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.

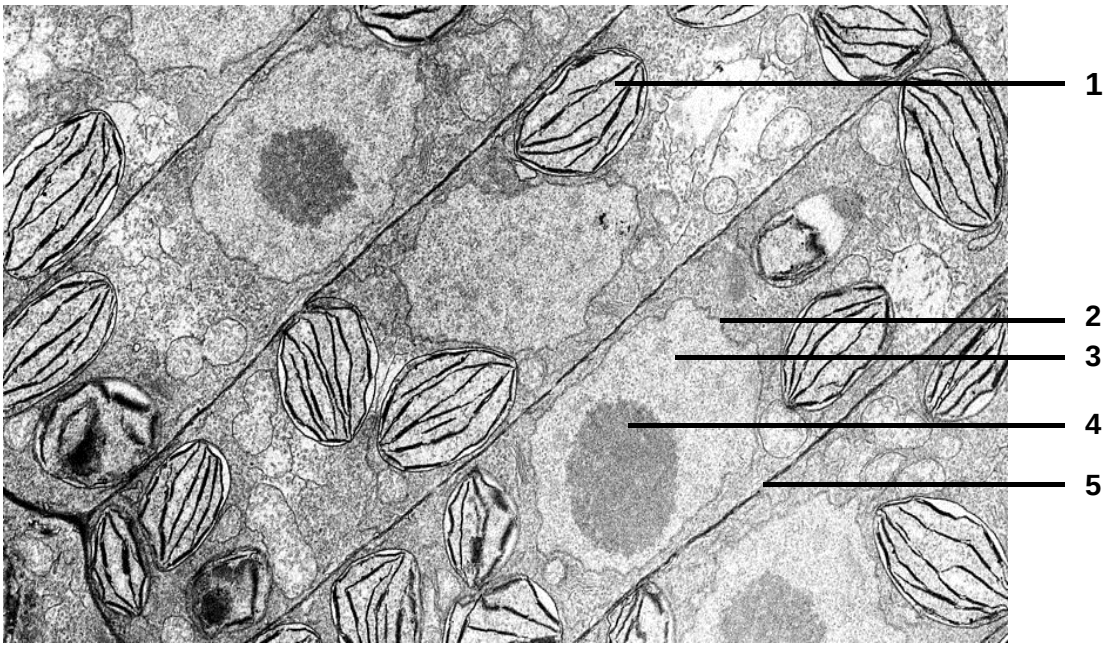
Read the instructions on the Answer Sheet very carefully.

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.

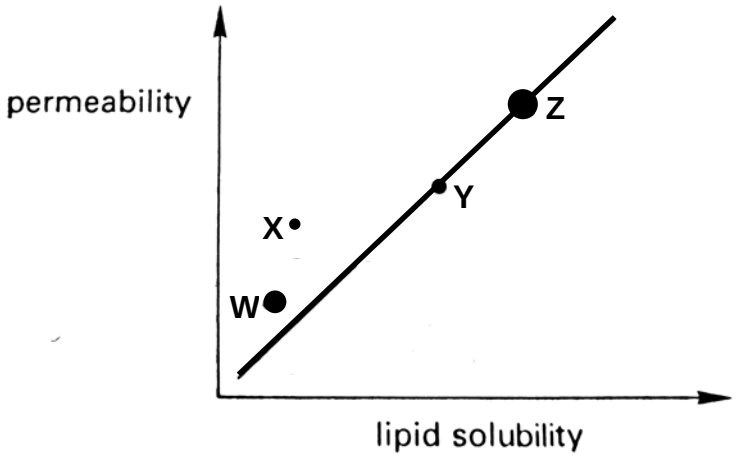
A 1, 2, 3 and 4

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

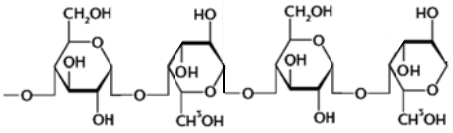
B Summer; a higher proportion of saturated fatty acids prevents phospholipids from moving too far apart at higher temperatures

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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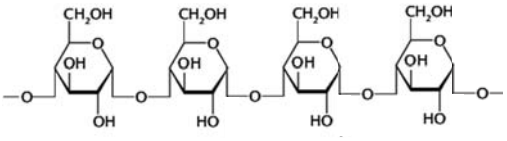
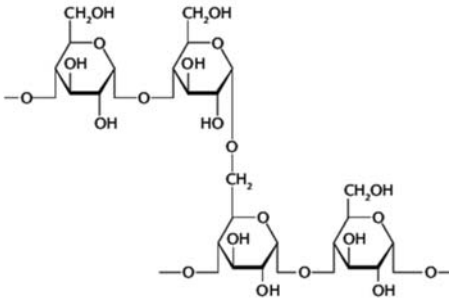
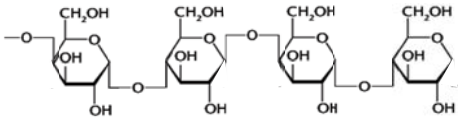


3



4



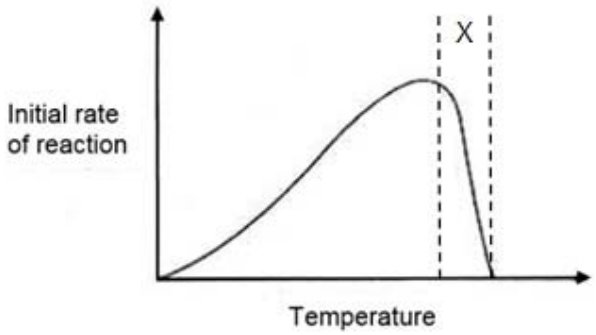
A 1, 3 and 4 only

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

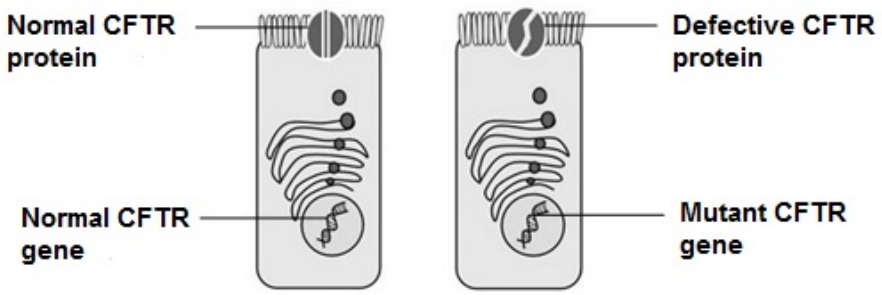
B 1 and 2 only

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?

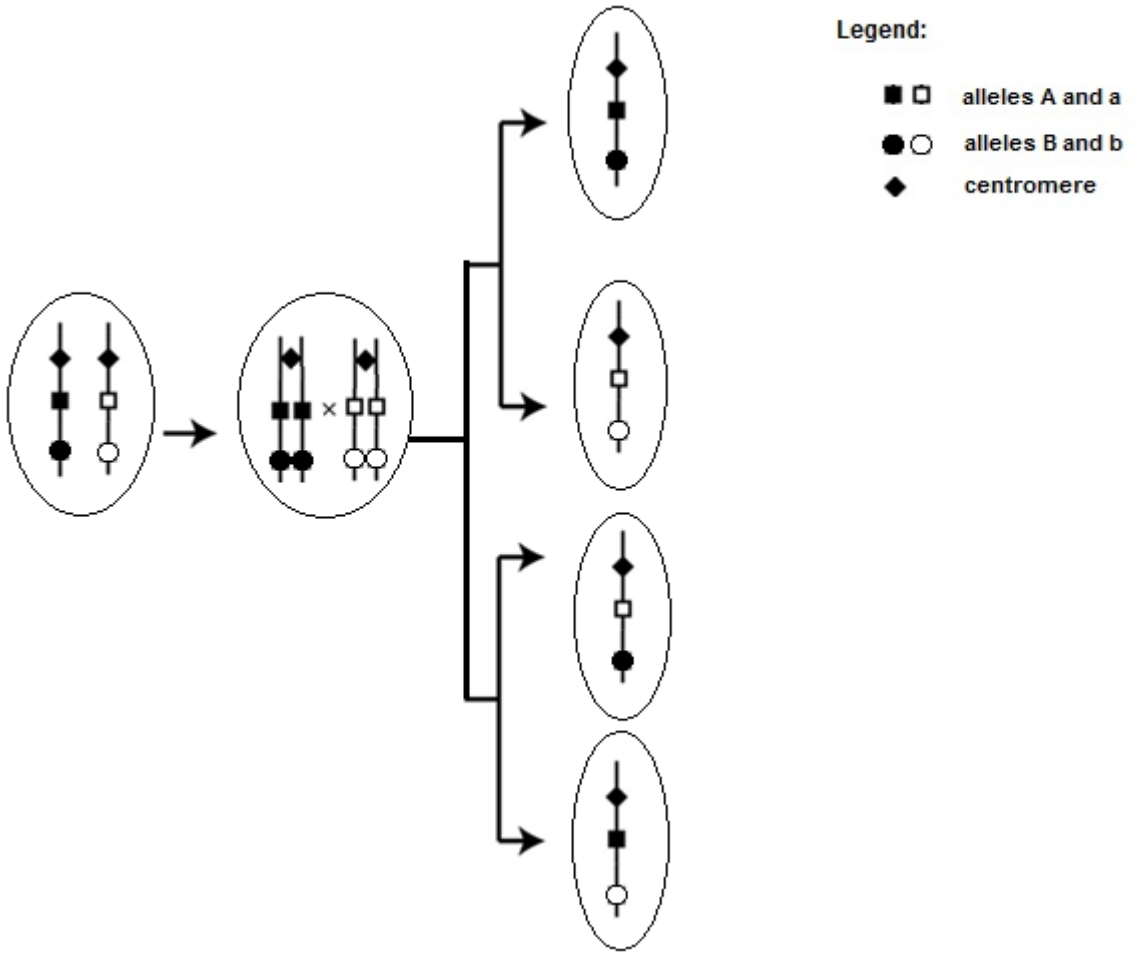
A There is a decrease in protein synthesis to shorten the spindle fibres during anaphase to pull the chromosomes to opposite poles of the cell.

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?

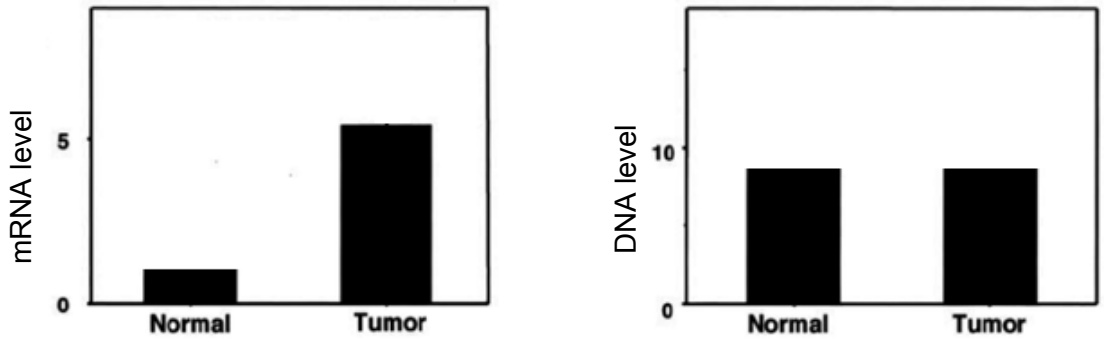
A Random assortment and segregation of homologous chromosomes result in different combinations of paternal and maternal chromosomes in the gametes.

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

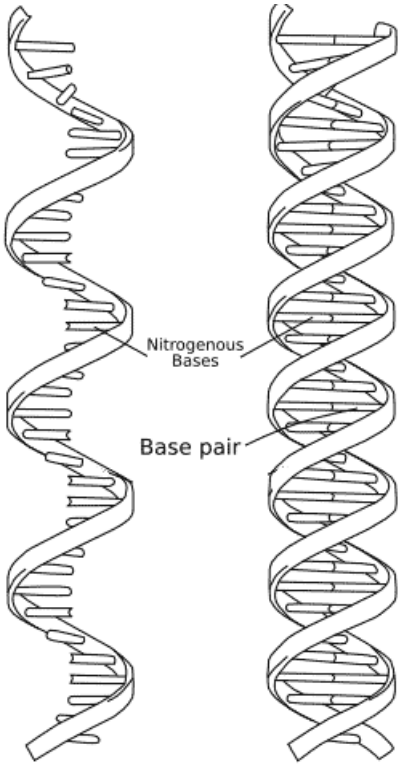
A 1, 3 and 4 only

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?

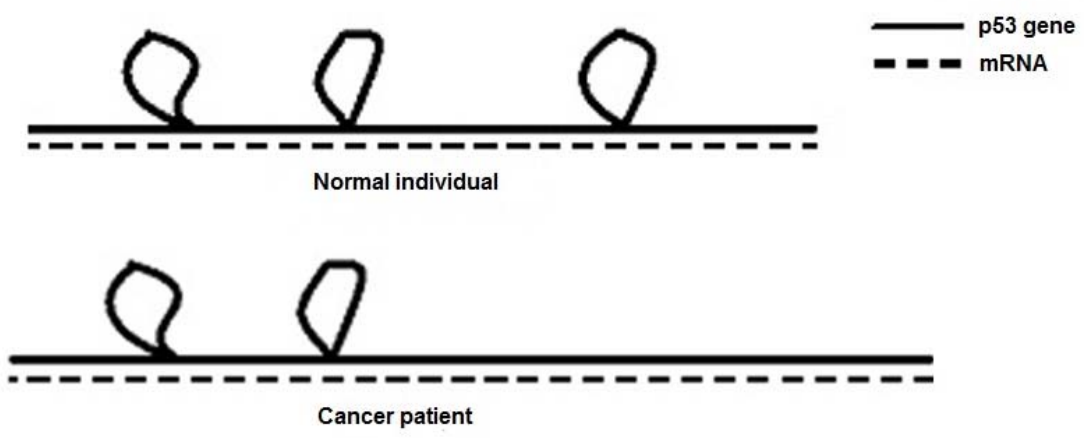
A 5 → 4 → 3 → 1 → 2

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.

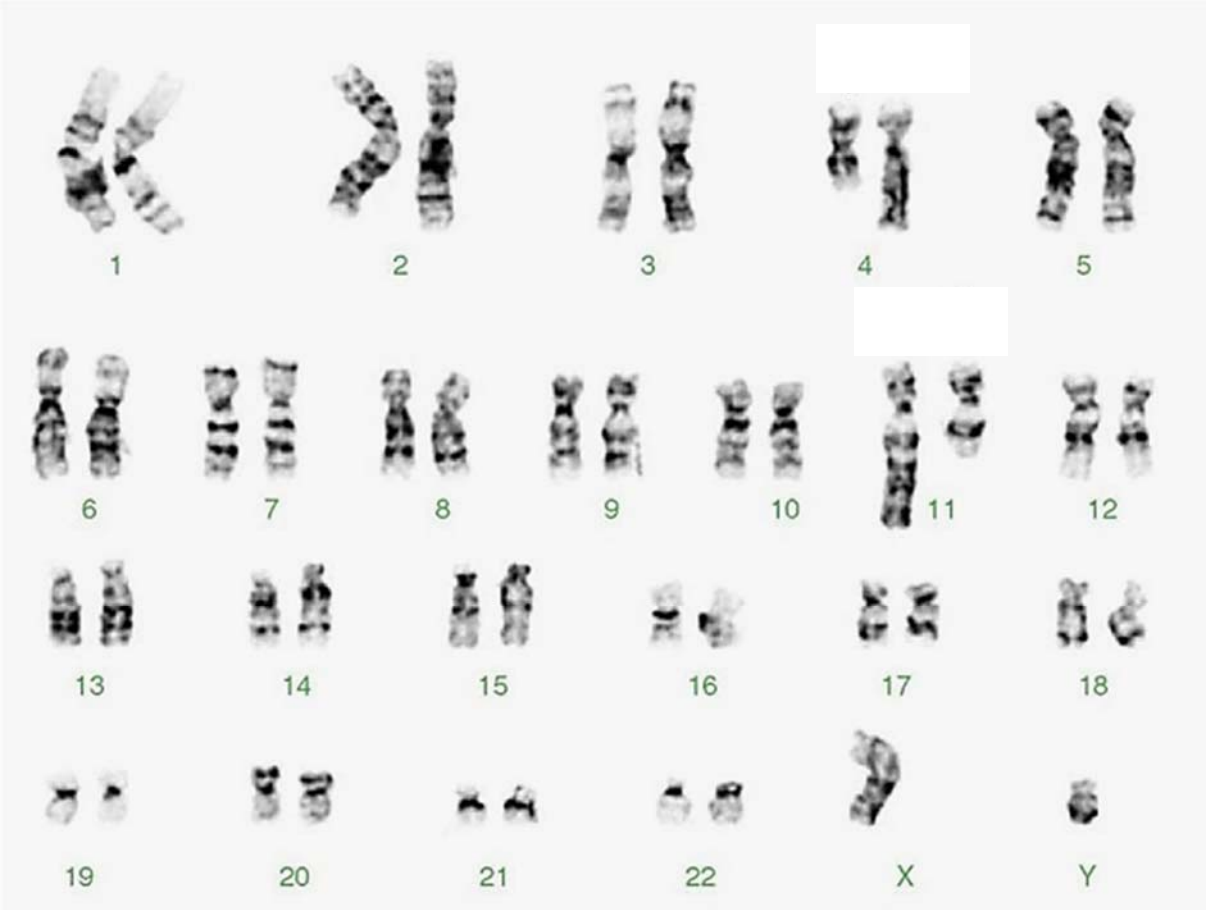
14 Many of the most effective antibiotics used in modern medicine are compounds made by fungi that inhibit bacterial protein synthesis. Among the most commonly used drugs are Chloramphenicol, Cycloheximide and Rifampicin. The results of the exposure to eukaryotic and prokaryotic cells to the above three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

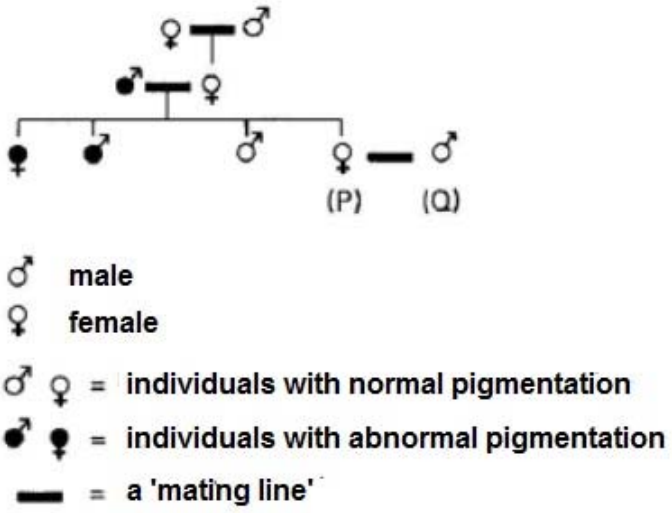
17 In a cross between red haired cattle and white haired cattle, the offspring produced are always a colour called roan (light red). If the roan cattle are interbred, they produce white, roan and red offspring.

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?

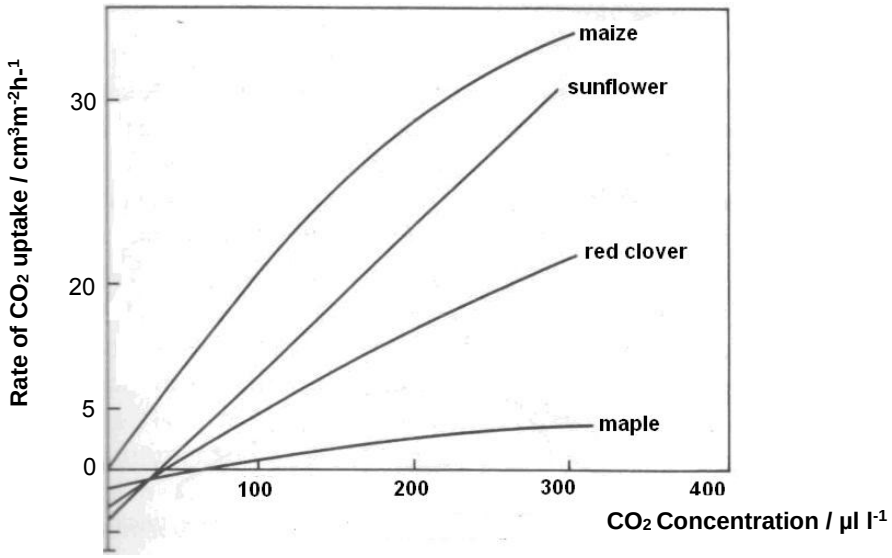
A No change in rate as Calvin cycle occurs in the stroma and not at thylakoid membranes.

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?

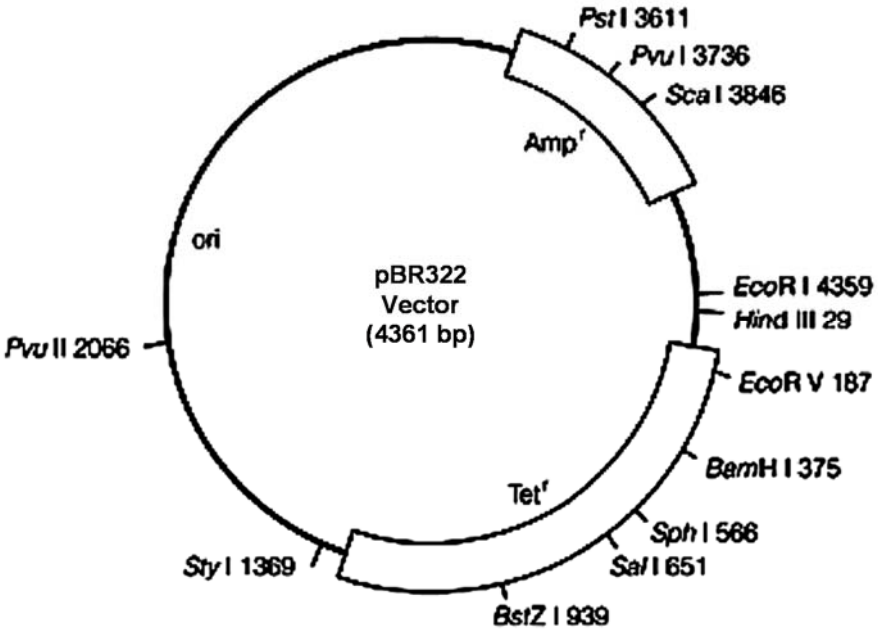
A Pigeons are unrelated to all the other three species due to differences in forelimb anatomy.

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?

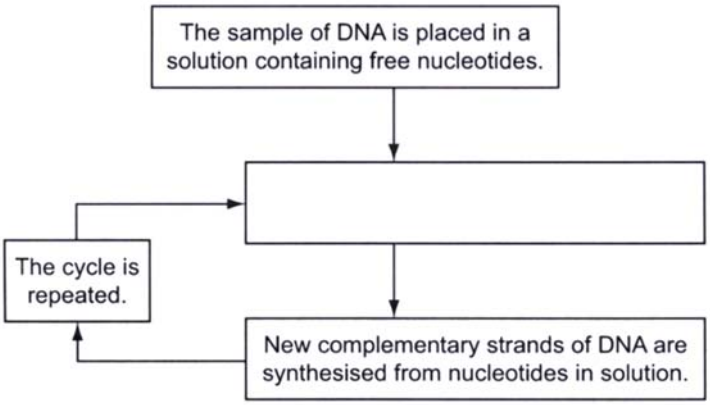
A 1 and 2 only

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?

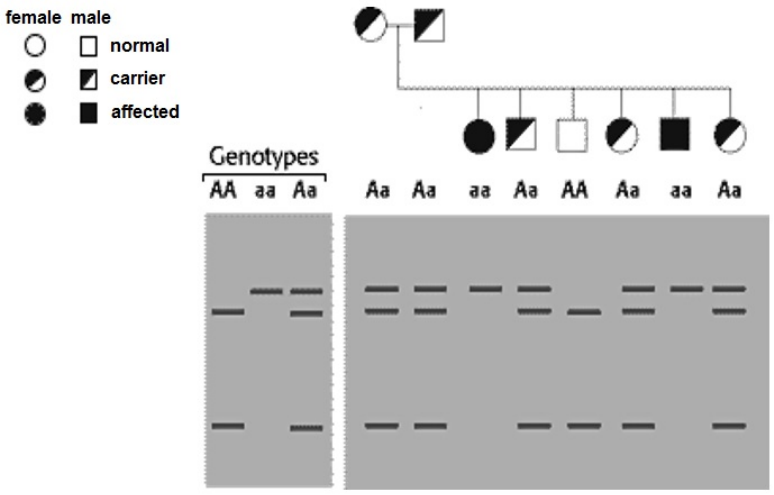
A Complementary strands of DNA are separated.

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.

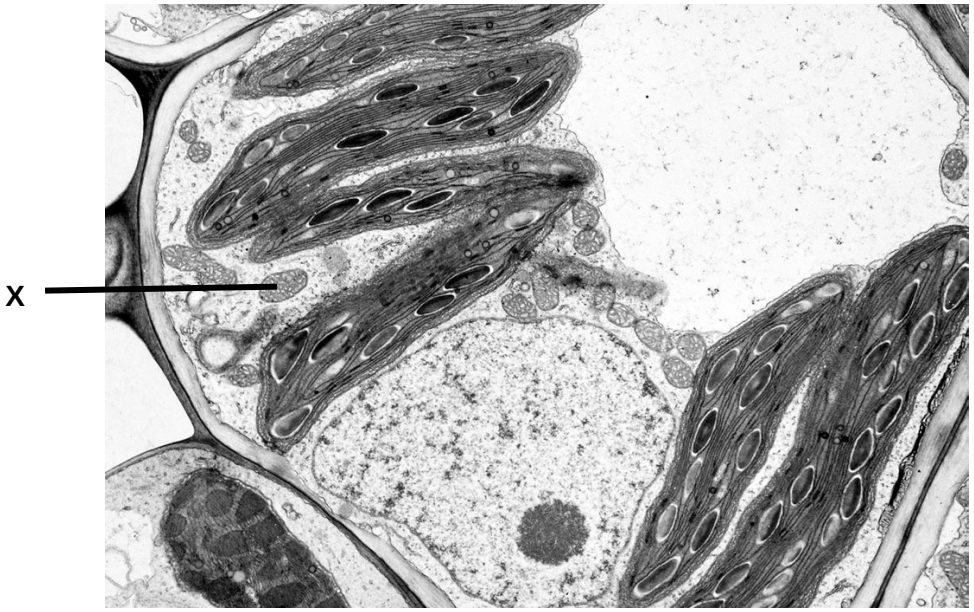


Fig. 1.1

(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.

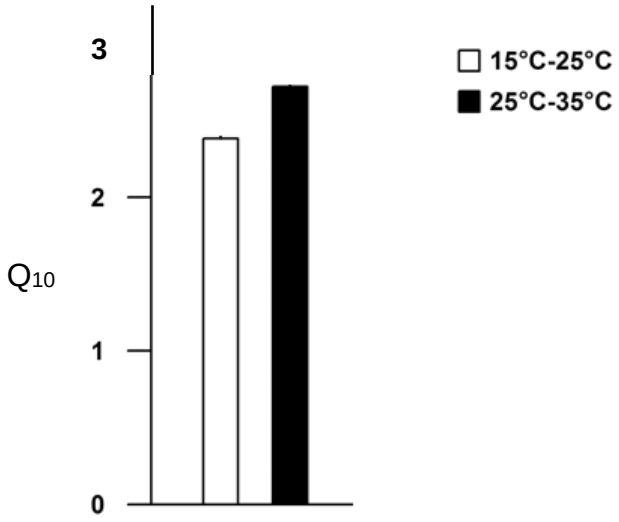


Fig. 1.2

(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.

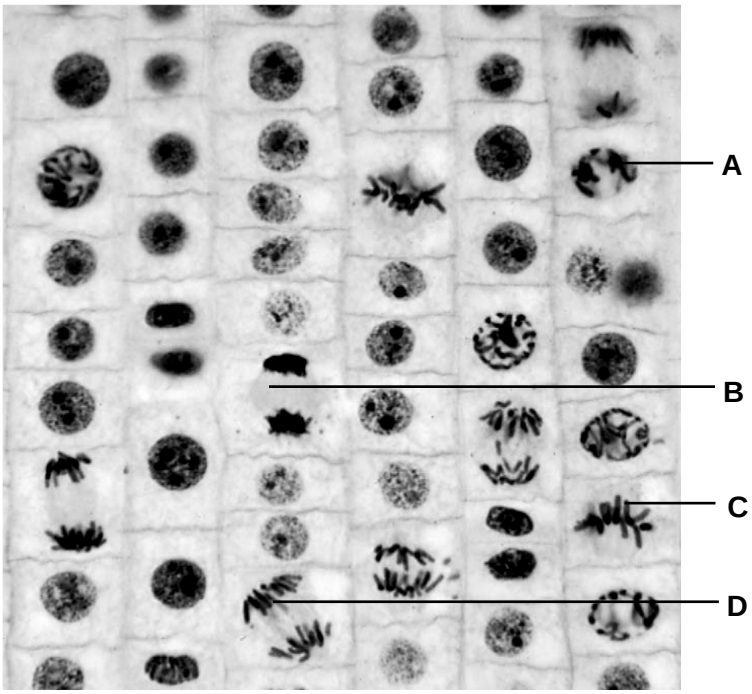


Fig. 2.1

(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

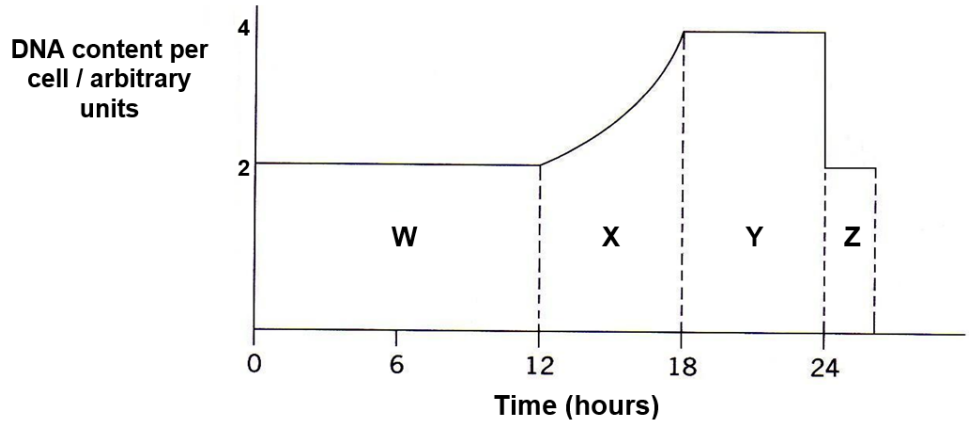


Fig. 2.2

(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.

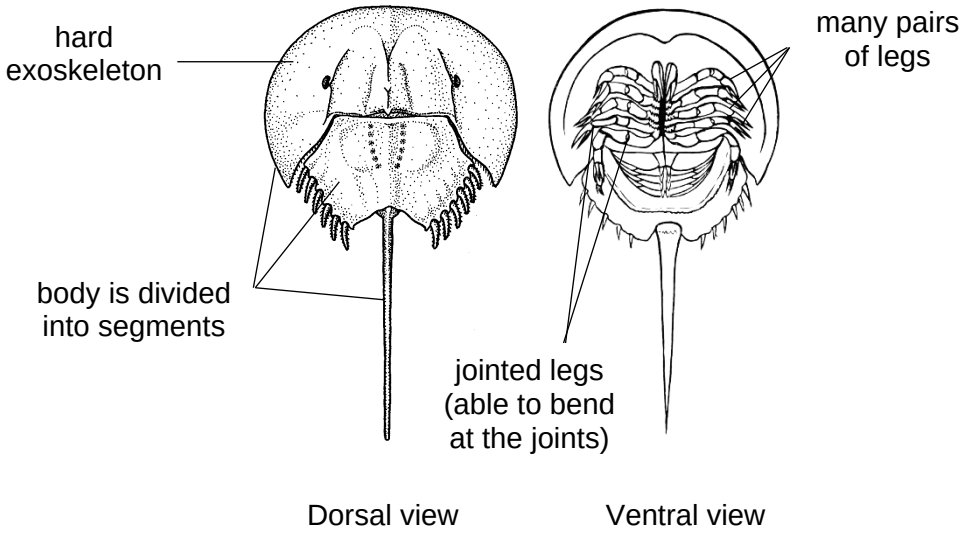


Fig. 3.1

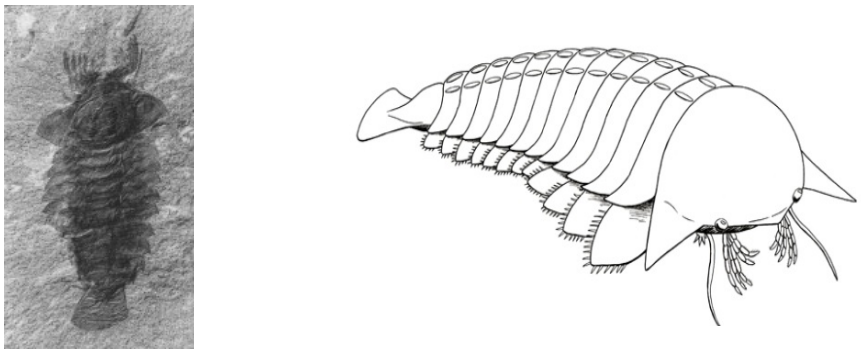


Fig. 3.2

(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.

[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]

(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.

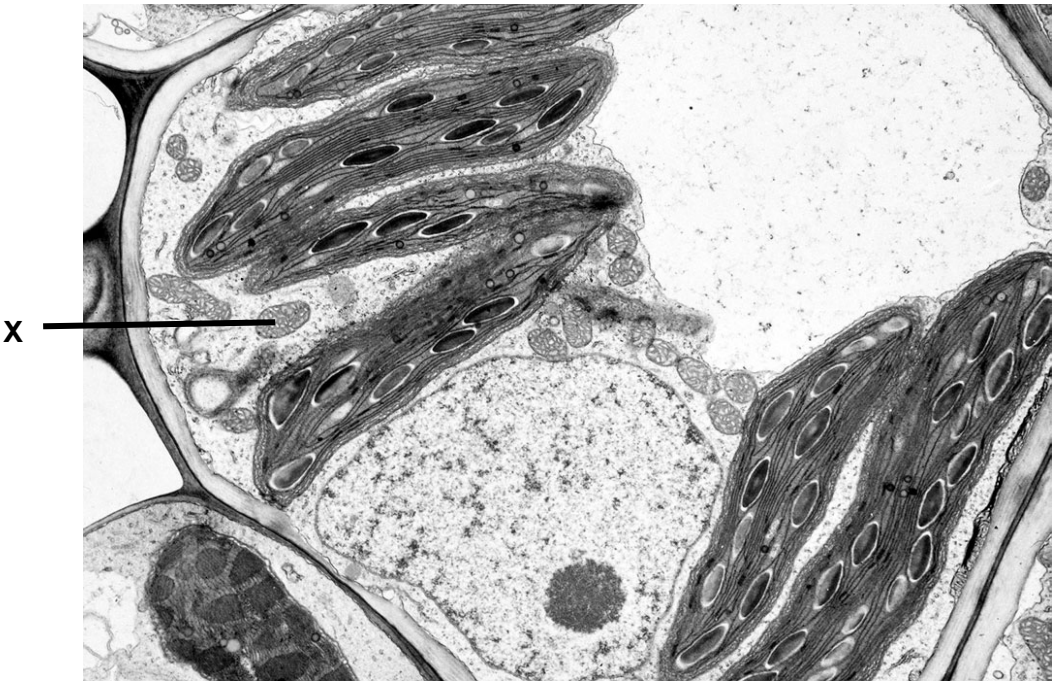


Fig. 1.1

(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]

(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.

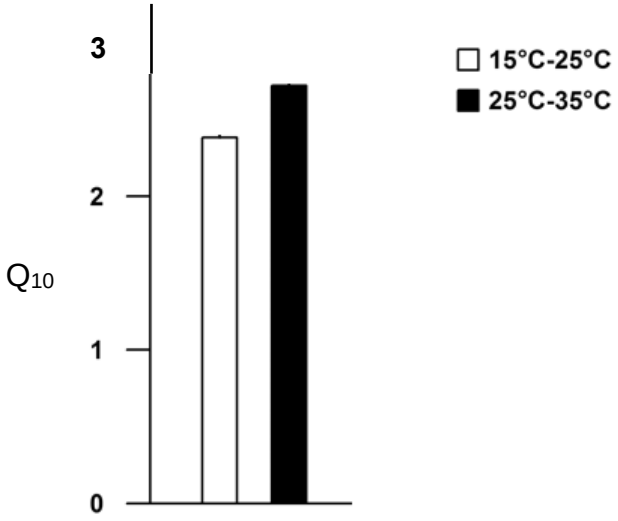


Fig. 1.2

(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.

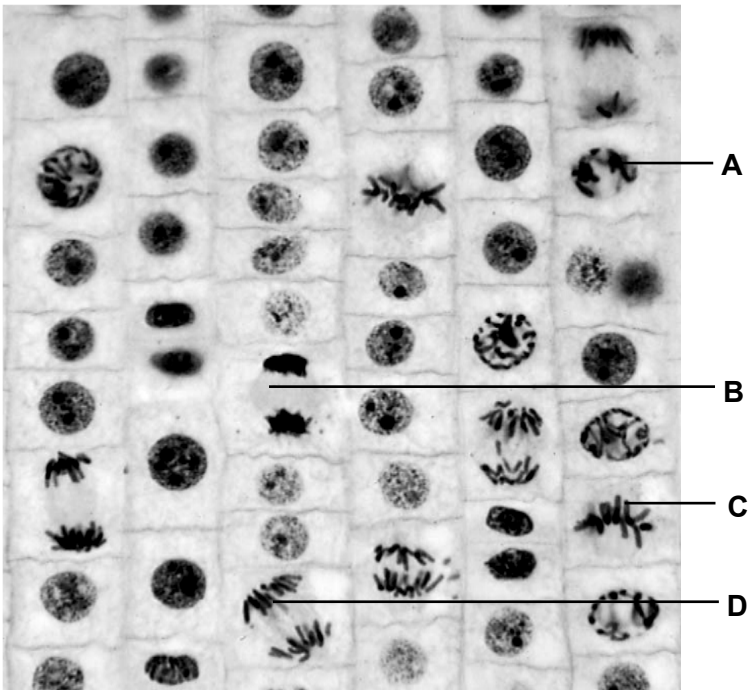


Fig. 2.1

(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]

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

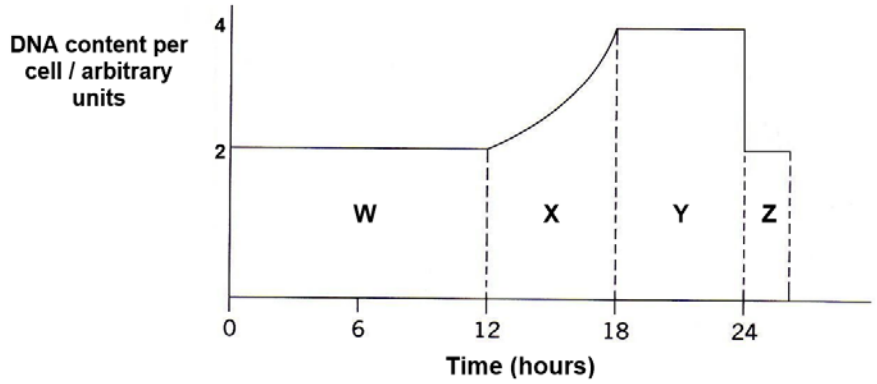


Fig. 2.2

(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 2 to 4 a.u. due to semi-conservative replication of DNA during S phase of Interphase;

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^BH C^Bh C^WH C^Wh** **C^BH C^Bh C^WH C^Wh** 1m

Punnett Square:

	C^BH	**C^Bh**	**C^WH**	**C^Wh**
C^BH	**C^BC^BHH 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^BC^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.

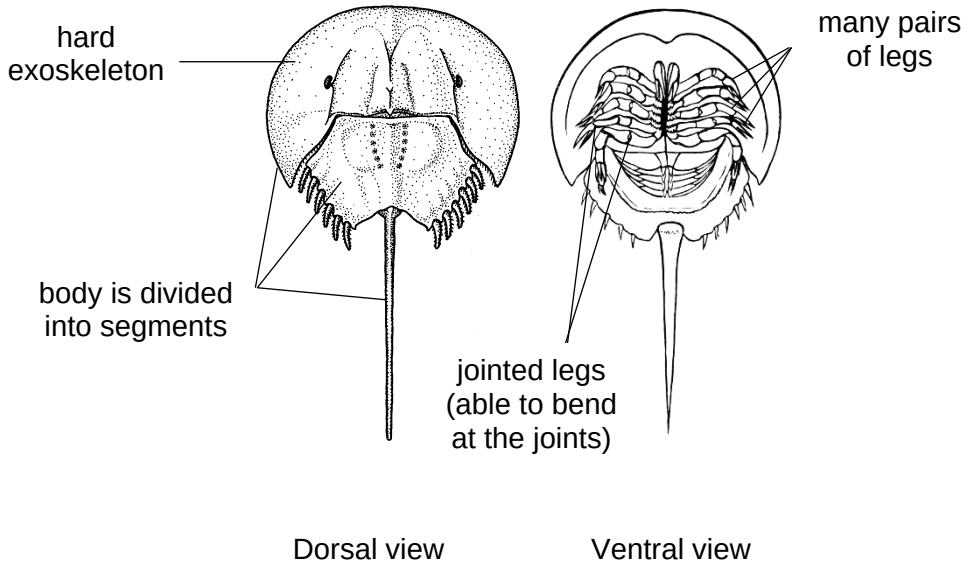


Fig. 3.1

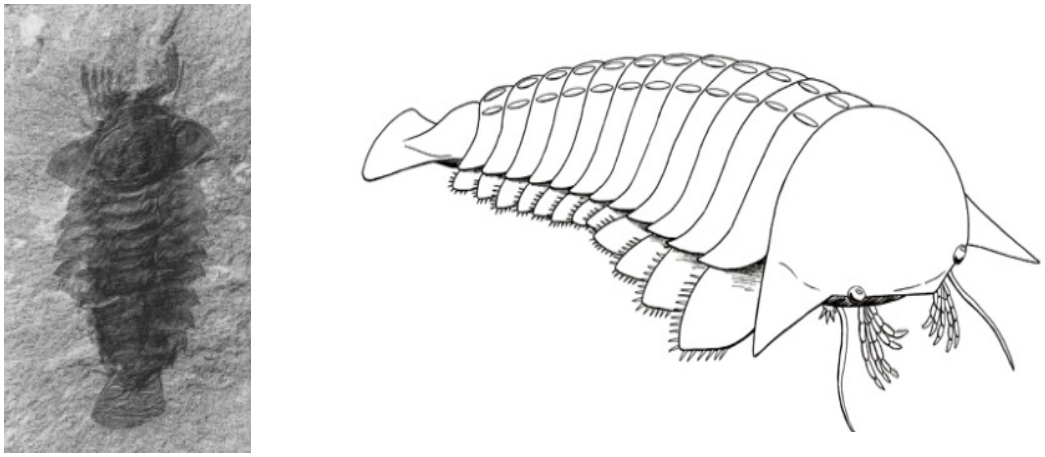


Fig. 3.2

(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**

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

(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;**

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 <u>reverse transcriptase;</u>**
2. **to form a <u>single stranded</u> <u>complementary DNA</u> (cDNA);**
3. **<u>RNase</u> is used to remove the mRNA template strand from the DNA/RNA hybrid;**
4. **<u>DNA polymerase</u> then used to synthesize the complementary strand to cDNA strand to obtain a <u>double stranded cDNA molecule</u>;**
5. **<u>DNA linkers</u> with a (appropriate) restriction site are added to the <u>blunt ends</u> of the ds cDNA by terminal transferase;**
6. **Use of <u>restriction enzyme</u> to produce <u>sticky ends</u> 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 <u>inactivated by insertion</u> of insulin cDNA/ OWTTE;**
8. **Cut by <u>same</u> restriction enzyme used to cleave ds cDNA;**
9. **to produce complementary sticky ends that will anneal with ds cDNA via <u>complementary base pairing with formation of H bonds</u>;**

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]