V** only

18 The following statements are some findings of scientists in an attempt to investigate the evolutionary relationship between the anteater, armadillo and pangolin.

I Anteater, armadillo and pangolin feed primarily on insects such as ants.

II Anteater, armadillo and pangolin have long tongue and strong digging limbs.

III The tongues of the anteater and armadillo are connected to the hyoid bone while the tongue of pangolin is not.

IV There is a higher percentage similarity between the DNA sequences of Anteater and armadillo than with the pangolin.

V There is very low percentage similarity between the DNA sequences of anteater and pangolin as well as between the armadillo and pangolin.

Which of the following conclusions can be drawn from the statements given above?

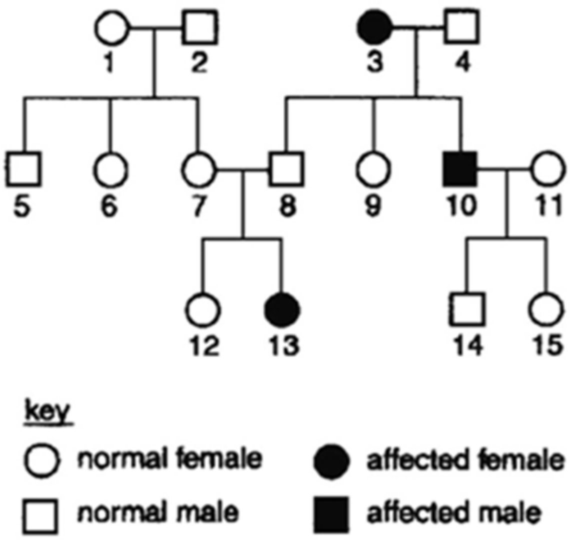
A The anteater and pangolin have experienced divergent evolution as shown by homologous structures between their hyoid bones and tongues.

B The anteater and pangolin have experienced convergent evolution as shown by homologous structures in their hyoid bones and tongues.

C The armadillo and pangolin have experienced divergent evolution as shown by the low similarity between their DNA sequences.

D The anteater and armadillo have experienced divergent evolution as shown by similarities in their DNA sequences and homologous anatomical structures.

19 The pedigree chart below shows the inheritance of a recessive condition known as human albinism. Only homozygous recessive individuals are albinos.



What is the probability of individual 9 being a heterozygous carrier?

A 0.00 **B** 0.25 **C** 0.50 **D** 1.00

20 The feature of silky feathers in show fowl is caused by a recessive allele. A pure breeding bird with normal feathers was crossed with a bird with silky feathers and all the offspring were normal. The offspring were then allowed to interbreed.

Which of the following statements would be true about the F_2 generation?

1 The expected ratio of normal to silky would be 3:1.

2 Half of the F_2 birds would be heterozygous.

3 A quarter of the F_2 birds would be homozygous.

4 Some of the normal birds would be pure breeding.

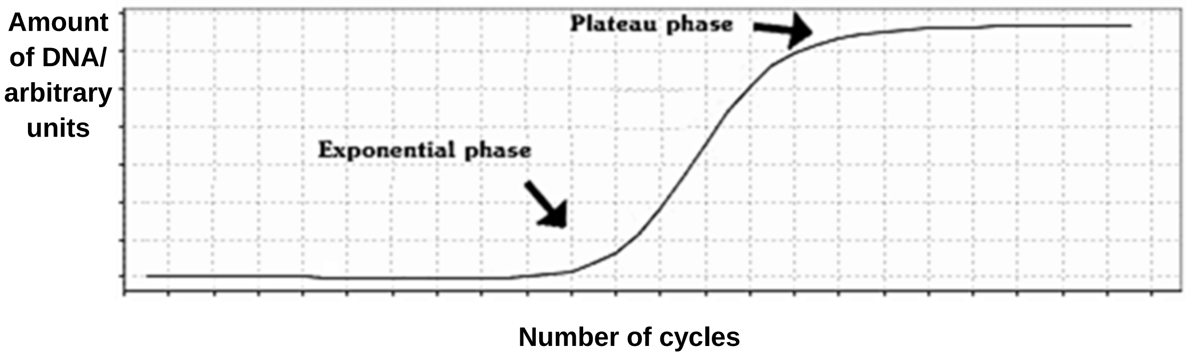
A 1, 2 and 3

B 2, 3 and 4

C 1, 2 and 4

D 1 and 2 only

21 During the process of polymerase chain reaction (PCR), the amount of DNA synthesised can be traced using fluorescent probes and the measurements are shown in the following plot. The process initially goes through an exponential phase followed by a plateau phase eventually.



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

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

B During the exponential phase, the temperature is always maintained at the optimum temperature of 72°C hence there is rapid amplification.

C During the plateau phase, the reaction mixture is being depleted of ribonucleotides.

D During the plateau phase, *Taq* polymerase may be denatured.

22 The dashed lines in the template sequence represent a long sequence of bases to be amplified.

Template

5' ATTCGGACTTG - GTCCAGCTAGAGG 3'

3' TAAGCCTGAAC - CAGGTCGATCTCC 5'

Which of the following sets of primers can be used in the PCR for the amplification of the following DNA sequence?

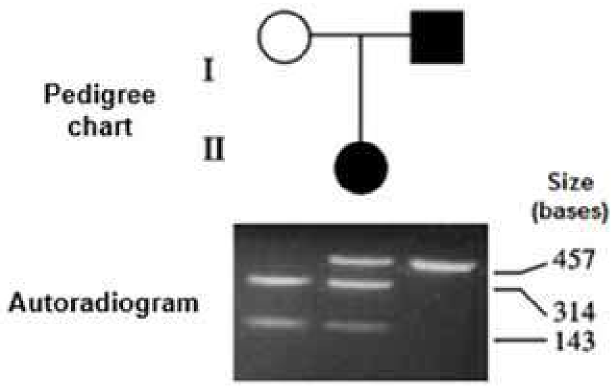
A **5'** GTCCAGC **3'** & **5'** CCTGAAC **3'**

B **5'** ATTCGGA **3'** & **5'** CCTCTAG **3'**

C **5'** GGACTTG **3'** & **5'** GCTGGAC **3'**

D **5'** AUUCGGA **3'** & **5'** GAUCUCC **3'**

23 A family with a history of a genetic disease is studied using restriction digestion of the DNA samples containing the gene responsible for the disease. The pedigree chart of the family is aligned with the autoradiogram obtained from Southern blotting. (Shaded symbols in the pedigree chart indicate individuals affected by disease.)



Based on the information given, which of the following can be deduced?

A The disease allele is dominant to the normal allele.

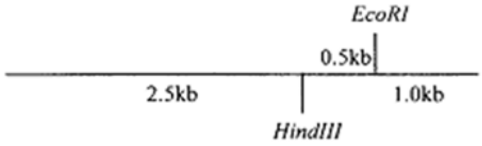
B The mutation creates a new restriction site in the affected gene.

C One of the parents in generation **I** is a carrier.

D The offspring in generation **II** is a carrier.

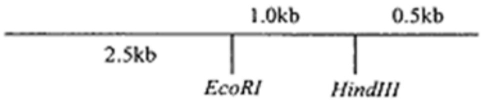
24 Digestion of a 4 kb DNA molecule with *EcoR*I yields two fragments of 1 kb and 3 kb each. Digestion of the same molecule with *Hind*III yields fragments of 1.5 kb and 2.5 kb. Finally, digestion with *EcoR*I and *Hind*III in combination yields fragments of 0.5 kb, 1 kb and 2.5 kb. How would a restriction map indicating the positions of the *EcoR*I and *Hind*III cleavage sites look like?

A

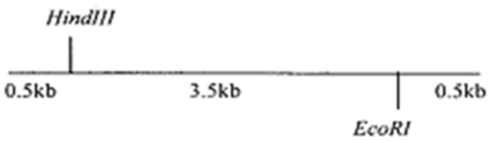


B

C



D



25 Which of the following statements about the human genome project (HGP) is **false**?

A HGP aims to identify all the genes in human and to determine the DNA sequences of these genes.

B HGP aims to allow genetic testing to take place for earlier detection of genetic diseases

C HGP allows defective genes to be replaced through gene therapy

D HGP allows comparative studies to be made between humans and other organisms to identify similar genes associated with diseases.

26 Recent advances in the field of stem cell research have shown that induced pluripotent stem cells (iPS cells) can be artificially derived from adult somatic cells. iPS cells are mostly similar to natural pluripotent cells. This implies that iPS cells can

A theoretically differentiate into all cell types.

B theoretically differentiate into any of the three germ layers.

C theoretically differentiate into gametes.

D theoretically capable of transdifferentiation.

27 Which of the following regarding embryonic stem cells and hematopoietic stem cells is true?

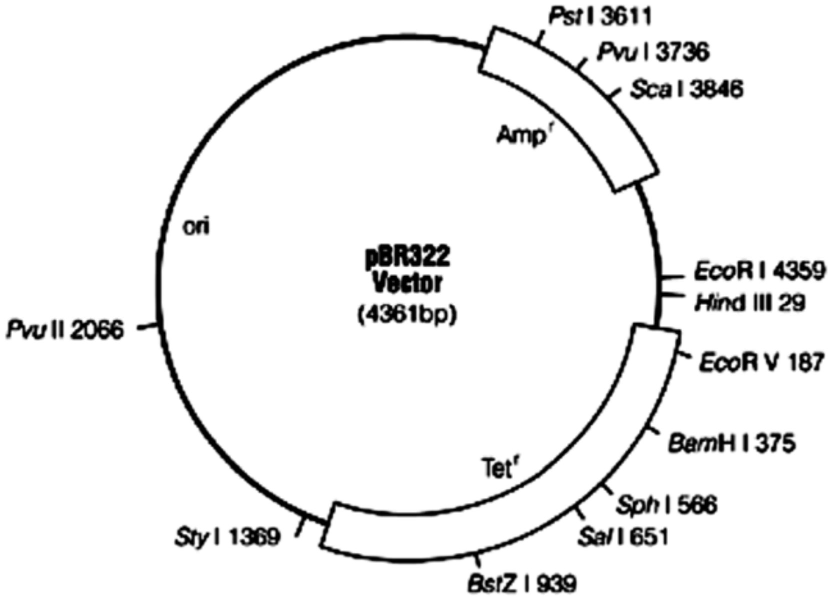
A As embryonic stem cells develop, they turned into hematopoietic stem cells as they lose their ability to differentiate into all types of cells.

B Embryonic stem cells have more genes than hematopoietic stem cells and thus are able to form more types of cells.

C Under normal conditions, embryonic stem cells express more of their genes compared to the hematopoietic stem cells.

D Both stem cells are derived from the zygotic stem cells with the hematopoietic stem cells having a lower differentiation potential compared to the embryonic stem cells.

28 The pBR322 vector is used to clone a eukaryotic gene, which has been digested by the restriction endonuclease *BamHI*.



Following transformation, bacterial cells were grown in four different media, as shown below:

1 Nutrient broth containing ampicillin
2 Nutrient broth containing tetracycline
3 Nutrient broth containing ampicillin and tetracycline
4 Nutrient broth without ampicillin and tetracycline

Which of the following media would bacterial cells containing the recombinant plasmids grow in?

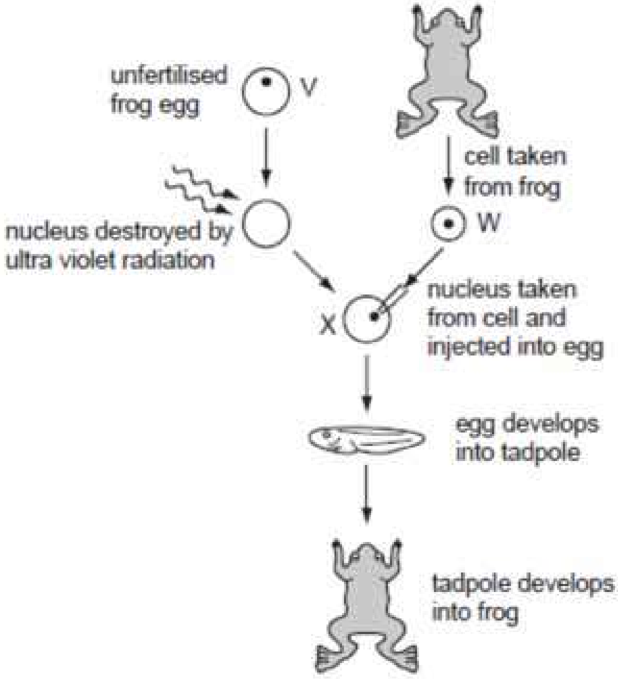
A **4** only

B **1** and **2**

C **2** and **3**

D **1** and **4**

29 The diagram shows how genetically identical frogs can be developed from unfertilised frog eggs. The diploid number for frogs is 26.

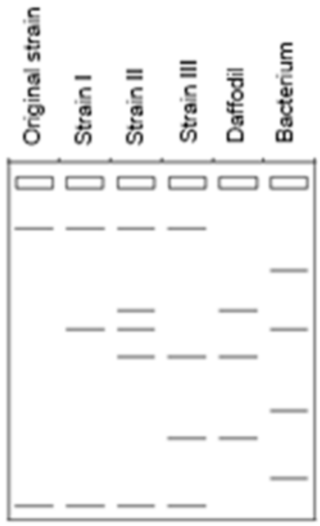


Which combination of numbers correctly identifies the number of chromosomes in each type of cell?

	V	W	X
A	13	13	26
B	13	26	13
C	13	26	26
D	26	26	13

30 An attempt was made to produce Golden rice. To determine whether or not DNA from the daffodils and the bacterium had been successfully incorporated in the DNA of the rice, scientists used PCR and gel electrophoresis to produce DNA profiles.

The following DNA profiles belong to the original strain of rice, three strains **I** to **III** of genetically modified Golden rice, and the species of daffodil and bacterium used to incorporate beta-carotene genes in the rice.



Which one of the strain(s) of Golden rice has successfully incorporated DNA from both the daffodil and the bacterium?

A Strain **I** only

B Strain **II** only

C Strain **I** and **III** only

D Strain **II** and **III** only

End of Paper

CANDIDATE NAME: ______________________________________ INDEX NUMBER _________

CG _________

SERANGOON JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2017

BIOLOGY 8875
Higher 1

PAPER 1

Thursday
21 September 2017

1 hour

Additional materials:
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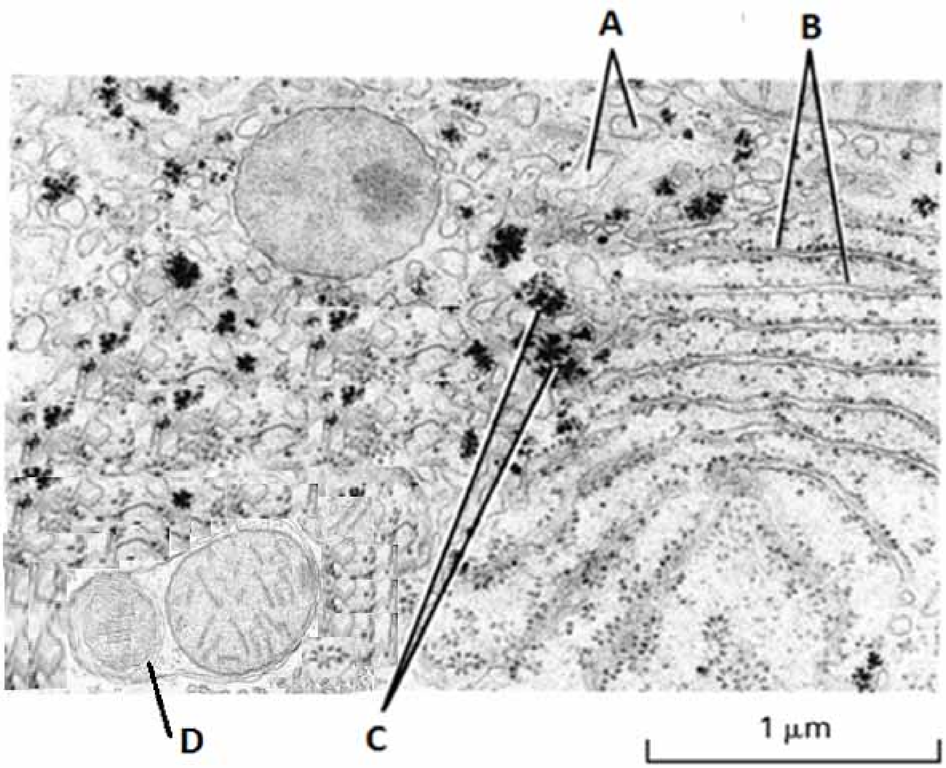

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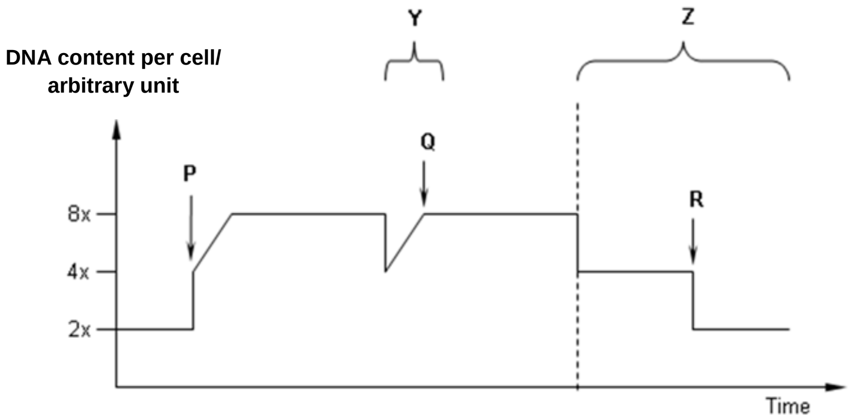
A 2 only **B** 1 and 2 only **C** 2 and 3 only **D** 2, 3 and 4 only

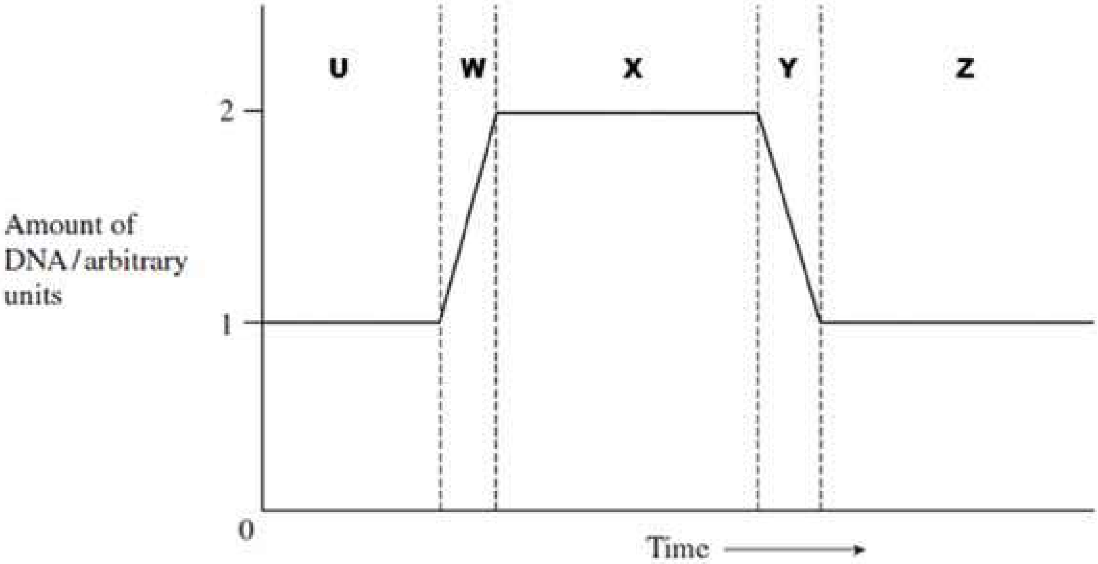
4 The graph represents the changes in the DNA content within a cell at different stages in the cell cycle.



Name the events occurring at **P**, **Q** and **R**, and identify the stage where meiosis is occurring.

	P	Q	R	Meiosis occurring at
A	S phase	Fertilisation	Cytokinesis	**Y**
B	Fertilisation	Interphase	Cytokinesis	**Z**
C	S phase	Prophase	Telophase	**Y**
D	Fertilisation	Metaphase	Telophase	**Z**

5 The graph shows changes in the amount of DNA in a cell during one cell cycle. The letters U – Z marks out the different phases in the cell cycle.



Many drugs that are used to treat cancer work at different time periods during the cell cycle.

(i) Cisplatin binds to DNA and stops free DNA nucleotides from joining together.

(ii) Drug B stops spindle fibres from shortening.

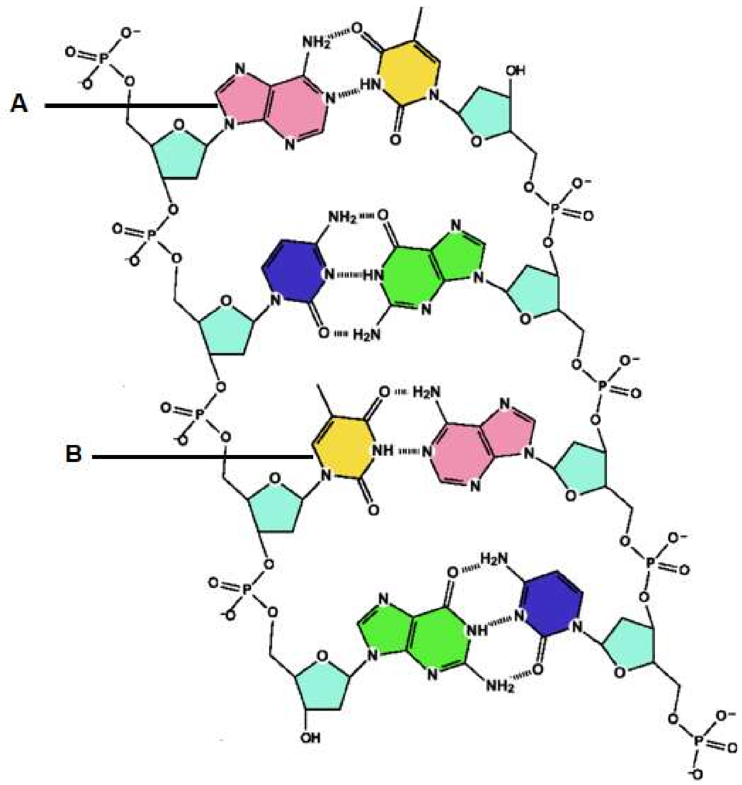
With reference to the cell cycle above, determine where these 2 drugs work.

	Cisplatin	Drug B
A	W	X
B	W	Y
C	U	X
D	U	Z

6 During the production of fruit juice, enzymes are used to break down the components of cell walls. Which carbohydrate will be produced by this hydrolysis?

A Sucrose
B Maltose
C α - glucose
D β - glucose

7 The figure below shows a DNA molecule.



Which statement(s) correctly describe the polynucleotide?

1 The structure labelled **A** corresponds to that of a purine, while the structure labelled **B** corresponds to that of a pyrimidine.

2 The antiparallel nature of DNA double helix allows phosphodiester bonds to form between the nitrogenous bases of opposite strands.

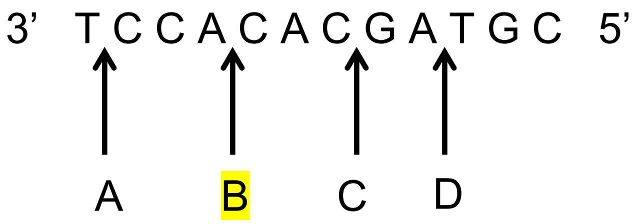
3 Distance between adjacent deoxyribonucleotides is 3.4 Å and one turn consists of 10 deoxyribonucleotides. (Note: 10 Å = 1 nm)

4 The wound DNA double helix consists of alternating major grooves and minor grooves along its axis which are essential for the binding with proteins.

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

8 The RNA triplet UAG acts as a stop codon terminating the synthesis of a polypeptide. The diagram shows a template strand of DNA which codes for four amino acids.

Where would a mutation, introducing a thymine nucleotide, result in the termination of translation?



9 The non-template strand of a gene is analyzed and 20% of its bases are found to be adenine and 30% of its bases are cytosine. The corresponding template DNA strand of this gene has 10% cytosine.

What is the ratio of purine to pyrimidine found in pre-mRNA transcribed from this gene?

A 1 : 1

B 2 : 3

C 3 : 2

D 3 : 7

10 Which of the following statement(s) about cancer is / are true?

I Individuals who inherit one mutant tumour suppressor gene are more likely to develop cancer than individuals with two non-mutant copies.

II Cancer is a result of increased cell division which promotes the mutation of a proto-oncogene.

II Mutagenic activation of a single oncogene is sufficient to cause a normal cell to develop into a cancerous cell.

A I only

B I and II only

C I and III only

D I, II and III

11 Which of the following statements correctly compares oxidative phosphorylation and non-cyclic photophosphorylation?

A Both types of phosphorylation produce ATP and oxygen as end products.

B Both types of phosphorylation produce ATP and the reduced form of a redox reagent.

C Oxidative phosphorylation is involved in the conversion of one form of chemical energy to another while non-cyclic photophosphorylation is involved in converting light energy to chemical energy.

D Water is an electron donor in non-cyclic photophosphorylation while it is an electron acceptor in oxidative phosphorylation.

12 What happens to most of the reduced NAD molecules in cell metabolism?

A They act as oxidising agents in glycolysis.

B They are oxidised in inner mitochondrial membrane for ATP formation.

C They are oxidised in the Calvin cycle.

D They combine with succinic acid as part of Krebs cycle.

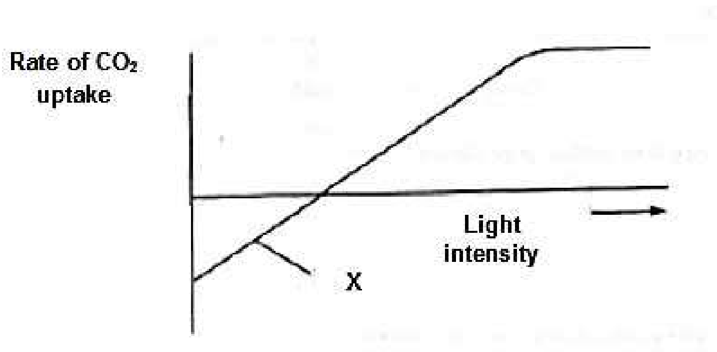
13 Rotene and oligomycin are two metabolic poisons which affect cellular respiration. The effects of rotene and oligomycin on aerobic respiration are summarised in the table.

	Ability to use glucose	**Ability to use oxygen**	**ATP yield**
Rotene	Yes	No	Decreases
Oligomycin	Yes	Yes	Decreases

Which of the following correctly identifies the specific functions of these two metabolic poisons?

	Rotene	**Oligomycin**
A	Electron transport inhibitor	Inhibits ATP synthase
B	Inhibits ATP synthase	Electron transport inhibitor
C	Dissipate proton gradient	Inhibits ATP synthase
D	Inhibits ATP synthase	Dissipate proton gradient

14 In the graph below, the rate of CO_2 uptake by plant cells is shown to vary with increasing light intensity.



Which of the following is true at point **X**?

A The plant is photosynthesizing.

B Rate of respiration equals rate of photosynthesis.

C CO_2 is a limiting factor.

D There is not enough light for photosynthesis to have commenced.

15 Which sequence of events correctly describes evolution?

1 Differential reproduction of the spiders occurs.

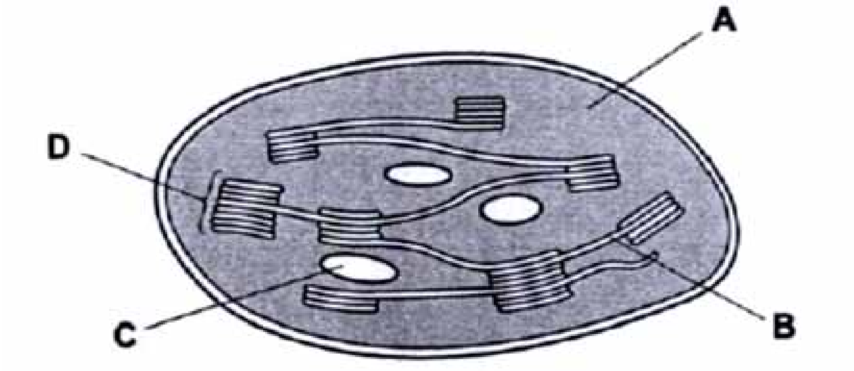
2 A new selection pressure occurs.

3 Allele frequencies within the spider population change.

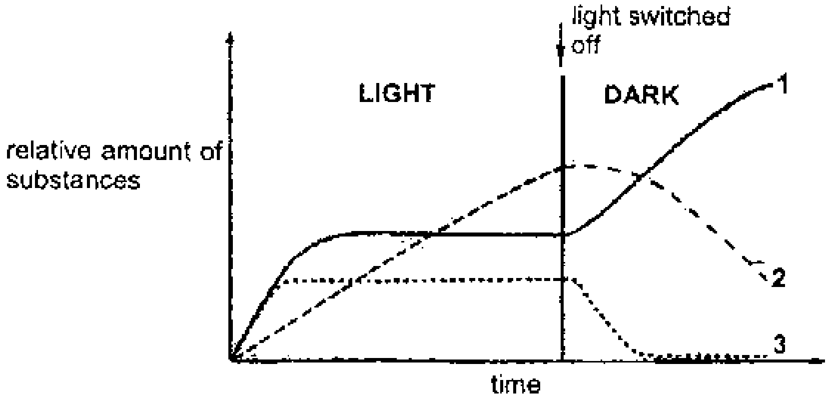
4 Poorly adapted spiders have decreased survivorship.

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

16 The diagram shows a section through a chloroplast. Where would the products of photophosphorylation be used? A



17 ^{14}C-labelled carbon dioxide was supplied to photosynthesising algae. The relative amounts of three organic compounds were measured. The diagram shows the results.



Which of the following are correct explanations for the graph above?

I *GP* level falls as shown in graph 2 due to the absence of reduced NADP when light is are switched off.

II *GP* level rises as shown in graph 1 due to the absence of ATP when light is switched off.

III Levels of RuBP and GP are constant during periods of light as they serve as intermediates in the Calvin cycle.

IV RuBP level falls as carboxylation of RuBP is independent of light as shown in graph 3.

V Sucrose level falls as shown in graph 3 due to the absence of ATP and reduced NADP.

A **I**, **II** and **V** only

B **I**, **II** and **III** only

C **II**, **III** and **IV** only

D **III**, **IV** and **V** only

18 The following statements are some findings of scientists in an attempt to investigate the evolutionary relationship between the anteater, armadillo and pangolin.

I Anteater, armadillo and pangolin feed primarily on insects such as ants.

II Anteater, armadillo and pangolin have long tongue and strong digging limbs.

III The tongues of the anteater and armadillo are connected to the hyoid bone while the tongue of pangolin is not.

IV There is a higher percentage similarity between the DNA sequences of Anteater and armadillo than with the pangolin.

V There is very low percentage similarity between the DNA sequences of anteater and pangolin as well as between the armadillo and pangolin.

Which of the following conclusions can be drawn from the statements given above?

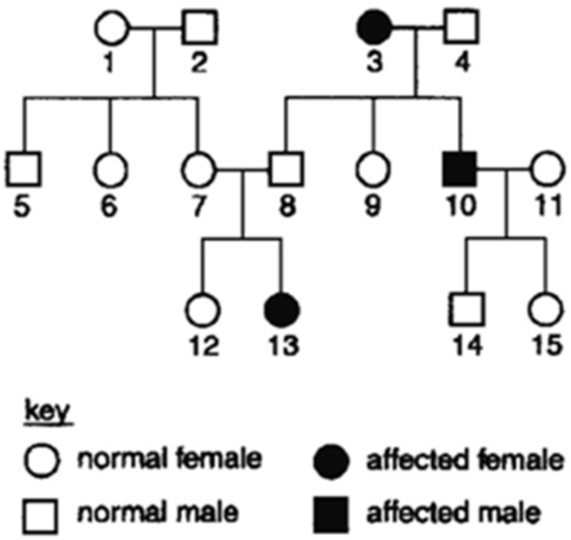
A The anteater and pangolin have experienced divergent evolution as shown by homologous structures between their hyoid bones and tongues.

B The anteater and pangolin have experienced convergent evolution as shown by homologous structures in their hyoid bones and tongues.

C The armadillo and pangolin have experienced divergent evolution as shown by the low similarity between their DNA sequences.

D The anteater and armadillo have experienced divergent evolution as shown by similarities in their DNA sequences and homologous anatomical structures.

19 The pedigree chart below shows the inheritance of a recessive condition known as human albinism. Only homozygous recessive individuals are albinos.



What is the probability of individual 9 being a heterozygous carrier?

A 0.00 **B** 0.25 **C** 0.50 **D** 1.00

20 The feature of silky feathers in show fowl is caused by a recessive allele. A pure breeding bird with normal feathers was crossed with a bird with silky feathers and all the offspring were normal. The offspring were then allowed to interbreed.

Which of the following statements would be true about the F_2 generation?

1 The expected ratio of normal to silky would be 3:1.

2 Half of the F_2 birds would be heterozygous.

3 A quarter of the F_2 birds would be homozygous.

4 Some of the normal birds would be pure breeding.

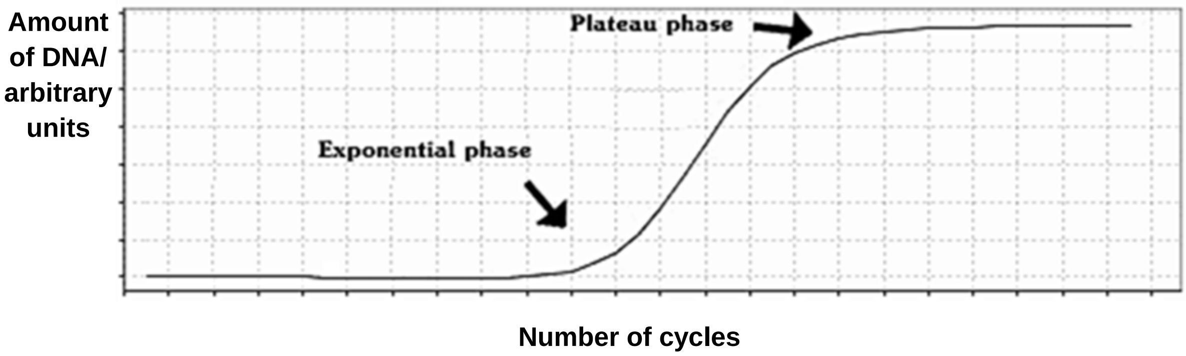
A 1, 2 and 3

B 2, 3 and 4

C 1, 2 and 4

D 1 and 2 only

21 During the process of polymerase chain reaction (PCR), the amount of DNA synthesised can be traced using fluorescent probes and the measurements are shown in the following plot. The process initially goes through an exponential phase followed by a plateau phase eventually.



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

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

B During the exponential phase, the temperature is always maintained at the optimum temperature of 72°C hence there is rapid amplification.

C During the plateau phase, the reaction mixture is being depleted of ribonucleotides.

D During the plateau phase, *Taq* polymerase may be denatured.

22 The dashed lines in the template sequence represent a long sequence of bases to be amplified.

Template

5' ATTCGGACTTG - GTCCAGCTAGAGG 3'

3' TAAGCCTGAAC - CAGGTCGATCTCC 5'

Which of the following sets of primers can be used in the PCR for the amplification of the following DNA sequence?

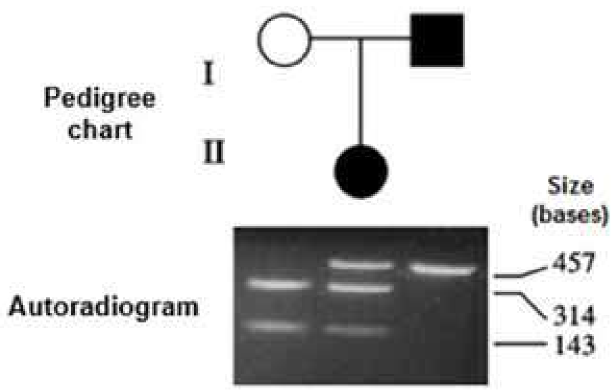
A **5'** GTCCAGC **3'** & **5'** CCTGAAC **3'**

B **5'** ATTCGGA **3'** & **5'** CCTCTAG **3'**

C **5'** GGACTTG **3'** & **5'** GCTGGAC **3'**

D **5'** AUUCGGA **3'** & **5'** GAUCUCC **3'**

23 A family with a history of a genetic disease is studied using restriction digestion of the DNA samples containing the gene responsible for the disease. The pedigree chart of the family is aligned with the autoradiogram obtained from Southern blotting. (Shaded symbols in the pedigree chart indicate individuals affected by disease.)



Based on the information given, which of the following can be deduced?

A The disease allele is dominant to the normal allele.

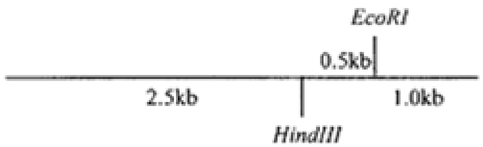
B The mutation creates a new restriction site in the affected gene.

C One of the parents in generation **I** is a carrier.

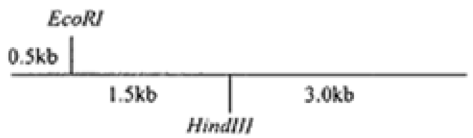
D The offspring in generation **II** is a carrier.

24 Digestion of a 4 kb DNA molecule with *Eco*RI yields two fragments of 1 kb and 3 kb each. Digestion of the same molecule with *Hind*III yields fragments of 1.5 kb and 2.5 kb. Finally, digestion with *Eco*RI and *Hind*III in combination yields fragments of 0.5 kb, 1 kb and 2.5 kb. How would a restriction map indicating the positions of the *Eco*RI and *Hind*III cleavage sites look like? A

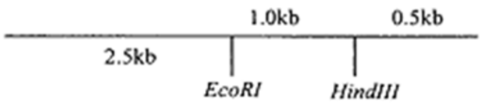
A



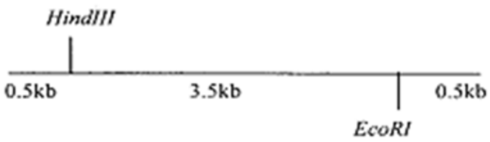
B



C



D



25 Which of the following statements about the human genome project (HGP) is **false**?

A HGP aims to identify all the genes in human and to determine the DNA sequences of these genes.

B HGP aims to allow genetic testing to take place for earlier detection of genetic diseases

C HGP allows defective genes to be replaced through gene therapy

D HGP allows comparative studies to be made between humans and other organisms to identify similar genes associated with diseases.

26 Recent advances in the field of stem cell research have shown that induced pluripotent stem cells (iPS cells) can be artificially derived from adult somatic cells. iPS cells are mostly similar to natural pluripotent cells. This implies that iPS cells can

A theoretically differentiate into all cell types.

B theoretically differentiate into any of the three germ layers.

C theoretically differentiate into gametes.

D theoretically capable of transdifferentiation.

27 Which of the following regarding embryonic stem cells and hematopoietic stem cells is true?

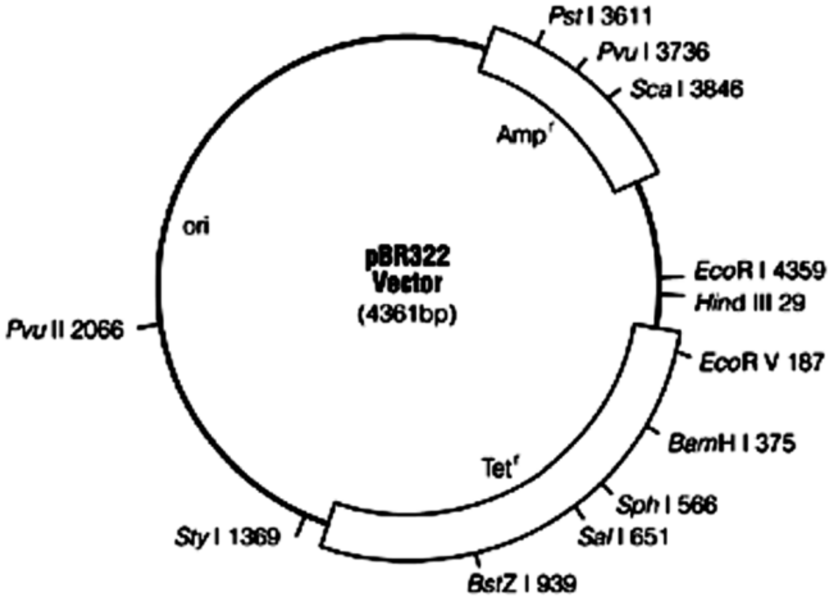
A As embryonic stem cells develop, they turned into hematopoietic stem cells as they lose their ability to differentiate into all types of cells.

B Embryonic stem cells have more genes than hematopoietic stem cells and thus are able to form more types of cells.

C Under normal conditions, embryonic stem cells express more of their genes compared to the hematopoietic stem cells.

D Both stem cells are derived from the zygotic stem cells with the hematopoietic stem cells having a lower differentiation potential compared to the embryonic stem cells.

28 The pBR322 vector is used to clone a eukaryotic gene, which has been digested by the restriction endonuclease *BamHI*.



Following transformation, bacterial cells were grown in four different media, as shown below:

1 Nutrient broth containing ampicillin
2 Nutrient broth containing tetracycline
3 Nutrient broth containing ampicillin and tetracycline
4 Nutrient broth without ampicillin and tetracycline

Which of the following media would bacterial cells containing the recombinant plasmids grow in?

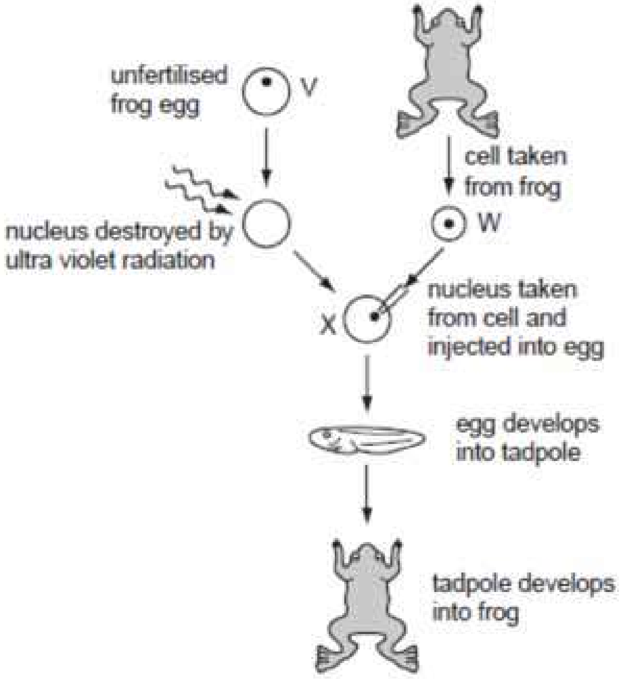
A **4** only

B **1** and **2**

C **2** and **3**

D **1** and **4**

29 The diagram shows how genetically identical frogs can be developed from unfertilised frog eggs. The diploid number for frogs is 26.

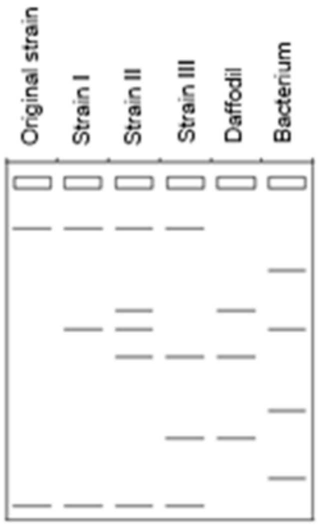


Which combination of numbers correctly identifies the number of chromosomes in each type of cell?

	V	W	X
A	13	13	26
B	13	26	13
C	13	26	26
D	26	26	13

30 An attempt was made to produce Golden rice. To determine whether or not DNA from the daffodils and the bacterium had been successfully incorporated in the DNA of the rice, scientists used PCR and gel electrophoresis to produce DNA profiles.

The following DNA profiles belong to the original strain of rice, three strains **I** to **III** of genetically modified Golden rice, and the species of daffodil and bacterium used to incorporate beta-carotene genes in the rice.



Which one of the strain(s) of Golden rice has successfully incorporated DNA from both the daffodil and the bacterium?

A Strain **I** only

B Strain **II** only

C Strain **I** and **III** only

D Strain **II** and **III** only

End of Paper

CANDIDATE NAME: ____ INDEX NUMBER _________

CG _________

SERANGOON JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2017

BIOLOGY
Higher 1
8875

Tuesday
18 September 2017

2 hours

Additional materials:
Writing paper

READ THESE INSTRUCTIONS FIRST

Write your name and index number in the spaces at the top of this page and on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

For Section A answer **all** questions.
For Section B, answer only one question.

INFORMATION FOR CANDIDATES

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

FOR EXAMINER'S USE	
Paper 1 (MCQ)	/30
Paper 2	
Section A	
1	/10
2	/11
3	/10
4	/9
Total	/40
Section B	
6 or 7	/20
P2 Total	/60
TOTAL (P1+P2)	/90
TOTAL (100%)	/100

This question paper consists of 10 printed pages.

Section A [40 marks]

Answer **all questions** in the spaces provided.

Question 1

There have been many breakthroughs in stem cell research in recent years. It has been discovered that stem cells are involved in the replacement of worn-out cells and repair of damaged tissues. Further research is being conducted to better understand the mechanism involved in controlling the behaviour of stem cells in order to better manipulate them to treat various diseases and disorders.

(a) State the type of stem cells involved in the replacement of worn-out cells and repair of damaged tissues, and describe the unique properties of this type of stem cells. [2]

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Stem cells undergo cell division to produce genetically identical daughter cells. **Fig. 1.1** shows two cells, each at a different stage of cell division.

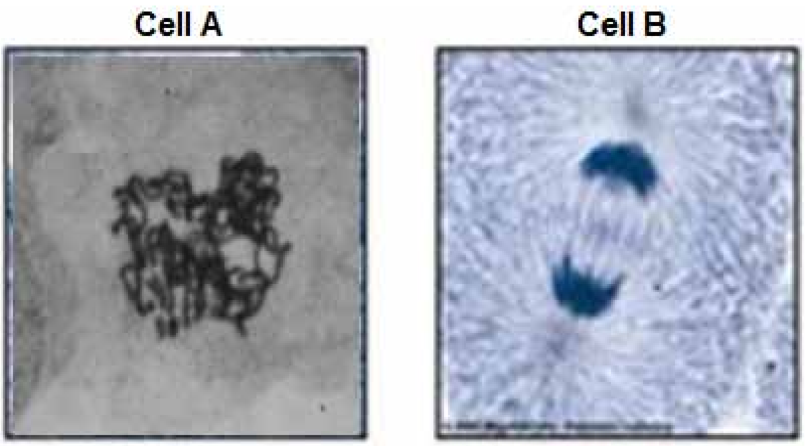

Fig. 1.1

(b)(i) With reference to **Fig. 1.1,** state the stages of cell division in **Cell A** and **Cell B**. [1]

Cell A: ……………………………………

Cell B: ……………………………………

(ii) The dysregulation of cell cycle can result in cancer. Outline the checkpoints that are present in normal cells to prevent this from occurring. [2]

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Fig. 1.2 shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.

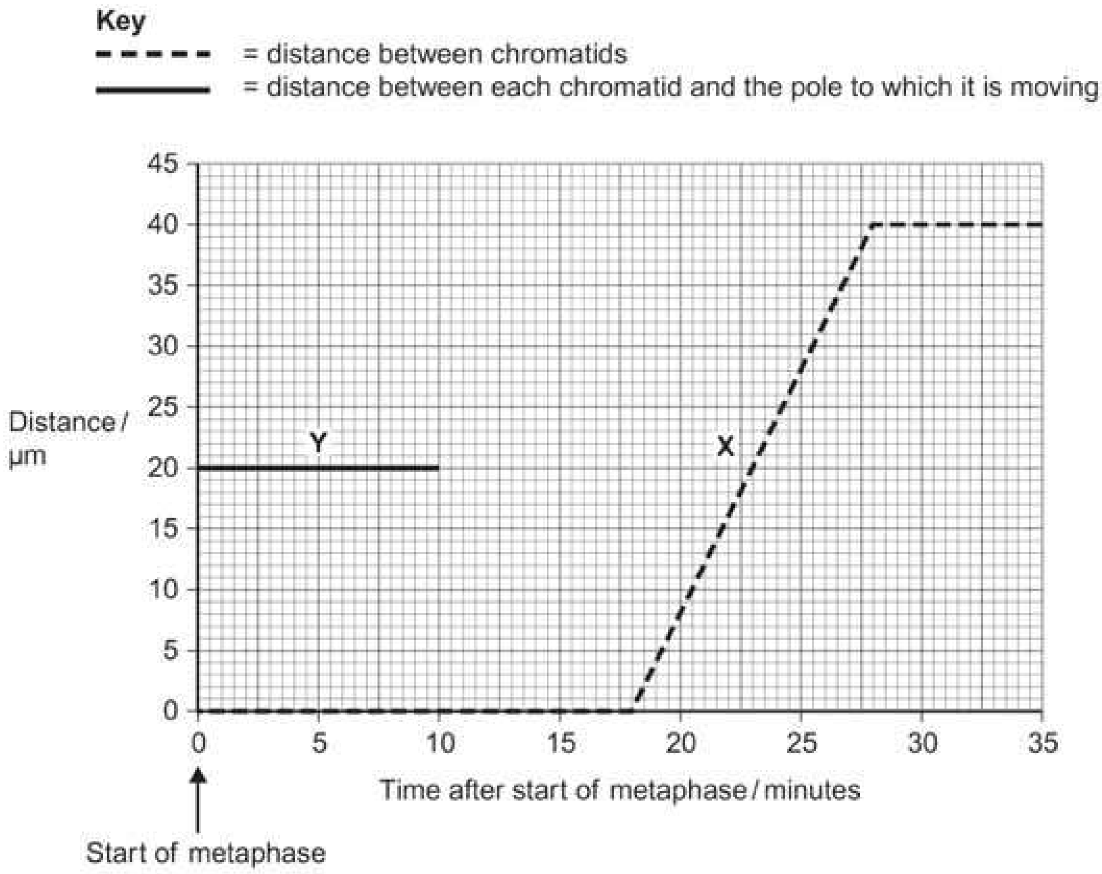

Fig. 1.2

(c)(i) With reference to **Fig. 1.2**, state the duration of metaphase in the cell. [1]

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(ii) Complete line **Y** on the graph. [1]

(iii) Account for your answer in **(c)(ii)**. [3]

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[Total: 10]

Question 2

A mutation was found in the gene coding for NADP oxidase in a family of flowering plant. NADP oxidase is an enzyme that converts NADPH to $NADP^+$.

(a) Explain the role of NADPH in photosynthesis. [2]

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(b) Using your knowledge of photosynthesis, predict the effect of this mutation on plants. [3]

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Rubisco is an enzyme required in the light-independent stage of photosynthesis. **Fig. 2.1** shows the effect of increasing temperature on the activity of two variations of Rubisco, **Rubisco C** and **Rubisco S**.

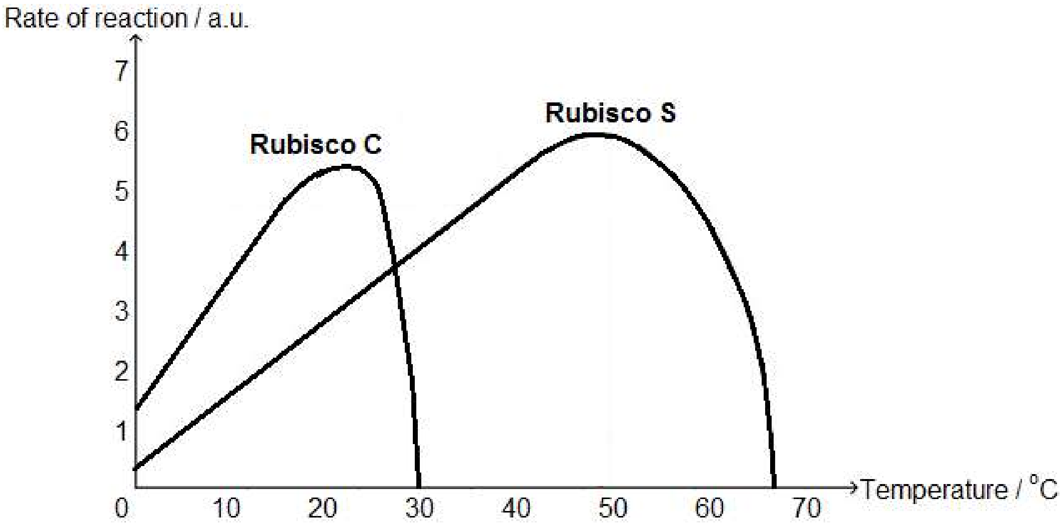

Fig. 2.1

(c) With reference to **Fig. 2.1**, compare the effect of temperature on the two enzymes. [3]

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(d) Explain how different alleles give rise to different Rubisco structure. [3]

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[Total: 11]

Question 3

Fig. 3.1 shows the schematic representation of a series of protein complexes found on the inner membrane of organelle **X** present in brown adipocytes.

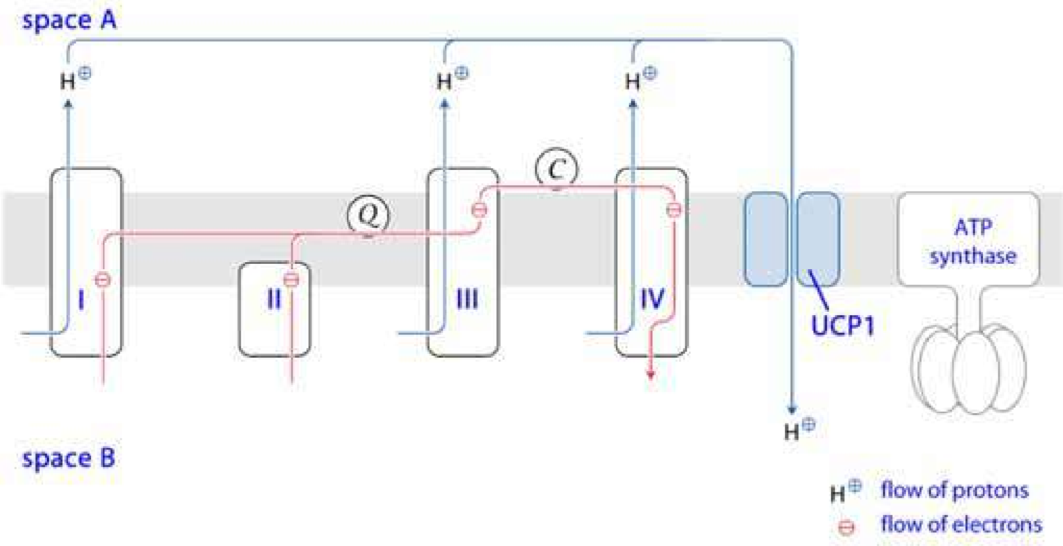

Fig. 3.1

(a)(i) State the identity of organelle **X**. [1]

....

(ii) Outline how ATP is usually synthesised in the inner membrane of organelle **X**. [4]

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....

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....

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(b) Brown adipocytes contain a unique protein, UCP1, which is not found in organelle **X** in any other cell type.

Evaluate the impact of UCP1 on ATP synthesis and suggest the physiological significance of brown adipose tissue. [3]

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(c) In other cell types, NADH and $FADH_2$ are used to drive ATP synthesis by ATP synthase. Using relevant information from **Fig. 3.1**, suggest and explain why more ATP is produced from NADH. [2]

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[Total: 10]

Question 4

The table below shows the amino acid differences in the cytochrome b protein between various vertebrates.

	Human	Elephant	Platypus	Ostrich	Starling	Crocodile	Lungfish	Coelacanth	Goldfish	Shark
Human		26	40	43	41	47	83	70	68	71
Elephant			45	45	48	50	84	72	63	74
Platypus				54	52	51	89	74	70	76
Ostrich					26	36	91	75	68	73
Starling						47	91	77	67	70
Crocodile							85	78	70	77
Lungfish								90	94	86
Coelacanth									83	78
Goldfish										88
Shark										

(a) Explain how differences in amino acid sequences in the cytochrome b chain allow the establishment of the phylogenetic tree. [2]

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(b) Suggest why homology still features prominently in evolutionary studies despite the advantages that molecular evidence can confer. [1]

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Giant anteaters, armadillos and Australian numbats (*Myrmecobius fasciatus*) have many similar traits. This led some to believe that they were closely related.

Table 4.1 shows the comparison of four characteristics between the three mammals.

Mammal	**Characteristics**			
	Diet	**Body**	**Snout**	**Tongue**
Armadillo	Feed on insects	Covered by bony keratinised plates	Pointy snout	Long tongues
Giant Anteater	Feed on ants and termites	Covered by hair	Elongated narrow snout	Long tongues
Numbats	Feed on termites	Covered by hair	Narrow snout	Long tongues

(c) Explain why variation is important in selection. [2]

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(d) Explain how the evolution of long tongues in numbats supports Darwin's theory of natural selection. [4]

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[Total: 9]

Section B [20 marks]

Answer **one** question in this section.

Write your answers on the separate writing paper provided.

Your answers may be illustrated by large, clearly labeled diagrams, ONLY where appropriate.

Your answers must be in continuous prose.

Question 5

(a) Using the induced-fit hypothesis, explain the mode of action of enzymes. [6]

(b) With reference to haemoglobin, explain the significance of bonds in maintaining the protein's structure and function. [8]

(c) Discuss the social implications of genetically modifying plants. [6]

OR

Question 6

(a) Compare competitive and non-competitive inhibition of enzyme action. [6]

(b) Describe the process of mitosis and its importance in living cells. [8]

(c) Discuss the ethical implications of genetically modifying plants. [6]

END OF PAPER

CANDIDATE NAME: ____________________________________ INDEX NUMBER _________

CG _________

SERANGOON JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2017

BIOLOGY
Higher 1
8875

ANSWER SCHEME

2 hours

Additional materials:
Writing paper

READ THESE INSTRUCTIONS FIRST

Write your name and index number in the spaces at the top of this page and on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

For Section A answer **all** questions.
For Section B, answer only one question.

INFORMATION FOR CANDIDATES

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

FOR EXAMINER'S USE	
Paper 1 (MCQ)	/30
Paper 2	
Section A	
1	/10
2	/11
3	/10
4	/9
Total	/40
Section B	
6 or 7	/20
P2 Total	/60
TOTAL (P1+P2)	/90
TOTAL (100%)	/100

This question paper consists of 10 printed pages.

Section A [40 marks]

Answer **all questions** in the spaces provided.

Question 1

There have been many breakthroughs in stem cell research in recent years. It has been discovered that stem cells are involved in the replacement of worn-out cells and repair of damaged tissues. Further research is being conducted to better understand the mechanism involved in controlling the behaviour of stem cells in order to better manipulate them to treat various diseases and disorders.

(a) State the type of stem cells involved in the replacement of worn-out cells and repair of damaged tissues, and describe the unique properties of this type of stem cells. [2]

- **Adult stem cells** [1]

  Any 2 properties [1]*:*
- **Undifferentiated cells found in differentiated tissues**
- **Multipotent → Able to differentiate into a limited range of cell types**
- **Able to undergo mitotic cell division for self-renewal**

Stem cells undergo cell division to produce genetically identical daughter cells. **Fig. 1.1** shows two cells, each at a different stage of cell division.

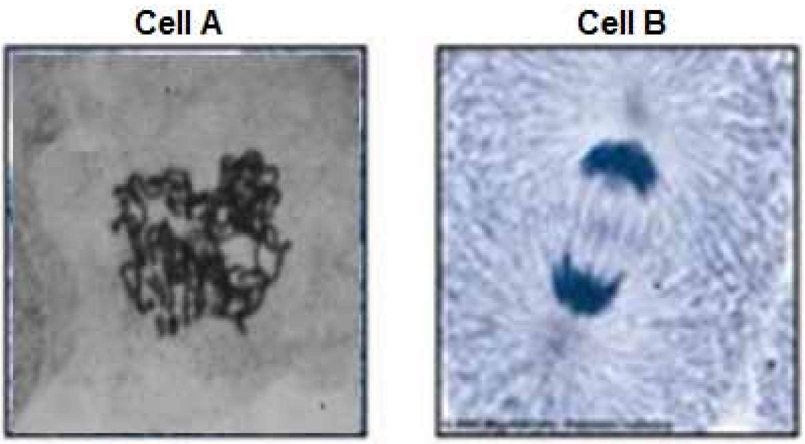


Fig. 1.1

(b)(i) With reference to **Fig. 1.1,** state the stages of cell division in **Cell A** and **Cell B**. [1]

Cell A: Prophase

Cell B: Anaphase

(ii) The dysregulation of cell cycle can result in cancer. Outline the checkpoints that are present in normal cells to prevent this from occurring. [2]

Any 2

- **G1 checkpoint: assesses if the environmental conditions (presence of growth factors and nutrients, absence of DNA damage, adequate cell size) are favourable for cell division to proceed**
- **G2 checkpoint: assesses if DNA replication is completed and cell size is adequate.**
- **M checkpoint: assesses if all chromosomes are attached to the mitotic spindle at their kinetochores and arrests the mitotic cell at metaphase if centromeres are not properly attached to kinetochore microtubules, hence preventing entry into anaphase.**

Fig. 1.2 shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.

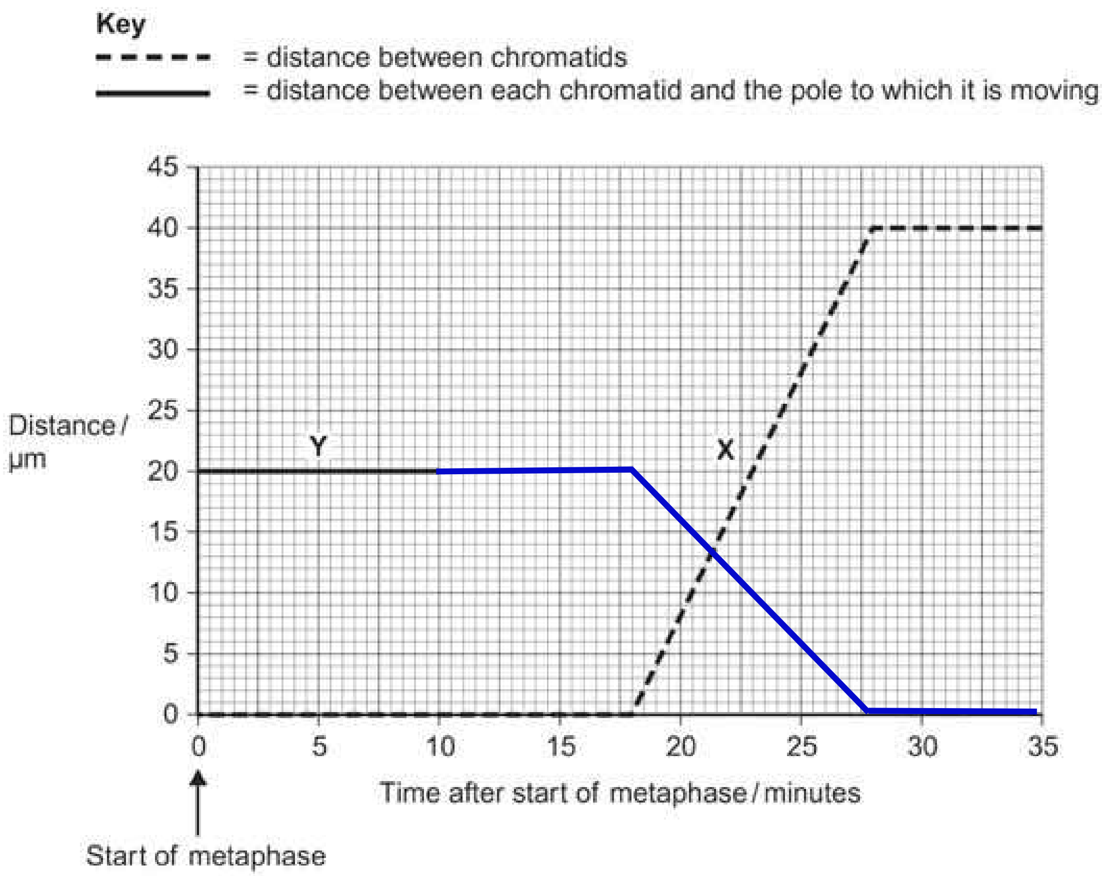


Fig. 1.2

(c)(i) With reference to **Fig. 1.2**, state the duration of metaphase in the cell. [1]

- **18 min**

(ii) Complete line **Y** on the graph. [1]

(iii) Account for your answer in **(c)(ii)**. [3]

- **Chromosomes align singly at the metaphase plate during metaphase of mitosis OR sister chromatids are attached to microtubules from opposite poles at metaphase**
- **Sister chromatids start to separate to become daughter chromosomes and migrate towards the opposite poles in anaphase, as shown at 18th min of line X when distance between chromatids starts to increase. Hence distance between chromatid and pole will start to decrease at 18th min.**
- **Distance between chromatids reach a plateau/maximum at 28th min, chromosomes arrived at opposite poles. Hence, distance between chromatid and pole will be minimum at 28th min.**

[Total: 10]

Question 2

A mutation was found in the gene coding for NADP oxidase in a family of flowering plant. NADP oxidase is an enzyme that converts NADPH to $NADP^+$.

(a) Explain the role of NADPH in photosynthesis. [2]

- **Provides reducing power/H+ to reduce**
- **Phosphoglyceric acid (PGA)/glycerate-3-phosphate (GP) to glyceraldehyde-3-phosphate (GALP)/phosphoglyceraldehyde (PGAL)/triose phosphate (TP)**

(b) Using your knowledge of photosynthesis, predict the effect of this mutation on plants. [3]

- **Mutation will result in low or no NADP oxidase activity**
- **Less conversion of NADPH to $NADP^+$ for light reaction of photosynthesis (OR less reduction of PGA to GALP in Calvin cycle)**
- **Less ATP is synthesized (or less glucose produced)**

Rubisco is an enzyme required in the light-independent stage of photosynthesis. **Fig. 2.1** shows the effect of increasing temperature on the activity of two variations of Rubisco, **Rubisco C** and **Rubisco S**.

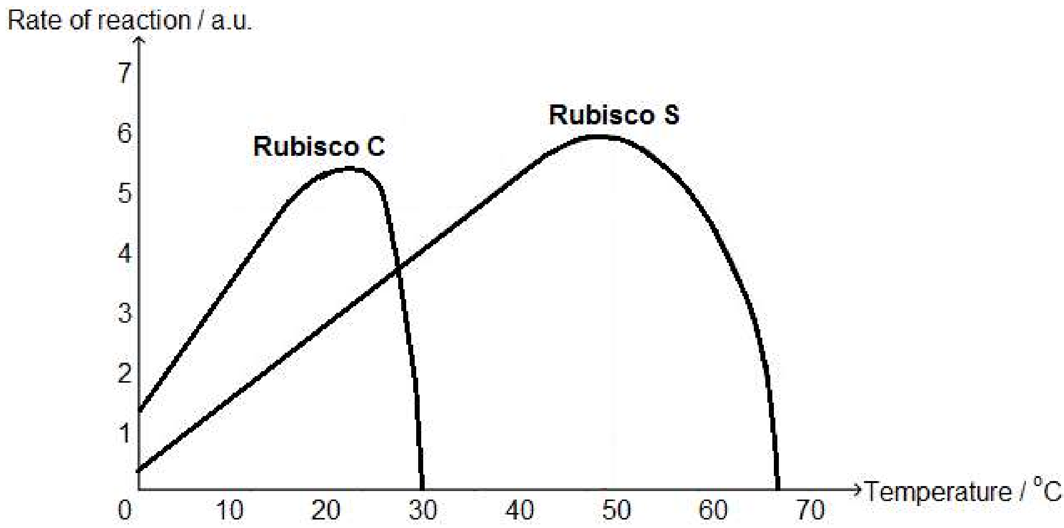


Fig. 2.1

(c) With reference to **Fig. 2.1**, compare the effect of temperature on the two enzymes. [3]

- **Both Rubisco C and Rubisco S has an increased rate of reaction as temperature increases up to optimum temperature OR both Rubisco C and Rubisco S are denatured at temperatures higher than optimum.**
- **Rubisco C has a lower optimum temperature of 20ºC as compared to Rubisco S at 50 ºC where rate of reaction is at a maximum**
- **Rubisco C reaches a lower maximum rate of reaction of 5.5 a.u. at a faster rate as compared to Rubisco S which reaches a maximum rate of reaction of 6 a.u at a slower rate.**

(d) Explain how different alleles give rise to different Rubisco structure. [3]

- **Different alleles have different <u>DNA nucleotide sequence</u> that results in a <u>different mRNA/codon sequence</u> after transcription**
- **Thus will result in <u>different amino acid sequence</u> / primary structure after translation**
- **Different <u>R group interactions</u> between amino acids affects folding of the polypeptide chain, giving rise to different <u>3D conformation</u> in the tertiary structure**

[Total: 11]

Question 3

Fig. 3.1 shows the schematic representation of a series of protein complexes found on the inner membrane of organelle **X** present in brown adipocytes.

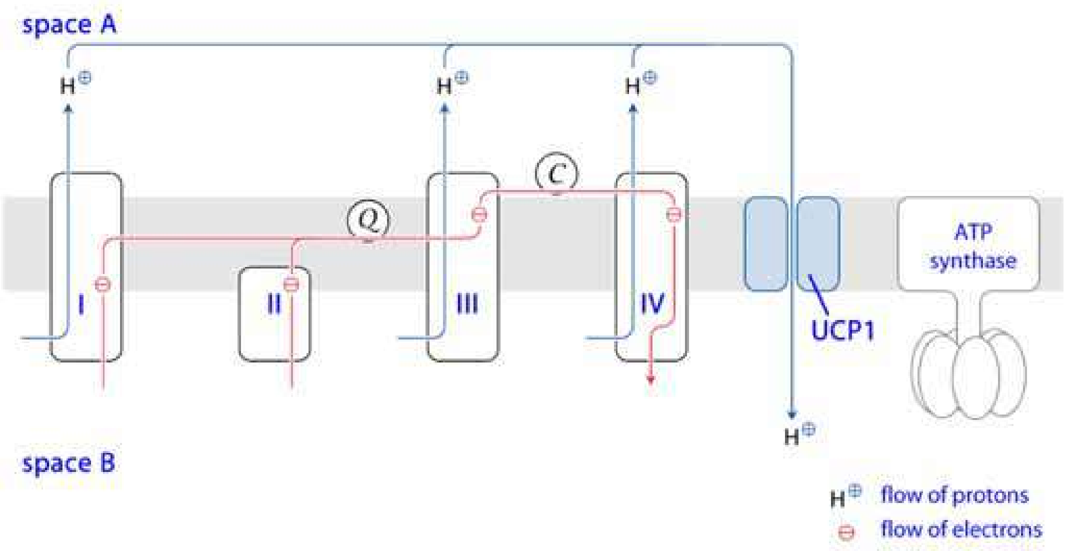


Fig. 3.1

(a)(i) State the identity of organelle **X**. [1]

Mitochondrion

(ii) Outline how ATP is usually synthesised in the inner membrane of organelle **X**. [4]

- **NADH and FADH$_2$ carry hydrogen in the form of protons and electrons where proton remain in the matrix and electrons are passed along the progressively lower energy electron carriers in the electron transport chain.**
- **Energy released is used to pump H+ from the matrix to the intermembrane space via active transport which sets up a concentration gradient (high H+ conc in intermembrane space, low conc in the matrix)**
- **H+ diffuse down the concentration gradient from the intermembrane space to matrix via the stalked particle**
- **Provides a proton motive force that drives the synthesis of ATP by ATP synthase by phosphorylation of ADP and inorganic phosphate (chemiosmosis).**

(b) Brown adipocytes contain a unique protein, UCP1, which is not found in organelle **X** in any other cell type.

Evaluate the impact of UCP1 on ATP synthesis and suggest the physiological significance of brown adipose tissue. [3]

- **As UCP1 allows protons to leak back into the matrix without passing through the ATP synthase,**
- **Loss of H+ concentration gradient, no ATP will be synthesized**
- **The energy released from the spontaneous flow of protons through UCP1 is lost as heat, which helps to keep the organisms warm.**

(c) In other cell types, NADH and $FADH_2$ are used to drive ATP synthesis by ATP synthase. Using relevant information from **Fig. 6.2**, suggest and explain why more ATP is produced from NADH. [2]

- **NADH donates electrons to complex I while $FADH_2$ donates to complex II. The energy released from transfer of electrons through the complexes is used to pump protons across the inner membrane.**
- **NADH allows for more chances to pumps more protons across the gradient, which powers the ATP synthase and gives us 3 ATP per molecule of NADH, while $FADH_2$ produces 2 ATP during the ETC because it gives up its electron to complex II, bypassing complex I.**

[Total: 10]

Question 4

The table below shows the amino acid differences in the cytochrome b protein between various vertebrates.

	Human	Elephant	Platypus	Ostrich	Starling	Crocodile	Lungfish	Coelacanth	Goldfish	Shark
Human		26	40	43	41	47	83	70	68	71
Elephant			45	45	48	50	84	72	63	74
Platypus				54	52	51	89	74	70	76
Ostrich					26	36	91	75	68	73
Starling						47	91	77	67	70
Crocodile							85	78	70	77
Lungfish								90	94	86
Coelacanth									83	78
Goldfish										88
Shark										

(a) Explain how differences in amino acid sequences in the cytochrome b chain allow the establishment of the phylogenetic tree. [2]

- **Percentage of amino acid difference indicates relatedness where few difference indicates recent common ancestor**
- **Provides quantitative data to construct phylogenetic tree**

(b) Suggest why homology still features prominently in evolutionary studies despite the advantages that molecular evidence can confer. [1]

Any 1

- **Less expensive as it does not rely on machines**
- **DNA/protein samples might be limited or unavailable**

Giant anteaters, armadillos and Australian numbats (*Myrmecobius fasciatus*) have many similar traits. This led some to believe that they were closely related.

Table 4.1 shows the comparison of four characteristics between the three mammals.

Mammal	**Characteristics**			
	Diet	**Body**	**Snout**	**Tongue**
Armadillo	Feed on insects	Covered by bony keratinised plates	Pointy snout	Long tongues
Giant Anteater	Feed on ants and termites	Covered by hair	Elongated narrow snout	Long tongues
Numbats	Feed on termites	Covered by hair	Narrow snout	Long tongues

(c) Explain why variation is important in selection. [2]

- **Genetic variation results in variation in <u>phenotype</u> between individuals in a population**
- **Giving rise to <u>different reproductive success</u> between individuals OR**
- **Under a particular selective pressure, individuals with the advantageous variation are <u>selected for</u>.**

(d) Explain how the evolution of long tongues in numbats supports Darwin's theory of natural selection. [4]

- **Genetic variation give rise to <u>different tongue lengths</u> in (ancestral) numbats**
- **Under a <u>selection pressure</u> of limited food/ big termite nests/ deep termite nests/AVP**
- **Numbats with longer tongues have a selective advantage/ will be selected for because they can probe deeper into termite nests / AVP**
- **Numbats with longer tongues will survive, reproduce and pass down alleles encoding for longer tongues to the next generation**
- **Over time, the frequency of alleles coding for long tongues will increase.**

[Total: 9]

Section B [20 marks]

Answer **one** question in this section.

Write your answers on the separate writing paper provided.

Your answers may be illustrated by large, clearly labeled diagrams, ONLY where appropriate.

Your answers must be in continuous prose.

Question 5

(a) Using the induced-fit hypothesis, explain the mode of action of enzymes. [6]

1. **Enzyme <u>specific</u> in its action due to <u>complementary</u> 3D configuration/conformation of active site to that of substrate;**
2. **The induced fit model suggests that the enzyme and the substrate do not fit together exactly;**
3. **<u>Effective</u> collisions between enzymes and (specific) substrate molecules result in substrate binding to active site of enzyme;**
4. **The enzyme undergoes a 3D conformation change, which improves the fit between substrate and enzyme;**
5. **to form enzyme-substrate (ES) complexes;**
6. **Product formed that no longer fits into active site and is released;**

(b) With reference to haemoglobin, explain the significance of bonds in maintaining the protein's structure and function. [8]

1. **Peptide bonds between amine groups and carboxyl groups of amino acids at primary structure of organisation**
2. **Hydrogen bonds between –CO and –NH groups of the polypeptide backbone;**
3. **Ref. to overall 3D configuration/ globular shape of haemoglobin;**
4. **Each globin polypeptide is folded such that the bulk of the hydrophobic amino acid residues are buried in the interior of the globular structure;**
5. **Ref. to haem binding pocket lined with hydrophobic amino acids to provide a hydrophobic environment for hydrophobic haem group to bind;**
6. **Hydrophilic amino acid residues are on the outside;**
7. **Haemoglobin is soluble in aqueous medium and hence a good transport protein for oxygen in blood;**
8. **The two polypeptide chains in each dimer are held together by mainly hydrophobic interactions;**
9. **The two dimers are held together by weak hydrogen and ionic bonds;**
10. **Resulting in the ability of the two dimers to move with respect to each other;**
11. **This allows for cooperativity;**
12. **When an oxygen molecule binds to/is released from 1 haemoglobin subunit, the binding/ release induces a conformational change in the remaining subunit;**
13. **Which increases/ lowers the affinity for oxygen of the remaining three oxygen binding sites respectively;**
14. **This facilitates the loading and unloading of oxygen;**

(c) Discuss the social implications of genetically modifying plants. [6]

1) Use of vectors which confer antibiotic-resistance might result in these genes being passed on to other potential harmful bacteria which hampers treatment.
2) New allergens produced that are dangerous to people with allergy who consume them.
3) Genetically modified crops might establish themselves as weeds as they are able to withstand unfavourable environmental conditions.
4) Spread of resistance from genetically modified crops to weeds might result in the production of superweeds that are resistant to herbicides.
5) Genetically engineered organisms, if introduced into the environment, might upset the balance of the ecosystem as it might lead to increased competition for space and nutrients.
6) Loss of biodiversity

OR

Question 6

(a) Compare competitive and non-competitive inhibition of enzyme action. [6]
(b)

Features	**Competitive**	**Non-competitive**
Structure of inhibitor	**Resembles substrate;**	**Does not resemble substrate;**
Binding site of inhibitor	**Binds to active site of enzyme;**	**Binds to enzyme at a region other than the active site;**
Mechanism of inhibition	**Blocks substrates from binding to active site of the enzyme;**	**Blocks substrates from binding to active site by changing the conformation of the active site;**
Effect of high substrate concentration on inhibition **Achieving Vmax**	**Inhibition can be reversed at high substrate concentration;** **V_{max} in the presence of inhibitor can be very close to that of reaction in the absence of inhibitor;**	**Inhibition cannot be reversed at high substrate concentration;** **V_{max} in the presence of inhibitor is less than that of reaction in the absence of inhibitor;**
Similarities: **1. At low substrate concentration, rate of reaction in the presence of inhibitors is**		

slower than that in the absence of inhibitor;

(c) Describe the process of mitosis and its importance in living cells. [8]

Process of mitosis: any 6 from PMAT (at least one from each stage)

Prophase:
- **Chromatin condenses to chromosome**
- **Sister chromatids joined at centromere**
- **Centrioles migrate to opposite poles**
- **Mitotic spindles begin to form; nuclear envelope disintegrates**
- **Nucleolus disappears**

Metaphase:
- **Centrioles reached opposite poles**
- **Spindle fibres attached to kinetochore**
- **Chromosomes align on metaphase plate**

Anaphase
- **Centromeres divide**
- **Sister chromatids separate and move to opposite poles**
- **Shortening of kinetochore microtubules/spindle fibres**

Telophase
- **Chromosomes reached opposite poles**
- **Chromosomes uncoiled to chromatin fibers**
- **Spindle fibers disintegrates**
- **Nuclear envelope reforms**
- **Nucleoli reappears,**
- **Forms two** genetically identical **daughter nuclei**

Importance (max 2):
- Maintains **genetic stability** to produce **genetically identical** nuclei
- **Increase number of cells** for **growth**
- **Asexual reproduction**
- **Replace damaged cell** and **regeneration**

(d) Discuss the ethical implications of genetically modifying plants. [6]

- **GM plants grown as crops may lead to consumers having allergies as foreign proteins are produced in the plants, companies need to label their GM crops for consumers to make informed choices / consumer safety is compromised;**
- **Animal genes may be introduced to plant genomes, leading to concern of vegetarians or some religious groups which followers are not allowed to consume certain animals;**
- **GM crops lead to benefits that rich countries can enjoy due to more financial resources at the expense of poorer countries (e.g. increasing dependence of poor countries on rich countries for expensive GM crops), increasing rich-poor divide;**

- **GM crops can produce higher quality food to allow large companies that develop the technology / reduce costs to increase profit margins to out-compete small scale farmers, increasing rich-poor divide;**
- **Patenting the GM crops reduces them to the level of objects and if patenting is not allowed, a company might not be able to protect the results of their research program.**
- **Tampering with nature, where the mixing of genes among species may be seen as violation of organisms natural intrinsic values, crossing species boundaries;**

END OF PAPER

Civics Group	Index Number	Name (use BLOCK LETTERS)

H1

ST. ANDREW'S JUNIOR COLLEGE
2017 JC2 BT2

H2 BIOLOGY **9744/1**

Paper 1: Multiple Choice Mark Scheme

Tuesday 19th September 2017 1 hour

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

READ THESE INSTRUCTIONS FIRST

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

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

There are **30** questions in this paper. Answer all questions. For each question, there are four possible answers, A, B, C and D.

Choose the one you consider correct and record your choice in soft pencil on the separate multiple choice answer sheet.

INFORMATION TO CANDIDATES

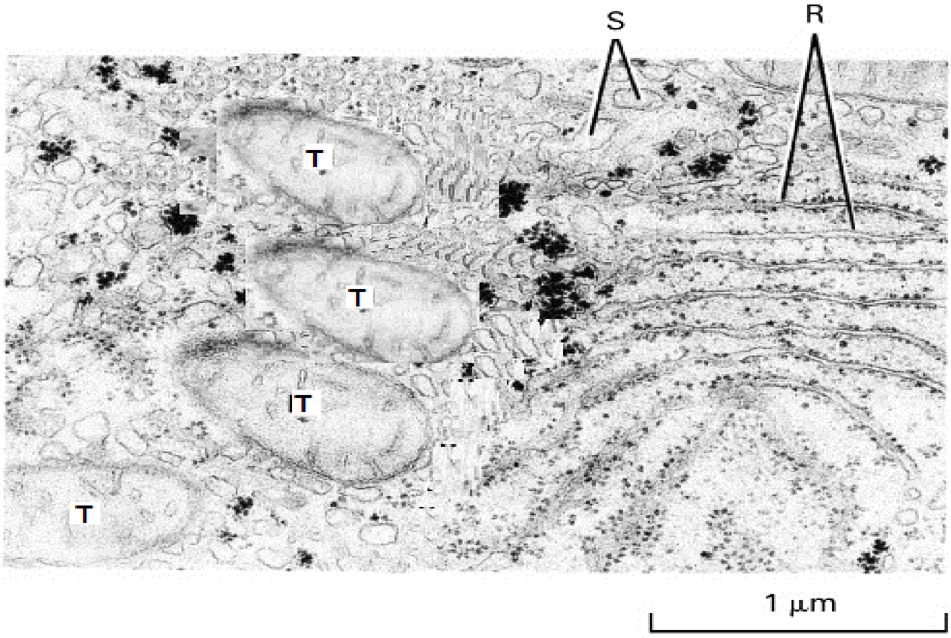
Each correct answer will score one mark. A mark will not be deducted for wrong answer. Any rough working should be done in this booklet.

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

This document consists of **16** printed pages.

[Turn over

1 The figure below shows an electron micrograph of an eukaryotic cell.



Which of the following option correctly matches the structures **R**, **S** and **T** to their respective functions?

	R	S	T
A	Involved in proteins glycosylation	Site of lipid synthesis	To convert light energy to chemical energy
B	Site of protein synthesis	Site of detoxification reaction	Supplying cellular energy
C	Site of detoxification reaction	Involved in protein glycosylation	Remove worn out organelles
D	Site of protein synthesis	Contains proteins to be secreted	Storage of starch

2 Which comparative statement(s) concerning biological molecules is/are correct?

1 A collagen molecule is a fibrous protein that contains many amino acids with hydrophobic R-groups whereas a haemoglobin molecule is a globular protein with no amino acids with hydrophobic R-groups.
2 Sucrose hydrolysis results in glycosidic bond breakage and the production of equal proportions of fructose and α-glucose molecules, whereas cellulose hydrolysis results in only β-glucose molecules.
3 The glycosidic bonds of glycogen are formed between two α-glucose molecules, whereas in amylopectin, the bonds are formed between an α-glucose molecule and a β-glucose molecule.

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

3 Which two features contribute to the great tensile strength of cellulose?

1 glycosidic bonds linking the long chains of 1,4 α-glucose molecules
2 the -OH groups of the glucose molecules project outwards and form H bonds with neighbouring chains
3 the strength of the glycosidic bonds between the neighbouring chains of molecules
4 the successive glucose molecules are orientated at 180° to each other

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

4 The statements below are about bonds found in biological molecules.

1 They are formed by condensation.
2 Oxygen is part of the bond.
3 ATP is hydrolysed to form the bonds.
4 The bonds contain potential energy.

Which statements are correct for the bonds in the primary structure of proteins?

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

5 The cell surface membrane structure is described as a 'fluid mosaic'.

Which statement describes the 'mosaic' part of the cell surface membrane?

A the different patterns that are obtained by the moving phospholipid molecules
B the random distribution of cholesterol molecules within the phospholipid bilayer
C the regular pattern produced by the phospholipid heads and membrane proteins
D the scattering of the different proteins within the phospholipid bilayer

6 What supports the view that a membrane protein is involved in active transport?

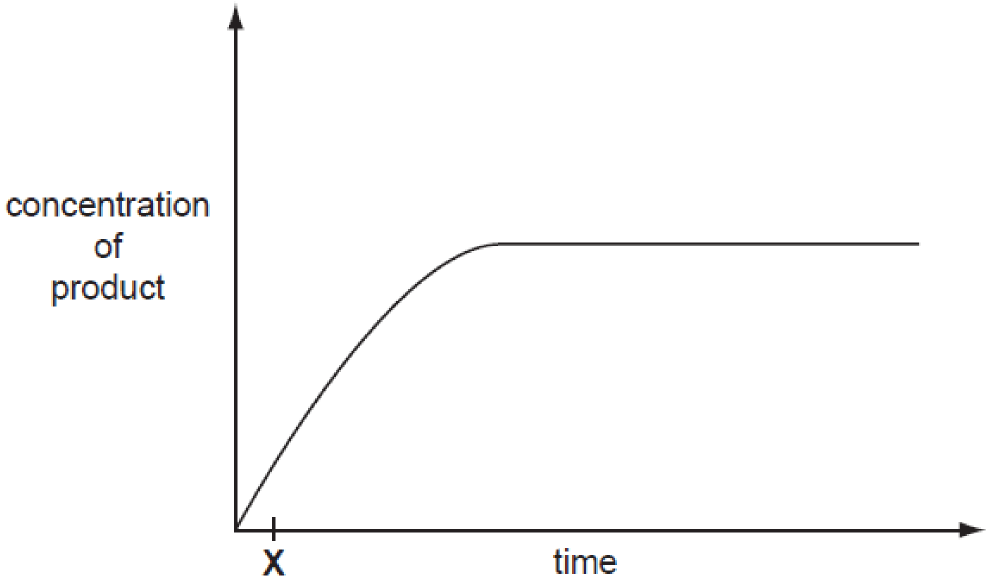
A It allows movement of molecules across a membrane if concentration differences exist.
B It can only function if mitochondria are supplied with sufficient oxygen.
C It has a tertiary structure with a binding site with a specific shape.
D It is found in the cell surface membranes and the mitochondrial membranes.

7 What would be shown by a microscopic examination of a root tip squash?

1 cells with large nuclei at interphase
2 cells not dividing and nuclei undergoing mitosis
3 nuclei with paired homologous chromosomes visible
4 cell walls forming

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

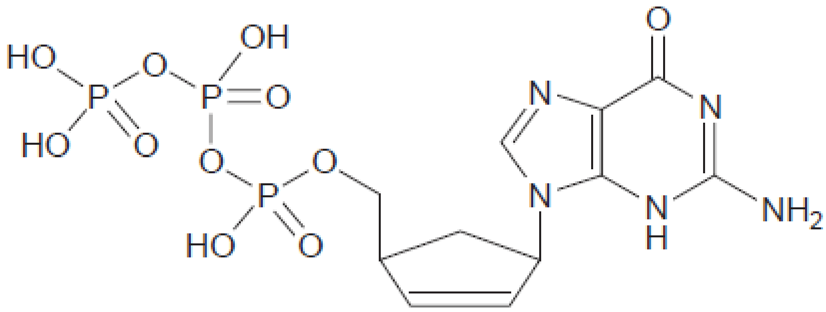
8 The graph shows the course of an enzyme-catalysed reaction at 30 °C.



What is true at time X?

A Most enzyme molecules will have free active sites.
B The number of available substrate molecules is high.
C The number of enzyme-substrate complexes is low.
D The rate remains the same if more enzyme is added.

9 The diagram shows the molecular structure of a chemical that can inhibit the activity of reverse transcriptase (which catalyses the reaction of synthesis of complementary deoxyribonucleic acid using ribonucleic acid as template). It is an analogue of a naturally occurring nucleic acid monomer.



Which option is correct?

	Analogue	Naturally occurring monomer
A	Acts as a competitive inhibitor	Is an activated DNA nucleotide
B	Acts as a non-competitive inhibitor	Is an activated RNA nucleotide
C	Acts as a competitive inhibitor	Is an activated RNA nucleotide
D	Acts as a non-competitive inhibitor	Is an activated DNA nucleotide

10 Which row is correct for adenine?

	has a single ring structure	is a purine	joins to its complementary base with 3 hydrogen bonds
A	✓	✓	✓
B	✓	✗	✗
C	✗	✓	✗
D	✗	✗	✓

key
✓ = correct
✗ = incorrect

11 Meselson and Stahl investigated DNA in bacteria. They grew bacteria in a medium with only heavy nitrogen, 15N, until all of the bacterial DNA contained only heavy nitrogen.

These bacteria were then moved from the heavy nitrogen medium and cultured in a medium with only light nitrogen, 14N.

Some bacteria were collected from each of the next three generations and their DNA was analysed.

Hybrid DNA contains both heavy and light nitrogen.

Which row shows the correct DNA of the first and third generations?

	DNA of first generation	DNA of third generation
A	all hybrid	half hybrid, half light
B	all hybrid	one quarter hybrid, three quarter light
C	half hybrid, half heavy	half hybrid, one quarter heavy, one quarter light
D	half hybrid, half light	one quarter hybrid, three quarter light

12 Scientists have made a nucleic acid (HNA) that has a sugar with the same number of carbon atoms as glucose instead of deoxyribose. Although genetic information can be stored by HNA, naturally occurring DNA polymerase cannot replicate HNA.

Which statements could explain why naturally occurring DNA polymerase cannot replicate HNA?

1. DNA polymerase cannot form bonds between the sugars of two HNA nucleotides.
2. DNA polymerase cannot form hydrogen bonds between two HNA nucleotides.
3. HNA nucleotides do not fit into the active site of DNA polymerase.
4. The shape of an HNA nucleotide is slightly larger than that of a DNA nucleotide.

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

13 Rifampicin is an antibiotic used to treat tuberculosis.

It works by inhibiting RNA polymerase in bacteria.

Which of these processes will be directly inhibited by this antibiotic?

1 ATP synthesis
2 transcription
3 translation

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

14 Transcription in eukaryotic cells results in the formation of pre-mRNA, which is made up of exons and introns.

Which of the following statements correctly describes what happens during the formation of mature mRNA from the pre-mRNA?

A The 5’ of the intron is cut, and joined to the branch-point sequence, followed by the cutting of the 3’ end to form the lariat loop.
B RNA splicing occurs, where all introns are recognised as they share highly similar sequences and are excised.
C RNA splicing occurs, where all the introns are excised and some of the exons joined together so that they can be transcribed.
D The addition of the 5’ cap and the 3’ poly-A tail occurs, followed by RNA splicing.

15 Electron micrographs may show large numbers of ribosomes forming chains along mRNA molecules.

What is the advantage of this arrangement, compared to when ribosomes appear singly on the mRNA?

A Different polypeptides can be produced simultaneously.
B Fewer tRNA molecules are required to translate the polypeptide.
C Large polypeptide chains can be produced.
D Polypeptides can be produced more rapidly.

16 In dogs, a gene on chromosome 27 is responsible for the curliness of the dog's hair. One form of this gene produces an enzyme with arginine at residues 151, but a mutant allele of the gene produces an enzyme which has cysteine at this point.

This latter form causes kinks in the keratin so that the coat is curlier. In heterozygotes, both alleles are co-dominant so an intermediate 'wavy' coat can be observed in the phenotype.

In this context, what is meant by gene mutation?

A change in the gene locus
B chromosome 27 inversion
C production of a new protein
D structural change in DNA

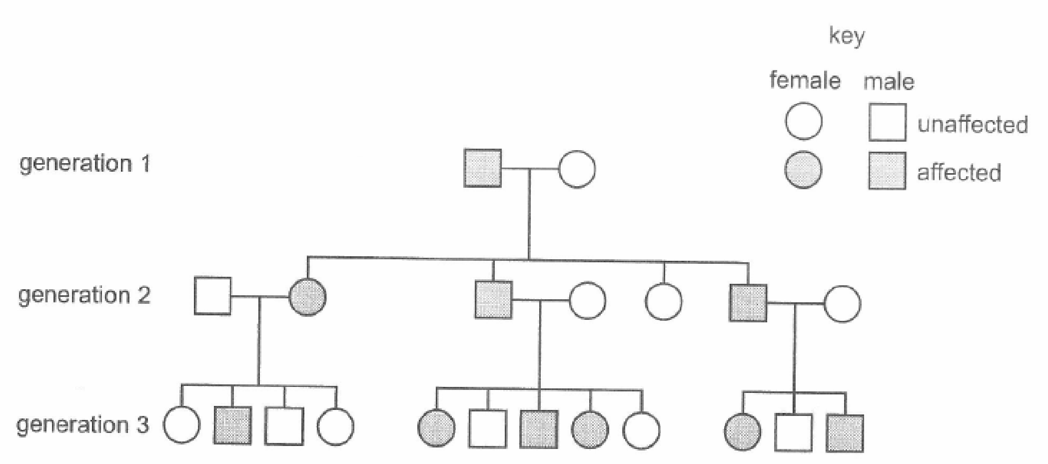
17 In mice, the allele for black hair colour (B) is dominant and brown hair colour (b) is recessive.

The agouti allele (A) causes banding on hairs so that the colour of the coat appears paler, black hair appears grey and brown hair appears beige. The recessive, non-agouti allele (a) gives a continuous pigment in the hairs so that the coat appears darker.

What would be the expected ratio of grey : beige : black : brown offspring if the parents had the genotypes Aabb and aaBb?

A 1 : 1 : 1 : 1
B 3 : 3 : 1 : 1
C 6 : 3 : 3 : 1
D 9 : 3 : 3 : 1

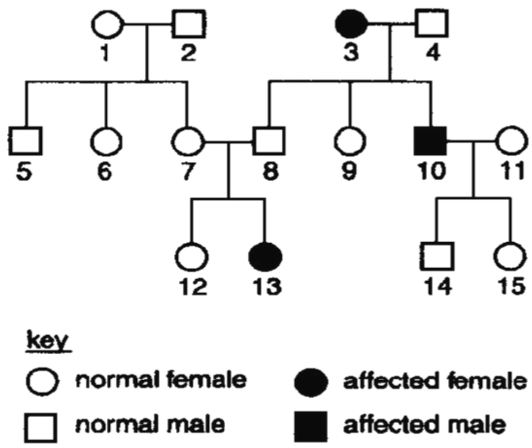
18 The pedigree shows the inheritance of a genetic condition in a family for three generations.



Which evidence indicates that this genetic condition is autosomal?

A Affected females always have affected sons.
B Affected males do not pass it on to their sons.
C Affected parents always have affected offspring.
D Males and females are equally affected.

19 The family tree shows the inheritance of a condition caused by the change in nucleotide sequence of gene **R**.



What is the probability that the first child is an affected girl when individual 7 mated with an affected male instead?

A 0
B 0.25
C 0.50
D 0.75

20 Stages of aerobic respiration are shown below.

1 Glycolysis
2 Citric acid cycle
3 Electron transfer chain

Which stage(s) involve(s) **both** phosphorylation of intermediates and generation of ATP?

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

21 The table below shows reactions occurring in a plant cell, and their respective locations.

	Reaction	**Location in a cell**
1	ribulose bisphosphate + CO_2 → glycerate-3-phosphate	Stroma
2	glucose + ATP → glucose-6-phosphate + ADP	Matrix
3	oxygen + $4H^+$ + $4e^-$ → 2 H_2O	Stroma
4	oxaloacetate + acetyl-CoA → citrate	Matrix

Which of the following is / are **incorrectly** matched?

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

22 Which statements help to explain the low yield of ATP from anaerobic respiration compared to aerobic respiration?

1 Energy in the chemical bonds of lactate can be obtained only after oxidation to pyruvate.

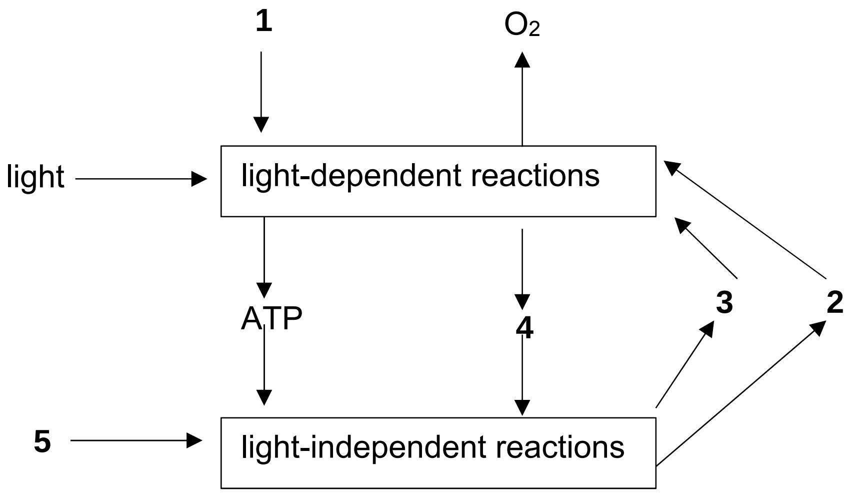
2 The electron transport chain is responsible for most of the transfer of chemical bond energy from glucose to ATP.

3 The decarboxylation of pyruvate in anaerobic respiration in yeast is not linked to ATP synthesis.

4 As a result of glycolysis, there is a net gain of only two molecules of ATP from each glucose molecule.

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

23 The diagram summarises the process of photosynthesis.



Which row identifies the reactants **1, 2, 3, 4** and **5**?

	1	2	3	4	5
A	Carbon dioxide	ADP + phosphate	reduced NAD	NAD	water
B	Carbon dioxide	reduced NAD	ADP + phosphate	NADP	water
C	water	NAD	reduced NAD	ADP + phosphate	Carbon dioxide
D	water	NADP	ADP + phosphate	reduced NADP	Carbon dioxide

24 Which of the following is **not** the consequence of natural selection?

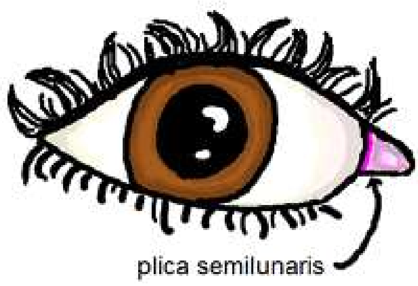
A The field mustard plant survived a summer drought in southern California because some individuals contained alleles that made them flower earlier. Plants with flowers wilt more easily than plants without flowers. Now, almost all the field mustard plants in California flower in spring.

B In areas with fewer predators of herbivorous insects, plants which produce higher concentrations of alkaloids (which are toxic to insects) dominated the landscape. Most of the herbivorous insects in these areas are found to be able to accumulate alkaloids in their bodies without affecting their metabolism.

C Endemic to New Zealand, the kakapo (a large flightless bird) had no natural predators before the humans arrived. They have evolved to have very few offspring throughout their entire lifespan. This phenomenon is also common for other island species which do not have natural predators in their respective habitats.

D Maple probably has the most variation in bark of any tree species. Japan experiences tornadoes which destroy large trees like the maple. Over the last few decades, it was observed that only the Japanese maple with dark-coloured bark remained.

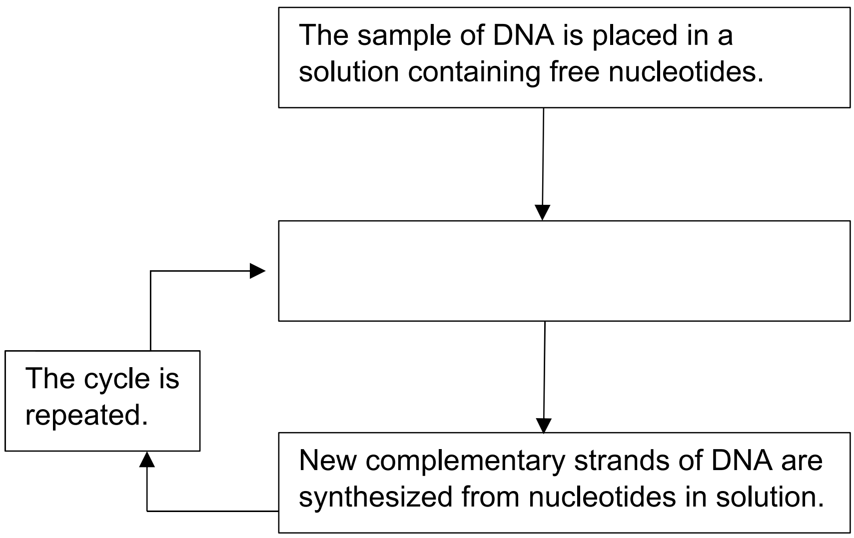
25 The plica semilunaris is a small fold of tissue on the inside corner of the eye. It is the vestigial remnant of the nictitating membrane, an organ that is fully functional in some other species of mammals. For example, in diving animals like beavers and manatees, the nictitating membrane is transparent and moves across the eye to protect it while under water.



Which of the following statements **least** explains the presence and structure of plica semilunaris in humans?

A Early ancestors of humans were not divers.
B Any presence of nictitating membrane in non-diving mammals posed a selective disadvantage for individuals who had it.
C Mutations occurred to reduce the size of nictitating membrane in humans to its present-day vestigial structure as there was no use for it.
D The genes involved in producing the plica semilunaris were inherited from a common ancestor shared by humans, beavers and manatees.

26 The polymerase chain reaction is summarised in the flowchart below.



Which statement completes the flow chart?

A Complementary strands of DNA are separated.
B Free nucleotides join on the end of DNA strands.
C Small sections of DNA are formed.
D Strands of DNA bind to RNA primers.

27 The statements are about restriction enzymes, which are naturally occurring molecules used in genetic engineering.

1 Restriction enzymes cut foreign DNA into smaller fragments.

2 Restriction enzymes are made by bacteria in response to bacteriophages.

3 Restriction enzymes cut DNA creating sticky ends.

4 Restriction enzymes cut at specific sequences of six nucleotides within the strands of a DNA molecule.

Which statements correctly describe the natural role of **all** restriction enzymes?

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

28 Some of the features of different types of stem cells are listed.

1 They are able to develop into all cell types of the body to form a whole organism
2 They can develop into a wide range of different types of cell
3 They have active telomerase enzyme
4 They can only develop into a limited range of cell types

Which of the following will be shown by embryonic stem cells?

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

29 The following statements are about genetically modified crops.

1 All crops, including genetically modified crops, are unnatural as they have been produced by artificial methods.

2 Genetically modified crops are produced by adding single genes.

3 Genetically modified crops can cross-fertilise with non-modified crops.

4 Genetically modified crops can be adapted to their environment.

5 Genetically modified crops can produced more quickly than selectively bred crops.

Which statements best support the view that genetically modified crops could help resolve world food shortages?

A 1 and 5
B 2 and 3
C 2 and 4
D 4 and 5

30 One type of genetically modified corn has

- a gene for the production of Bt toxin which protects the plant against a specific insect;
- a 'pat'-gene for tolerance to the herbicide 'Basta'. This gene is used to select plants with the Bt toxin gene;
- an 'amp'-gene which was introduced in the plant together with the Bt toxin gene. This gene gives resistance to the antibiotic ampicillin.

There is concern that the 'amp' gene may transfer to enterobacteria in the human intestine during nucleic acid digestion making treatment with ampicillin ineffective for diseases caused by enterobacteria.

Which statement explains why the transfer of this gene from the plant to bacteria in the human intestine is unlikely?

A An origin of replication and appropriate prokaryotic promoters are required for the 'amp' gene to be expressed.

B Bacteria cannot take up any DNA released during digestion of the plants by human nuclease enzyme, without the presence of a vector.

C 50% of the enterobacteria isolated from humans are 'amp' resistant.

D All plant DNA is digested and destroyed in the human intestine during digestion of plant cells by enzymes including human nuclease enzymes.

END OF PAPER

SAJC H1 PRELIM 2017 PAPER 1
ANSWER SCHEME

1	**B**	11	**B**	21	**C**
2	**A**	12	**D**	22	**A**
3	**D**	13	**C**	23	**D**
4	**A**	14	**A**	24	**D**
5	**D**	15	**D**	25	**C**
6	**B**	16	**D**	26	**A**
7	**B**	17	**A**	27	**B**
8	**B**	18	**D**	28	**C**
9	**A**	19	**B**	29	**D**
10	**C**	20	**A**	30	**D**

Civics Group	Index Number	Name (use BLOCK LETTERS)

H1

ST. ANDREW'S JUNIOR COLLEGE
2017 Preliminary Examination

H1 BIOLOGY **8875/2**

Paper 2: Core

Tuesday 12 September 2017 2 hours

Additional Materials: Answer Paper
Cover Sheet for Section B

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** the questions.

Section B
Compulsory question to be answered on writing paper provided.

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

For Examiner's Use	
Section A	
1	/16
2	/12
3	/12
Sub-total	/40
Section B	
4 or 5	/20
Total	/60

This document consists of **11** printed pages.

[Turn over

Section A

Answer **all** *questions*.

QUESTION 1

Hormones, insulin and glucagon, are proteins that regulate the concentration of blood glucose level. Type 2 diabetes is characterized both by insulin resistance, a condition in which various tissues in the body no longer respond properly to insulin action, and by subsequent progressive decline in beta (β)-cell function to the point that the cells can no longer produce enough additional insulin to overcome the insulin resistance. Researchers are actively exploring use of stem cells as a potential source of deriving new β-cells to treat type 2 diabetes.

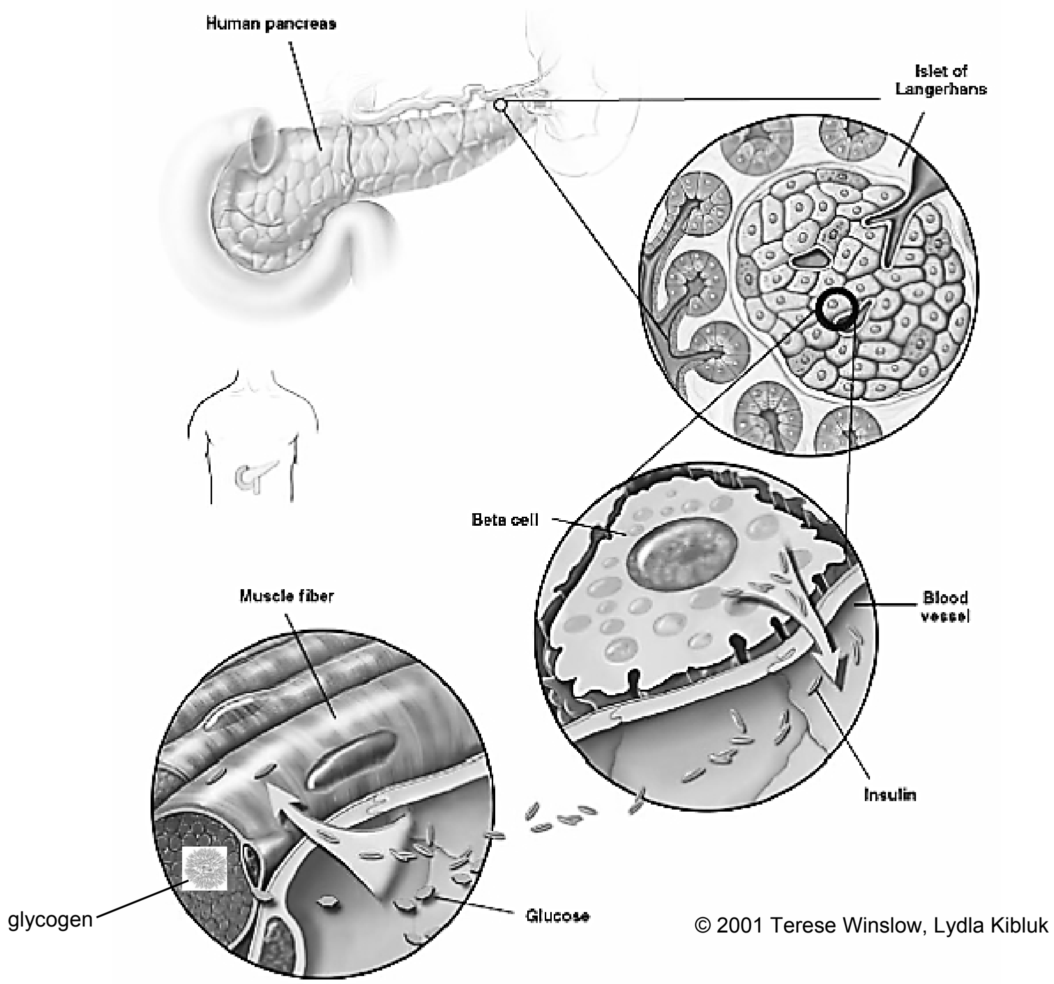


Fig. 1

The pancreas is located in the abdomen, adjacent to the duodenum (the first portion of the small intestine). A cross section of the pancreas shows the islet of Langerhans which is the functional unit of the endocrine pancreas. Encircled is the beta cell that synthesizes and secretes insulin. Beta cells are located adjacent to blood vessels and can easily respond to changes in blood glucose concentration by adjusting insulin production.

(a) Cells that secrete proteins contain a lot of rough endoplasmic reticulum (rER) and a large Golgi body.

(i) Describe how the rER is involved in the production of insulin.

…………………………………………………………………………………………
…………………………………………………………………………………………[1]

(ii) Describe how the Golgi body is involved in the secretion of insulin.

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…………………………………………………………………………………………[2]

(b) Using type II diabetes as an example, explain how environment affects phenotype.

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…………………………………………………………………………………………[3]

(c) Insulin binds to receptors on the membrane of the muscle cells allow entry of glucose into the muscle cells leading to a lowering of blood glucose concentration. Suggest how a change in the amino acid sequence of the receptor found in the plasma membrane of the muscle cell could make the cell resistant to insulin.

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…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………[2]

(d) Describe how phospholipids are arranged in a plasma membrane.

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…………………………………………………………………………………………………

……………………………………………………………………………………………[3]

(e) Phospholipids are a type of lipid. Lipids, in general, are made up of glycerol and fatty acids monomers covalently bonded together. Name the covalent bond and describe the breakage of this bond.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………[2]

Experiments have indicated that pancreatic stem cells (PSCs) can serve as sources of insulin secreting cells.

(f) State the source of PSCs and explain the PSCs' normal functions.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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……………………………………………………………………………………………[2]

(g) Suggest an advantage of using the patient's own PSCs to regenerate tissue or organs.

…………………………………………………………………………………………………

……………………………………………………………………………………………[1]

[Q1 Total: 16]

QUESTION 2

Epidermal growth factor (EGF) is released by cells, and is picked up either by the cell itself or by neighboring cells. It regulates the production of a number of proteins in target cells. Protein produced and its effect depends on the type of target cell.

Fig. 2 shows how EGF regulates 3 genes.

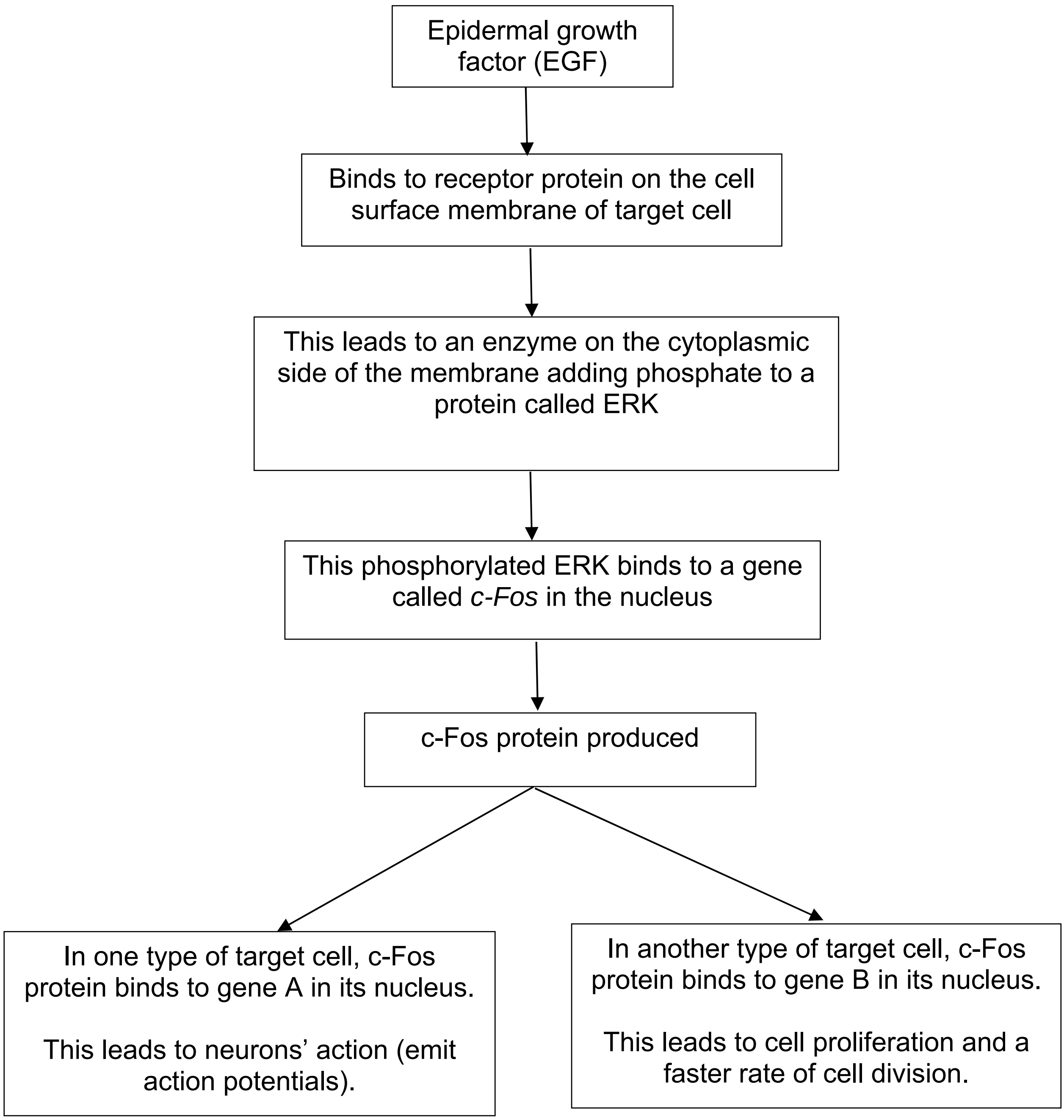

Fig. 2

(a) Name the **two** transcription factors in Fig. 2.

………………………………………………………………………………………………

………………………………………………………………………………………………[1]

(b) Dysregulation of checkpoints of cell division allows gene mutations, e.g. *c-Fos* gene, to occur spontaneously and accumulation of gene mutations can result in uncontrolled cell division and cancer.

(i) During which part of the cell cycle are gene mutations most likely to occur?

………………………………………………………………………………………[1]

(ii) Suggest an explanation for your answer in **(b)(i)**.

………………………………………………………………………………………

………………………………………………………………………………………[1]

(c) Gene B has been associated with a significant number of human cancers. Scientists used polymerase chain reaction (PCR) to make multiple copies of gene B extracted from a patient's cancer tissue sample.

The reaction mixture includes the sample of DNA to be copied plus the following ingredients:

- DNA primers
- buffer solution
- heat-stable DNA polymerase (Taq polymerase)
- deoxyribonucleoside triphosphates (deoxyATP, deoxyTTP, deoxyCTP and deoxyGTP)

(i) Suggest why a buffer needs to be present in the reaction mixture.

………………………………………………………………………………………..

………………………………………………………………………………………..[1]

(ii) The deoxyribonucleoside triphosphates that are added to the reaction mixture are the monomers used for making the new DNA strands.

Suggest **one further** reason for adding the deoxyribonucleoside triphosphates to the reaction mixture.

………………………………………………………………………………………..

………………………………………………………………………………………..[1]

(iii) In the first stage of PCR, the mixture is heated to a temperature of around 90^oC to denature the DNA. Suggest why high temperatures are needed to separate the two DNA strands.

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…………………………………………………………………………………………….[2]

(iv) At the end of several cycles of PCR, many copies of the DNA sample in the reaction mixture will have been made. The DNA samples are then separated out to produce a DNA banding pattern.

State the technique used to separate out the DNA samples **and** describe how this technique works.

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…………………………………………………………………………………………….[4]

(d) Methotrexate is a drug used in the treatment of cancer. It is a competitive inhibitor and affects the enzyme folate reductase.

Explain why this drug does not affect other enzymes.

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…………………………………………………………………………………………….[1]

[Q2 Total : 12]

QUESTION 3

(a) An example of an aquatic salamander, the olm, *Proteus anguinus*, is shown in the photograph below. This species is an amphibian endemic to the caves of Slovenia and Croatia.

Olms have a number of special adaptations: external gills as adults, undeveloped eyes, lack of skin pigmentation and a slow metabolic rate.

Magnification × 0.1

(i) Explain what is meant by the phrase 'endemic to the caves of Slovenia and Croatia'.

……………………………………………………………………………………………..

……………………………………………………………………………………………[1]

(ii) Olms evolved from small populations of amphibians that lived in caves. These caves became blocked off from other caves by rock barriers.

Suggest how natural selection could have led to the evolution of the olm.

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…………………………………………………………………………………………[5]

(b) A transgenic animal is one that carries a foreign gene that has been deliberately inserted into its genome. The foreign gene is constructed using recombinant DNA methodology. In addition to the gene itself, the DNA usually includes other sequences to enable it to be expressed correctly by the cells of the host.

Atlantic salmon (foreground) which normally grows in Spring and Summer was genetically modified to produce the Aquadvantage® salmon (background).

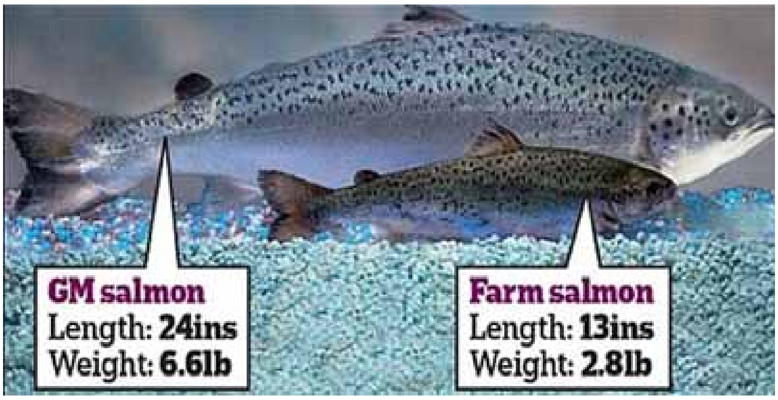

Fig.3.1

Credits : http://foreverconscious.com/wp-content/uploads/2014/04/gmo-salmon-compare.png

(i) Explain why the genetically engineered Aquadvantage® salmon (GM salmon) is considered a transgenic animal.

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…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(ii) Describe the **effect** of the genetic modifications carried out on the GM salmon.

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....[1]

(iii) Explain the significance of the transgenic GM salmon in solving the demand for food in the world.

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…..[1]

(iv) State one ethical and one environmental implications of GM salmon.

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....[2]

[Q3 Total : 12]

Section B

Answer **one** question.

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

Your answers must be in continuous prose, where appropriate.

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

4 **(a)** Explain what is meant by primary, secondary, tertiary and quaternary structure of haemoglobin. [10]

(b) Haemoglobin is a globular protein. Using a named example of fibrous protein, give **three** differences between fibrous and globular proteins. [3]

(c) Explain how the allele for haemophilia may be passed from a man to his grandchildren.

You may use genetic diagrams to support your answer. [7]

[Q4 Total: 20]

OR

5 **(a)** Describe the structure of a chloroplast. [6]

(b) Describe how, in photosynthesis, light energy is converted into chemical energy, in the form of ATP. [8]

(c) Outline the steps of the Calvin cycle. [6]

[Q5 Total: 20]

\- **END OF PAPER –**

Civics Group	Index Number	Name (use BLOCK LETTERS)

H1

ST. ANDREW'S JUNIOR COLLEGE
2017 Preliminary Examination

H1 BIOLOGY **8875/2**

Paper 2: Core (Mark Scheme)

Tuesday 12 September 2017 2 hours

Additional Materials: Answer Paper
Cover Sheet for Section B

READ THESE INSTRUCTIONS FIRST

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Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** the questions.

Section B
Compulsory question to be answered on writing paper provided.

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

For Examiner's Use	
Section A	
1	/16
2	/12
3	/12
Sub-total	/40
Section B	
4 or 5	/20
Total	/60

This document consists of 18 printed pages.

[Turn over

Section A

Answer **all** *questions*.

QUESTION 1

Hormones, insulin and glucagon, are proteins that regulate the concentration of blood glucose level. Type 2 diabetes is characterized both by insulin resistance, a condition in which various tissues in the body no longer respond properly to insulin action, and by subsequent progressive decline in beta (β)-cell function to the point that the cells can no longer produce enough additional insulin to overcome the insulin resistance. Researchers are actively exploring use of stem cells as a potential source of deriving new β-cells to treat type 2 diabetes.

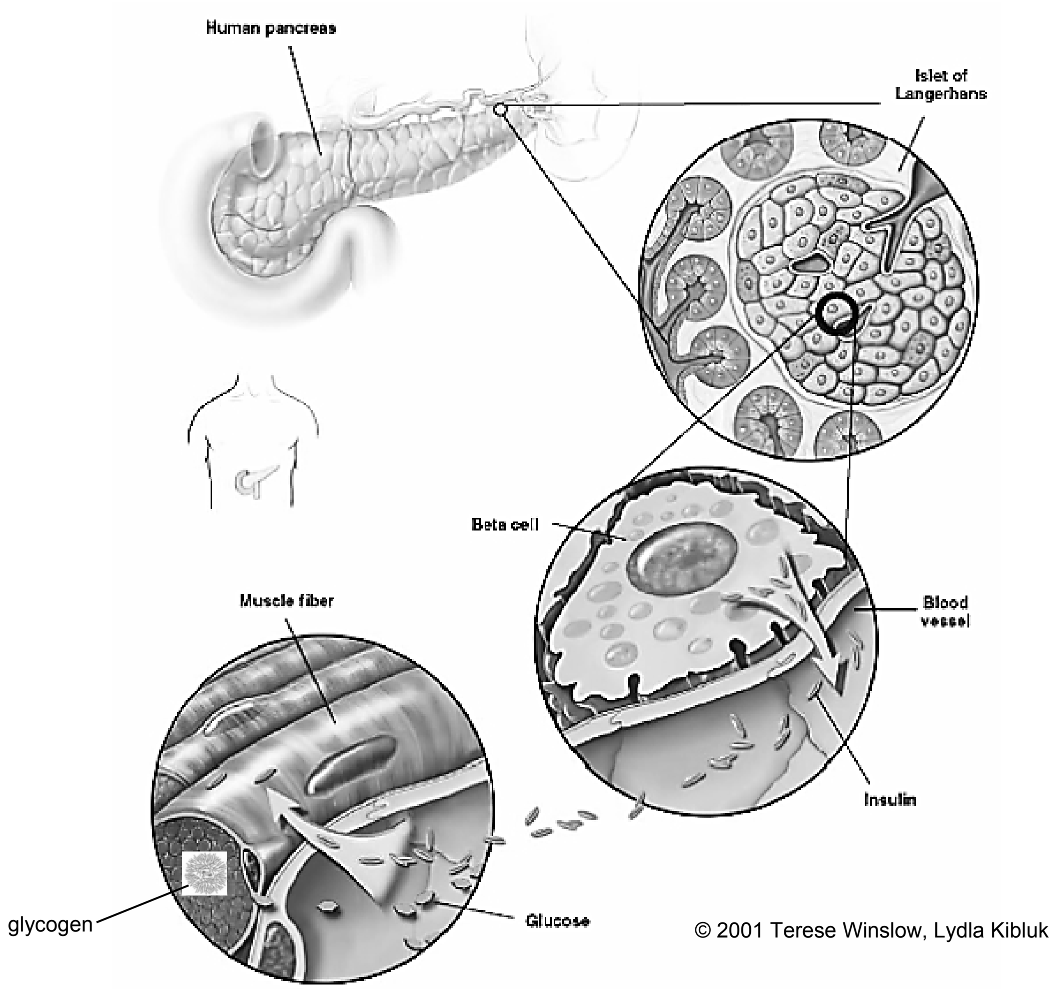

Fig. 1

The pancreas is located in the abdomen, adjacent to the duodenum (the first portion of the small intestine). A cross section of the pancreas shows the islet of Langerhans which is the functional unit of the endocrine pancreas. Encircled is the beta cell that synthesizes and secretes insulin. Beta cells are located adjacent to blood vessels and can easily respond to changes in blood glucose concentration by adjusting insulin production.

(a) Cells that secrete proteins contain a lot of rough endoplasmic reticulum (rER) and a large Golgi body.

(i) Describe how the rER is involved in the production of insulin.

…………………………………………………………………………………………………….[1]

1 (RER has) **bound** ribosomes for protein synthesis
[**REJECT**: make amino acid]
[ACCEPT: amino acids joined together / polypeptide]

2 **Chemical** modification / post-translational modification of polypeptide

Note:
Point 2 is accepted in view that students have not learnt about the processing of insulin in detail. Chemical modification of insulin e.g cleavage of pro-insulin to insulin is done in the Golgi body

(ii) Describe how the Golgi body is involved in the secretion of insulin.

…………………………………………………………………………………………………….[2]

1 (Golgi body) further chemically modifies (insulin) ;
2 **packages** (insulin) into **secretory vesicles** which **move towards the cell surface membrane** (and fuse with it, to release insulin out of the cell) ;

(b) Using type II diabetes as an example, explain how environment affects phenotype.

…………………………………………………………………………………………………….[3]

1 people with functional pancreas/with no type I diabetes have **functional genes which code for insulin release;**
(insulin is secreted when blood glucose level increases);
2 **overeating** of sugary foods for a long period of time causes repeated stimulation of the pancreas;
which responds by **secreting high levels of insulin**;
3 **repeated exposure** of target cells to large amounts of insulin **desensitizes** the cells' responsiveness to insulin;
4 result in the target cells **failing to take in glucose**; (blood glucose stays high) resulting in type II diabetes;

(c) Insulin binds to receptors on the membrane of the muscle cells allow entry of glucose into the muscle cells leading to a lowering of blood glucose concentration. Suggest how a change in the amino acid sequence of the receptor found in the plasma membrane of the muscle cell could make the cell resistant to insulin.

…………………………………………………………………………………………………….[2]

[Max 1]

1 Different amino acid sequence lead to different interactions between R groups of amino acids,
2 leading to **different tertiary structure** / **three-dimensional** structure (of receptor) ;

[Compulsory]
3 (so insulin) does not fit / bind / is not complementary ;
[**REJECT**: any reference to ‘active site’, ‘enzyme-substrate complex’ or insulin not fitting/binding to an enzyme]

(d) Describe how phospholipids are arranged in a plasma membrane.
…………………………………………………………………………………………………[3]
1 (phospholipid molecules arranged as a) bilayer ; [**ACCEPT** : double layer]
2 Polar phosphate head / charged phosphate group (of phospholipid molecules) faces outwards and interacts with aqueous medium of the external environment and the cytoplasm ;
3 Non-polar hydrocarbon chains of fatty acids in phospholipid molecules form the interior of the plasma membrane / cell membrane / cell surface membrane ;

(e) Phospholipids are a type of lipid. Lipids, in general, are made up of glycerol and fatty acids monomers covalently bonded together. Name the covalent bond and describe the breakage of this bond.
…………………………………………………………………………………………………[2]
1 ester bond ; [Reject: ester]
2 Addition of 1 water molecule across each ester bond (via hydrolysis reaction) ;
3 Products of hydrolysis are the **hydroxyl group (-OH) in the glycerol molecule** and the **carboxyl group (-COOH) of a fatty acid** ;

Experiments have indicated that pancreatic stem cells (PSCs) can serve as sources of insulin secreting cells.

(f) State the source of PSCs and explain the PSCs’ normal functions.
…………………………………………………………………………………………………[2]
1 Pancreas ;
2 Give rise to pancreatic cells, to growth, **repair and maintenance** of pancreatic tissues.

(g) Suggest an advantage of using the patient’s own PSCs to regenerate tissue or organs.
…………………………………………………………………………………………………[1]
1 No immune response (to own tissue)
/ tissue will not be rejected
[Reject: “cells will not be rejected” as context is on tissue regeneration]

[Q1 Total: 16]

QUESTION 2
Epidermal growth factor (EGF) is released by cells, and is picked up either by the cell itself or by neighboring cells. It regulates the production of a number of proteins in target cells. Protein produced and its effect depends on the type of target cell.

Fig. 2 shows how EGF regulates 3 genes.

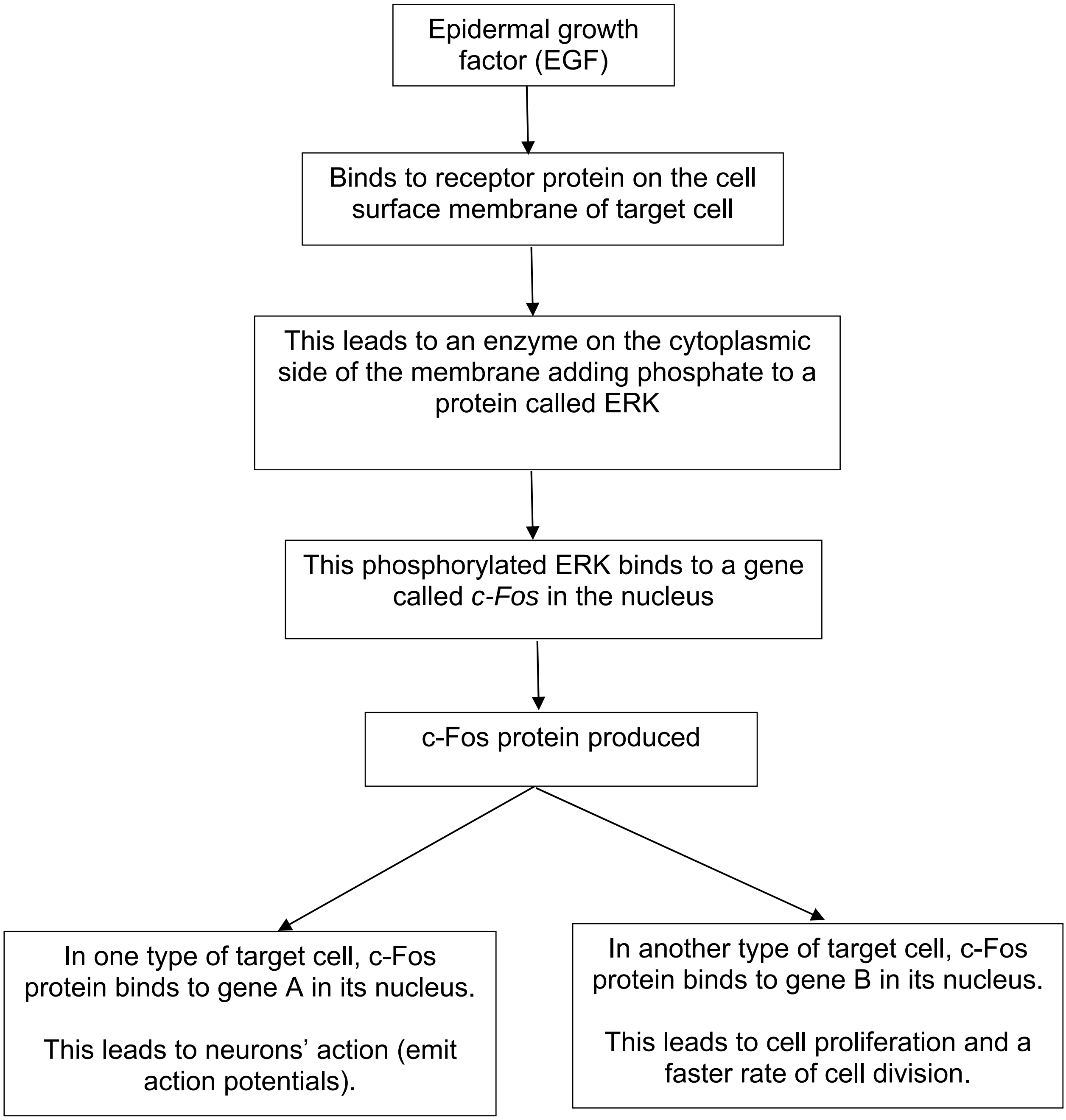

Fig. 2

(a) Name the **two** transcription factors in Fig. 2.

……………………………………………………………………………………………………[1]

1 Phosphorylated ERK ; AND
c-Fos (protein)

(b) Dysregulation of checkpoints of cell division allows gene mutations, e.g. *c-Fos* gene, to occur spontaneously and accumulation of gene mutations can result in uncontrolled cell division and cancer.

(i) During which part of the cell cycle are gene mutations most likely to occur?

……………………………………………………………………………………………[1]

1 S phase of interphase ;

(ii) Suggest an explanation for your answer in **(b)(i)**.

……………………………………………………………………………………………[1]

1 DNA replication via semi-conservative replication ;

(c) Gene B has been associated with a significant number of human cancers. Scientists used polymerase chain reaction (PCR) to make multiple copies of gene B extracted from a patient's cancer tissue sample.

The reaction mixture includes the sample of DNA to be copied plus the following ingredients:

- DNA primers
- buffer solution
- heat-stable DNA polymerase (Taq polymerase)
- deoxyribonucleoside triphosphates (deoxyATP, deoxyTTP, deoxyCTP and deoxyGTP)

(i) Suggest why a buffer needs to be present in the reaction mixture.

……………………………………………………………………………………………………[1]

1 to control the pH
/ to stop the polymerase denaturing
/ to optimise pH for polymerase activity

(ii) The deoxyribonucleoside triphosphates that are added to the reaction mixture are the monomers used for making the new DNA strands.

Suggest **one further** reason for adding the deoxyribonucleoside triphosphates to the reaction mixture.

……………………………………………………………………………………………………[1]

1 *Ideas that* it is a source of energy / AW ;
(hydrolysis of the dATP to dAMP and PP release energy which is used in the catalysis of phosphodiester bonds in the polynucleotide chain)

(iii) In the first stage of PCR, the mixture is heated to a temperature of around 90^{o}C to denature the DNA. Suggest why high temperatures are needed to separate the two DNA strands.

……………………………………………………………………………………………….…[2]

1 *Idea of* <u>many</u> hydrogen bonds between **complementary** strands together ;
2 Hydrogen bonds break because of increased <u>kinetic energy</u> / vibrations ;

(iv) At the end of several cycles of PCR, many copies of the DNA sample in the reaction mixture will have been made. The DNA samples are then separated out to produce a DNA banding pattern.

State the technique used to separate out the DNA samples **and** describe how this technique works.

……………………………………………………………………………………………….…[4]

1 <u>Gel</u> **electrophoresis** ;
2 **Load** (10 μl of) sample into the **wells** in agarose **gel** ;
Gel electrophoresis conducted at 100V till tracking dye move to ¾ length of gel
3 **DNA is negatively-charged** due to negatively-charged sugar-phosphate backbone **move towards the positively-charged electrode**
4 through an agarose matrix which acts as a **molecular sieve** ;
5 DNA fragments separated by size ; where shorter DNA fragments move faster [Reject: further] than longer ones;

(d) Methotrexate is a drug used in the treatment of cancer. It is a competitive inhibitor and affects the enzyme folate reductase.

Explain why this drug does not affect other enzymes.

……………………………………………………………………………………………[1]

1 Methotrexate / drug is only similar shape to specific substrate / only fits this active site;

OR

Methotrexate / drug is a different shape to other substrates / will not fit other active sites;

[Q2 Total : 12]

QUESTION 3

(a) An example of an aquatic salamander, the olm, *Proteus anguinus*, is shown in the photograph below. This species is an amphibian endemic to the caves of Slovenia and Croatia.

Olms have a number of special adaptations: external gills as adults, undeveloped eyes, lack of skin pigmentation and a slow metabolic rate.

Magnification × 0.1

(i) Explain what is meant by the phrase 'endemic to the caves of Slovenia and Croatia'.

....[1]

1 they are { found only in Slovenia and Croatia / not found in other countries / only found in these caves } ;

(ii) Olms evolved from small populations of amphibians that lived in caves. These caves became blocked off from other caves by rock barriers.

Suggest how natural selection could have led to the evolution of the olm.

....[5]

1 Genetic variation exists within the olm population (due to mutation)

2 Different selection pressures / different ecological niches available in different parts of the cave ; such as different types of food available;

3 description of a beneficial characteristic
/ e.g. undeveloped eyes as the cave is dark allows olm to develop its other senses to ensure its survival ; etc

4 Individuals with a selective advantage in the cave **survived** till reproductive age **and reproduce**; and

5 pass on their advantageous/beneficial alleles to their offspring;

6 Over many generations, allele frequencies change and olms with external gills as adults, undeveloped eyes, lack of skin pigmentation and a slow metabolic rate, became the predominant phenotype.

(b) A transgenic animal is one that carries a foreign gene that has been deliberately inserted into its genome. The foreign gene is constructed using recombinant DNA methodology. In addition to the gene itself, the DNA usually includes other sequences to enable it to be expressed correctly by the cells of the host.

Atlantic salmon (foreground) which normally grows in Spring and Summer was genetically modified to produce the Aquadvantage® salmon (background).

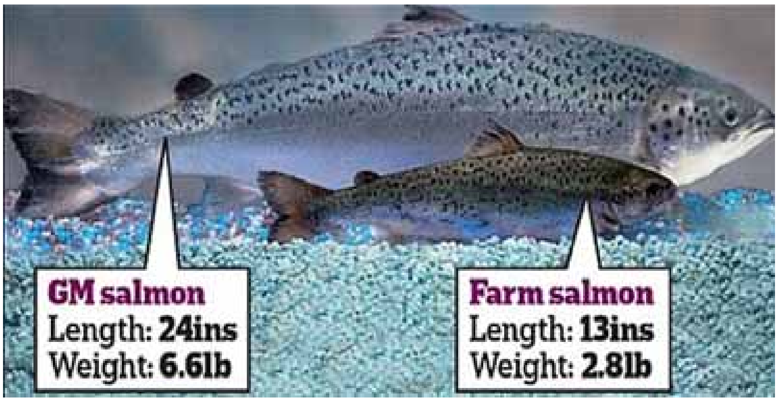

Fig.3.1

Credits : http://foreverconscious.com/wp-content/uploads/2014/04/gmo-salmon-compare.png

(i) Explain why the genetically engineered Aquadvantage® salmon (GM salmon) is considered a transgenic animal.

……………………………………………………………………………………[2]

1 Active growth hormone gene from <u>Pacific Chinook salmon</u> ;
2 Combined with regulatory sequences / promoter of the <u>ocean pout</u> ;
3 Inserted into genome of fertilized Atlantic salmon eggs ;

(ii) Describe the **effect** of the genetic modifications carried out on the GM salmon.

……………………………………………………………………………………[1]

1 GM salmon produces higher levels of fish growth hormone ;
Accelerated growth rate of fish ;
/ Reaches its desired market length in a shorter period of time ;
[REJECT] GM salmon grows to larger size

(iii) Explain the significance of the transgenic GM salmon in solving the demand for food in the world.

……………………………………………………………………………………[1]

1 Increased yield ; grow to its full length in a shorter period of time
/ More fish can be harvested in a year ;
/ Allows salmon to grow all year around (instead of only during Spring and Summer).

(iv) State one ethical and one environmental implications of GM salmon.
……………………………………………………………………………………..[2]

Disruption of ecological balance [Environmental]

1 Ecological balance is disrupted
Accidental release of transgenic organisms into the environment might upset the balance of the ecosystem.

2 Fast-growing salmon may outcompete the wild salmon population and affect the food chain.

3 Larger transgenic salmon may be preferably selected as mates over smaller wild types.

4 Danger that the active growth hormone gene is transferred to other fish.

AND

Animal rights issue [Ethical]

1 Animal rights – GM animals may suffer unnecessarily;

- Eg. Increased use of the growth hormone may have harmful effects on fish health .

[Q3 Total : 12]

Section B

Answer one question.

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

Your answers must be in continuous prose, where appropriate.

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

4 **(a)** Explain what is meant by primary, secondary, tertiary and quaternary structure of haemoglobin. [10]

(b) Haemoglobin is a globular protein. Using a named example of fibrous protein, give **three** differences between fibrous and globular proteins. [3]

(c) Explain how the allele for haemophilia may be passed from a man to his grandchildren.

You may use genetic diagrams to support your answer. [7]

[Q4 Total: 20]

OR

5 **(a)** Describe the structure of a chloroplast. [6]

(b) Describe how, in photosynthesis, light energy is converted into chemical energy, in the form of ATP. [8]

(c) Outline the steps of the Calvin cycle. [6]

[Q5 Total: 20]

\- **END OF PAPER –**

QUESTION 4(a)
Explain what is meant by primary, secondary, tertiary and quaternary structure of haemoglobin. [10]

Primary structure (max 2)
1 Refers to the type, <u>number</u> and <u>sequence</u> of amino acids in a linear polypeptide chain ;
2 making up each haemoglobin polypeptide (individual α and β subunits)
3 ref (each α-chain is) <u>141</u> amino acids long and (each β-chain is) <u>146</u> amino acids long
4 <u>Peptide bond</u> involved in joining all amino acid monomers together

Secondary structure (max 2)
5 Refers to the folding of the polypeptide into regular structures
6 α-helices / coiling of polypeptide chain into a regular helical conformation.
7 hydrogen bonds formed between the –CO group of peptide bond on one amino acid and the –NH group on peptide bond of another amino acid

Tertiary structure (max 3)
8 the folding of the polypeptide chain into its unique 3-dimensional shape;
ref. globular shape of haemoglobin
9 Amino acids far away in primary structure are brought close together (by R group interaction);
10 Non-polar/hydrophobic (side chains of) amino acids are buried in the interior;
Polar and charged/hydrophilic (side chains of) amino acids are on the surface;
11 Bonds involved include hydrophobic interactions, hydrogen bonds and ionic bonds
between R groups of amino acids within each polypeptide chain

Quaternary structure (max 3)
12 Refers to the arrangement of the polypeptide subunits within a protein that is made up of more than one polypeptide chain
/ spatial arrangement of more than one polypeptide chain
13 Association of prosthetic haem group per subunit to form a conjugated polypeptide ;
14 ref. to the association of 2α and 2β subunits to form functional haemoglobin molecule
15 Bonds involved include hydrophobic interactions, hydrogen bonds and ionic bonds
between R groups of amino acids in the four subunits

Teachers' comments:
It is important to state the definitions of each level of folding and tailor your points to the haemoglobin case study. Note that disulfide bonds are not present in haemoglobin.

QUESTION 4(b)
Haemoglobin is a globular protein. Using a named example of fibrous protein, give three differences between fibrous and globular proteins. [3]

	Fibrous	Globular
1	Collagen – structural protein	Haemoglobin - transport protein
2	insoluble / large	Soluble / small
3	Primary, (mainly) secondary, and quaternary structure, no tertiary structure	Primary, secondard, tertiary and quaternary structure
4	Repeated amino acid sequences / ref. gly-X-proline or gly-X-hydroxyproline motif	Little repetition

QUESTION 4(c)
Explain how the allele for haemophilia may be passed from a man to his grandchildren. You may use genetic diagrams to support your answer. [7]

1 (haemophilia) allele on X chromosome / X-linked inheritance ;
2 <u>allele</u> recessive ;
3 man, / homogametic / has one X chromosome
4 one Y chromosome (which does not have blood clotting allele) ;
[ACCEPT symbol: X^H and X^h explained]
5 Only daughter(s) get his X chromosome ;
[ACCEPT symbol: X^HX^h ; mother is normal and not a carrier]
6 Grandson(s) has 50% chance of carrying (haemophilia) allele ;
[ACCEPT symbol: X^HY **and** X^hY]
7 Granddaughter(s) has 50% chance of carrying (haemophilia) allele ;
[ACCEPT symbol: X^HX^H **and** X^HX^h or X^hX^h]

QUESTION 5(a)
Describe the structure of a chloroplast. **[6]**

1. double membrane ;
2. stroma ;
3. contains enzymes ; named enzyme, e.g. rubisco (Calvin cycle);
4. also sugars / lipids / starch ;
5. 70S ribosomes ;
6. Circular DNA ;
7. Internal membrane system consisting of stacks of thylakoids called grana interconnected via intergranal lamella ;
8. (grana) membranes hold, photosynthetic pigments / ATP synthase / ETC (electron transport chain) ;
9. Size : 3 – 10 μm

QUESTION 5(b)
Describe how, in photosynthesis, light energy is converted into chemical energy, in the form of ATP. [8]

1 Light energy absorbed by chlorophyll / pigments in photosystems ;
2 energy transferred from light harvesting complexes til it reaches special chlorophyll a in reaction centre ;
3 electron, excited and captured by primary electron acceptor ;
4 electron passes along, chain of electron carriers / ETC ; of decreasing energy level ;
5 energy released used to pump protons ;
from stroma into thylakoid space ;
6 thylakoid membrane impermeable to protons ;
7 proton gradient formed ;
8 protons move down gradient through ATP synthase ;
9 ATP produced from ADP and Pi ;

QUESTION 5(c)
Outline the steps of the Calvin cycle. [6]

1 RuBP (Ribulose bisphosphate) combines with carbon dioxide ;
2 catalysed by **rubisco (ribulose bisphosphate carboxylase)** ;
3 forms unstable 6C compounds which produced two molecules of phosphoglycerate (PGA) ;
4 PGA conveted to phosphoglyceraldehyde (PGAL) ;
5 using reduced NADP and ATP (from light dependent stage / photophosphorylation) ;
6 some PGAL used to regenerate RuBP ;
7 using ATP ;
8 (one) PGAL (exit Calvin cycle) to form hexose / carbohydrates

Prep list for Prelim Practical 2017

For Question 1

Per student

Item	Quantity	Remarks
0.5% Starch suspension*	15 cm^3	Starch powder mixed with cold water, unboiled.
1% Amylase + 1% albumin	15 cm^3	Prepare separately as 1% solutions then mix together and labelled as “Solution X”.
Iodine*	1:10 dilution, 10 ml	In amber dropping bottle
5ml syringes*	4	
Plastic droppers*	4	
test-tubes*	5	
Plastic vials*	4	
Black card*	1	10cm by 10cm
White tile	1	
Aqueous copper sulfate solution	1 dropping bottle	
Diluted sodium hydroxide	1 dropping bottle	
Microscope slides	3	
Ethanol (denatured) solution	1 dropping bottle	
500ml beaker	1	
Plastic 500ml beaker	1	
Bunsen burner	1	
Tripod stand & wire gauze	1 set	
Spotting tile	1	
test-tube rack	1	
Stop watch	1	
Label stickers	14	
Hand lens	1	
Paper towel	3	
Lighter	1	
Hot water at side bench	-	

* items to be changed per shift

For Question 2

Per student

Item	Quantity	Remarks
Microscope with ×10 eyepiece and ×40 objective lenses	1	
M16390/5 Slide **E**	1	Each slide contains 3 different samples (Mesophytic, hydrophytic, xerophytic leaf)

TEMASEK JUNIOR COLLEGE
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JC 2/ IP YEAR 6 2017

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CENTRE NUMBER	S					INDEX NUMBER		
CLASS	C	G			/	1	6	

H1 BIOLOGY

8875/01

Paper 1 Multiple Choice

Monday 18 September 2017
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and index number on the Answer Sheet in the spaces provided unless this has been done for you.

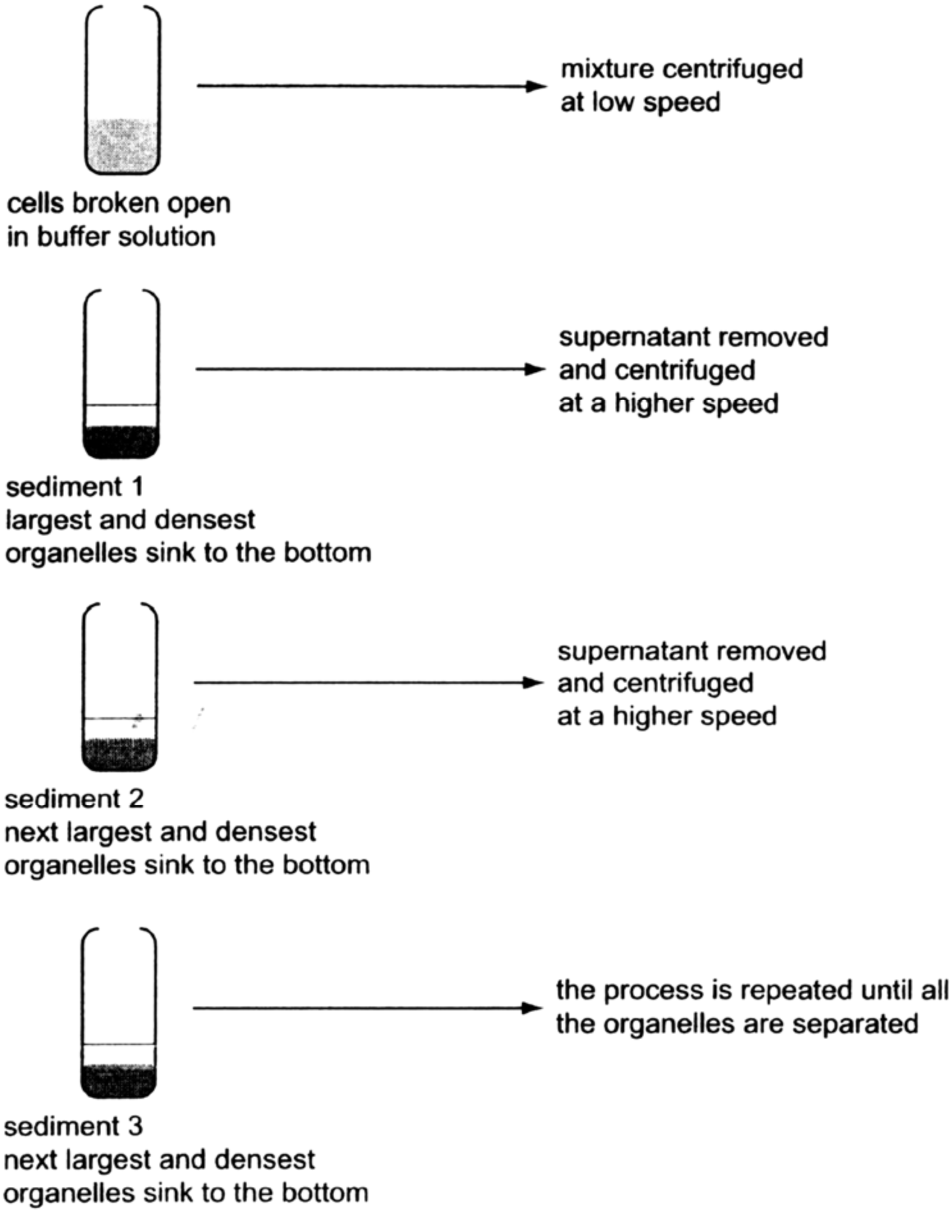
There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the one you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.

Read the instructions on the Multiple Choice Answer Sheet very carefully.

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

This document consists of **16** printed pages.

1 Fractionation is used to separate plant cell components of a leaf extract according to their size and density. The diagram shows the main steps in fractionation.

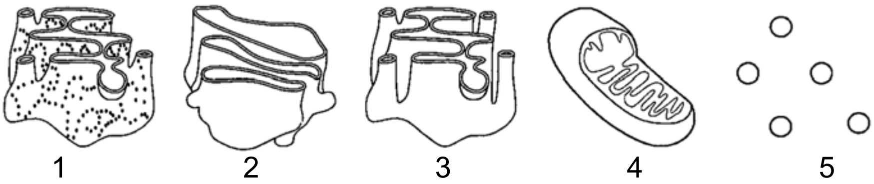


DCPIP and buffer solution were added to each sediment and the mixtures were left in the light for fifteen minutes. When DCPIP is reduced, it will turn from blue to colourless.

Which sediment(s) will cause DCPIP to be colourless?

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

2 The diagram shows five different structures that can be observed in cells.



Which structures would be present in large quantities in a cell that is actively synthesising the following molecules?

	Extracellular glycolipids	Proteins
A	1, 4, 5	3, 4, 5
B	1, 3, 4, 5	1, 2, 4, 5
C	2, 3, 4, 5	1, 2, 4, 5
D	2, 3, 4, 5	1, 3, 4, 5

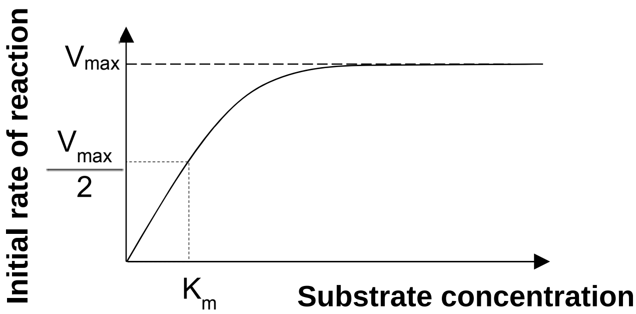
3 Keratin is a fibrous protein in skin, hair and nails. The features of one form of keratin are listed.

1 The peptide chain has mainly small amino acid residues.
2 Each peptide chain forms an α-helix.
3 Two helices coil together.
4 Covalent bonds link adjacent helices.

Which features are the same in collagen molecule?

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

4 The value K_m is the substrate concentration at which the rate of an enzyme-catalysed reaction is half its maximum rate, $\frac{Vmax}{2}$. The K_m was measured in the presence of a competitive inhibitor and a non-competitive inhibitor.



How will the value of K_m be affected in the presence of inhibitors?

	value of K_m in presence of	
	competitive inhibitor	non-competitive inhibitor
A	less	less
B	less	more
C	more	less
D	the same	more

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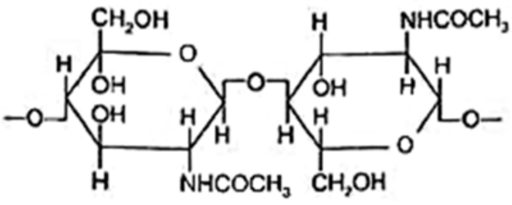
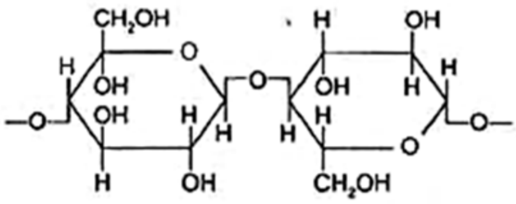
5 The diagrams show short sections of some common polysaccharides and modified polysaccharides.



1



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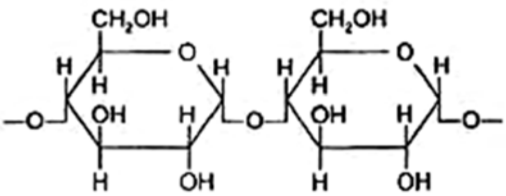
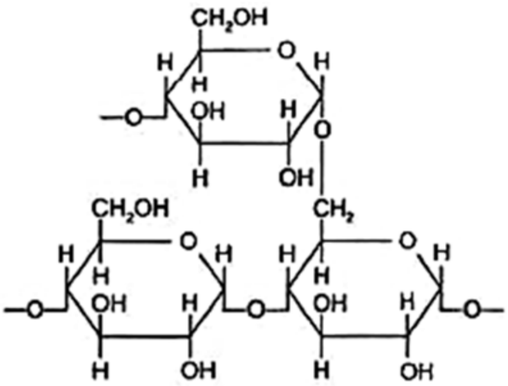


3



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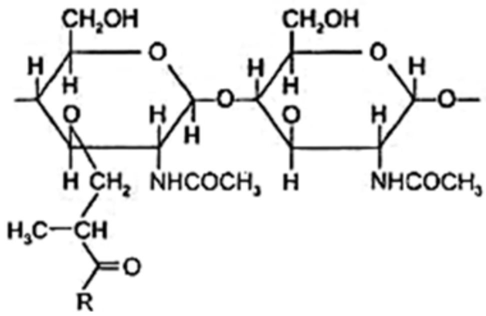


5

The polysaccharides can be described as below.

- polysaccharide F is composed of β-glucose monomers with 1,4 glycosidic bonds
- polysaccharide G is composed of α-glucose monomers with 1,4 and 1,6 glycosidic bonds
- polysaccharide H is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β-1,4 glycosidic bonds
- polysaccharide J is composed of α-glucose monomers with 1,4 glycosidic bonds
- polysaccharide K is composed of N-acetylglucosamine monomers with β-1,4 glycosidic bonds

Which shows the correct pairings of polysaccharide descriptions and diagrams?

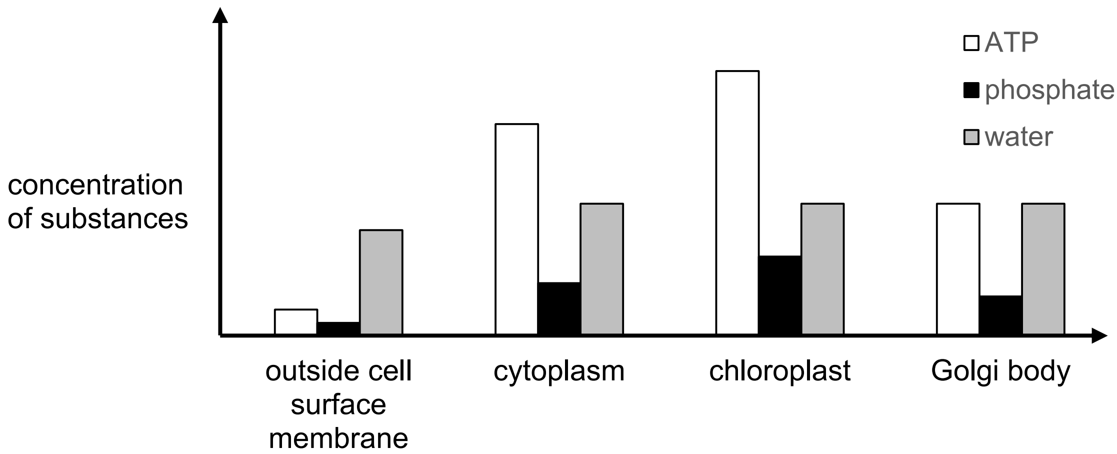
	polysaccharide F	polysaccharide G	polysaccharide H	polysaccharide J	polysaccharide K
A	2	4	5	3	1
B	2	5	4	1	3
C	3	4	1	2	5
D	3	5	4	1	2

6 Which of the following statement about membranes is correct?

1 All intracellular membranes in a eukaryotic cell have the same type of lipids and proteins.
2 The outer and inner membranes of mitochondria have the same type of transport proteins.
3 Carbohydrates form part of glycoproteins or glycolipids in the membranes.
4 All plant cell membranes have cholesterol.

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

7 The chart shows the concentration of some substances outside the cell surface membrane, in the cytoplasm, in the chloroplast and in the Golgi body of a plant cell.



Which statement about the direction of movement of these substances and the process by which they are moving is correct?

A ATP is leaving the chloroplast by facilitated diffusion, water is leaving the plant cell by osmosis.
B Phosphate and ATP are entering the chloroplast and Golgi body by active transport.
C Phosphate and ATP are leaving the Golgi body by facilitated diffusion, water is leaving the plant cell by osmosis.
D Phosphate is entering the chloroplast by facilitated diffusion, water is entering the chloroplast by osmosis.

8 No crossing over occurs during meiosis in male fruit flies of the species *Drosophila melanogaster.*

The diagram shows the four pairs of homologous chromosomes present in a testis cell of a male fly.

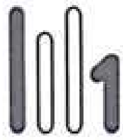
Which set of chromosomes in a gamete nucleus shows the genetic variation resulting from independent assortment?

A

B

C

D



9 What is the role of stem cells with regards to the function of adult tissues and organs?

A Stem cells are fully differentiated cells that reside under the surface of epithelial tissue, in position to take over the function of the tissue when the overlying cells become damaged or worn out.

B Stem cells are totipotent cells that divide asymmetrically, giving rise to one daughter cell that remains a stem cell and one daughter cell that will differentiate to replace damaged and worn out cells in the adult tissue or organ.

C Stem cells are embryonic cells that persist in the adult, and can give rise to all of the cell types in the body.

D Stem cells are cells that have yet to express the genes and produce proteins characteristic of their differentiated state, but do so when needed for repair of tissues and organs.

10 A gene coding for an ion channel consists of 249 999 base pairs, which have 26 introns and 27 exons. During mRNA processing, a final transcript of 3570 bases is left.

How many additional amino acids would have been needed had the gene not contained introns?

A 82 143

B 83 324

C 83 333

D 83 342

11 Antibiotics are used to kill pathogens that infect people, without causing damage to human cells.

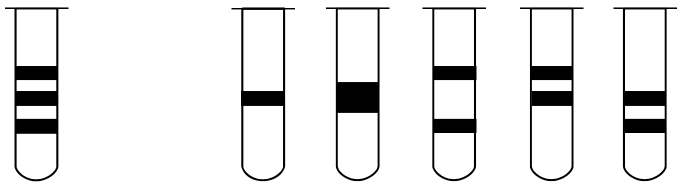
Different antibiotics work in different ways.

- Erythromycin binds to bacterial ribosomes.
- Nystatin binds to ergosterol which replaces cholesterol in pathogenic fungi.
- Rifampicin binds to bacterial RNA polymerase.
- Ciprofloxacin binds to DNA topoisomerase (enzyme that removes supercoiling of DNA).

Which antibiotic directly inhibits the following process in pathogens?

	Membrane formation	DNA replication	Transcription	Translation
A	rifampicin	ciprofloxacin	erythromycin	nystatin
B	rifampicin	nystatin	erythromycin	ciprofloxacin
C	nystatin	ciprofloxacin	rifampicin	erythromycin
D	nystatin	rifampicin	ciprofloxacin	erythromycin

12 Cells of the bacterium *E. coli* were grown for many generations on a medium containing only the heavy isotope of nitrogen ^{15}N. The cells were then transferred to a medium containing only ^{14}N and grown for two generations. Samples of the bacteria were then removed from the culture. The DNA from each sample was extracted and centrifuged at very high speeds in a solution of caesium chloride. The diagram below illustrates the distribution of DNA in various centrifuge tubes, 1, 2, 3, 4 and 5.



Which of the centrifuge tube above would support the hypothesis of conservative and semi-conservative DNA replication?

	conservative replication	semi-conservative replication
A	4	2
B	2	3
C	3	4
D	5	1

13 Which of the following statement is correct?

1 Each nucleosome consists of DNA wound twice around a histone octamer, a protein core made up of 4 different types of histone proteins.
2 Negatively charged histones bind tightly to positively charged DNA via ionic attractions.
3 The 10nm fibre coils to form a 30nm chromatin fibre or solenoid.
4 The 8 nucleosomes assemble to form looped domains, which are attached to chromosome scaffolds.
5 The looped domains coil further to form highly condensed chromosomes during prophase.

A 1, 2, 3
B 1, 3, 5
C 1, 3, 4, 5
D 2, 3, 4, 5

14 In most organisms, six different triplets of the DNA strand that is complementary to mRNA code for the amino acid serine: AGA, AGG, AGT, AGC, TCA and TCG.

In the yeast *Candida albicans*, a seventh DNA triplet, GAC, also codes for serine. In most organisms, this triplet codes for leucine.

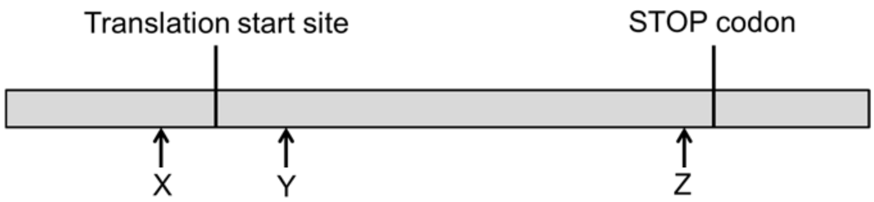
The diagram shows part of an mRNA molecule from *C. albicans*.

	AGU	UCG	CGG	UCA	AGC	ACC	UGG
codon number	11	12	13	14	15	16	17

Which mutation of the DNA that is complementary to this mRNA could result in *C. albicans* producing a polypeptide with a continuous sequence of five serines in it?

A substituting a purine with a pyrimidine in the DNA coding for codon 13
B substituting a purine with a pyrimidine in the DNA coding for codon 16
C substituting a pyrimidine with a purine in the DNA coding for codon 13
D substituting a pyrimidine with a purine in the DNA coding for codon 16

15 During the process of transcription, errors sometimes occur such that certain nucleotides are repeated. The diagram shows a strand of mRNA produced from a particular gene.



Which of the following event will most likely lead to the synthesis of a non-functional protein?

A One base pair is inserted at **X**.
B Three base pairs are inserted at **X**.
C One base pair is inserted at **Y**.
D Three base pairs are inserted at **Z**.

16 The speech defect known as stuttering may involve two genes, **G** and **N**. Most people are homozygous for the alleles **g** and **n** and are not stutterers.

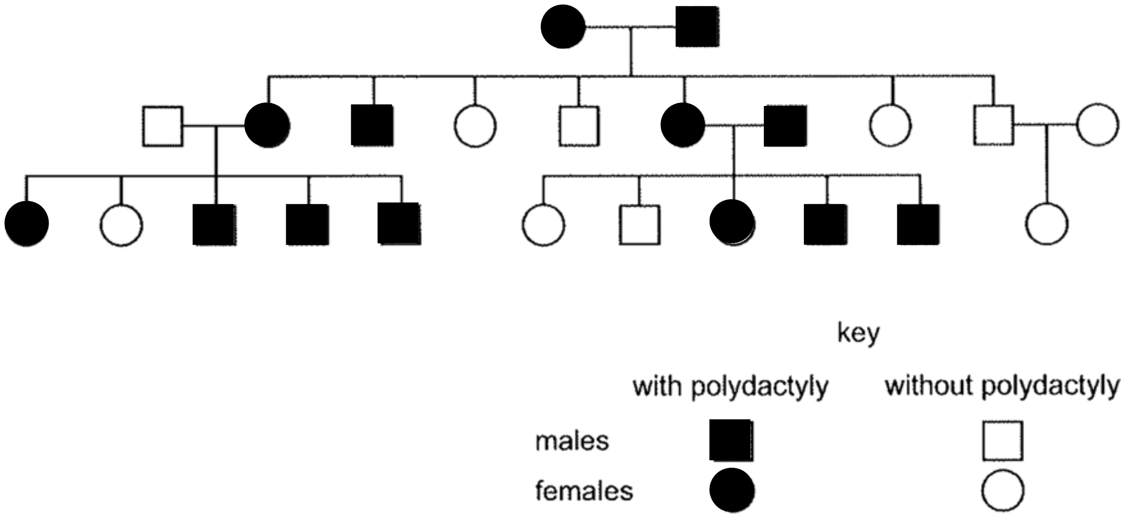
However, recent research has shown that the presence of either of the mutant alleles **G** or **N** can cause stuttering in heterozygotes.

Using this information, which proportion of the children of a couple, the father with genotype **Ggnn** and the mother **ggNn**, are likely to be stutterers?

A 3/16
B 8/16
C 9/16
D 12/16

17 Polydactyly is a genetic condition, controlled by a single gene, in which people are born with extra fingers and toes.

The diagram shows the pedigree of a family.



What is true about the inheritance of polydactyly?

	The allele coding for polydactyly is dominant	The allele coding for polydactyly is autosomal	Offspring of parents with polydactyly will all inherit the allele	More males than females will inherit the polydactyly allele
A	True	True	False	False
B	True	False	False	True
C	False	False	False	True
D	False	False	True	True

18 Which statement concerning chrysanthemum plants, of the genus *Dendranthema,* is a valid example of how the environment may affect the phenotype?

A Anthocyanins and anthoxanthins are vacuolar pigments, whereas xanthophylls and carotenes are pigments found in membrane-bound organelles known as plastids. These, together with molecules known as co-pigments, are responsible for the variation observed in petal colour in *Dendranthema.*

B Identical genetic crosses performed between varieties of *Dendrathema* result in a greater proportion of offspring plants with plastids exhibiting a yellow colour when grown in a field and a greater proportion of offspring plants with colourless plastids when grown in a glasshouse.

C The seeds of a cross between *Dendranthema weyrichii* and *Dendranthema grandiflora* produce plants that are far more frost-tolerant and exhibit an extended flowering season compared with both parent plants.

D The seeds of a cross between *Dendranthema weyrichii* (height varying between 12.5–15.0 cm) and *Dendranthema grandiflora* (height varying between 8.0–25.0 cm) produce plants, when grown in natural day length, of a height varying between 55.0–71.0 cm.

19 The pigment haemoglobin found in red blood cells of mammals and birds combines readily with oxygen.

DNA analysis has revealed that a form of haemoglobin is found in a wide range of unrelated phylogenetic groups including bacteria, annelids, anthropods and leguminous plants.

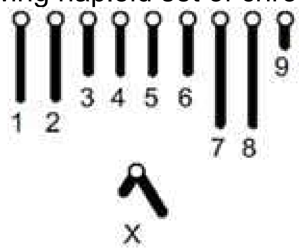
Which evolutionary processes could account for the distribution of haemoglobin in such a wide variety of organisms?

	adaptive radiation	conservation of genes	natural selection
A	✓	✓	✓
B	✓	✓	✗
C	✓	✗	✓
D	✗	✓	✓

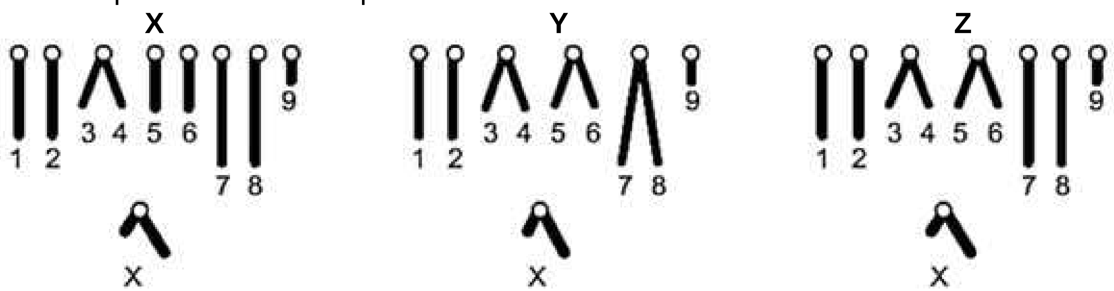
key
✓ true
✗ false

20 In some Australian insects, new species have arisen through changes that occurred to chromosomes in an ancestral species. Such changes may involve the joining of chromosomes, the loss of whole or parts of chromosomes, and rearrangement of the genetic material within chromosomes.

One ancestral species has the following haploid set of chromosomes.



Three new species have the haploid sets of chromosomes shown below.



What is the most likely order in which these species appear?

A ancestral species, species **Z**, species **X**, species **Y**.
B ancestral species, species **X**, species **Y**, species **Z**.
C ancestral species, species **Y**, species **X**, species **Z**.
D ancestral species, species **X**, species **Z**, species **Y**.

21 Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less that 1% of the population. However, by 2006, the proportion of males was almost 50% of the population.

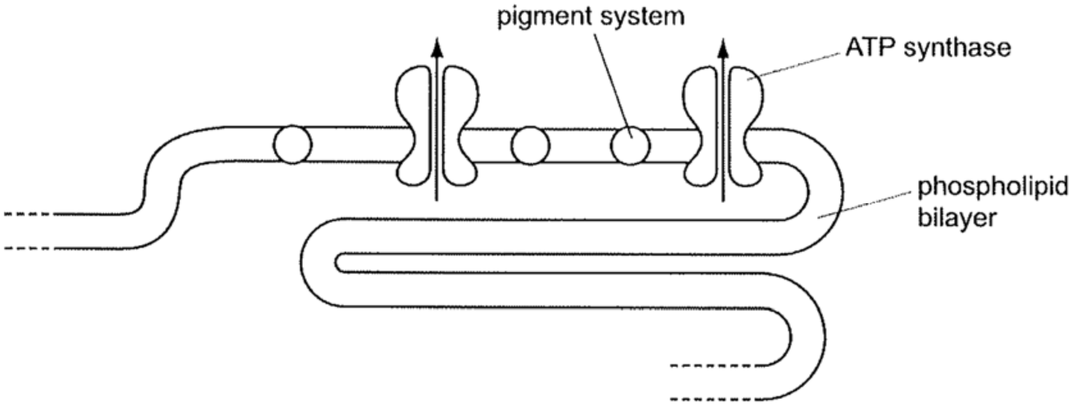
Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

1 *Wolbachia* acts as a selective agent.
2 The selective killing of male embryos is an example of artificial selection.
3 When infected with *Wolbachia,* male embryos that are homozygous for the recessive allele of the suppressor gene die.
4 All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.
5 The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

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

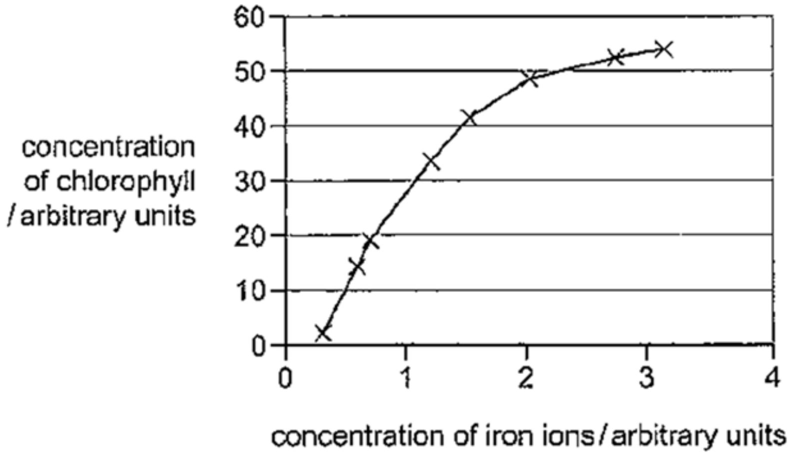
22 The diagram shows a small part of a thylakoid membrane. The arrows represent the movement of a particular reaction product through the ATP synthase.



From which chemical was this product derived from?

A NADH **B** NADPH **C** Oxygen **D** Water

23 The concentration of chlorophyll in the leaves of beetroot plants grown in increasing concentrations of iron ions was measured. The concentration of the breakdown products of chlorophyll was not determined. The graph shows the results.



What conclusions can be drawn from the results?

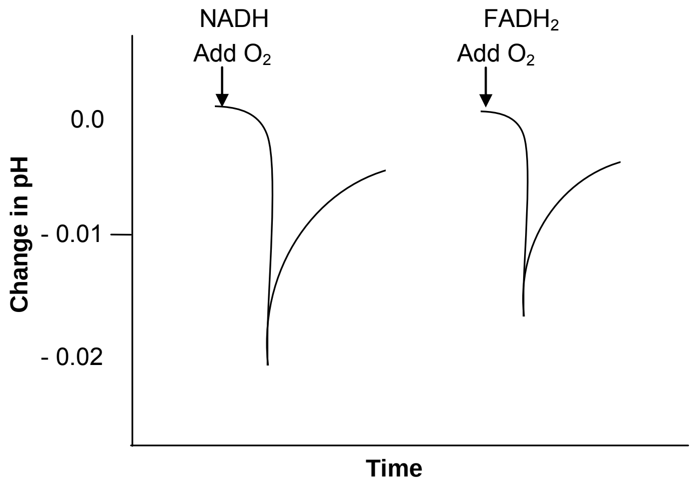
1 Concentration of chlorophyll was directly proportional to the concentration of iron ions.
2 Concentration of iron ions was a limiting factor for the production of chlorophyll.
3 Plants given a higher concentration of iron ions synthesised more chlorophyll.
4 Plants given a higher concentration of iron ions increased their rate of photosynthesis.

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

24 Which set of reactions releases the smallest number of ATP molecules by substrate level phosphorylation?

A conversion of glucose to ethanol and carbon dioxide
B conversion of glucose to lactic acid
C glycolysis of glucose
D one turn of the Krebs cycle

25 Isolated mitochondria were incubated with NADH in one experiment and an equal amount of $FADH_2$ in another set up. The mitochondria were initially deprived of oxygen. A known quantity of oxygen was then added and the pH of the intermembrane space was monitored. The result is shown in the graph.

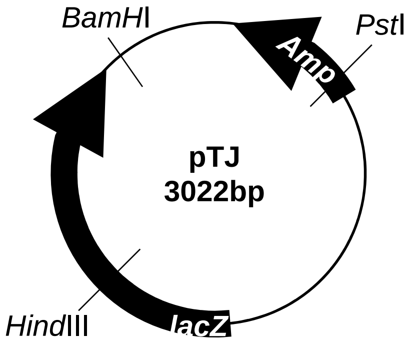


Which of the following can be concluded based on the results?

1 Upon the addition of oxygen, glycolysis and subsequently link reaction, Krebs cycle and oxidative phosphorylation occurred.
2 Electron transfer was initiated by the addition of oxygen.
3 The pH drop was greater with NADH than with $FADH_2$, which is consistent with the greater ATP yield that accompanies the oxidation of NADH.
4 The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

A 1 only
B 2 and 4 only
C 2, 3 and 4 only
D All of the above

26 The restriction sites and selectable markers on the vector pTJ are shown below.



If the gene for C protein were to be inserted into *lacZ* site, what should be added to the agar plate in order to screen for recombinant clones and how would the recombinant clones appear?

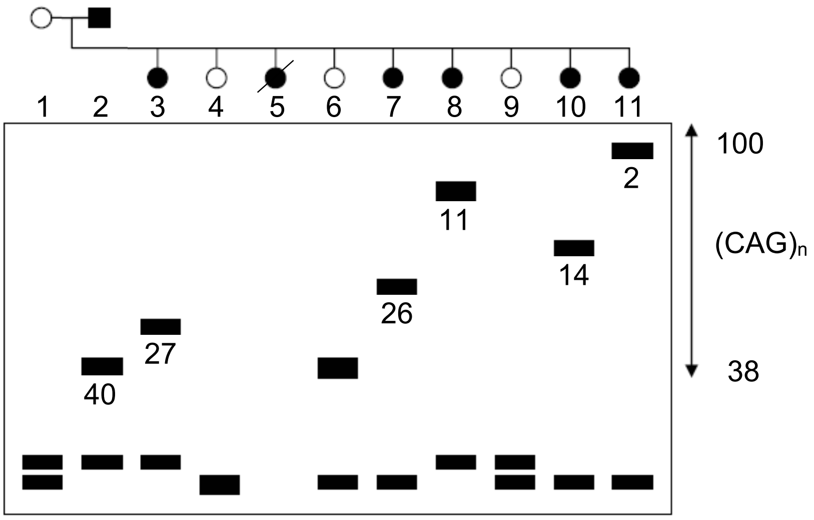
	Chemicals to be added		Colour of colonies
A	ampicillin	X-gal	Blue
B	β-galactosidase	X-gal	Blue
C	ampicillin	X-gal	White
D	β-galactosidase	lactose	White

27 Which of the following is correct?

	Polymerase Chain Reaction	Translation
A	Occurs in the nucleus	Occurs in the cytoplasm
B	Requires ribonucleic acids	Does not require deoxyribonucleic acids
C	Synthesizes selected section of the DNA	Synthesizes selected section of the mature mRNA
D	Uses information on the template between the primers	Uses information on the template between the start and stop codons

28 The diagram below shows the results of electrophoresis of PCR fragments. Individuals with Huntington's disease have nucleotide sequence CAG that repeats from 36 to more than 120 times.

The male parent (individual 2) suffers from Huntington's disease when he was 40 years old. Six of his children (individuals 3, 5, 7, 8, 10, 11) suffer from Huntington's disease, and the age at which the symptoms first began is shown by the number below the band containing the PCR fragments.



What conclusion can be drawn from the data above?

A Individuals 4, 6, and 9 have not inherited the allele that causes Huntington's disease.

B Individuals 4, 6, and 9 will still develop Huntington's disease at some point in their lives, since the disease is inherited as a dominant trait.

C Individuals 4 and 9 do not have the trait, and will not get Huntington's disease, but individual 6 is likely to have the disease when she reaches her father's age of 40.

D Two of the three will develop the disease, since it is inherited as a dominant trait, but the data does not allow us to predict which two.

29 What is a concern over the creation of genetically modified farmed animals?

1 Some genetically modified food products may cause allergies.

2 Gene transfer between genetically modified farmed animals and those in the wild may alter the gene pool of the species in the wild.

3 Overproduction of certain gene products may cause undue stress to the genetically modified farmed animals.

4 Some genetically modified food products may not be acceptable to certain groups of people.

A 1 and 4

B 2 and 3

C 1, 3 and 4

D All of the above

30 The Human Genome Project (HGP) has brought about great advancements in health and medicine.

Which of the following statements about HGP is correct?

	intended application	ethical concerns
A	developing diagnostic test to identify the gender of a foetus by detecting the presence of the foetal Y chromosome	designing of new antibody-based medicines which target proteins coded for by oncogenes
B	using a suspect's genetic pre-disposition to violent behaviour in criminal trials	screening the genetic make-up of an individual for genetic predisposition to cancer to determine if the individual is suitable to work in a nuclear power plant
C	comparing homologous genes of different human populations to trace lineages and migration patterns	comparing homologous genes to determine evolutionary relationships between organisms
D	prescribing suitable drugs to minimise adverse side effects due to the individual's inability to metabolize the medicine	publishing genetic information of specific individuals in a database readily accessible by the public

TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC 2/ IP YEAR 6 2017

CANDIDATE NAME							
CENTRE NUMBER	S					INDEX NUMBER	
CLASS	C	G			/	1	6

H1 BIOLOGY

Paper 2 Structured Questions

8875/02
Tuesday 12 September 2017
2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use staples, paper clips, 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.

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

For Examiner's Use	
Paper 1	**/30**
Paper 2	**/60**
Q1	**/12**
Q2	**/13**
Q3	**/15**
Essay	**/20**
Total	**/90**

This document consists of **12** printed pages.

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

1 Fig. 1.1 shows an electron micrograph of a plant cell.

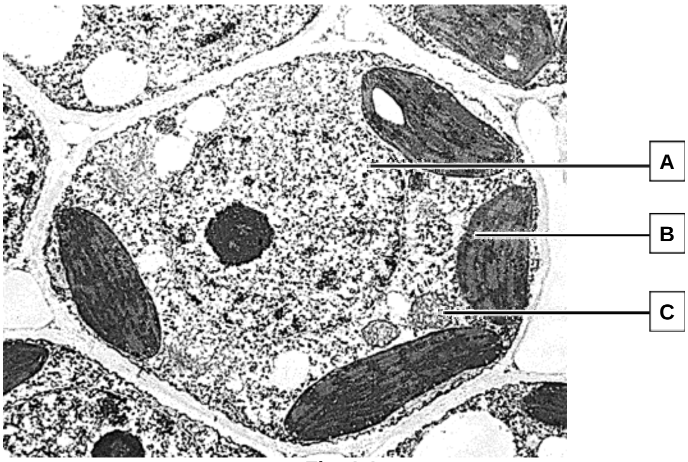


Fig. 1.1

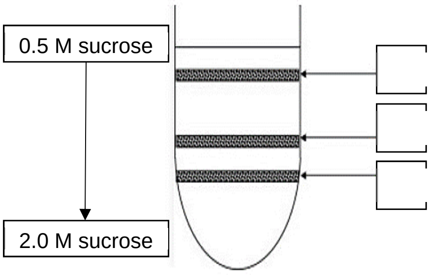
(a) Identify organelles **B** and **C**.

Organelle **B**: ________________________________ [1]

Organelle **C**: ________________________________ [1]

(b) Extracts from the homogenised plant cells in Fig. 1.1 were added to a sucrose density gradient and centrifuged at high speed to separate the various organelles.

(i) Label the bands where organelles **A**, **B** and **C** can be found after centrifugation.



[3]

(ii) Explain your answer in **(b)(i)**.

____

____

____

____ [2]

In a separate experiment, protoplasts (plant cells with cell wall removed) were first treated with three different reagents – ethanol, distilled water and buffer solution, for two hours. The treated cells were then subjected to the density gradient centrifugation.

Fig. 1.2 shows the thickness of the lowest band for each type of treated cell after density gradient centrifugation.

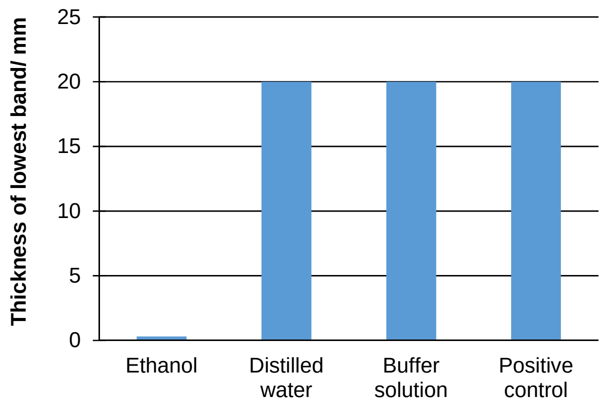


Fig. 1.2

(c) Explain the effects of the different reagents on the thickness of the lowest band.

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____ [3]

Fig. 1.3 shows another component found in animal cell membranes.

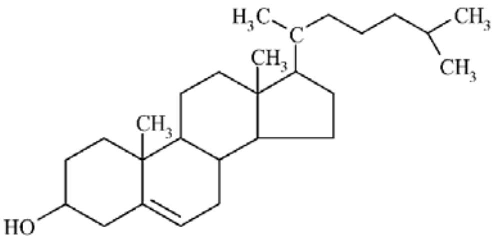

Fig. 1.3

(d) Explain how the molecule shown in Fig. 1.3 performs its function in cell membranes.

____

____

____

____ [2]

[Total: 12]

2 **(a)** Explain why mRNA is formed as a continuous strand during transcription while one of the DNA strands is formed discontinuously during replication.

____

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____

____

____ [3]

(b) Outline the process of transcription.

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____ [3]

Several types of rRNA and tRNA are transcribed as a single strand precursor RNA. Following transcription, each rRNA (16S, 23S, 5S) and tRNA molecule is cleaved in a process known as RNA trimming to form mature rRNA and tRNA molecules, as shown in Fig. 2.1.

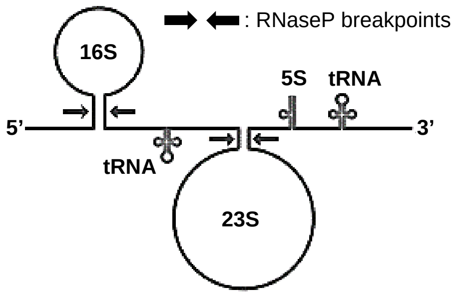

Fig. 2.1

(c) State where rRNA genes are found.

____ [1]

(d) Compare the process of RNA trimming and post-transcriptional modification for mRNA.

[2]

(e) Relate how the single-stranded structure of rRNA and tRNA facilitates their roles.

[4]

[Total: 13]

3 Anole lizards are found throughout the Caribbean and the surrounding mainland. An investigation was carried out to determine the relationships between these lizard species using DNA analysis. Fig. 3.1 shows a continuous part of the base sequence of a region of DNA that is read in the 5' → 3' direction. The base number of the first nucleotide of each row is shown on the left of the sequence.

```
001 TTTTTTTTGT CATGCTGTGT CTTCTGGACT GCAATACTAT ATCTGCTAGA
051 ATGATTTCCG TGGGTAACGA TGTCCCCTGG ATCCTGATTT TTGCCGTTCT
101 CCCAAATTCT GGTTGTATTA AATGCTGTAA ATGTCTCCAT AACATGTCTC
151 ATTGCTATAC CATGTCTCCC AAAACCCAAT TTTGTCATAT TATGTACCCA
201 AGACTCTGGT ACTATGTTTC CTGGGGCATA ATTTTGGCAC AATCTCTCTC
251 CCTCGCCCTG TTCCCTGCAG GAAAGTATGG TGCCTTGGAT GCGGGGGCTC
301 TGCTGGCGCT GCTGCCACTA ACGGAAGACC AGGAGAGCAA GGTGCGCCTC
351 TATGCCCTGA AGGCTCTGAC TGTCTTGGCT GTATTCGTAC GAGACCCAGT
401 ACCCCTCCTG CCCCACATCC CTCTGCTGCA GGAGCGCAGC CAGGATCCCA
```

Fig. 3.1

(a) Design two 12bp long primers **X** and **Y** that can be used to amplify the sequence that spans from nucleotide 052 and 392.

Primer **X**: ______________________________

Primer **Y**: ______________________________ [2]

Fig. 3.1 shows the phylogenetic relationships among Anole lizards. The results from gel electrophoresis of amplified *rtdr1y* and *kank1* sequences are also shown.

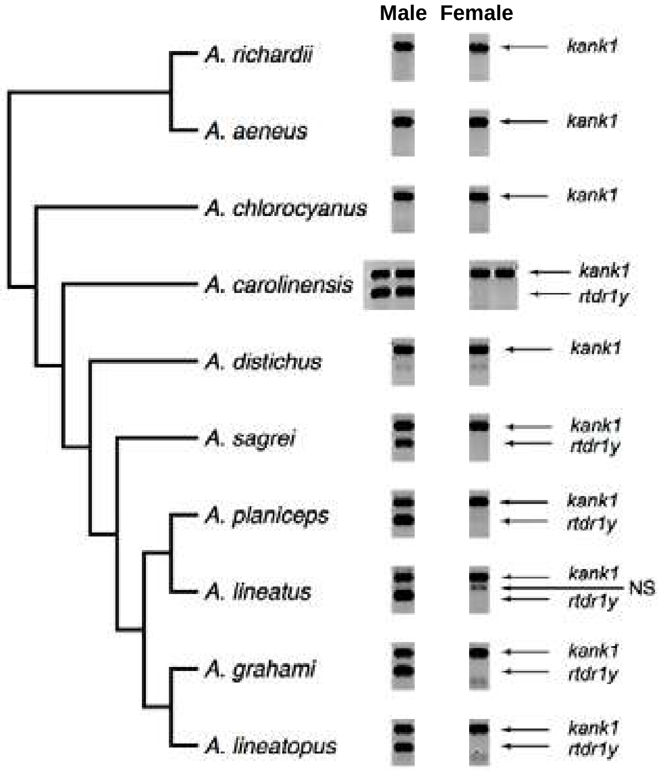

Fig. 3.1

(b) Explain which type of chromosome *rtdr1y* sequence is found on.

Commented [OKE1]: State the type of chromosome on which the *rtdr1y* sequence is found on.

____

____

____

____ [2]

The phylogenetic relationship between organisms is typically established through the use of *cytochrome c* gene, which is encoded in the nuclear DNA.

(c) Explain why *cytochrome c* gene is used for phylogenetic studies.

____

____

____

____

____

____ [3]

Fig. 3.2 shows the process in which cytochrome c is involved in.

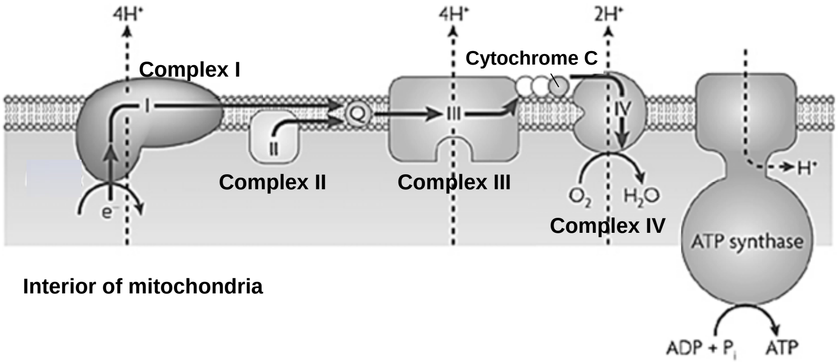

Fig. 3.2

(d) Explain the significance of cytochrome c in the process shown.

____

____

____

____

____

____ [3]

Anole lizards are found in different ecological niches throughout the Caribbean and the surrounding mainland as shown in Fig. 3.3. Each species is found only on one island or a small group of islands, apart from *Anolis carolinensis* which is found in mainland Florida.

Some species live on twigs, others in the trunk, and others in the grass. Species that live on twigs have long tails and short legs; species that live in the grass have short tails; and species that live on low tree trunks have long legs. The species that live on twigs all look similar, whether they are the species from Cuba, Hispaniola, Jamaica, or Puerto Rico.

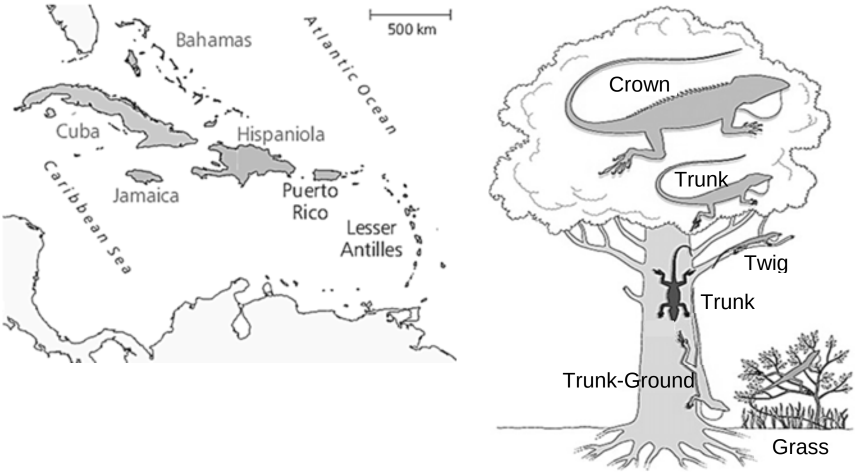

Fig. 3.3

Fig. 3.4 shows phylogenetic relationship of *Anolis* found in different ecological niches on four Caribbean islands.

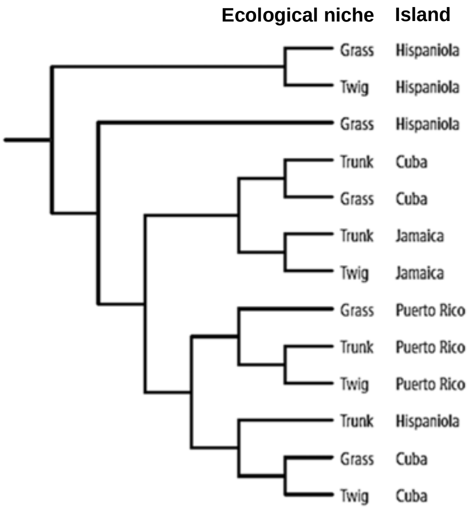

Fig. 3.4

(e) Explain how the different species of lizards that are morphologically similar might have arisen in different islands.

[5]

[Total: 15]

Section B

Answer **one** question.
Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must set out in sections **(a)**, **(b)** etc., as indicated in the question.

EITHER

4 **(a)** Discuss the pros and cons of using embryonic stem cells in medical research. [7]

(b) Using Bt corn as an example, discuss the potential benefits and issues of genetically modified crops. [8]

(c) Describe the natural and applied roles of restriction enzymes. [5]

[Total: 20]

OR

5 **(a)** Describe the factors affecting the rate of photosynthesis. [8]

(b) Distinguish between the structures of the polysaccharides found in plant cells. [5]

(c) Explain how the double membrane organelles in a plant cell synergize to ensure the cell's survival. [7]

[Total: 20]

TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC 2/ IP YEAR 6 2017

CANDIDATE NAME								
CENTRE NUMBER	S					INDEX NUMBER		
CLASS	C	G			/	1	6	

H1 BIOLOGY

Paper 2 Structured Questions

8875/02
Tuesday 12 September 2017
2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
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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.

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

For Examiner's Use	
Paper 1	**/30**
Paper 2	**/60**
Q1	**/12**
Q2	**/13**
Q3	**/15**
Essay	**/20**
Total	**/90**

This document consists of **12** printed pages.

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

1 Fig. 1.1 shows an electron micrograph of a plant cell.

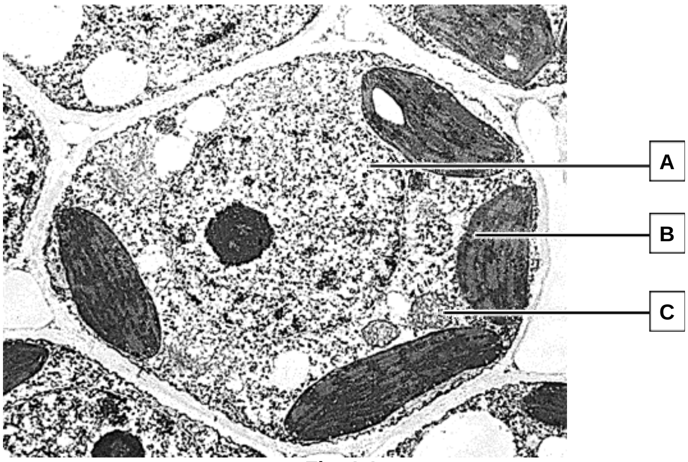


Fig. 1.1

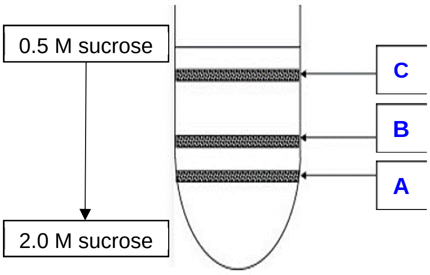
(a) Identify organelles **B** and **C**.

Organelle **B**: **Chloroplast** [1]

Organelle **C**: **Mitochondrion** [1]

(b) Extracts from the homogenised plant cells in Fig. 1.1 were added to a sucrose density gradient and centrifuged at high speed to separate the various organelles.

(i) Label the bands where organelles **A**, **B** and **C** can be found after centrifugation.



[3]

(ii) Explain your answer in **(b)(i)**. [2]

1. **Density gradient**
2. **Organelles will separate according to their densities.**
3. **Nucleus - heaviest**

   Chloroplast - medium size

   Mitochondria – smallest size

In a separate experiment, protoplasts (plant cells with cell wall removed) were first treated with three different reagents – ethanol, distilled water and buffer solution, for two hours. The treated cells were then subjected to the density gradient centrifugation.

Fig. 1.2 shows the thickness of the lowest band for each type of treated cell after density gradient centrifugation.

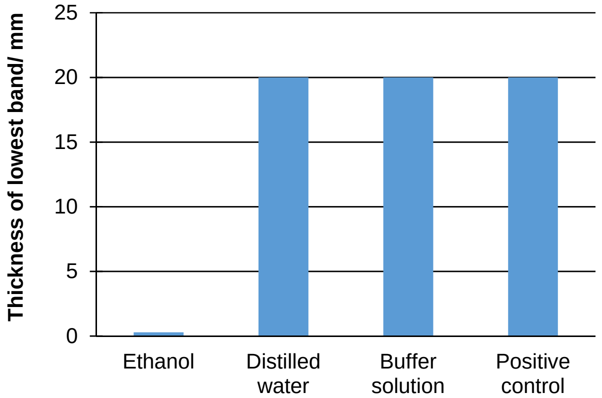


Fig. 1.2

(c) Explain the effects of the different reagents on the thickness of the lowest band. [3]

- **0mm Ethanol – organic solvent – dissolves phospholipid bilayers thus no intact organelles (nucleus) can be obtained.**
- **0mm Distilled water - Net movement of water molecules into nucleus,**
  - **It has double membrane, therefore remained intact.**
- **20mm Buffer solution –no net movement of water molecules, thus intact nucleus**

Fig. 1.3 shows another component found in animal cell membranes.

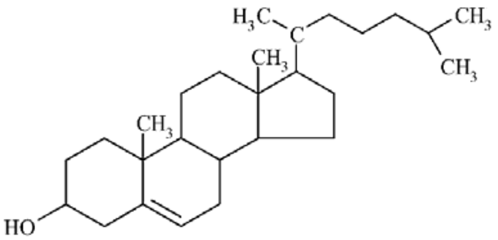


Fig. 1.3

(d) Explain how the molecule shown in Fig. 1.3 performs its function in cell membranes. [2]

1. **At higher temperatures cholesterol reduce membrane fluidity.**
2. **At lower temperatures cholesterol helps prevent membranes from freezing by disrupting the close packing of phospholipids.**

[Total: 12]

2 **(a)** Explain why mRNA is formed as a continuous strand during transcription while one of the DNA strands is formed discontinuously during replication. [3]

1. **DNA and RNA polymerases synthesize the new strands in the 5'→3' direction.**
2. **template for DNA replication is double-stranded and anti-parallel, while template for mRNA synthesis is single-stranded.**
3. **the direction of unwinding of the DNA template occurs opposite to the direction of synthesis for the lagging strand.**

(b) Outline the process of transcription. [3]

1. **General Transcription Factors bind to TATA box and promoter**
2. **Recruit the RNA polymerase to form the Transcription Initiation Complex (TIC).**
3. **RNA polymerase separate the two strands**

4. **RNA polymerase synthesizes the RNA in the 5'→3' direction**
5. **Free ribonucleotides form base pairs with the template strand.**
6. **Phosphodiester bonds formed between adjacent ribonucleotides**

7. **RNA polymerase transcribes the termination and polyadenylation signal**
8. **pre-mRNA is cut and released from the polymerase.**
9. **The DNA winds to re-form the double helix.**

Several types of rRNA and tRNA are transcribed as a single strand precursor RNA. Following transcription, each rRNA (16S, 23S, 5S) and tRNA molecule is cleaved in a process known as RNA trimming to form mature rRNA and tRNA molecules, as shown in Fig. 2.1.

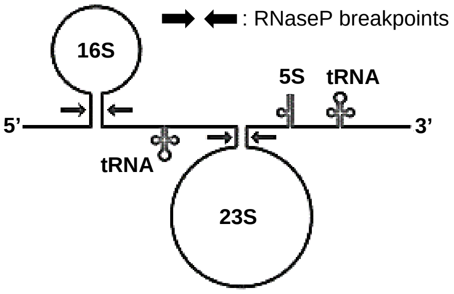


Fig. 2.1

(c) State where rRNA genes are found. [1]

Nucleolus/ Mitochondria/ Chloroplasts

(d) Compare the process of RNA trimming and post-transcriptional modification for mRNA. [2]

1. **(Difference) Trimming – rRNA and tRNA are formed from a pre-RNA strand, whereas post-transcriptional modification for mRNA – only mature mRNA formed from pre-mRNA.**
2. **(Difference) RNaseP is involved in trimming, whereas splicing involves spliceosome.**
3. **(Similarity) both processes involve the removal of segments (e.g. intron for pre-mRNA) that are not required.**

(e) Relate how the single-stranded structure of rRNA and tRNA facilitates their roles. [4]

1. **Single stranded structure –allow bases to fold back upon themselves, held in shape by hydrogen bonds between complementary base pairs**
2. **rRNA - formation of the small ribosomal subunit, and the large ribosomal subunit.**
3. **tRNA – formation of a structure that can fit into the E, P, A sites found on the large ribosomal subunit.**
4. **Allows complementary base pairing of its anticodon with the codon of mRNA during translation to ensure that the correct sequencing of amino acids on the polypeptide chain.**

[Total: 13]

3 Anole lizards are found throughout the Caribbean and the surrounding mainland. An investigation was carried out to determine the relationships between these lizard species using DNA analysis. Fig. 3.1 shows a continuous part of the base sequence of a region of DNA that is read in the 5' → 3' direction. The base number of the first nucleotide of each row is shown on the left of the sequence.

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151	ATTGCTATAC	CATGTCTCCC	AAAACCCAAT	TTTGTCATAT	TATGTACCCA
201	AGACTCTGGT	ACTATGTTTC	CTGGGGCATA	ATTTTGGCAC	AATCTCTCTC
251	CCTCGCCCTG	TTCCCTGCAG	GAAAGTATGG	TGCCTTGGAT	GCGGGGGCTC
301	TGCTGGCGCT	GCTGCCACTA	ACGGAAGACC	AGGAGAGCAA	GGTGCGCCTC
351	TATGCCCTGA	AGGCTCTGAC	TGTCTTGGCT	GTATTCGTAC	GAGACCCAGT
401	ACCCCTCCTG	CCCCACATCC	CTCTGCTGCA	GGAGCGCAGC	CAGGATCCCA

Fig. 3.1

(a) Design two 12bp long primers **X** and **Y** that can be used to amplify the sequence that spans from nucleotide 052 and 392.

Primer **X**: **Forward primer: 5' TGATTTCCGTGG 3'**

Primer **Y**: **Reverse primer: 3' CATAAGCATGCT 5'** [2]

Fig. 3.1 shows the phylogenetic relationships among Anole lizards. The results from gel electrophoresis of amplified *rtdr1y* and *kank1* sequences are also shown.

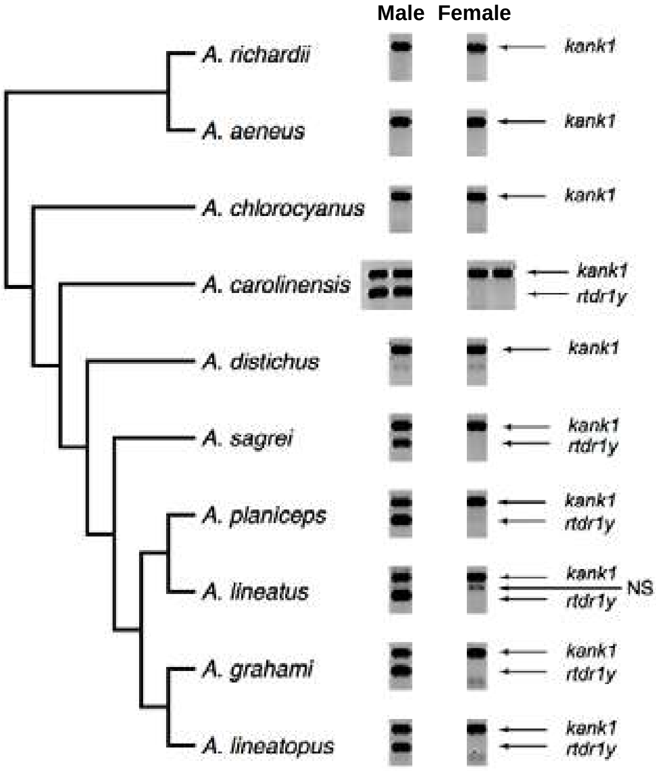


Fig. 3.1

(b) Explain which type of chromosome *rtdr1y* sequence is found on. [2]

1. **Y chromosome**
2. **as the BAND is only found in the males.**

Commented [OKE1]: State the type of chromosome on which the *rtdr1y* sequence is found on.

The phylogenetic relationship between organisms is typically established through the use of *cytochrome c* gene, which is encoded in the nuclear DNA.

(c) Explain why *cytochrome c* gene is used for phylogenetic studies. [3]

1. **highly conserved gene, important function in aerobic respiration.**
2. **Any mutation would result in a non-functional protein that cause death of organisms.**
3. **Thus, comparison of sequences non-essential for the survival of the organism is conducted for phylogenetic studies.**

Fig. 3.2 shows the process in which cytochrome c is involved in.

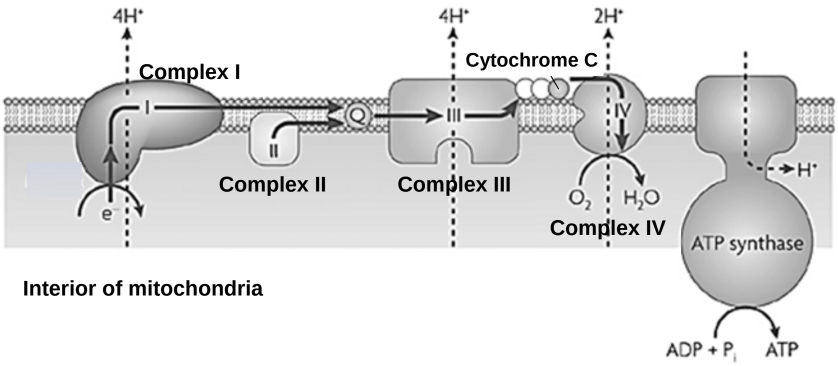


Fig. 3.2

(d) Explain the significance of cytochrome c in the process shown. [3]

1. **an electron carrier**
2. **flow of electrons down the ETC**
3. **The energy released from the**
4. **is used to create a steep proton gradient across the inner mitochondrial membrane.**
5. **to drive ATP synthesis via ATP synthase in a process known as chemiosmosis.**

Anole lizards are found in different ecological niches throughout the Caribbean and the surrounding mainland as shown in Fig. 3.3. Each species is found only on one island or a small group of islands, apart from *Anolis carolinensis* which is found in mainland Florida.

Some species live on twigs, others in the trunk, and others in the grass. Species that live on twigs have long tails and short legs; species that live in the grass have short tails; and species that live on low tree trunks have long legs. The species that live on twigs all look similar, whether they are the species from Cuba, Hispaniola, Jamaica, or Puerto Rico.

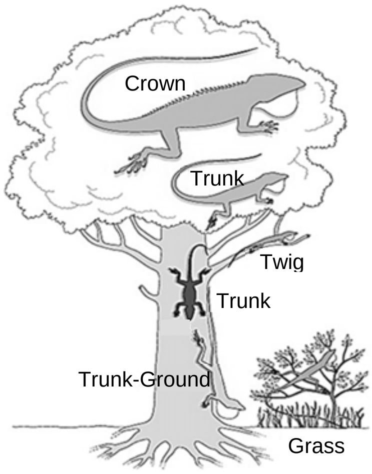


Fig. 3.3

Fig. 3.4 shows phylogenetic relationship of *Anolis* found in different ecological niches on four Caribbean islands.

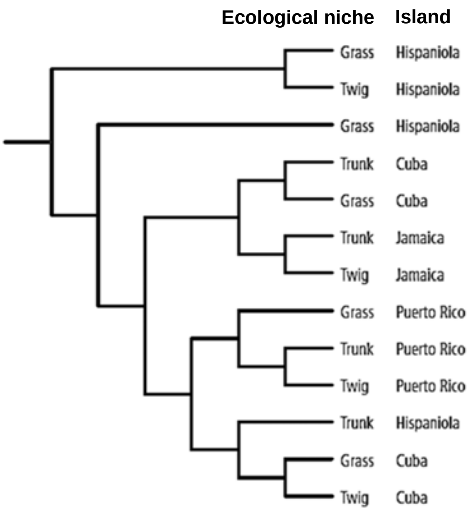


Fig. 3.4

(e) Explain how the different species of lizards that are morphologically similar might have arisen in different islands.

1. **Ref to leg and tail lengths due to genetic variation in the lizards**
2. **different islands that has different selection pressures.**

3. **Lizards that have the favourable alleles that confer longer legs were able to escape from their predators**
4. **survive till reproductive age and reproduce to produce viable and fertile offspring,**
5. **Thus, the frequency of favourable alleles would increase.,**
6. **the lizards do NOT interbreed with one another.**
7. **As the different islands have similar habitats,**
8. **the lizards in different islands evolve independently, thus they look morphologically similar.**

[Total: 15]

Section B

Answer **one** question.
Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must set out in sections **(a)**, **(b)** etc., as indicated in the question.

EITHER

4 **(a)** Discuss the pros and cons of using embryonic stem cells in medical research. [7]

Source of ESC

1. **ESC are derived from the inner cell mass (ICM) of the blastocyst from excess embryos produced during *in vitro* fertilisation (IVF) procedures.**

Pros

2. **ESC are pluripotent.**
3. **Able to differentiate into almost any cell type to form any organ or type of cell**
4. **Thus, development of tissues or organs can be studied.**
5. **capable of dividing and self-renewal for long periods**

Cons

6. **disagreement on moral status of embryo.**
7. **No moral status : ball of cells that cannot survive outside the womb, no bodily characteristics, is not conscious and cannot feel anything.**
8. **same moral status as a human being: potential to become a living, viable human being.**
9. **using embryonic stem cells for scientific research is tantamount to killing a life.**
10. **Religious objection**
11. **Disrespect for the value of human life.**
12. **De-sensitization to the destruction of human life.**
13. **Alternatives such as induced pluripotent stem cells.**
14. **Unable to form the extra-embryonic membranes or the placenta.**

(b) Using Bt corn as an example, discuss the potential benefits and issues of genetically modified crops. [8]

Benefits [4]

1. **insertion of a gene from *Bacillus thuringiensis* into the corn**
2. **which produces the protein Bt delta endotoxin.**
3. **Kills the common pest European Corn Borer that destroys corn crops.**
4. **Endotoxin is extremely selective, only kills certain insects. Thus, there is no need to spray insecticides on their crops to get rid of the pests.**
5. **Endotoxin is considered safe for human consumption.**
6. **Farmers can save money on the purchase of insecticides,**
7. **increase their crop yields and productivity,**

Safety considerations

1. **However, a 2009 study has found that rats fed with genetically modified corn had problems with the liver, kidneys, heart, adrenal glands and spleen.**

2. Therefore, no conclusive studies that prove human consumption of Bt corn is indeed safe.

3. genes for antibiotic resistance in vector may be transferred from the transgenic plant to other bacteria, making them antibiotic-resistant.

Possible threats to environment

4. The caterpillars that feed on milkweed plants that contain Bt corn pollen are more likely to have lower survival rates.

5. spread of pesticide resistance to weeds.

Legal issues

6. patents for the Bt corn and its seeds,
   a. farmers who distribute and share Bt corn seeds may be sued for patent infringement or be exposed to other legal challenges.
   b. farmer B who have Bt corn in their fields though they did not "purchase" the Bt corn seeds may be sued.

Financial issues

7. Farmers are now dependent on the biotech companies for a continuous supply of seeds. This can be very expensive.

(c) Describe the natural and applied roles of restriction enzymes. [5]

1. Restriction enzymes are enzymes with active site that recognizes and binds to restriction site, that is palindromic in sequence and
2. hydrolyzing the phosphodiester bond between two specific nucleotides.

3. protect bacteria from viruses by degrading incoming viral (foreign) DNA.

Applied Roles

4. A specific restriction enzyme is used to cut the DNA molecule which contains the gene of interest.
5. The same restriction enzyme is used to cut the plasmid vector.

6. The complementary sticky ends of restriction fragments anneal spontaneously to form recombinant DNA.

7. Restriction enzymes digest DNA samples to create restriction fragments for DNA fingerprinting,
8. fragments are separated based on size in gel electrophoresis.

[Total: 20]

Commented [OKE2]: 2015/MCT/H1/P2/Q5c
Describe, with a named example, the natural and applied uses of restriction enzymes. [7]

Natural uses

1. Example EcoRI, BamHI, SmaI, etc
2. Restriction enzymes are synthesized naturally in bacteria to protect the bacteria from viruses
3. by degrading incoming viral (foreign) DNA.
4. Each restriction enzyme recognizes and binds to a specific sequence of 4 to 8 nucleotides on viral DNA molecule called a restriction site (Must have mentioned virus in either point 2, 3, or 4)
5. by hydrolyzing the phosphodiester bond at a position between two specific adjacent nucleotides.
6. The bacterial genome is protected from the action of the restriction enzyme by methylation,
7. where a methyl ($-CH_3$) group is added to an Adenine or Cytosine base at the restriction sites.

Applied uses

8. allow formation of recombinant DNA;
9. RE is used to isolate DNA or gene of interest from organism DNA;
10. The same RE is used to cut plasmid/vector.
11. Restriction fragments produced by restriction enzymes can have sticky ends or blunt ends.
12. RE recognizes the palindromic restriction sites to generate complementary sticky ends for the formation of recombinant DNA.
13. Sticky ends allow cut DNA fragments to anneal spontaneously by forming hydrogen bonds with complementary sticky ends of DNA fragments cut up by the same enzyme.
14. Blunt ends make annealing more difficult. It requires an additional step of ligating sticky ends/ linker DNA to the restriction fragments for hydrogen bonds to form

Additional point to credit for H2 students:

15. Generate DNA fragments from genomic DNA when preparing genomic DNA library (OWTTE)
16. AVP

Modified from VJC/Prelim09/P3/Q4a

Examiner's Report

- Candidates should distinguish clearly the natural uses and applied uses of restriction enzymes.
- Candidates should analyse the question carefully as the question asked about the role of restriction enzymes in genetic engineering, NOT the entire process of genetic engineering.
- The restriction enzyme cuts at the restriction sites that flank both ends of the genes (or else the gene will be disrupted) to isolate the gene.
- Candidates should write cut the gene of interest out from the DNA, instead of cut the gene of interest (or else the gene will be disrupted).
- Candidates should note that only endonucleases hydrolyses the internal phosphodiester bonds between two specific adjacent nucleotides, while exonuclease hydrolyses the phosphodiester bonds between two specific adjacent nucleotides from the ends.

... [1]

OR

5 **(a)** Describe the factors affecting the rate of photosynthesis. [8]

1. **Effects of light intensity on:**
    a. **excitation of electrons.**
    b. **photolysis of water,**
    c. **chemiosmosis,**
    d. **stomata opening**

2. **Light quality (λ of light)**
    a. **red or blue light preferred over green light**

3. **Effects of CO_2 concentration**
    a. **rate of photosynthesis increases as the concentration of carbon dioxide increases.**

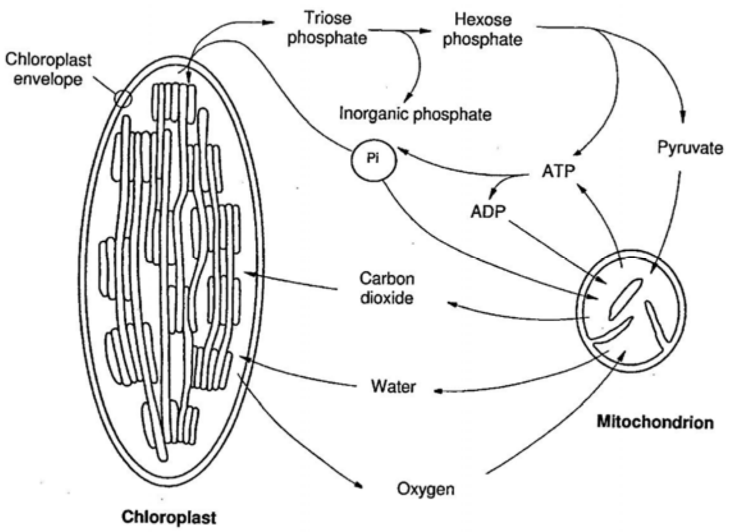
4. **Effects of temperature**
    a. **Ref to enzymatic reactions in Calvin cycle.**
5. **Effects of O_2 concentration**
    a. **As the concentration of oxygen increases, the rate of photosynthesis decreases.**
    b. **whereby O_2 competes with CO_2 for the active site of Rubisco.**

(b) Distinguish between the structures of the polysaccharides found in plant cells. [5]

Ref to:

1. **Monomer**
2. **Types of bonds**
3. **Formation of chian**
4. **Structure of polysaccharide**
5. **Projection of hydroxyl groups on chains**
6. **Cross-linkage between chains**
7. **AVP**

(c) Explain how the double membrane organelles in a plant cell synergize to ensure the cell's survival. [7]



Ref to

1. **The nucleus contain genes that code for proteins required for mitochondria, chloroplast, and ribosomal proteins and genes that code for rRNA required for the assembly of ribosome.**

2. **The mitochondria**

   a. **synthesize ATP during aerobic respiration. To supply energy for metabolic processes.**

   b. **CO_2 released during aerobic respiration used during carbon fixation to synthesize glyceraldehyde-3-phosphate/ glucose in the chloroplast.**

   c. **Water released during aerobic respiration can be used during photolysis of water in light reaction**

3. **The chloroplasts**
   a. **synthesize organic compounds for aerobic respiration in the mitochondria.**

   b. **O_2 released can be used in oxidative phosphorylation during aerobic respiration in the mitochondria.**

[Total: 20]

Page 12: [1] Commented [OKE2]	Ong Kian Eng	26/09/2017 05:38:00 PM

2015/MCT/H1/P2/Q5c

Describe, with a named example, the natural and applied uses of restriction enzymes. [7]

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2. **Restriction enzymes are synthesized naturally in bacteria to protect the bacteria from viruses**
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4. **Each restriction enzyme recognizes and binds to a specific sequence of 4 to 8 nucleotides on viral DNA molecule called a restriction site (Must have mentioned virus in either point 2, 3, or 4)**
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7. **where a methyl ($-CH_3$) group is added to an Adenine or Cytosine base at the restriction sites.**

Applied uses

8. **allow formation of recombinant DNA;**
9. **RE is used to isolate DNA or gene of interest from organism DNA;**
10. **The same RE is used to cut plasmid/vector.**
11. **Restriction fragments produced by restriction enzymes can have sticky ends or blunt ends.**
12. **RE recognizes the palindromic restriction sites to generate complementary sticky ends for the formation of recombinant DNA.**
13. **Sticky ends allow cut DNA fragments to anneal spontaneously by forming hydrogen bonds with complementary sticky ends of DNA fragments cut up by the same enzyme.**
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16. **AVP**

Modified from VJC/Prelim09/P3/Q4a

Examiner's Report

- **Candidates should distinguish clearly the natural uses and applied uses of restriction enzymes.**

- **Candidates should analyse the question carefully as the question asked about the <u>role of restriction enzymes in genetic engineering</u>, NOT the entire process of genetic engineering.**
- **The <u>restriction enzyme cuts at the restriction sites that flank both ends of the genes (or else the gene will be disrupted) to isolate the gene</u>.**
- **Candidates should write <u>cut the gene of interest out from the DNA</u>, instead of cut the gene of interest (or else the gene will be disrupted).**
- **Candidates should note that only <u>endonucleases</u> hydrolyses the <u>internal</u> phosphodiester bonds between two specific adjacent nucleotides, while exonuclease hydrolyses the phosphodiester bonds between two specific adjacent nucleotides <u>from the ends</u>.**

Candidates should NOT confuse phages and bacteria, ie. <u>restriction enzymes should be found in bacteria to protect the bacteria from invading phages</u> (NOT protect the phage DNA from bacteria).

VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2017

NAME : ______________________________________

CT CLASS : ______________________________________

H1 BIOLOGY **8875/1**

Paper 1 Multiple Choice **1 hour**

Additional material: Multiple choice answer sheet

READ THESE INSTRUCTIONS FIRST

Write your name, exam number on the answer sheet provided.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

There are **30** questions in this paper. Answer all questions. For each question there are four possible answers A, B, C and D.
Choose the **one** you consider correct and record your choice **in soft pencil** on the separate 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 paper.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of 20 printed pages, including cover page

1 Which of the following is a false statement regarding centrioles and ribosomes?

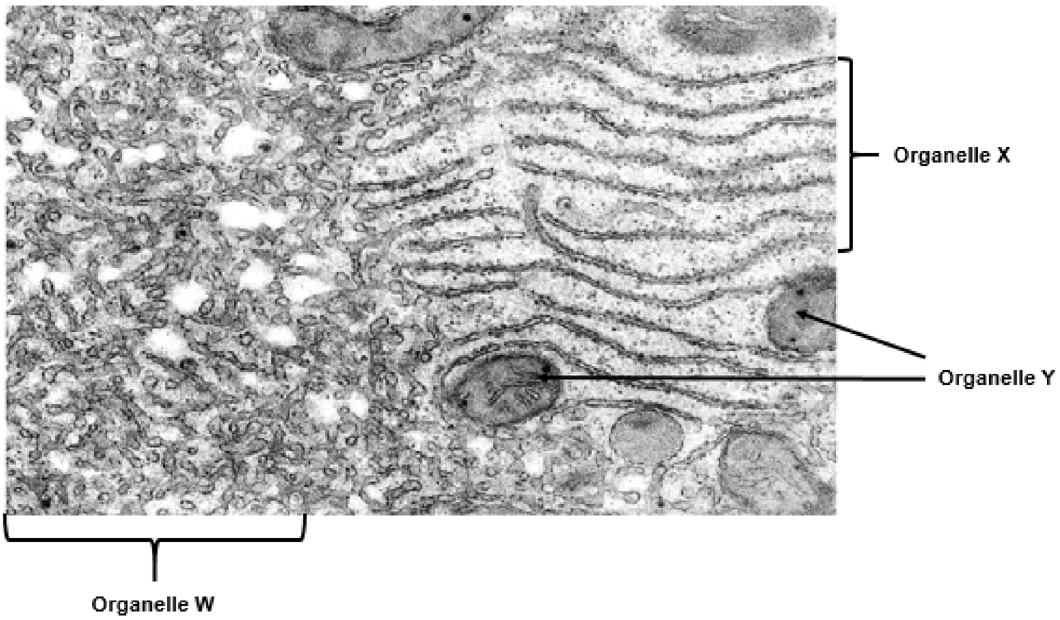
A Both are non-membrane bound organelles.

B Only centrioles are present in a cell undergoing mitosis.

C Both are present in dividing and non-dividing animal cells.

D Under high temperature, both will be denatured as they have a proteinaceous component.

2 Fig 2 shows three cell organelles W, X and Y.



Which of the following statements about these organelles is true?

A Only organelle Y contains RNA.

B Only organelle W contains carbohydrates and phospholipids.

C Organelle X has 80S ribosomes whereas organelle Y has 70S ribosomes.

D Organelles X and Y have double membranes whereas organelle W has a single membrane.

3 Which set of factors shown below will produce the **least** fluid cell surface membrane?

A	● High proportion of cholesterol ● High temperature
B	● Low proportion of phospholipids with saturated fatty acids ● High temperature
C	● Low proportion of phospholipids with unsaturated fatty acids ● Low temperature
D	● High proportion of phospholipids with unsaturated fatty acid ● Low temperature

4 Fig 4 shows a repeating unit found in a biomolecule.

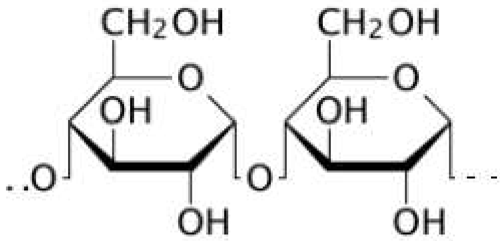


Fig 4

In which of the following biomolecules, would one expect to find the above repeating unit?

X Absent
√ Present

	Cellulose	**Glycogen**	**Amylose**	**Collagen**
A	X	X	√	X
B	√	X	√	X
C	√	X	X	√
D	X	√	√	X

5 Fig 5 below is an electron micrograph of a stained fiber of deoxyhemoglobin S (HbS).

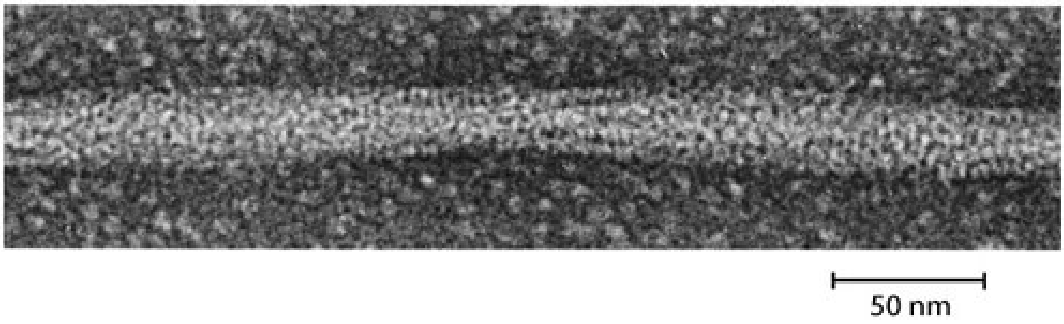


Fig 5

[From G. Rykes, R.H. Crepeau, and S.J. Edelstein. *Nature* 272(1978):509.]

Source: http://www.nslc.wustl.edu/sicklecell/part2/molecular.html

Which of the following statements is true?

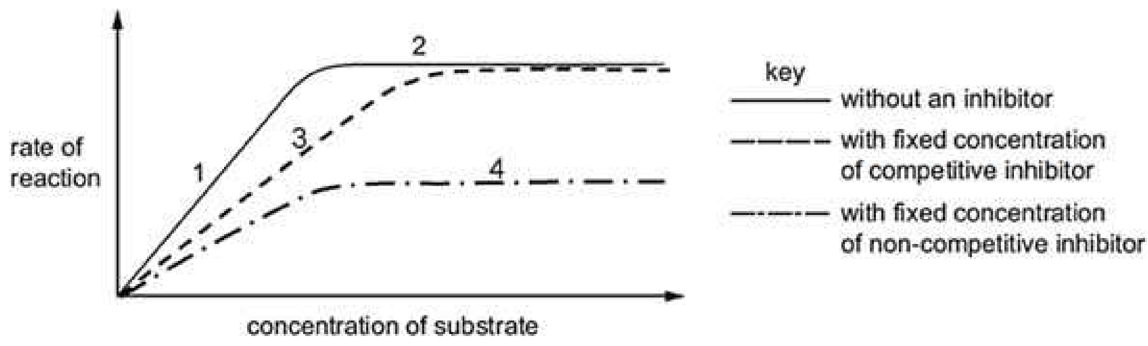
A Mutation in the red blood cell results in the production of HbS which precipitates out as long rigid fibers under low oxygen concentration.

B The long HbS molecule is insoluble due to its large molecular size and this results in the sickling of red blood cells.

C The aggregration of HbS molecules, under low oxygen concentration, causes the fiber to be precipitated out of solution, resulting in the sickling of red blood cells.

D Under low oxygen concentration, HbS molecules form a triplex helix structure, causing the cell membrane of the red blood cells to be more rigid and hence they sickled.

6 The graph shows the effect of increasing the concentration of substrate on the rate of enzyme catalysed reaction.



What is limiting the rate of the enzyme-catalysed reaction at 1, 2, 3 and 4 on the graph?

	1	2	3	4
A	enzyme concentration	substrate concentration	competitive inhibitor	non-competitive inhibitor
B	enzyme concentration	substrate concentration	non-competitive inhibitor	competitive inhibitor
C	substrate concentration	enzyme concentration	competitive inhibitor	non-competitive inhibitor
D	substrate concentration	enzyme concentration	non-competitive inhibitor	competitive inhibitor

7 What causes genetic variation in gametes during meiosis?

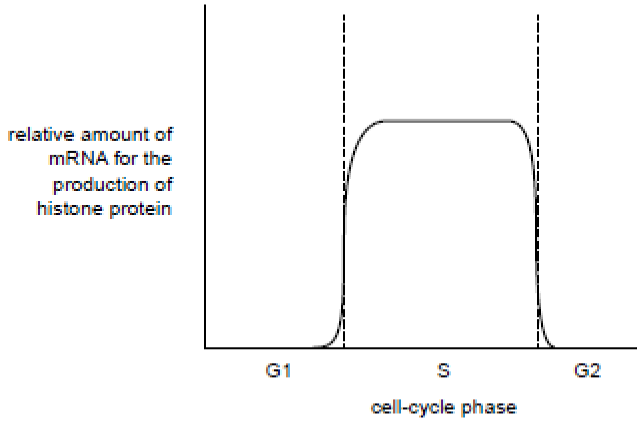
A Crossing over of sister chromatids during prophase I and random orientation of homologous chromosomes in metaphase II

B Crossing over in prophase I and random orientation of homologous chromosomes in metaphase I

C Pairing of maternal and paternal chromosomes during prophase I and crossing over in metaphase I

D Random orientation and segregation of homologous chromosomes during prophase I and metaphase I

8 The graph below shows the relative amount of mRNA for the production of histone protein at different times throughout a cell cycle.



Using your knowledge of the cell cycle and the information in the graph, it is correct to state that

A DNA replication occurs most actively in the G1 phase.

B histone genes are highly active throughout the cell cycle.

C histone protein synthesis occurs simultaneously with DNA synthesis.

D histone protein is not present in the cell during the G1 and G2 phases.

9 The sequence below depicts the template strand of a hypothetical gene. The exons are in bold type.

3′ **TAC AAA** CCG GCC **TTT GCC AAA** CCC AAC CTA **AAT ATG AAA ATT** 5′

An allele for this gene codes for a polypeptide with only five amino acids. This is caused by a mutation in one of the exons. Which of the following describes the change(s) that results in the formation of the shorter polypeptide?

A Deletion of one adenine

B Addition of two cytosines

C Substitution of thymine with adenine

D Addition of cytosine and removal of adenine

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

- Drug 1 inhibits the action of DNA ligase.
- Drug 2 resembles the shape of a DNA nucleotide.
- Drug 3 attaches irreversibly to the DNA molecule.
- Drug 4 binds irreversibly to the active site of DNA polymerase.

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

	Daughter strands of varying lengths are synthesized.	Only fragments are synthesized at the end of replication process.	Phosphodiester bonds cannot be formed.	Template strand becomes inaccessible by the enzyme.
A	4	3	2	1
B	2	4	3	1
C	2	1	4	3
D	3	2	1	4

11 The following events occur during transcription.

P. Bonds break between complementary bases.
Q. Bonds form between complementary bases.
R. Phosphodiester bonds form.
S. Free nucleotides pair with complementary nucleotides.

Which options correctly depicts the frequency of the events occurring in the nucleus?

	Occurs once	**Occurs twice**
A	P, R, S	Q
B	Q, R, S	P
C	R, S	P, Q
D	P, S	Q, R

12 The following statements are descriptions of polynucleotides found in eukaryotes.

1. Has catalytic properties
2. Can associate closely with specific proteins
3. Has variable length
4. Has fixed length and can fold into specific shape
5. Can be subjected to degradation by cytoplasmic enzymes

Which row matches the description to its function?

	Stores coded information	Provides a site for amino acid to bind	Forms a ribosome	Serves as a template for translation
A	4	5	1, 3	2
B	3, 5	1	2	4
C	2	4	1	3, 5
D	1, 5	2	4	3

13 The following two examples illustrate the inheritance of a sex-linked gene on the X-chromosome. In the parental generation (*P*), the homogametic sex is homozygous for colour in both examples.

Cat	**Magpie Moth**
black dominant to yellow	normal colour dominant to pale colour
P Black male x yellow female	*P* Pale colour male x normal female
F 1 yellow male to 1 black female	*F* 1 normal male to 1 pale female

In these crosses, the heterogametic sex is…

A male in the cat, female in the moth
B female in the cat, male in the moth
C male in both the cat and moth
D female in both the cat and moth

14 After pollinating plant 1, which had rough stems and yellow flowers, with plant 2, which had rough stems and white flowers, 80 seeds were obtained. When sown, these seeds grew into plants showing the four combinations of characteristics as follows:

26 with rough stems and yellow flowers.
12 with smooth stems and yellow flowers.
33 with rough stems and white flowers.
9 with smooth stems and white flowers.

Assuming that yellow is the dominant flower colour, which one of the following options is confirmed by these results?

	plant 1 is heterozygous for	**plant 2 is heterozygous for**
A	stem surface and flower colour	flower colour only
B	stem surface and flower colour	stem surface only
C	flower colour only	flower colour and stem surface
D	stem surface only	flower colour and stem surface

15 Flamingos are birds that live by lakes. The feather colour of flamingos may vary from white to pink to red. To investigate the inheritance of feather colour, a scientist performed the following crosses and recorded the feather colour of all the offspring when one year old. The diet of the offspring was also recorded.

Cross	**Feather colour of parents**	**Feather colour of all one-year-old offspring**	**Diet of offspring**
1	white × white	white	aquatic plants
2	red × white	white	aquatic plants
3	white × white	pink	algae and crustaceans
4	red × white	pink	algae and crustaceans

Based on this information, a correct conclusion would be that…

A both the parents in cross 1 must be homozygous for white feather colour.

B white feather colour is recessive to red feather colour

C the feather colour of flamingos is influenced by their environment.

D two parents, both with pink feather colour, would produce pink offspring

16 Tyrosinase is an enzyme that catalyses the conversion of the amino acid tyrosine into the black pigment melanin. It is responsible for the black fur colour of some rabbits.

A group of rabbits kept at 30 °C resulted in 90% of the rabbits with light fur colour. A second group of rabbits kept at 10 °C resulted in 90% of the rabbits with black fur colour.

Which hypothesis is supported by these results?

A	An inhibitor is present in rabbit skin cells that can bind strongly to tyrosinase when the external temperature is 30 °C.
B	At 10 °C external temperature there are fewer tyrosinase-tyrosine complexes formed and less melanin is produced.
C	Tyrosinase is an enzyme that is coded for by a gene that is switched off when the external temperature is 10 °C.
D	Tyrosinase is a temperature-sensitive molecule that is only activated when the external temperature is 30 °C.

17 In a common genetic condition afflicts children, the mutant allele differs from the wild-type allele by a single nucleotide substitution. This substitution eliminates a *NheI* restriction site so that the mutant allele is not cut by the restriction enzyme, *NheI*. A pedigree of a family exhibiting this condition is shown in Fig. 17.1.

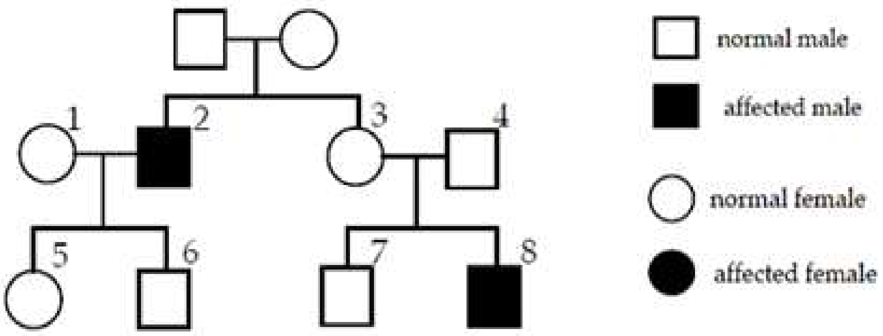


Fig 17.1

The DNA from four individuals in the pedigree were isolated and subjected to polymerase chain (PCR) reaction. This technique amplifies a 1000 bp portion of their DNA that includes the *NheI* site that is affected by the mutation.
The PCR products are then digested with *NheI* and analysed.

The DNA fragments from the digest are run on an agarose gel and the results are shown in Fig. 17.2.

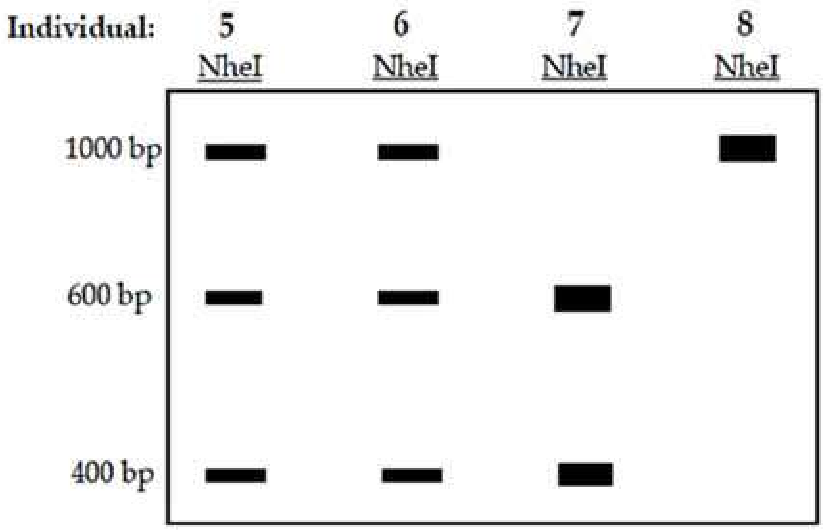
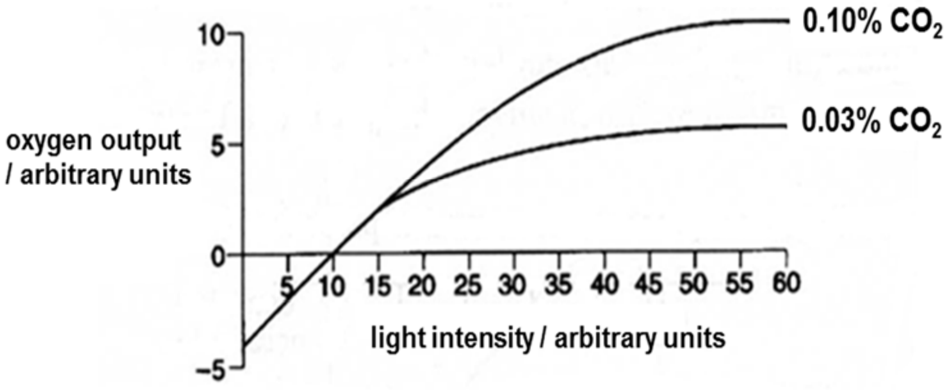


Fig. 17.2

Based on the data in Fig. 17.1 and Fig. 17.2, identify the correct mode of inheritance, and the probability of Individuals 3 and 4 of having a daughter who will be affected.

	Mode of inheritance of disease	**Probability**
A	autosomal dominant	0.125
B	autosomal recessive	0.25
C	X-linked dominant	0
D	X-linked recessive	0.5

18 The graph shows the oxygen output of a green plant at different light intensities in two separate setups with different concentrations of carbon dioxide in the surrounding air.



What can be deduced from the graph above?

I At 10 arbitrary units of light intensity, the rate of photosynthesis is equivalent to the rate of respiration.

2 Concentration of carbon dioxide limits the rate of photosynthesis when light intensity exceeds 15 arbitrary units.

3 Enzymes catalysing carbon fixation are saturated at high light intensities (above 30 arbitrary units) in both experiments.

4 Oxygen output can be used to quantify the rate of photosynthesis due to their role as final acceptor of protons and electrons.

A 1 only

B 1 and 2 only

C 3 and 4 only

D 2, 3 and 4 only

19 Which of the following statements show a difference between cyclic and non-cyclic photophosphorylation?

A Cyclic photophosphorylation only involves PSI and PSII whereas non-cyclic photophosphorylation only involves PSI, PSII and NADP.

B Light is required to boost electrons cyclic photophosphorylation whereas for non-cyclic photophosphorylation, the energy comes from photolysis of water.

C Only non-cyclic photophosphorylation produces protons which is required for the generation of the proton gradient for ATP synthesis.

D Oxygen is produced in non-cyclic photophosphorylation only.

20 Metformin is widely used to reduce high blood sugar levels caused by diabetes.

It exerts its activity through increasing glucose uptake and utilisation by cells. Metformin has also been shown to affect mitochondrial respiration in the following ways:

- Decreases the activity of the enzyme (pyruvate dehydrogenase) that converts pyruvate to acetyl CoA
- Inhibit one of the electron carriers in the electron transport chain

Which of the following are possible observations of cells that have been treated with metformin?

1. An increase in oxygen uptake by the cells.
2. A decrease in the pH of the cytoplasm
3. An increase in the breakdown of glucose.
4. A decrease in the carbon dioxide release.

A 1 and 4 only

B 2 and 3 only

C 3 and 4 only

D 2, 3 and 4 only

21 Two respirometers (one shown in Fig 22) were set up to investigate the rate of respiration in spiders. To one setup, the spiders were fed a diet containing a drug before the experiment. For this setup, the drop of fluid remained stationary after a short distance from the starting position. Distance moved is shorter than the control setup.

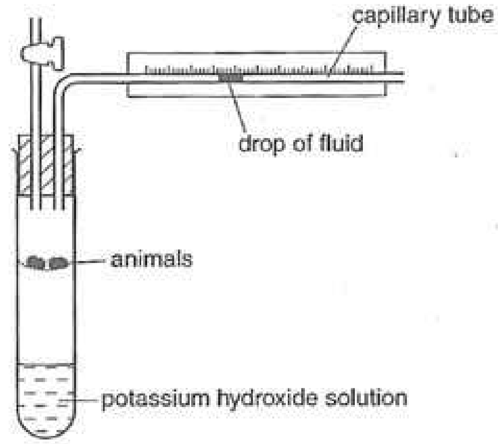


Fig 22

What could be a possible explanation for this observation?

A The oxygen content in the boiling tube was depleted.

B A mutation occurred that causes the ATP synthase to become hyperactive.

C A drug was introduced that act as an ion channel on the mitochondrial membrane.

D Inhibitor of the electron carriers in the electron transport chain was added to the animal's diet.

22 Which feature does **not** support Darwin's theory of natural selection?

A adaptations to the environment, e.g. increased density of fur in bears in cold climates

B homologous molecular structures, e.g. ATP in diverse organisms

C similar anatomy, e.g. same number of neck vertebrae among mammals

D similar structures for specific functions, e.g. fin of whale and shark

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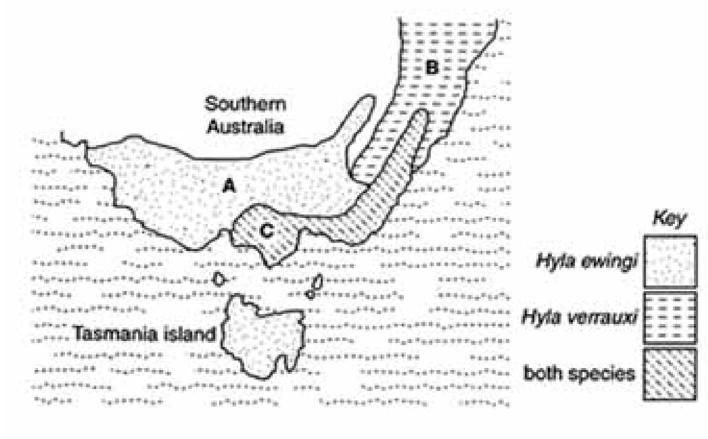
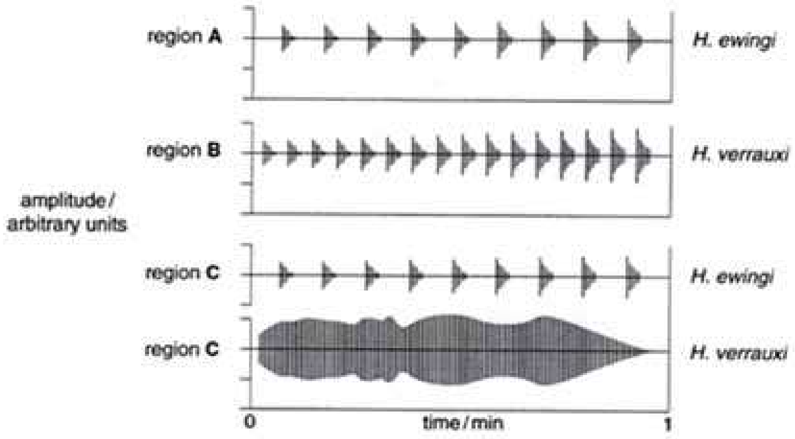
23 *Hyla ewingi* and *Hyla verrauxi* are two closely related species of tree frogs from southern Australia.



DNA sequence comparisons show a high level of homology and interbreeding can occur to produce viable offspring. Mate selection is based on females responding to the frequency of mating calls emitted by male frogs. The following data shows the pulse frequency and amplitude in the mating calls of *H. ewingi* and *H. verrauxi* from the regions **A**, **B** and **C**.



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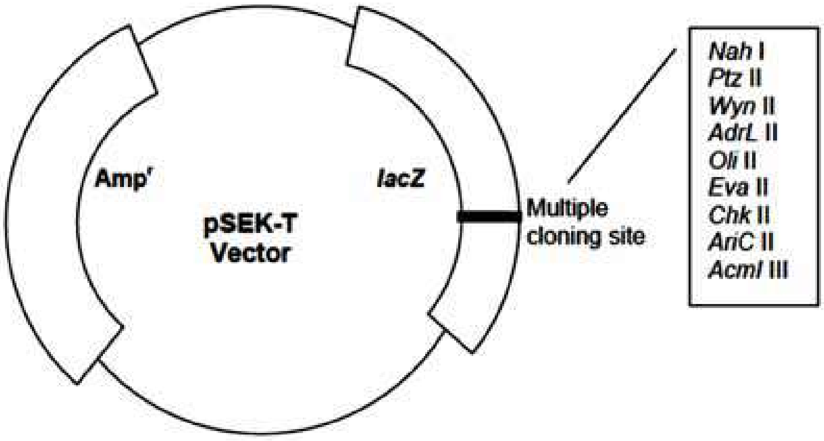

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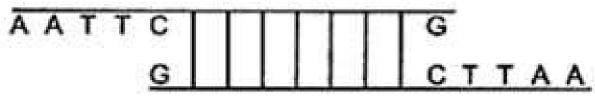

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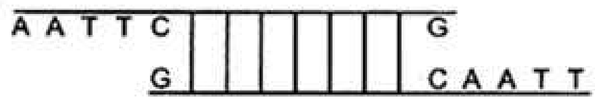

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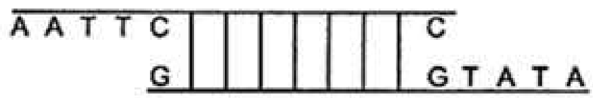

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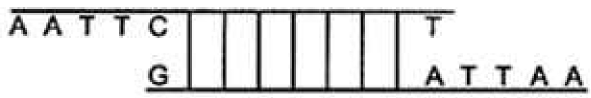

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	embryonic stem cells	**hematopoietic stem cells**
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B Transfer of selection marker to bacteria that reside in the human gut thereby conferring upon the bacteria antibiotic resistance

C Spread of the *Bt* gene from cultivated corn to wild relative which would then lead to the loss of biodiversity

D Transfer of *Bt* gene to the pests thereby increasing their resistance to the *Bt* toxin

-End of paper-

VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2017

NAME : _______Answers______________________

CT CLASS : ____________________________________

H1 BIOLOGY **8875/1**

Paper 1 Multiple Choice **1 hour**

Additional material: Multiple choice answer sheet

READ THESE INSTRUCTIONS FIRST

Write your name, exam number on the answer sheet provided.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

There are **30** questions in this paper. Answer all questions. For each question there are four possible answers A, B, C and D.
Choose the **one** you consider correct and record your choice **in soft pencil** on the separate 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 paper.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of 20 printed pages, including cover page

1 Which of the following is a false statement regarding centrioles and ribosomes?

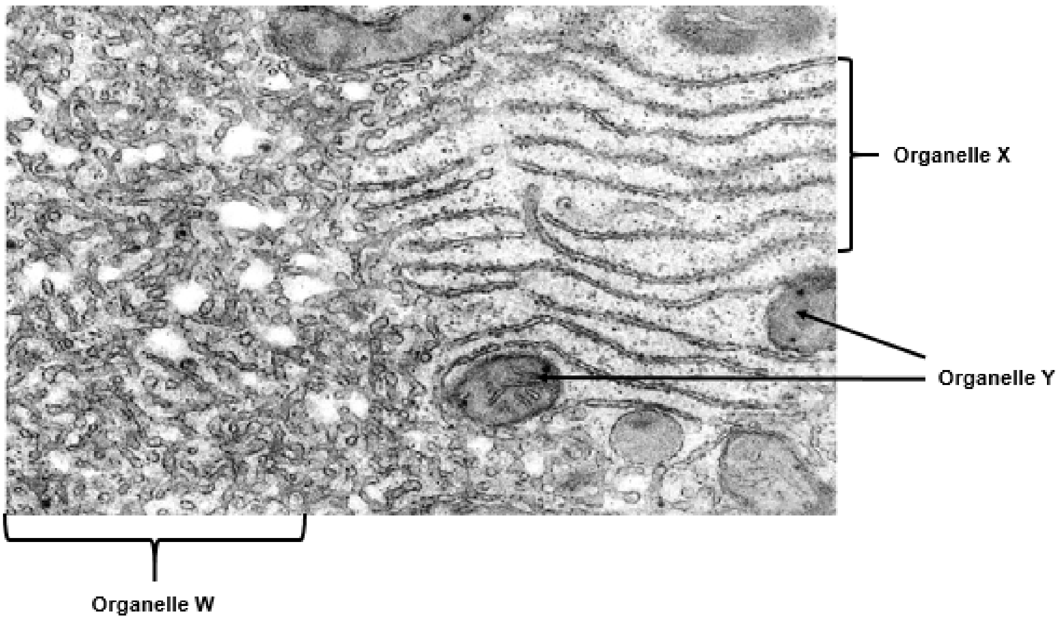
A Both are non-membrane bound organelles.

B Only centrioles are present in a cell undergoing mitosis.

C Both are present in dividing and non-dividing animal cells.

D Under high temperature, both will be denatured as they have a proteinaceous component.

2 Fig 2 shows three cell organelles W, X and Y.



Which of the following statements about these organelles is true?

A Only organelle Y contains RNA.

B Only organelle W contains carbohydrates and phospholipids.

C Organelle X has 80S ribosomes whereas organelle Y has 70S ribosomes.

D Organelles X and Y have double membranes whereas organelle W has a single membrane.

3 Which set of factors shown below will produce the **least** fluid cell surface membrane?

A	• High proportion of cholesterol • High temperature
B	• Low proportion of phospholipids with saturated fatty acids • High temperature
C	• Low proportion of phospholipids with unsaturated fatty acids • Low temperature
D	• High proportion of phospholipids with unsaturated fatty acid • Low temperature

4 Fig 4 shows a repeating unit found in a biomolecule.

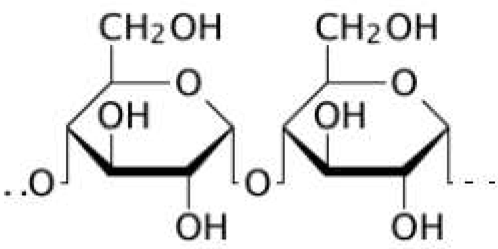


Fig 4

In which of the following biomolecules, would one expect to find the above repeating unit?

X Absent
√ Present

	Cellulose	Glycogen	Amylose	Collagen
A	X	X	√	X
B	√	X	√	X
C	√	X	X	√
D	X	√	√	X

5 Fig 5 below is an electron micrograph of a stained fiber of deoxyhemoglobin S (HbS).

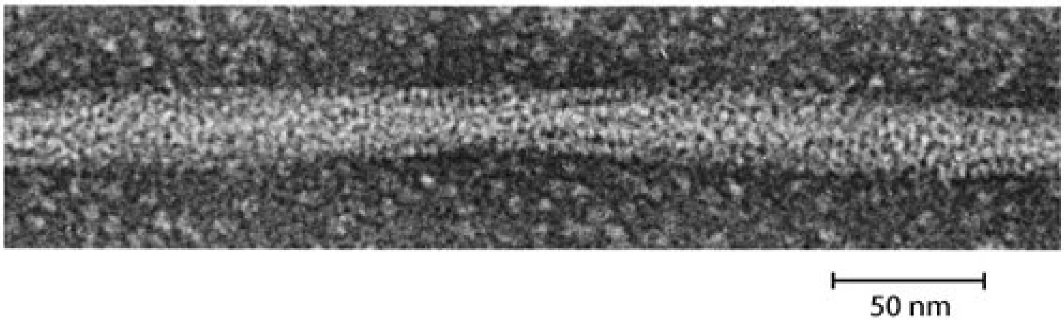


Fig 5

[From G. Rykes, R.H. Crepeau, and S.J. Edelstein. *Nature* 272(1978):509.]
Source: http://www.nslc.wustl.edu/sicklecell/part2/molecular.html

Which of the following statements is true?

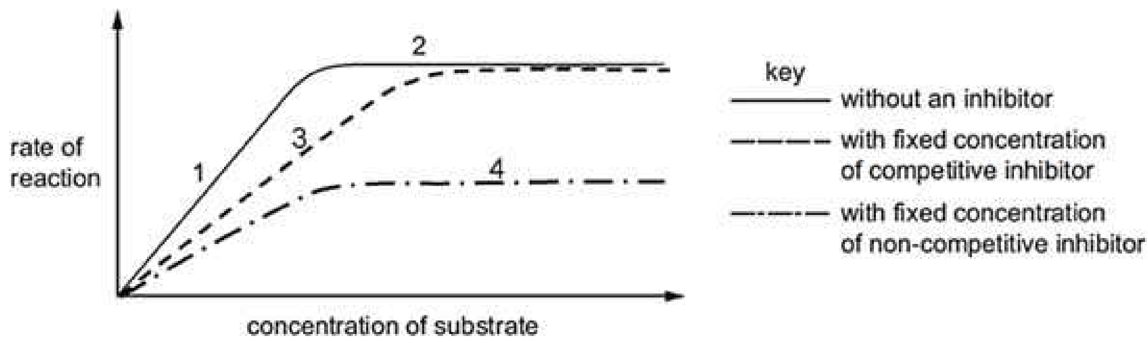
A Mutation in the red blood cell results in the production of HbS which precipitates out as long rigid fibers under low oxygen concentration.

B The long HbS molecule is insoluble due to its large molecular size and this results in the sickling of red blood cells.

C The aggregration of HbS molecules, under low oxygen concentration, causes the fiber to be precipitated out of solution, resulting in the sickling of red blood cells.

D Under low oxygen concentration, HbS molecules form a triplex helix structure, causing the cell membrane of the red blood cells to be more rigid and hence they sickled.

6 The graph shows the effect of increasing the concentration of substrate on the rate of enzyme catalysed reaction.



What is limiting the rate of the enzyme-catalysed reaction at 1, 2, 3 and 4 on the graph?

	1	2	3	4
A	enzyme concentration	substrate concentration	competitive inhibitor	non-competitive inhibitor
B	enzyme concentration	substrate concentration	non-competitive inhibitor	competitive inhibitor
C	substrate concentration	enzyme concentration	competitive inhibitor	non-competitive inhibitor
D	substrate concentration	enzyme concentration	non-competitive inhibitor	competitive inhibitor

7 What causes genetic variation in gametes during meiosis?

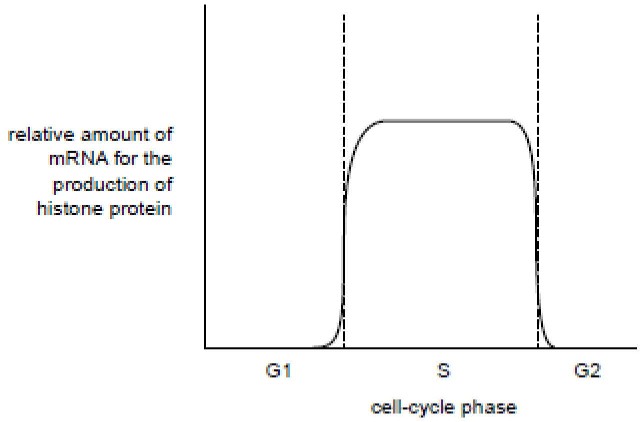
A Crossing over of sister chromatids during prophase I and random orientation of homologous chromosomes in metaphase II

B Crossing over in prophase I and random orientation of homologous chromosomes in metaphase I

C Pairing of maternal and paternal chromosomes during prophase I and crossing over in metaphase I

D Random orientation and segregation of homologous chromosomes during prophase I and metaphase I

8 The graph below shows the relative amount of mRNA for the production of histone protein at different times throughout a cell cycle.



Using your knowledge of the cell cycle and the information in the graph, it is correct to state that

A DNA replication occurs most actively in the G1 phase.

B histone genes are highly active throughout the cell cycle.

C histone protein synthesis occurs simultaneously with DNA synthesis.

D histone protein is not present in the cell during the G1 and G2 phases.

9 The sequence below depicts the template strand of a hypothetical gene. The exons are in bold type.

3′ **TAC AAA** CCG GCC **TTT GCC AAA** CCC AAC CTA **AAT ATG AAA ATT** 5′

An allele for this gene codes for a polypeptide with only five amino acids. This is caused by a mutation in one of the exons. Which of the following describes the change(s) that results in the formation of the shorter polypeptide?

A Deletion of one adenine

B Addition of two cytosines

C Substitution of thymine with adenine

D Addition of cytosine and removal of adenine

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

- Drug 1 inhibits the action of DNA ligase.
- Drug 2 resembles the shape of a DNA nucleotide.
- Drug 3 attaches irreversibly to the DNA molecule.
- Drug 4 binds irreversibly to the active site of DNA polymerase.

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

	Daughter strands of varying lengths are synthesized.	Only fragments are synthesized at the end of replication process.	Phosphodiester bonds cannot be formed.	Template strand becomes inaccessible by the enzyme.
A	4	3	2	1
B	2	4	3	1
C	2	1	4	3
D	3	2	1	4

11 The following events occur during transcription.

P. Bonds break between complementary bases.
Q. Bonds form between complementary bases.
R. Phosphodiester bonds form.
S. Free nucleotides pair with complementary nucleotides.

Which options correctly depicts the frequency of the events occurring in the nucleus?

	Occurs once	**Occurs twice**
A	P, R, S	Q
B	Q, R, S	P
C	R, S	P, Q
D	P, S	Q, R

12 The following statements are descriptions of polynucleotides found in eukaryotes.

1. Has catalytic properties
2. Can associate closely with specific proteins
3. Has variable length
4. Has fixed length and can fold into specific shape
5. Can be subjected to degradation by cytoplasmic enzymes

Which row matches the description to its function?

	Stores coded information	Provides a site for amino acid to bind	Forms a ribosome	Serves as a template for translation
A	4	5	1, 3	2
B	3, 5	1	2	4
C	2	4	1	3, 5
D	1, 5	2	4	3

13 The following two examples illustrate the inheritance of a sex-linked gene on the X-chromosome. In the parental generation (*P*), the homogametic sex is homozygous for colour in both examples.

Cat	**Magpie Moth**
black dominant to yellow	normal colour dominant to pale colour
P Black male x yellow female	*P* Pale colour male x normal female
F 1 yellow male to 1 black female	*F* 1 normal male to 1 pale female

In these crosses, the heterogametic sex is…

A male in the cat, female in the moth
B female in the cat, male in the moth
C male in both the cat and moth
D female in both the cat and moth

14 After pollinating plant 1, which had rough stems and yellow flowers, with plant 2, which had rough stems and white flowers, 80 seeds were obtained. When sown, these seeds grew into plants showing the four combinations of characteristics as follows:

26 with rough stems and yellow flowers.
12 with smooth stems and yellow flowers.
33 with rough stems and white flowers.
9 with smooth stems and white flowers.

Assuming that yellow is the dominant flower colour, which one of the following options is confirmed by these results?

	plant 1 is heterozygous for	**plant 2 is heterozygous for**
A	stem surface and flower colour	flower colour only
B	stem surface and flower colour	stem surface only
C	flower colour only	flower colour and stem surface
D	stem surface only	flower colour and stem surface

15 Flamingos are birds that live by lakes. The feather colour of flamingos may vary from white to pink to red. To investigate the inheritance of feather colour, a scientist performed the following crosses and recorded the feather colour of all the offspring when one year old. The diet of the offspring was also recorded.

Cross	**Feather colour of parents**	**Feather colour of all one-year-old offspring**	**Diet of offspring**
1	white × white	white	aquatic plants
2	red × white	white	aquatic plants
3	white × white	pink	algae and crustaceans
4	red × white	pink	algae and crustaceans

Based on this information, a correct conclusion would be that…

A both the parents in cross 1 must be homozygous for white feather colour.

B white feather colour is recessive to red feather colour

C the feather colour of flamingos is influenced by their environment.

D two parents, both with pink feather colour, would produce pink offspring

16 Tyrosinase is an enzyme that catalyses the conversion of the amino acid tyrosine into the black pigment melanin. It is responsible for the black fur colour of some rabbits.

A group of rabbits kept at 30 °C resulted in 90% of the rabbits with light fur colour. A second group of rabbits kept at 10 °C resulted in 90% of the rabbits with black fur colour.

Which hypothesis is supported by these results?

A	An inhibitor is present in rabbit skin cells that can bind strongly to tyrosinase when the external temperature is 30 °C.
B	At 10 °C external temperature there are fewer tyrosinase-tyrosine complexes formed and less melanin is produced.
C	Tyrosinase is an enzyme that is coded for by a gene that is switched off when the external temperature is 10 °C.
D	Tyrosinase is a temperature-sensitive molecule that is only activated when the external temperature is 30 °C.

17 In a common genetic condition afflicts children, the mutant allele differs from the wild-type allele by a single nucleotide substitution. This substitution eliminates a *NheI* restriction site so that the mutant allele is not cut by the restriction enzyme, *NheI*. A pedigree of a family exhibiting this condition is shown in Fig. 17.1.

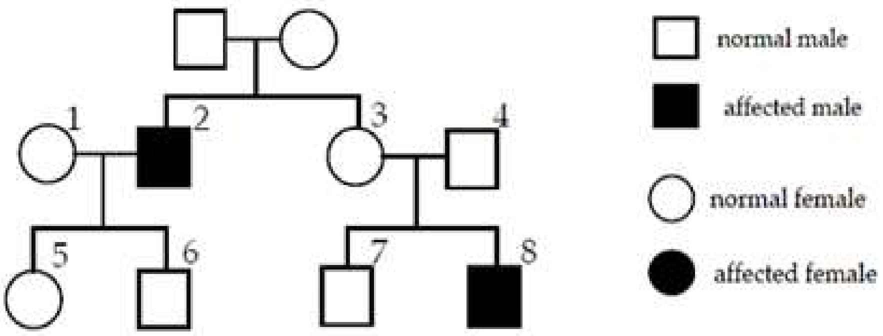


Fig 17.1

The DNA from four individuals in the pedigree were isolated and subjected to polymerase chain (PCR) reaction. This technique amplifies a 1000 bp portion of their DNA that includes the *NheI* site that is affected by the mutation.
The PCR products are then digested with *NheI* and analysed.

The DNA fragments from the digest are run on an agarose gel and the results are shown in Fig. 17.2.

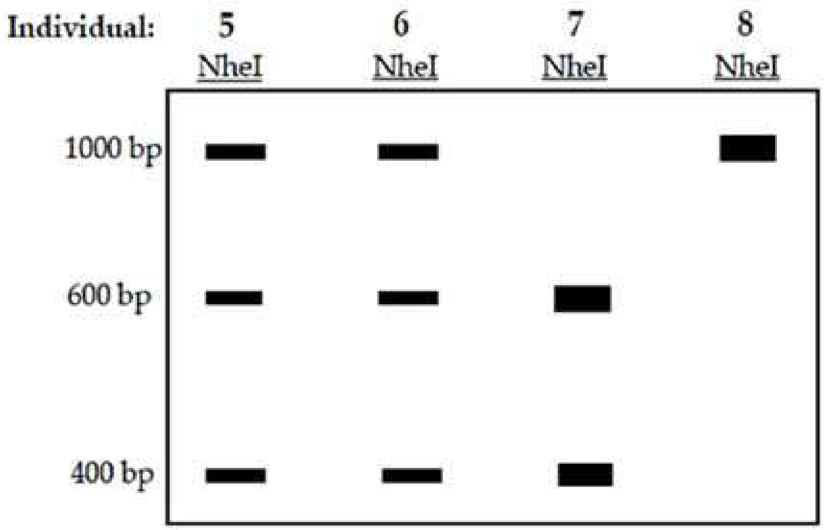
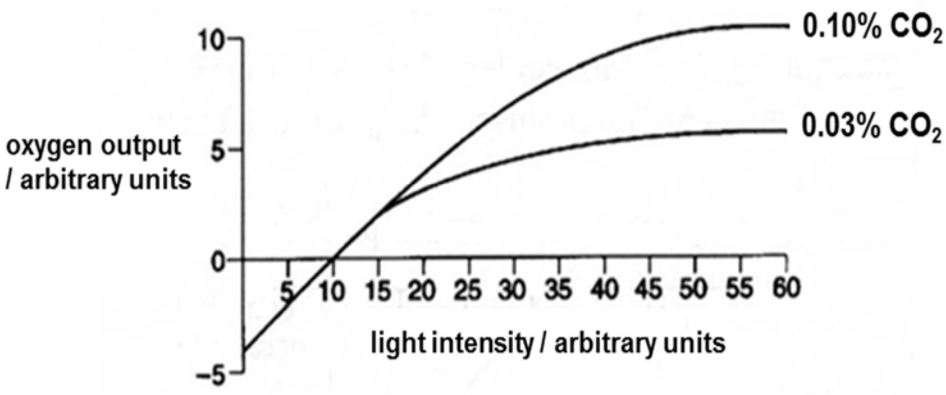


Fig. 17.2

Based on the data in Fig. 17.1 and Fig. 17.2, identify the correct mode of inheritance, and the probability of Individuals 3 and 4 of having a daughter who will be affected.

	Mode of inheritance of disease	**Probability**
A	autosomal dominant	0.125
B	autosomal recessive	0.25
C	X-linked dominant	0
D	X-linked recessive	0.5

18 The graph shows the oxygen output of a green plant at different light intensities in two separate setups with different concentrations of carbon dioxide in the surrounding air.



What can be deduced from the graph above?

I At 10 arbitrary units of light intensity, the rate of photosynthesis is equivalent to the rate of respiration.

2 Concentration of carbon dioxide limits the rate of photosynthesis when light intensity exceeds 15 arbitrary units.

3 Enzymes catalysing carbon fixation are saturated at high light intensities (above 30 arbitrary units) in both experiments.

4 Oxygen output can be used to quantify the rate of photosynthesis due to their role as final acceptor of protons and electrons.

A 1 only

B 1 and 2 only

C 3 and 4 only

D 2, 3 and 4 only

19 Which of the following statements show a difference between cyclic and non-cyclic photophosphorylation?

A Cyclic photophosphorylation only involves PSI and PSII whereas non-cyclic photophosphorylation only involves PSI, PSII and NADP.

B Light is required to boost electrons cyclic photophosphorylation whereas for non-cyclic photophosphorylation, the energy comes from photolysis of water.

C Only non-cyclic photophosphorylation produces protons which is required for the generation of the proton gradient for ATP synthesis.

D Oxygen is produced in non-cyclic photophosphorylation only.

20 Metformin is widely used to reduce high blood sugar levels caused by diabetes.

It exerts its activity through increasing glucose uptake and utilisation by cells. Metformin has also been shown to affect mitochondrial respiration in the following ways:

- Decreases the activity of the enzyme (pyruvate dehydrogenase) that converts pyruvate to acetyl CoA
- Inhibit one of the electron carriers in the electron transport chain

Which of the following are possible observations of cells that have been treated with metformin?

1. An increase in oxygen uptake by the cells.
2. A decrease in the pH of the cytoplasm
3. An increase in the breakdown of glucose.
4. A decrease in the carbon dioxide release.

A 1 and 4 only

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21 Two respirometers (one shown in Fig 22) were set up to investigate the rate of respiration in spiders. To one setup, the spiders were fed a diet containing a drug before the experiment. For this setup, the drop of fluid remained stationary after a short distance from the starting position. Distance moved is shorter than the control setup.

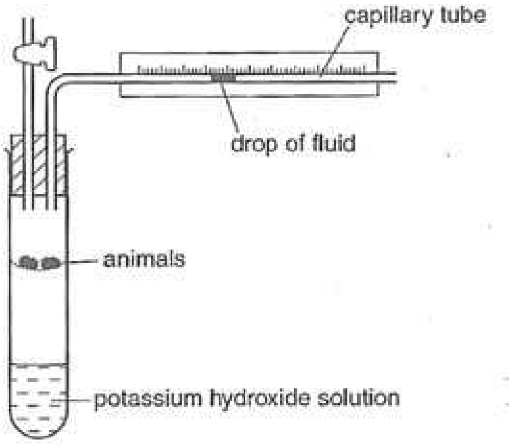

Fig 22

What could be a possible explanation for this observation?

A The oxygen content in the boiling tube was depleted.

B A mutation occurred that causes the ATP synthase to become hyperactive.

C A drug was introduced that act as an ion channel on the mitochondrial membrane.

D Inhibitor of the electron carriers in the electron transport chain was added to the animal's diet.

22 Which feature does **not** support Darwin's theory of natural selection?

A adaptations to the environment, e.g. increased density of fur in bears in cold climates

B homologous molecular structures, e.g. ATP in diverse organisms

C similar anatomy, e.g. same number of neck vertebrae among mammals

D similar structures for specific functions, e.g. fin of whale and shark

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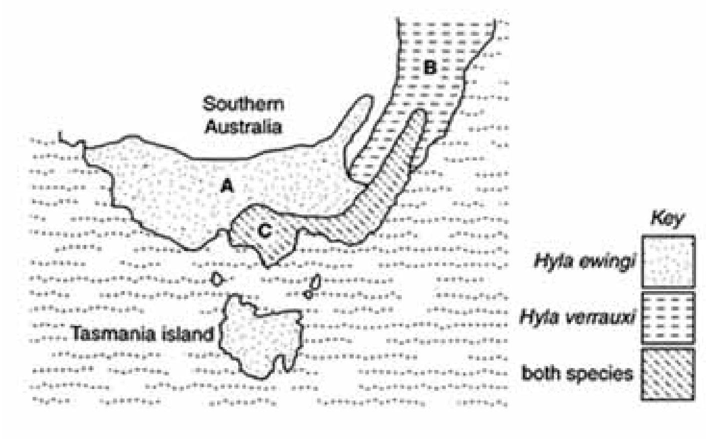
23 *Hyla ewingi* and *Hyla verrauxi* are two closely related species of tree frogs from southern Australia.



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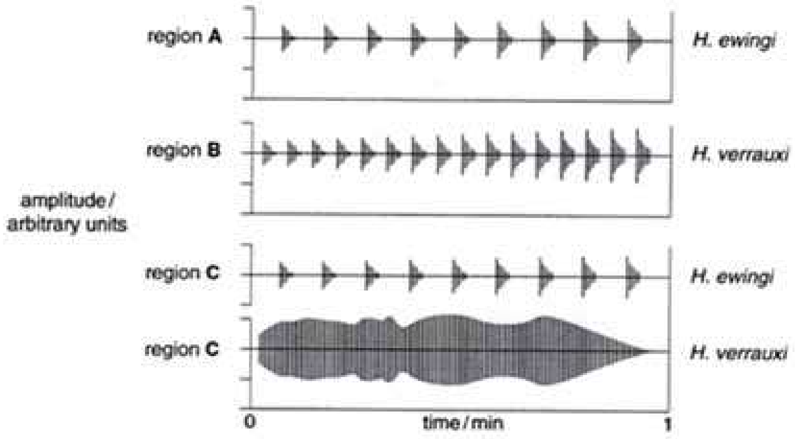

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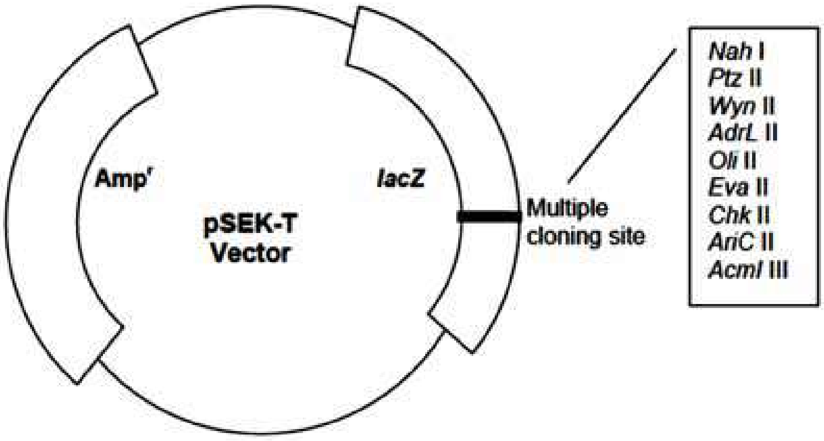

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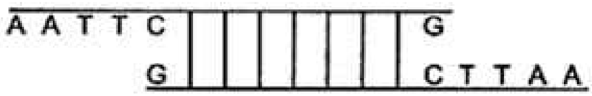

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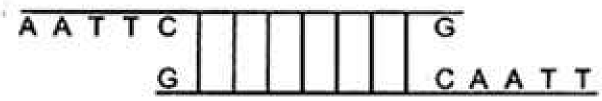
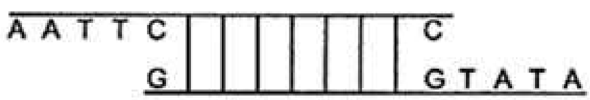
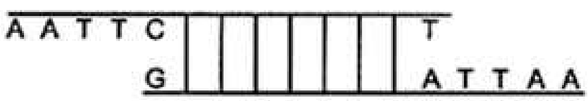


C



D



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II GM fish gaining a mating advantage over wild tilapia should they escape

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Which of their concerns is / are not valid?

A I and II

B II and III

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C Consideration of a suspect's genetic pre-disposition to violent behaviour in criminal trials

D The free availability and accessibility of the complete sequence of the human genome on the Internet.

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A Toxic effects of *Bt* on non-target insects e.g. monarch butterfly larvae could have predictable ecological consequences.

B Transfer of selection marker to bacteria that reside in the human gut thereby conferring upon the bacteria antibiotic resistance

C Spread of the *Bt* gene from cultivated corn to wild relative which would then lead to the loss of biodiversity

D Transfer of *Bt* gene to the pests thereby increasing their resistance to the *Bt* toxin

-End of paper-

VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2017

NAME : ______________________________

CT CLASS : ______________________________

H1 BIOLOGY **8875/2**

Paper 2 **2 hours**

READ THESE INSTRUCTIONS FIRST
Write your Name and CT class on all the work you hand in.
Write in dark blue or blue pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **one** question.
Write your answers on separate answer paper provided.

At the end of the examinations,
1. hand in section A and the one question you attempted from section B separately;
2. fasten all your work securely;
3. enter the number of the section B question you have answered in the grid opposite.

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

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
Total	

This document consists of 10 printed pages (including the cover page)
[Turn over]

Section A

1 Fig.1 shows an electron micrograph of an organelle. There are two distinct group of vesicles (Boxes B and C) associated with this organelle.

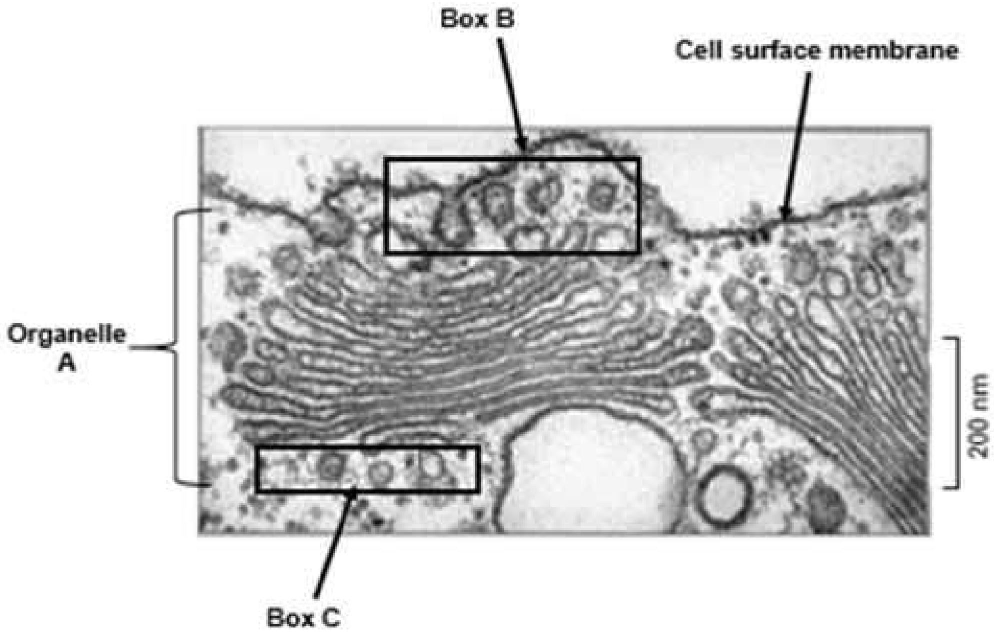

Fig. 1

(a) (i) Identify organelle A.

…………………………………………………………………………………………………… [1]

(ii) Describe the differences in the role of the vesicles in Boxes B and C.

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…………………………………………………………………………………………………… [4]

In Angelman syndrome, a severe and rare neurodevelopmental disorder, it has been reported that the lack of ubiquitin protein ligase E3A (*UBE3A*) expression leads to a disruption of structure and function of Organelle A. Ubiquitin protein ligases are enzymes that attach a small molecule called ubiquitin to certain proteins. Such proteins are then degraded by the cells.

(b) Suggest how the lack of E3A expression can lead to a disruption in the structure and function of Organelle A.

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The diameter of a prokaryotic cell is usually between 1-10 μm, whereas a typical eukaryotic cell is between 10-100 μm. The size of a cell is often restricted by its ability to metabolise nutrients to produce energy. A possible reason for the small size of the prokaryotes is the lack of membrane-bound organelles.

(c) Explain the importance of membrane-bound organelles in allowing the increase in size of eukaryotic cells.

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[Total: 10]

2 Fig 2 below shows a magnified view of the eukaryotic chromosome.

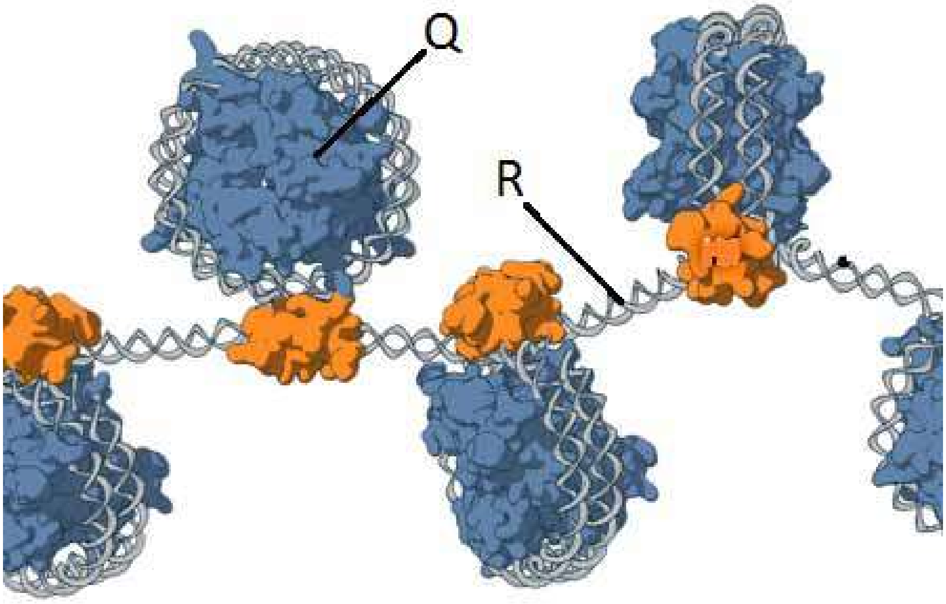

Fig. 2

(a)(i) Structures **R** and **Q** are two different biomolecules that make up a typical chromosome. Identify structures **R** and **Q**.

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…………………………………………………………………………………………………… [1]

(ii) State two structural differences between **R** and **Q**.

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(iii) With reference to Fig 2, discuss the significance of the interaction between **R** and **Q** in eukaryotes.

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The centromere is part of a eukaryotic chromosome that links sister chromatids together. During nuclear division, spindle fibres attach to the centromere via a specific type of proteins known as kinetochore.

(b)(i) Suggest how the kinetochore proteins is able to bind specifically to the centromeric sequences.

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…………………………………………………………………………………………… [2]

(ii) Explain the consequences to the cell if the kinetochore protein is unable to bind successfully to the centromere during cellular division.

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…………………………………………………………………………………………… [2]

(iii) Suggest what would happen to a chromosome if a mutation causes it to contain more than one centromeric sequence.

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[Total: 10]

3 Fig 3 shows the forearms of different vertebrates.

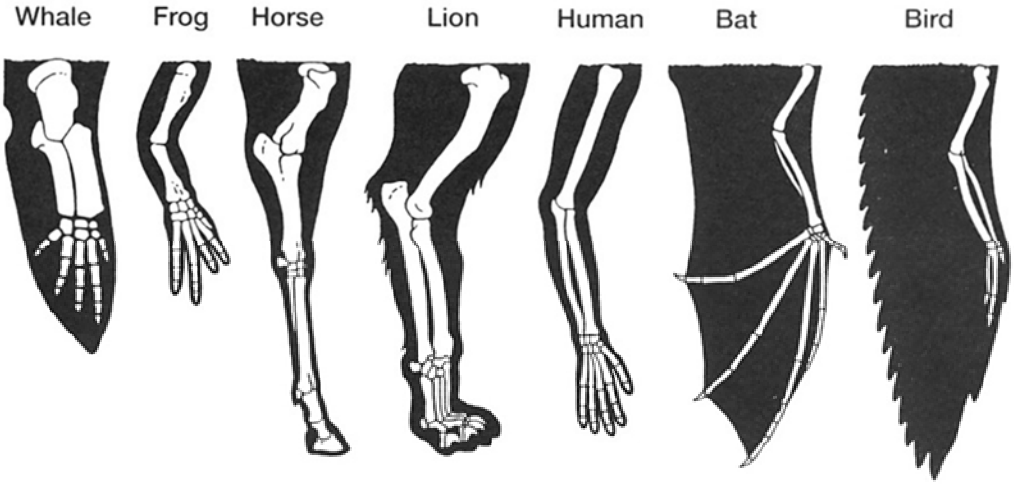

Fig 3

(a)(i) Using Fig 3, explain what is meant by “a homologous feature”.

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(ii) Explain how this provides evidence in support of Darwin’s theory of natural selection.

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(b) DNA from the fossil material of these birds were extracted and amplified. State the name of the technique used and outline the major steps involved.

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(c) State two advantages of using molecular data over morphological data to establish relationships between different vertebrates.

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[Total: 11]

4 Commercial aquaculture is the most rapidly growing segment of the agriculturalindustry, accounting for more than 60 million tons in 2012, versus 90 million tons of wild-caught fish. *AquAdvantage salmon* is a genetically modified (GM) Atlantic salmon developed by AquaBounty Technologies. The purpose of the modifications is to increase the speed at which the fish grows without affecting its ultimate size or other qualities. The fish grows to market size in 16 to 18 months rather than three years as shown in Fig 4.1 below.

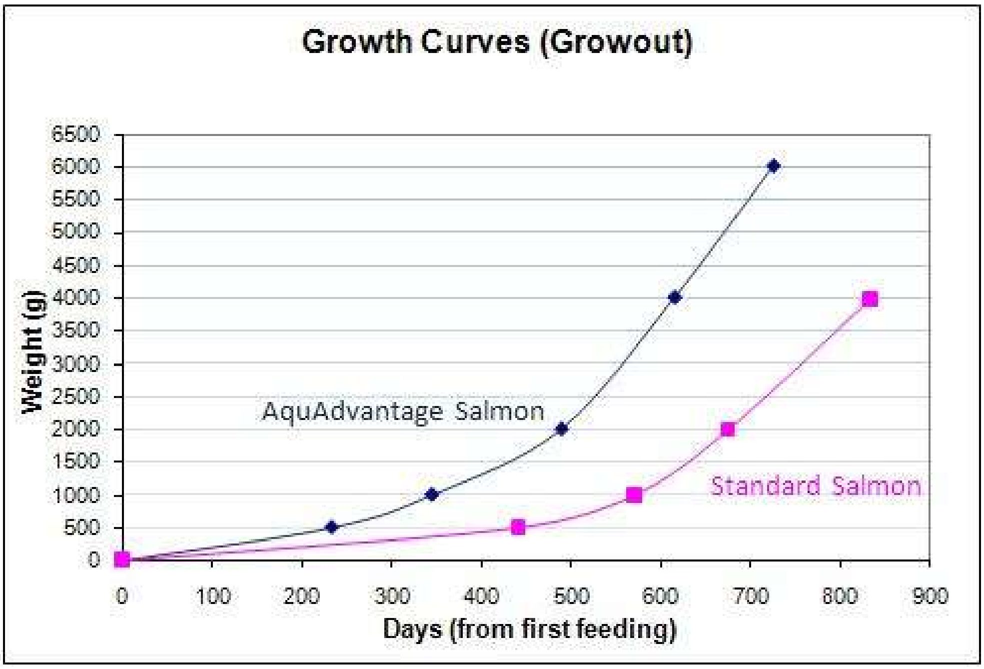

Fig 4.1
source: http://www.21stcentech.com/fishing-update-gmo-salmon-fda-approval-united-states/

(a) Describe how GM salmon is produced in the laboratory

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…………………………………………………………………………………………………… [4]

(b) Describe briefly the advantages of farming GM salmon (*AquAdvantage*) over normal salmon

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There are many public concerns about the impact of GM organisms on the natural ecosystems. The following chart shows the results of an experiment conducted by Biotech companies who made GM salmon.

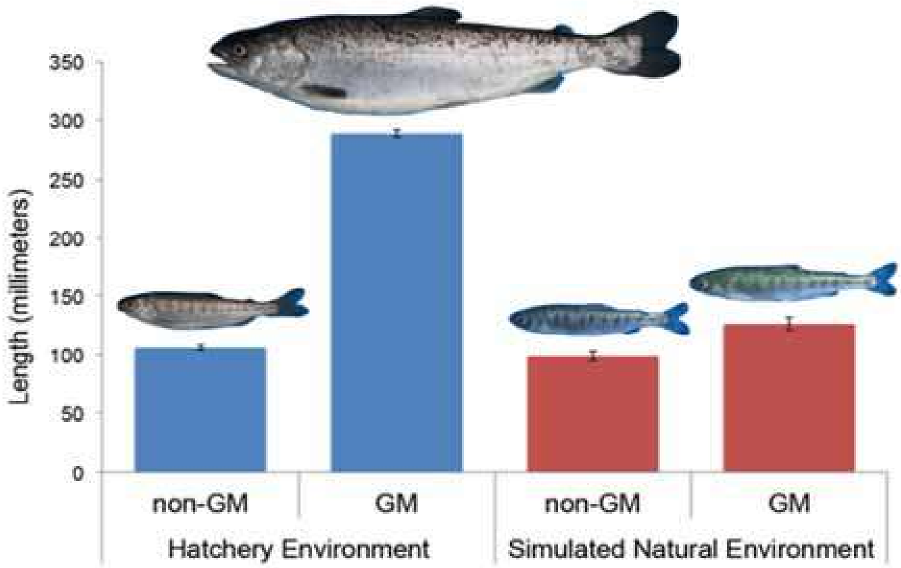

Fig 4.2

source: http://sitn.hms.harvard.edu/flash/2015/challenging-evolution-how-gmos-can-influence-genetic-diversity/

(c) With reference to Fig 4.2, explain why public worries on GMO could actually be unfounded.

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[Total: 9]

Section B

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.
Begin each of sections **(a)**, **(b)** etc. on a **FRESH SHEET** of answer paper.

Either

5 **(a)** Methylene blue, a common stain used to dye cells for microscopy work, can function as an effective hydrogen acceptor. It changes from blue to colourless upon reduction.

Using methylene blue, describe an experiment to study the effects of different concentrations of glucose on the enzyme catalysed reactions in respiring yeast cells. Explain the principles behind the design of your experiment. [9]

(b) A small amount of inhibitor is added to reaction mixture, explain how you would go about determining the mode of action of this inhibitor. [7]

(c) Using a named example, explain the normal function of stem cells in a living organism. [4]

[Total: 20]

Or

6 **(a)** Explain how the structural features of the cell membrane enable it to transport materials in and out of the cell [9]

(b) Explain the significance of having double membranes in organelles like mitochondria and chloroplasts [5]

(c) Outline the role of hydrogen bonds in biomolecules [6]

[Total: 20]

VICTORIA JUNIOR COLLEGE
BIOLOGY DEPARTMENT
JC2 PRELIMINARY EXAMINATIONS 2017
HIGHER 1 8755
PAPER 2

1

(a) (i) Identify organelle A. Support your answer with one observable feature, other than vesicles, shown in Fig 1.

Golgi body/ golgi apparatus;;
A stack of membranes with swollen ends;;

(ii) Describe the differences in the role of the vesicles that fuse with the forming face and the vesicles that are formed at the maturing face. [4]

Box C: [2m]
- vesicles contain proteins and/or lipids;
- transported from rER and sER;
- that will undergo chemical **modification** within the golgi body;
- **examples** of modification: glycolysation, phosphorylation etc

Box B: [2m]
- Packaging and transport function: Vesicles containing modified products will be transported to the cell membrane;
- where they **fuse** and **release** the products to the outside of the cell
- via **exocytosis**;

(b) Explain how the lack of E3A expression can lead to a disruption in the structure and function of the Golgi apparatus.
- Lack of gene expression means that the enzyme E3A is not **produced**/ transcribed and translated;;
- Proteins that are tagged by ubiquitin, are meant for **degradation**;;
- These proteins are either **damaged/abnormal/excess**;;
- Removal of these proteins help to maintain the normal functions of the GA (idea of);; (A: reverse argument)

(c) Explain the importance of membrane-bound organelles in allowing the increase in size of eukaryotic cells. [3]

- Increases in the size of a cell is only possible if it can meet the increases in **nutrient and energy** demands;;
- Membrane-bound organelles allows **compartmentation and specialisation;;**
- All the enzymes and substrates involved are located in one place;

- allows the setting up of an environment that is **optimal** to the functioning of the enzymes;
- and increase **efficiency** of metabolic processes;

(A: named example with the same idea eg. mitochondria that increases efficiency of respiration)

[Total: 11]

2

(a) (i) Structures R and Q are two different biomolecules that make up a typical chromosome. Identify structures R and Q. [1]

- R – DNA; Q – (histone) proteins;

(ii) State two structural differences between R and Q. [2]

- Type of bonds – Q contains peptide bond while R contains phosphodiester bonds
- Type of monomers – Q consists of amino acids while R consists of nucleotides
- Shape – Q is globular, compact while R has double helical shape
- AVP

(iii) With reference to Fig 2, discuss the significance of the interaction between R and Q in eukaryotes. [2]

- Ref large size of eukaryotic genome / ref length of eukaryote DNA molecule;
- R (DNA) is wrapped / wound around Q (proteins);
- to allow tight packing of the DNA molecule;
- To enable it to fit into a small space eg. nucleus of a cell;

(b) **(i)** Suggest how the kinetochore proteins is able to bind specifically to the centromeric sequences. [2]

- Ref specific **DNA sequences** of centromere constitute a **specific 3D shape;;**
- Which is complementary to the shape of the binding site for the kinetochore;;

(ii) Explain the consequences to the cell if the kinetochore protein is unable to bind successfully to the centromere during cellular division. [2]

- Spindle fibres **unable to attach properly** to each chromosomes;
- **Non-disjunction;**
- **Unequal separation** of chromosomes to each daughter cells;
- Idea of daughter cells may not be viable;

(iii) Suggest what would happen to a chromosome if a mutation causes it to contain more than one centromeric sequence. [1]

- It may fragment / break into pieces when different spindle fibres become attached to the same chromosome and pull it apart;; AVP;;

3 **(a)**

(i) Using Fig 3.1, explain what is meant by “a homologous feature”. [2]

- A structure with a <u>common evolutionary origin</u> / evidence that different species share a **common ancestor**;;
- that have been <u>modified to adapt</u> to a particular environment seen in different species / descent with modification to <u>serve different functions</u>;;

(ii) Explain how this provides evidence in support of Darwin’s theory of natural selection. [4]

- Forelimbs of different species show the **same basic plan** in terms of the <u>arrangement of bones</u>;;
- Provides evidence that **vertebrates** share a **common ancestor**;;
- Basic plan has been structurally **modified** through **natural selection**;;/ **descent with modification** has occurred in different species/ trait held by a common ancestor evolves into different variations over time;;
- which allows the limb to adapt to a certain method of locomotion (e.g. flying, swimming, etc.) in a particular environment;;/ adapt to different selective pressures in different environments;;

(b) DNA from the fossil material of these birds were extracted and amplified. State the name of the technique used and outline the major steps involved. [3]

- Polymerase chain reaction (PCR);;
- Major steps of PCR;;
  30 3-step cycle: Denaturation (95^oC), Annealing (45-55^oC) and Extension (72^oC)
- require dNTPs, ATP, Taq polymerase, forward and reverse primers;;

(c) State two advantages of using molecular data over morphological data to establish relationships between different vertebrates. [2]

- All forms of life use the same genetic language of **DNA and RNA and the genetic code** is universal;
- Even dissimilar organisms share genes inherited from a common ancestor;
- Hence, molecular data can be used to compare across all organisms, even microscopic organisms, some of which like amoeba can **change shape** and difficult to categorise based on morphology;;
- Adults and young may also appear different and hence making morphological comparisons challenging;;
- Convergent evolution resulting in organisms from different ancestral lineages sharing similar morphological features will make morphological comparisons difficult too;;

[2max]

[Total:11]

4

(a) Describe how GM salmon is produced in the laboratory [4]

- *What?*
- *Gene of interest : Growth hormone from Chinook*
- *How?*
- *Technicality of GMO : Microinjection/ Electroporation*
- *Recombinant DNA plus Promoter from Ocean pout introduced to target species of salmon*
- *Selection and breeding of GM salmon*
- *Why?*
- *GM salmon with growth hormone can feed and grow continuously, so bigger*

GM salmon

Recombinant DNA

- Antifreeze promoter from an Ocean pout
- Growth hormone gene from a Pacific Chinook salmon
- Fusing of a strong gene promoter such as the ocean pout antifreeze promoter leads to enhancement in the expression of the gene construct
- The recombinant DNA is then introduced into fertilized eggs of Atlantic salmon

There are two methods to modify salmon eggs to produce GM salmon:

(1 Mark awarded for ANY ONE method)

- **Microinjection** – foreign gene was microinjected into the cytoplasm of one-to-four cell embryos

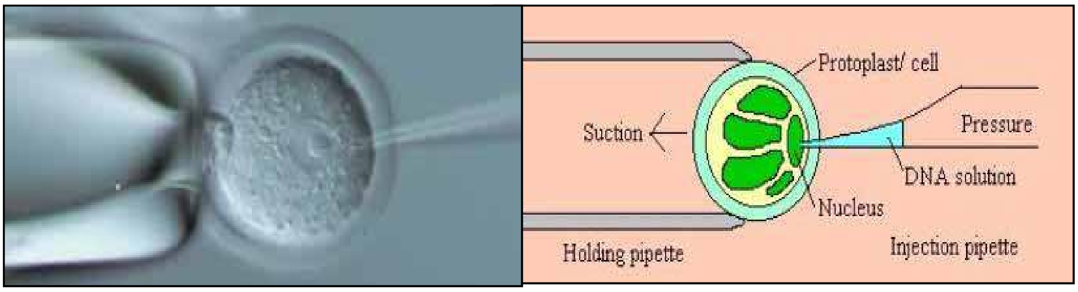
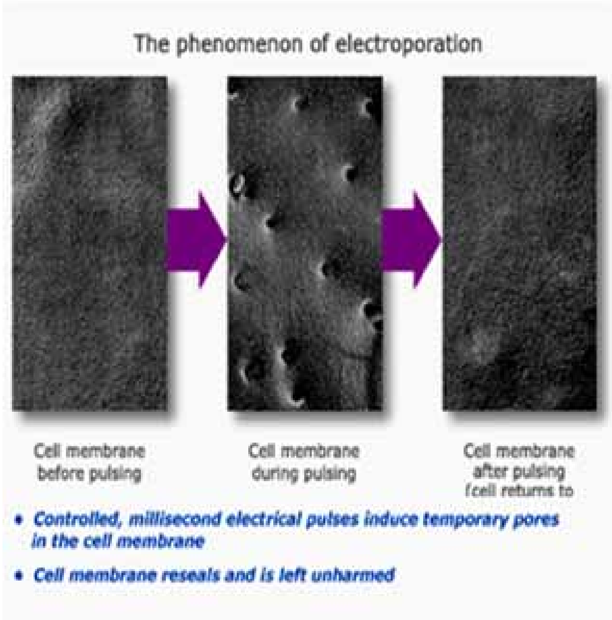


Figure 10: Techniques in production of GM salmon – (a) Microinjection
http://njms.umdnj.edu/departments/cell_biology_and_molecular_medicine/images/microinjection3.jpg)

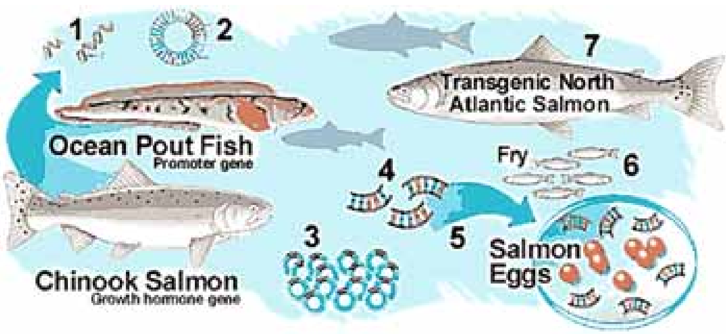
OR

- **Electroporation** – involves placing the eggs in a buffer solution containing DNA and applying short electrical pulses to create transient openings of the cell membrane, allowing the transfer of genetic material from solution into the cell

Figure 11: Techniques in production of GM salmon – (b) Electroporation
[http://www.inovio.com/images/IMG_electroporation.gif)](http://www.inovio.com/images/IMG_electroporation.gif)



- Subsequent selection and breeding led to development of the genetically modified salmon
- Due to the **year-round production** of growth hormone (due to the antifreeze promoter), this allows for **continuous feeding and growth** of the GM salmon.
- The GM salmon is able to grow quicker in size while feeding more efficiently (less feed is consumed to reach a larger size)



Producing a GM salmon

[4 max]

(b) Describe briefly the advantages of farming GM salmon (AquAdvantage) over normal salmon [2]

- GM salmon showed a **faster growth rate** then standard salmon

- Lesser resources need to farm the GM salmon

It reached 500g within 250 days compared to standard salmon that took 450 days for the same weight gain (allow similar comparisons for other quoted values at 1000/2000/4000g);; OR
GM salmon grew bigger than standard salmon, reaching 6000g by 700th day but even with another 150 days of growing, at 850 days, standard salmon reached only 4000g in weight;;

(c) There are many public concerns about the impact of Genetically modified organisms on the natural ecosystems. The following chart shows the results of an experiment conducted by Biotech companies who made GM salmon. Explain why public worries on GMO could actually be unfounded. [2]

- Although GM salmon grew over twice bigger than non-GM salmon at 300mm in the hatchery;
- GM salmon remained roughly the same size, if not, only slight larger at 130mm compared to 100mm in a simulated natural environment;;
- This shows that GM salmon, even if released into the wild, might not have a higher survival fitness and outcompete the wild non-GM salmon by outgrowing them;;
- Hence it is safe to farm and even release them into natural ecosystems;

ESQ

5 (a) Using methylene blue, describe an experiment to study the effects of different concentrations of glucose on the enzyme catalysed reactions in respiring yeast cells. Explain the scientific theory behind the design of your experiment. [8]

- Aerobic respiration involves the stages of glycolysis, link reaction, Krebs cycle and the Electron transport chain;
- As respiration process occurs, hydrogen atom are released which instead of being taken up by the usual **coenzymes like NAD**; or **FAD**;
- will now reduce Methylene blue as it is an effective hydrogen acceptor;
- This is indicated by a colour change in Methylene blue from blue to colourless;
- The rate at which this colour change occurs can thus be used to measure the rate of respiration of the yeast cells;
- Higher concentrations of glucose will take longer to process and thus a slower colour change

[3]

Experimental method

(General idea of the various steps in bold)

1. **Prepare five concentrations of glucose, ranging from 0.5%, 1%, 2% 5% and 10% from a stock solution;;**
2. **Label six boiling tubes A – G;**
3. Starting from the 10% stock solution, add equal volumes of distilled water and glucose to make $10cm^3$ of solution;;
4. Dilute each new solution made with equal volumes of distilled water and continue until all the five different concentrations of glucose are prepared, after which placing each tube in a rack;
5. **Into each tube add 3 drops of Methylene blue;**
6. **Add $5cm^3$ yeast solution to each tube noting the time;**
7. **Shake each tube to mix the contents and place back into the rack;**
8. **Do not disturb the tubes again but note the time taken for the blue colour to disappear from each tube;**
9. Repeat step 1-8 with replicates;

[5 max]

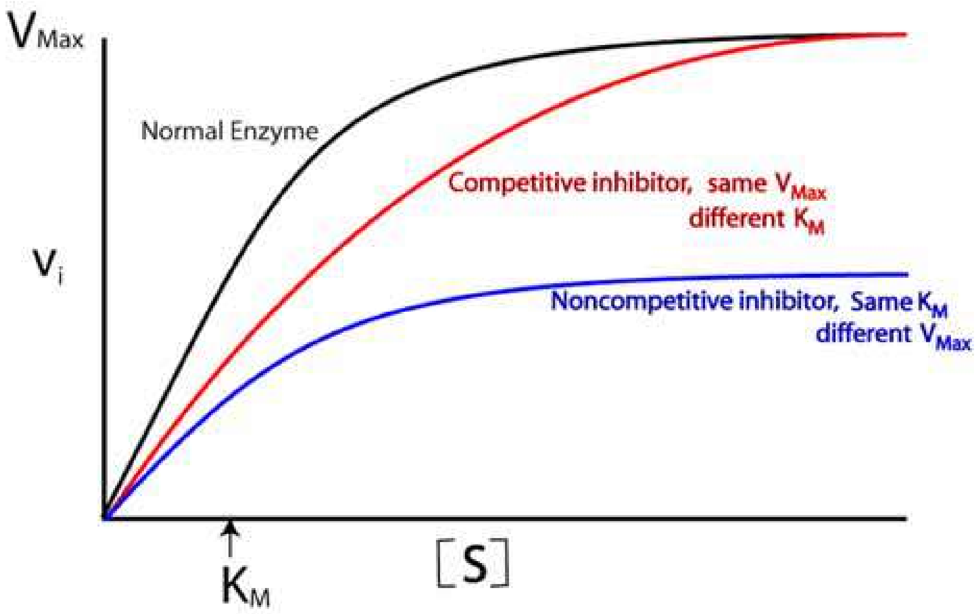
(b) A small amount of inhibitor is added to reaction mixture, explain how you would go about determining the mode of action of this inhibitor. [8]

Competitive inhibition (CI) (4max)

- Addition of a small amount of competitive inhibitor will have an impact on the lower concentrations of glucose;;
- At low substrate concentrations, CI molecules who have similar shapes to the original substrates, in this case glucose molecules, will compete for the active sites on the yeast enzymes;;
- Forming enzyme-inhibitor complexes instead of enzyme –substrate complexes;;
- This is because CI can also show affinity to the active sites but will have no enzymatic product at the end of the binding;;
- This results in a slower overall rate of enzymatic reaction;
- At higher substrate concentrations, say > 2%, the impact of adding CI is reduced by the presence of many more substrate molecules which result in a similar Kmax achieved for the enzymatic reaction. Km is changed;;

Non-competitive inhibition (NCI) (4max)

- Addition of NCI will have an impact on the Vmax and hence overall rate of reaction regardless of the substrate concentration;
- NCI molecules will probably bind to a site other than the active site, often called an allosteric site;;
- This alters the overall 3D conformation of the enzyme and hence changes the shape and configuration of the active site;;
- This prevents binding by the original substrates like glucose and hence no formation of enzyme-substrate complexes is possible;;.
- Depending on the concentration of NCI added, Vmax will be lowered but Km remains;;



(c) Using a named example, explain the normal function of stem cells in a living organism. [4]

Blood stem cell (**<u>haematopoietic</u> <u>stem cells</u>**);;

- <u>Haematopoietic stem cells</u> are **multipotent cells** with the ability to differentiate into the different **blood cells** and **immune cells**;;
- Major sources of <u>haematopoietic</u> <u>stem cells</u> include adult **bone marrow** and **umbilical cord blood**;;
- All the various types of blood cells are produced in the **bone marrow,** particularly in the ribs, vertebrae, breastbone and pelvis. These cells arise from a single type of cells called a **hematopoietic stem cell** (an adult <u>multipotent stem cell</u>);
- Umbilical cord blood is **human <u>blood</u> from the <u>placenta</u> and <u>umbilical cord</u>** that is rich in <u>hematopoietic</u> <u>stem cells</u>. The **haematopoietic stem cells** in the umbilical cord blood can be used to generate blood and immune cells;

OR
Embryonic stem cells;;

- **Pluripotent** stem cells derived from a group of cells called the inner cell mass, which is part of the early (4 – 5 day) embryo called the blastocyst;;
  Pluripotency refers to the ability to differentiate into almost any cell type to form any organ or type of cell;;

- Self-renewal- embryonic stem cells are “immortal”, i.e. these cells can **reproduce indefinitely** (can grow and divide for long periods in an undifferentiated state);;
  - Gives rise to cells from all three embryonic germ layers, ectoderm, mesoderm and endoderm;;

6 (a) Explain how the structural features of the cell membrane enable it to transport materials in and out of the cell [9]

- The cell membrane serves as boundary of cell;
- Selectively permeable to regulate movements of substances in and out;;
- Made up of mostly lipids (phospholipids and cholesterol), proteins and carbohydrates;;
- Phospholipid is most abundant, consists of two non-polar hydrocarbon chains and one polar phosphate head, phosphate molecules orientate to form a lipid bilayer;;
- Hydrophilic polar heads face the aqueous environment while the hydrophobic hydrocarbon tails face inwards and form a hydrophobic core within the lipid bilayer;;
- Only non-polar substances, like O_2 and CO_2 can move freely across the lipid bilayer via simple diffusion;
- Embedded within the lipid bilayers are protein carriers and protein channels which transport polar substances (eg glucose) and charged particles (eg ions) across the membrane;;
- These transport proteins are made up of both hydrophilic and hydrophobic amino acids;;
- The hydrophobic regions interact with the hydrophobic core of the lipid bilayer;
- The hydrophilic regions interact with the substances to be transported across;
- Pore of channel protein made of hydrophilic amino acids to allow ions to flow through down their concentration gradient via facilitated diffusion;;
- Ions like Na^+/K^+ will be transported against their concentration gradient via Na^+/K^+ pumps with the energy provided by ATP;;
- Conformational change in transport proteins allow substances to be moved across the membrane via facilitated diffusion or active transport;;
- Bulk transport can also take place with infolding of region of the plasma membrane which later pinches off to form a vesicle;
- Endocytosis allow larger substances to enter the cell enclosed within a membrane bound vesicle;
- Ref to pinocytosis (cell drinking) and phagocytosis (cell eating);
- Exocytosis is the secretion of substances out of the cell;
- Involves formation of vesicles from the Golgi apparatus;
- Secretory vesicles containing substances (digestive enzymes, peptide hormones) pinches from the trans face of the GA and migrates to the cell surface;
- The membrane of the secretory vesicle fuses with the plasma membrane and the contents are released out of the cell;

[9 max]

(b) Explain the significance of having double membranes in organelles like mitochondria and chloroplasts [5]

- Double membranes allow the compartmentalisation of space;;

- Creates the inner membrane space in mitochondria and thylakoid space in chloroplasts for the storage of protons (H^+ ions);;
- This is necessary for the build-up of a proton gradient that is the proton motive force behind the process of chemiosmosis that makes energy in the form of ATP;
- Increase in the surface area for **spatial arrangement** of reaction and attachment of components of the electron transport chain (ETC);;
- Without the inner membrane, the series of redox reactions occurring down the ETC as electrons are being passed on to the final electron acceptor will not be possible;;
- The creation of the matrix and stroma spaces in the mitochondria and chloroplasts respectively with the membrane segregation also allow separate reactions to occur and hence facilitate their **regulation** and control in cellular respiration and photosynthesis;;
- Double membranes also serve as evidence of the endosymbiont theory;
- Such inner membranes might have been derived from the ancestral cell membrane of the organelles who used to be free living while the outer membrane are remnants of the host cell membrane upon phagocytosis;

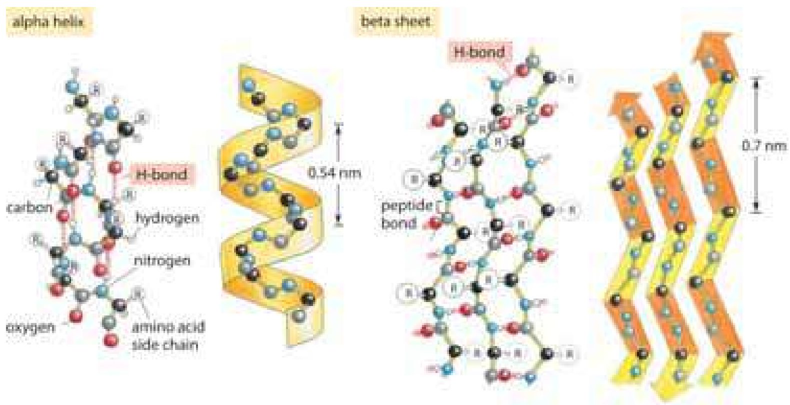
[5max]

(c) Outline the role of hydrogen bonds in biomolecules. [6]

Carbohydrates

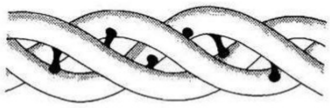
- In amylase, hydrogen bonserve to stabilise the helical structure
- In starch and glycogen, hydrogen bonds with water molecules forms a hydration shell that resulted in a partially soluble polysaccharide that can be approached and digested by hydrophilic enzymes;;
- In cellulose, the hydrogen atoms form **hydrogen bonds** with oxygen atoms in the same glucose molecule and other neighbouring glucose molecules;
- While these hydrogen bonds are individually weak, due to the large numbers of -OH groups, collectively they develop massive tensile strength;
- Also, between 60-70 cellulose molecules become tightly cross linked to form bundles called **microfibrils**, which are in turn held together in bundles called **fibres** by further hydrogen bonding, making the entire structure even stronger;;

Proteins



- Secondary structures like **alpha helix** and **beta pleated sheets** stabilised by H bonds;;
- At tertiary levels and above, a globular protein have non-polar, hydrophobic R groups point into the centre of the molecule, making them **water soluble**, since water clusters around their outward facing hydrophilic groups, but water cannot get into the molecule;;
- However, proteins that form long strands are known as **fibrous** proteins, and are mostly **insoluble** with hydrophobic R groups facing outwards;;
- **Interchain H bonds** within the triple helical structure of each tropocollagen, due to presence of many glycine residues, result in strong, tight coil with **high tensile strength;;**

❖ Hydrogen bonds between the residues stabilise the 3d structure of the tropocollagen.



❖ Covalent bonds form between tropocollagen molecules which stabilise the collagen fibre.

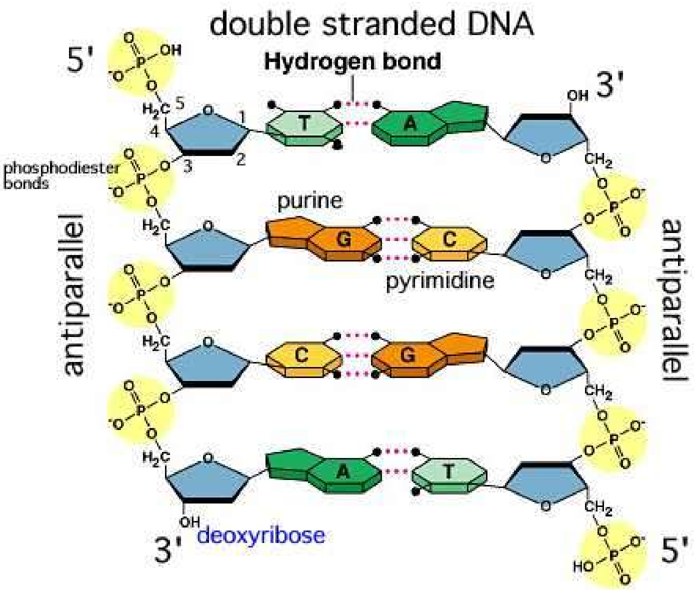
❖ Steric repulsion between proline and hydroproline side chain stabilise the whole helix of collagen.

Lipids

- Lack of hydrophilic components within lipid structures meant that it will not form H bonds with water molecules and hence will be insoluble in water, important as storage material or to provide buoyancy and insulation;;

DNA

- H bonds between nitrogenous bases of nucleotides in double helix DNA structure helps to stabilise it and maintain same width throughout;;


double stranded DNA
Hydrogen bond
5'
3'
OH
phosphodiester bonds
purine
pyrimidine
antiparallel
antiparallel
G
C
T
A
deoxyribose
3'
5'

[6 max]