Name:		Centre/Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 BIOLOGY

9744/01

Paper 1 Multiple Choice Questions

23 September 2022

Additional Materials: Multiple Choice Answer Sheet

1 hour

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your centre number, index number, name and class at the top of this page.

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.

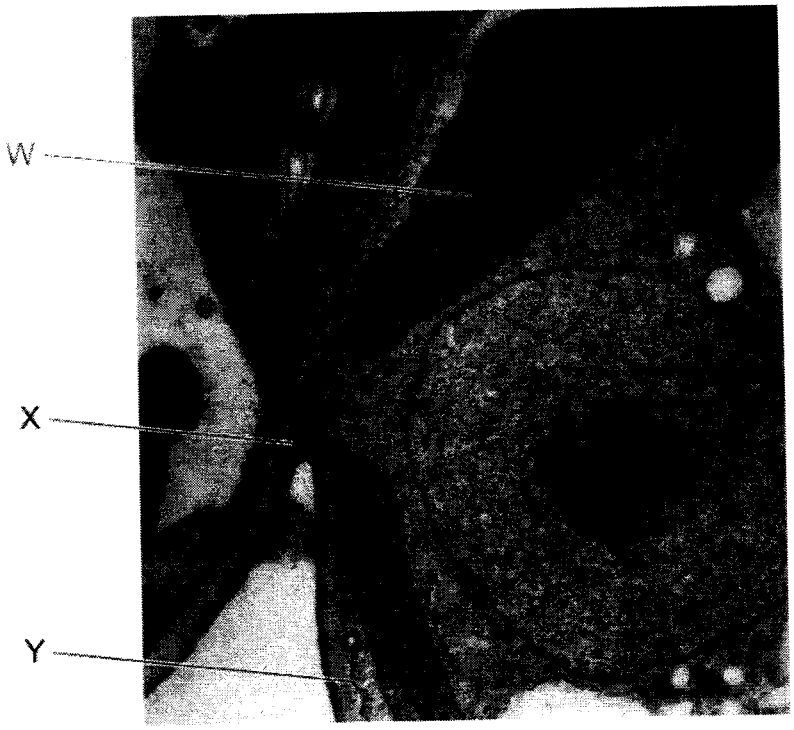
Read the instructions on the Answer Sheet very carefully.

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 **25** printed pages and **1** blank page.

[Turn over

1 The electron micrograph shows part of two cells.



Which of the labelled features enable these two cells to be identified as eukaryotic?

A W

B W and X

C W, X and Y

D None of the above

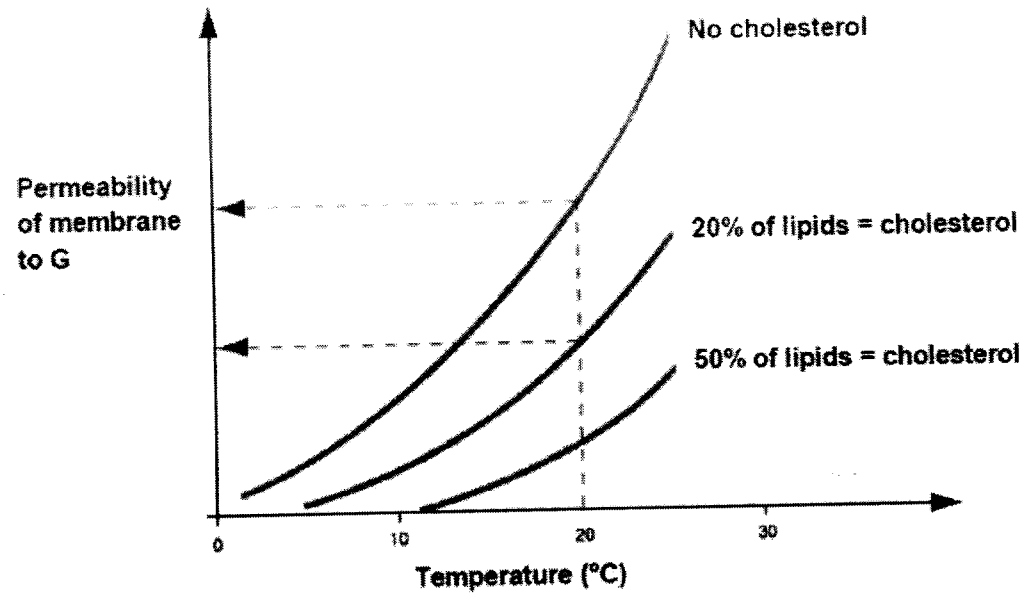
2 A sample of yeast cells was grown in a culture. Radioactive amino acids were added to the solution in which they were being grown. At various times, samples of the cells were taken and the amount of radioactivity in different organelles was measured. The results are shown in the table.

Time after radioactive amino acids were added to the solution/ minutes	Amount of radioactivity present/arbitrary units		
	P	Q	R
1	21	120	6
20	42	68	6
40	86	39	8
60	76	28	15
90	50	27	28
120	38	26	56

Which best describes the identities of organelles P, Q and R?

	P	Q	R
A	Golgi apparatus	Rough endoplasmic reticulum	Secretory vesicles
B	Rough endoplasmic reticulum	Secretory vesicles	Golgi apparatus
C	Rough endoplasmic reticulum	Golgi apparatus	Nucleus
D	Golgi apparatus	Secretory vesicles	Transport vesicles

3 The graph 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?

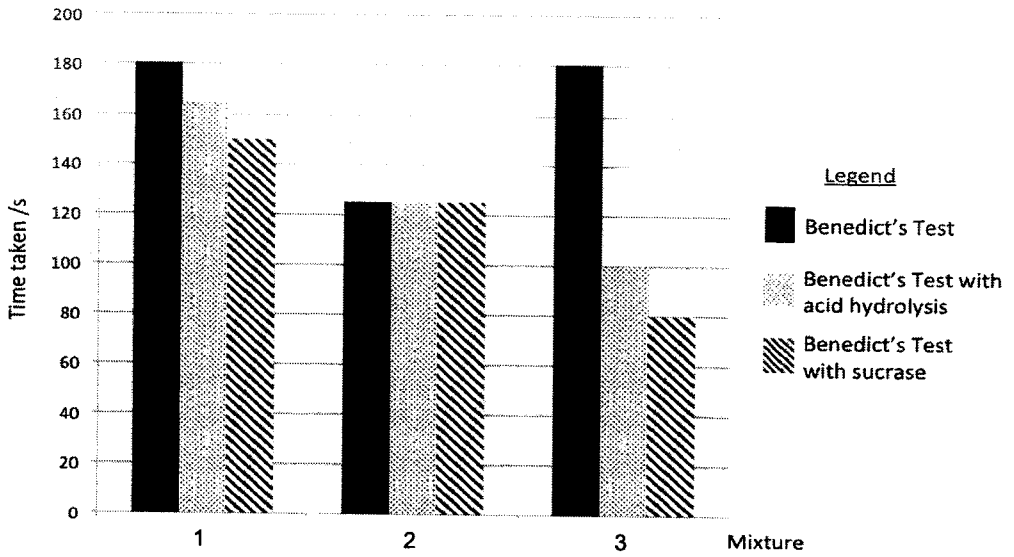
A Increase in temperature increases the permeability of the membrane to **G** as cholesterol increases the fluidity of the phospholipids.

B At 20°C, an increase in the proportion of cholesterol in the membrane increases the permeability of the 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.

4 Three mixtures (1, 2 and 3) containing different concentrations of glucose and sucrose were obtained. In order to determine the relative concentration of each substance in the mixture, the mixtures were subjected to different conditions before carrying out Benedict's Test. The time taken for brick-red precipitate to form was recorded in the graphs below.



Which statement can be concluded from these graphs?

A Mixture 2 contains equal concentrations of glucose and sucrose.

B Mixture 1 has a higher concentration of glucose than Mixture 2.

C Mixture 3 has a higher concentration of sucrose than Mixture 1.

D Mixture 3 has a lower concentration of sucrose than Mixture 1.

5 Each statement describes a similarity or difference between mitosis and meiosis.

Which statement is false?

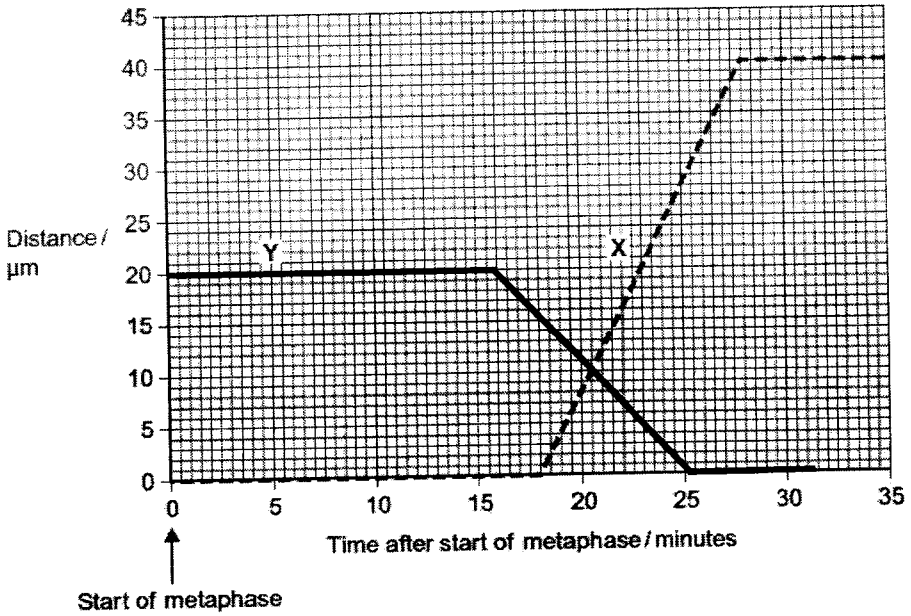
A Mitosis always produces diploid cells while meiosis always produces haploid cells.

B Mitosis always results in two daughter cells while meiosis always results in four daughter cells.

C Both mitosis and meiosis can occur in the absence of centrioles.

D Both mitosis and meiosis involve the separation of sister chromatids.

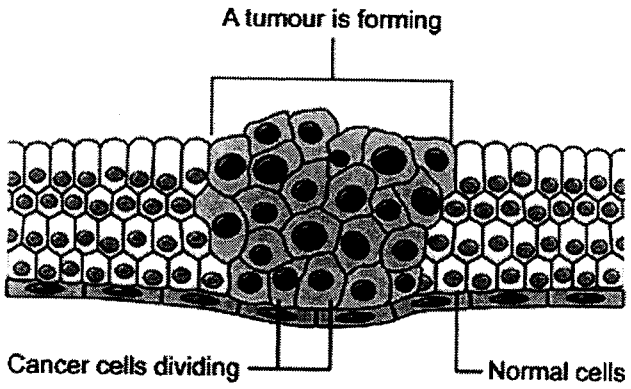
6 The graph shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.



Which row matches the stages happening at **X** and **Y** indicated?

	Duration of metaphase / min	**Increasing distance at X is due to**	**Measurement of X**	**Measurement of Y**
A	35	segregation of sister chromatids	distance between each chromatid and the pole	distance between chromatids
B	18	segregation of sister chromatids	distance between chromatids	distance between each chromatid and the pole
C	35	chromosomes align and segregate	distance between chromatids	distance between each chromatid and the pole
D	18	chromosomes align and segregate	distance between each chromatid and the pole	distance between chromatids

7 The diagram shows cancerous cells dividing in between normal cells.



Which statements can be concluded from the diagram?

1 Cancerous cells can undergo self-renewal due to presence of telomerase.
2 Cancerous cells invade normal cells by undergoing excessive mitosis.
3 A tumour is a localised mass of cells.
4 A tumour is formed after undergoing metastasis and angiogenesis.

A 1 and 2

B 2 and 3

C 1, 2 and 4

D All of the above

8 Which statements regarding the structure of RNA are correct?

1 mRNA is a single-stranded, straight polynucleotide.
2 tRNA is a double-stranded polynucleotide that has a three-dimensional L-shaped structure.
3 rRNA is made up of nucleotides with the presence -OH group on carbon-2 of pentose sugar.

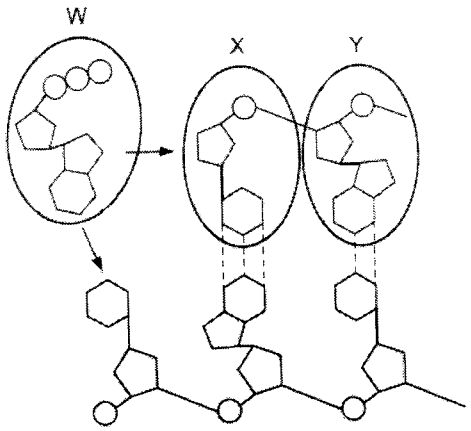
A 2

B 3

C 2 and 3

D 1, 2 and 3

9 The diagram shows the synthesis of a polynucleotide using a template strand. Molecule W is a nucleotide triphosphate.



Which statements are correct?

1 The base in W could be the purine, adenine.
2 The base in Y is the purine, guanine.
3 The base in X is the pyrimidine, cytosine.
4 The base in X could be the pyrimidine, uracil.

A 1, 3 and 4

B 2 and 3

C 1, 2 and 4

D 1 and 3

10 In 1958, an experiment was published by Meselson and Stahl investigating the way in which DNA replicates.

Escherichia coli bacteria were grown in a medium containing $^{15}NH_4Cl$. After very many generations, virtually all of the bacterial DNA contained ^{15}N and the DNA was described as 'heavy'.

The bacteria were then transferred to a medium containing $^{14}NH_4Cl$. The bacteria were allowed to reproduce for three generations in this medium. The bacterial DNA from each generation was extracted and the percentage of DNA molecules containing ^{14}N DNA was determined.

What is the percentage of DNA molecules containing ^{14}N in the third generation?

A 0%

B 25%

C 75%

D 100%

11 Part of the sense strand (non-template) in DNA is shown below.

3' CATGCGAATT 5'

Which of the following is the sequence of mRNA?

A 5' GUACGCUUAA 3'

B 5' AAUUCGCAUG 3'

C 5' CAUGCGAAUU 3'

D 5' UUAAGCGUAC 3'

12 Part of the amino acid sequences in normal and sickle cell haemoglobin are shown.

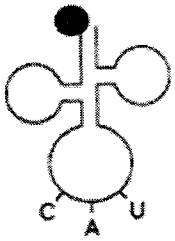
Normal haemoglobin	Sickle cell haemoglobin
thr-pro-glu-glu	thr-pro-val-glu

Possible mRNA codons for these amino acids are:

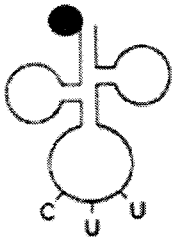
Amino Acid	mRNA codons
Glu	GAA GAG
Thr	ACU ACC
Pro	CCU CCC
Val	GUA GUG

Which tRNA molecule is not involved in the formation of this part of the sickle cell haemoglobin?

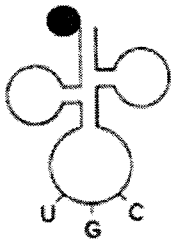
A



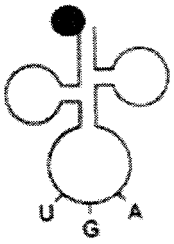
B



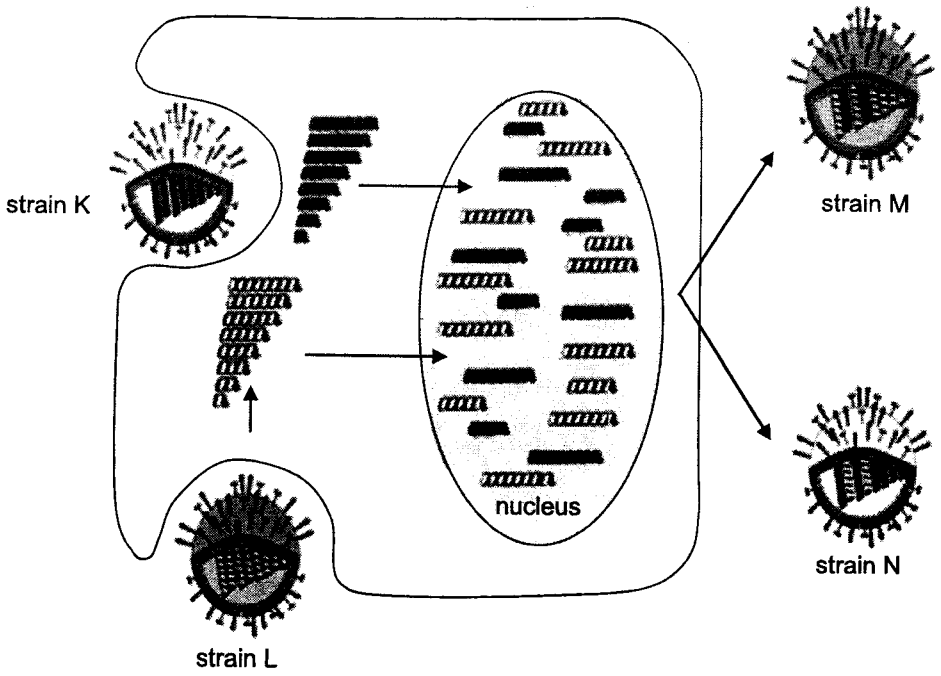
C



D



13 The diagram shows the emergence of new influenza strains, M and N, resulting in antigenic shift in influenza A.



Which events lead to antigenic shift?

	Name of event	Description
1	gene mutation	gene mutations in the viral genomes of strains K and L occurred in the cell resulting in strains M and N
2	recombination of viral genome	recombination of strains K and L resulted in new strains M and N
3	reassortment of viral genome	reassortment of the viral genomes of strains K and L occurred only when both strains infect the same cell

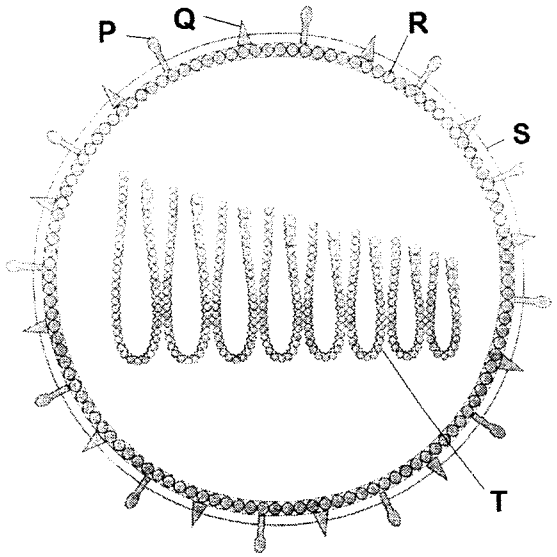
A 2

B 3

C 2 and 3

D 1, 2 and 3

14 The diagram shows the structure of an influenza virus.



Which statements concerning the lettered components are correct?

1 Mutations that disrupt the function of **R** will result in the inability of the virus to initiate infection in the host cell.

2 **P** and **Q** are unlikely targets for vaccination because they undergo mutation constantly.

3 New influenza viruses acquire **S** from host cell during budding.

4 The host cell enzymes are not required to form the complementary RNA from **T**.

A 1 and 2

B 3 and 4

C 1, 2 and 3

D 2, 3 and 4

15 Binary fission allows bacteria to divide and gives rise to genetically identical daughter cells. Scientists are interested in uncovering the genetic mechanisms that regulate and drive binary fission, to design novel antibiotics that could specifically target and interfere with the process.

They found out that during binary fission, bacteria produce the protein FtsZ which assemble into a ring-like structure at the centre of the cell. This causes the cytoplasm to divide into two, before synthesis of a new wall begins.

Which of the following statements can be deduced from the description above?

1 The genes that code for FtsZ can be found within a plasmid.

2 An antibiotic that inhibits the action of FtsZ will result in only one cell with more than one chromosome.

3 Mutations in genes coding for FtsZ will prevent the replication of DNA in binary fission.

4 The replicated chromosomes attach at the opposite ends of the parent bacterial cell before it divides into two daughter cells.

A 2

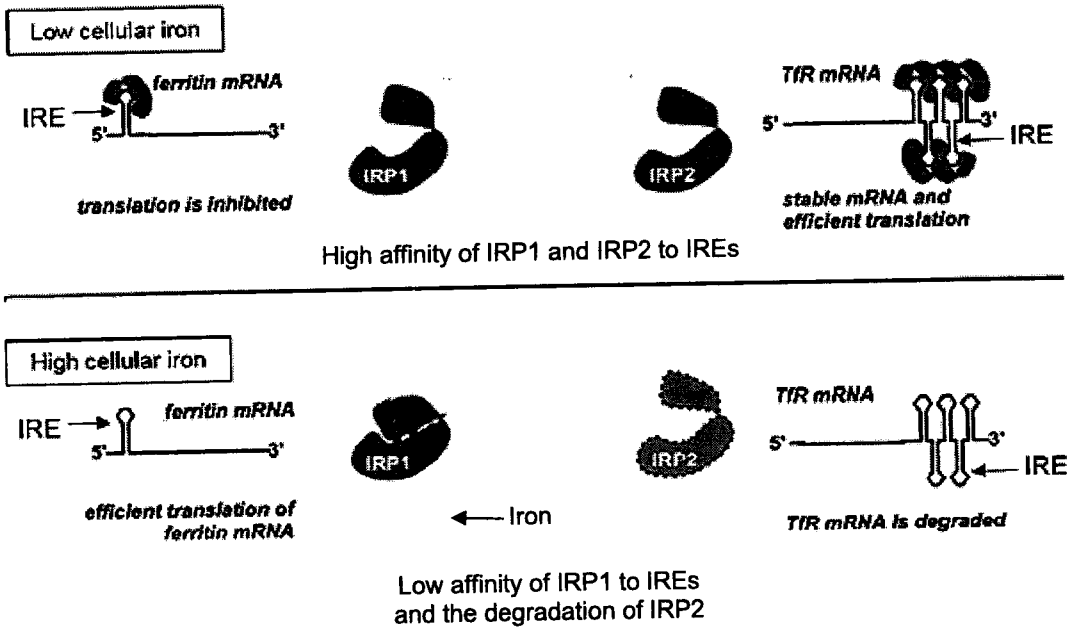
B 2 and 4

C 1 and 3

D 1, 2, 3 and 4

16 In mammalian tissues, iron enter cells via transferrin receptors (TfR) and are stored when they are bound by ferritin proteins. The synthesis of TfR and ferritin is regulated through translational controls by regulatory proteins IRP1 and IRP2, which bind to iron-responsive elements (IREs) found on mRNAs.

IREs are loops found at the 5' UTR of ferritin mRNA and 3' UTR of TfR mRNA respectively. The effects of different iron levels on IRP1 and IRP2 are shown in the figure.

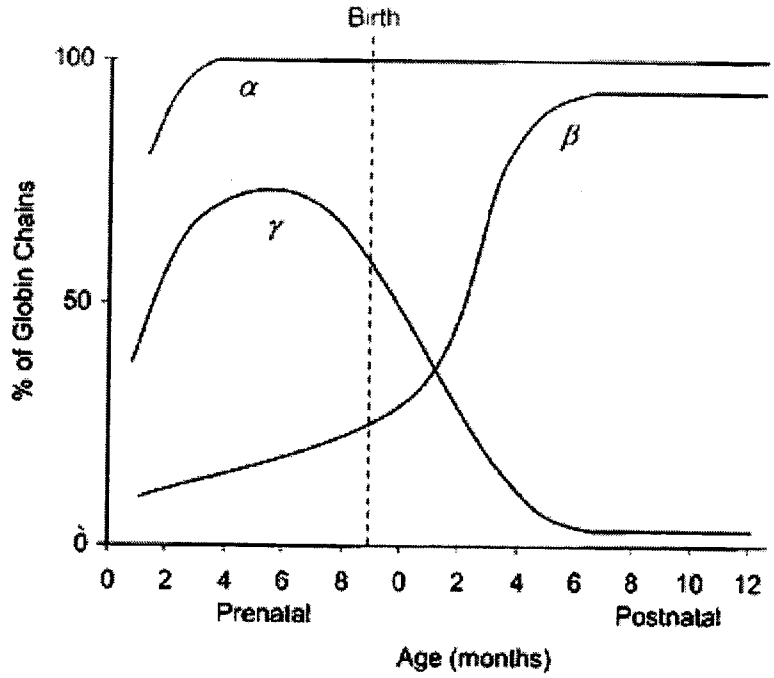


Which row correctly describes the translational control of ferritin mRNA and TfR mRNA?

	Cellular iron (Fe) levels	Ferritin levels	TfR levels
A	High	High	High
B	Low	Low	Low
C	High	High	Low
D	Low	High	Low

17 The globin gene family in humans consists of α, β and γ genes. These genes code for the globin chains that make up haemoglobin and are expressed at different levels during different developmental stages.

The graph shows the expression of the various globin chains during the prenatal (fetal) and postnatal (after birth) periods.



Which statement cannot account for the differences in the levels of expression of globin chains?

A	Methyl groups are added to regulatory sequences of γ-globin genes during the postnatal period, allowing for some proteins to bind.
B	A growth factor triggers the expression of a transcription factor that increases the rate of β-globin gene expression during the postnatal period.
C	Alternative splicing occurs in the mature mRNA of the α-globin and β-globin genes, resulting in differences in the rate of expression of globin chains during the prenatal period.
D	The shortening of poly(A) tail in the mRNA of globin genes reduces its stability, resulting in a decrease in the rate of expression of γ-globin chains during the postnatal period.

18 Two genes, Q and R, affect the size of the petals and the pigmentation of a flower.

Gene Q has two alleles, Q^L and Q^A. The genotype Q^LQ^L produces large petals, Q^LQ^A produces small petals, and in Q^AQ^A, petals are absent.

Gene R has two alleles. R produces a red pigment and is dominant over the allele r that produces no pigment.

A plant that is heterozygous at both gene loci was selfed. How many different phenotypes will be observed in the next generation?

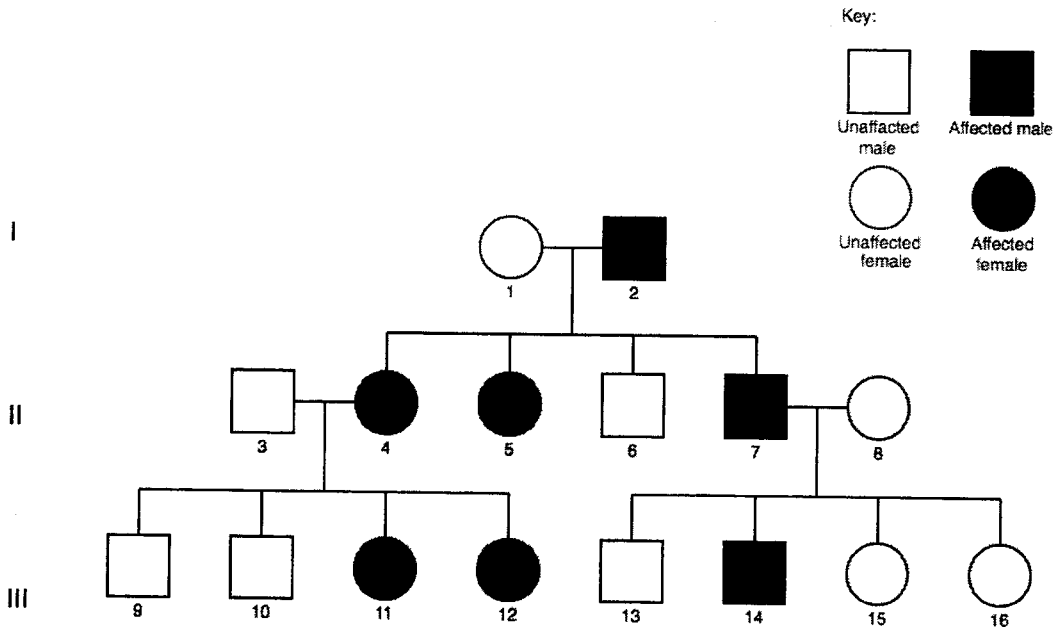
A 4

B 5

C 9

D 12

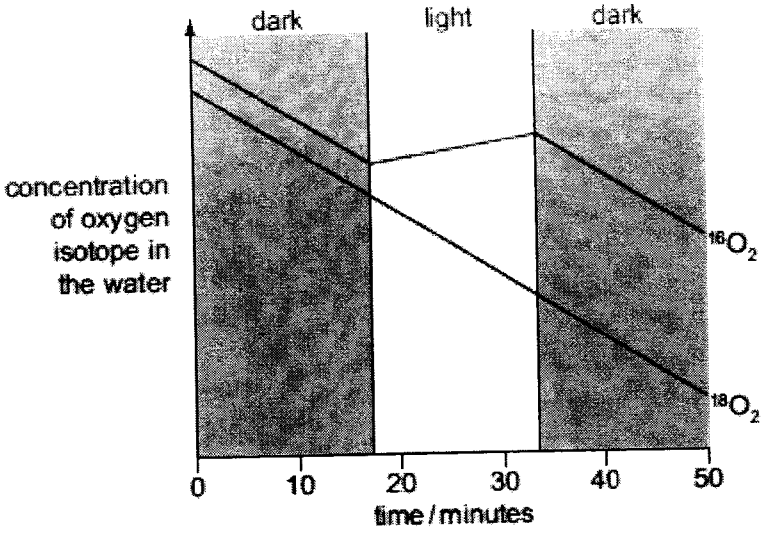
19 The figure shows a pedigree for the inheritance of polycystic kidney disease.



If the letters R and r denote dominant and recessive alleles respectively, what is the mode of inheritance for this disease and the most probable genotype of individual 11?

	Mode of inheritance	**Genotype of individual 11**
A	Autosomal dominant	RR
B	Autosomal recessive	rr
C	X-linked dominant	$X^R X^r$
D	X-linked recessive	$X^r X^r$

20 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.



Which is the best explanation for these results?

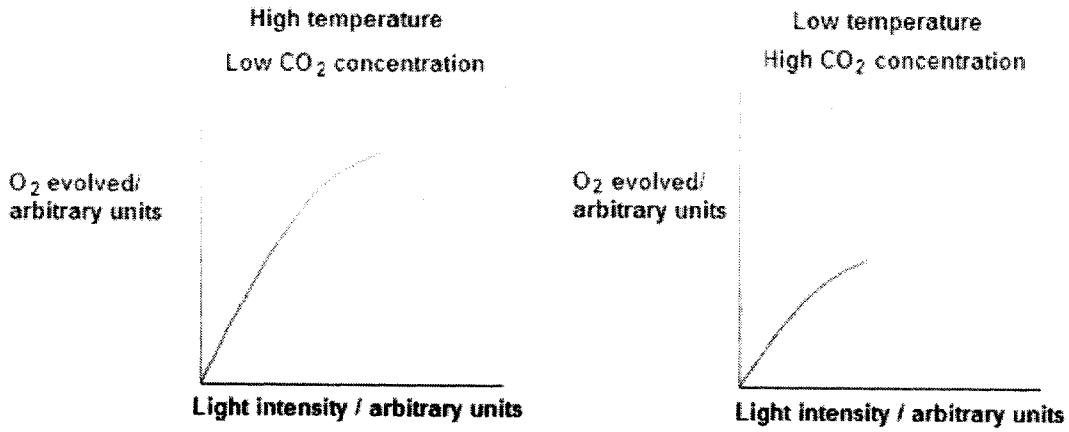
A Both isotopes of oxygen are used by the algae in the dark in respiration, but in the light, oxygen is produced from water in photorespiration.

B The algae can distinguish chemically between the two isotopes.

C The algae produce oxygen from the water used in photosynthesis, but only in the light.

D The two isotopes have different rates of diffusion.

21 Students investigated the rate of photosynthesis by measuring the volume 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.

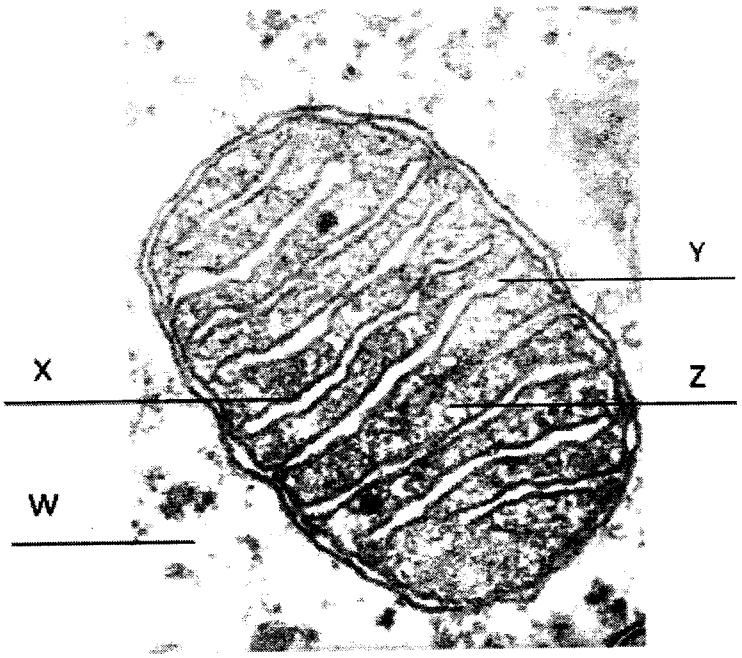
C Temperature and CO_2 concentration are both limiting factors.

D The greater the light intensity, the greater the rate of photosynthesis.

22 After vigorous exercise, changes occur in the muscle tissues. Comparing with resting muscles tissues, what will the changes be?

	ATP	lactate	pH
A	decreased	increased	decreased
B	increased	no change	increased
C	decreased	decreased	increased
D	increased	decreased	no change

23 The figure shows an electron micrograph of an organelle.



Which row correctly matches the respective processes with the corresponding structures?

	Formation of pyruvate	Oxidative phosphorylation	Direction of diffusion of H^+ ions	Formation of reduced co-enzymes
A	W	X	Z → Y	Z
B	Z	Y	Z → Y	W and Z
C	Z	Y	Y → Z	W
D	W	X	Y → Z	W and Z

24 The hormone insulin binds to the tyrosine kinase receptors and initiates various signal transduction pathways to generate cellular responses. Which of the following shows the correct sequence of events, following the binding of insulin to the receptor?

1 phosphorylation of tyrosine residues
2 signal amplification
3 dimerisation of tyrosine kinase receptor
4 signal transduction
5 activation of transcription factors

A 1 → 3 → 2 → 4 → 5
B 3 → 4 → 1 → 2 → 5
C 1 → 3 → 5 → 4 → 2
D 3 → 1 → 4 → 2 → 5

[Turn over

25 Nerve cells in the brain communicate by chemical molecules known as neurotransmitters. The following events, in the order shown, describe how the binding of a neurotransmitter to a nerve cell will elicit a cellular response.

1 Neurotransmitter binds to a G-protein linked receptor (GPLR) at the cell surface

↓

2 A change in conformation of the GPLR allows the binding of G proteins to its intracellular domain

↓

3 G protein releases a GDP molecule in exchange for GTP

↓

4 The alpha subunit of the G protein dissociates from the other subunits

↓

5 The alpha subunit of the G protein activates adenylyl cyclase, which in turn converts ATP into cyclic AMP (cAMP)

↓

6 cAMP activates protein kinase A (PKA), which in turn phosphorylates transmembrane protein channels

↓

7 Phosphorylated protein channels open, allowing the facilitated diffusion of specific ions into the nerve cell

Which events allow for the amplification of signal to occur?

A 2, 5 and 6

B 1, 2, 5 and 7

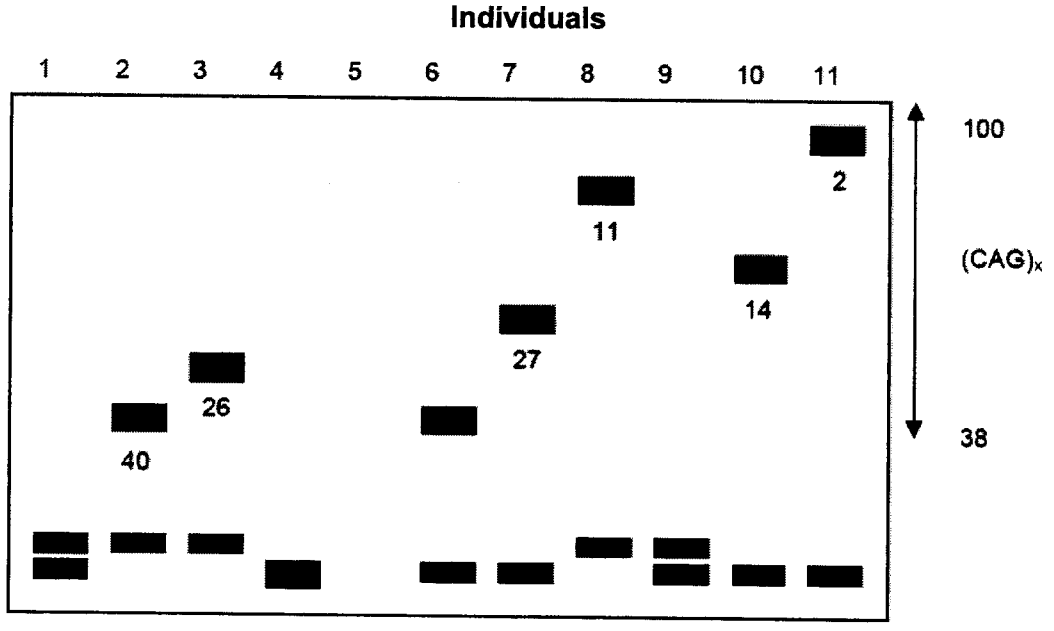
C 3, 4, 5, 6 and 7

D 1, 4 and 6

26 The data shows the results of electrophoresis of PCR fragments amplified using primers for the site that has been shown to be altered in Huntington's disease.

The inherited mutation in the Huntington's disease gene abnormally repeats the nucleotide sequence CAG from 36 up to more than 120 times of that. The male parent, shown as individual 2, had the onset of 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 from the PCR fragment.



What is the likely outcome for the normal individuals 4, 6, and 9?

A Individuals 4 and 9 do not have the trait, and will not get Huntington's disease, but individual 6 is likely to start the disease when he reaches his father's age of 40.

B Individuals 4, 6, and 9 have not inherited the defect causing Huntington's disease.

C 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.

D Two of the three will develop the disease, since it is inherited as a dominant trait, but the data does not allow you to predict which two.

27 The DNA for a heavy chain in a B-cell making IgG_4 antibody specific for retroviruses has the following structure: 5'–$V_{14}D_3J_2C_{\gamma 4}$-C_ε-$C_{\alpha 1}$-$C_{\alpha 2}$-3'. Knowing that IgM is the first antibody formed, how many individual rearrangements were required to go from the embryonic DNA to this B-cell DNA?

A 1

B 2

C 3

D 4

28 A monoclonal antibody specific for a virus was produced by identical plasma cells.

This antibody was treated with an enzyme to break the bonds between the variable and constant regions.

The separated variable and constant regions were then added to cells infected with the virus.

With regard to the experiment carried out, which statements are correct?

1 The constant regions would bind to different parts of the virus antigens.

2 The variable regions would all bind to the same part of the virus antigens.

3 The separated constant and variable regions cannot bind to the virus antigens.

4 Phagocytes will engulf the viruses.

A 2

B 3

C 1 and 2

D 2 and 4

29 Which statement does not explain why the population is the smallest unit that can evolve?

A Natural selection involves competition between individuals in a population.

B Evolution occurs when allele frequency in a population changes due to selection or chance events like infections with lethal diseases.

C Differential reproductive success is observed at the population level due to the phenotypic variations in the population.

D Evolution involves the introduction of advantageous mutations into the gene pool of a population as a result of a selective pressure.

30 Which effect of temperature increase on arctic ecosystems, will increase carbon dioxide in the atmosphere?

A Greater production of plants due to warmer temperatures and changing vegetation.

B Melting ice from glaciers and icebergs will cause sea levels to rise.

C Less ice and snow will cause incoming radiation to be absorbed more readily.

D Greater decomposition of organic matter currently stored in permafrost.

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Name:		Centre/Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 BIOLOGY

Paper 2 Structured Questions

9744/02

15 September 2022

2 hours

READ THESE INSTRUCTIONS FIRST:

Write your centre number, index number, name and class 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.

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

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

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

For Examiner's Use	
1	9
2	11
3	15
4	7
5	8
6	10
7	9
8	10
9	7
10	9
11	5
Total	100

This document consists of **24** printed pages and **2** blank pages.

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Section A: Structured Questions

Answer **all** questions.

Question 1

Fig 1 shows a transmission electron micrograph (TEM) of part of a hepatocyte. Hepatocytes make up 70 to 85% of the liver's mass.

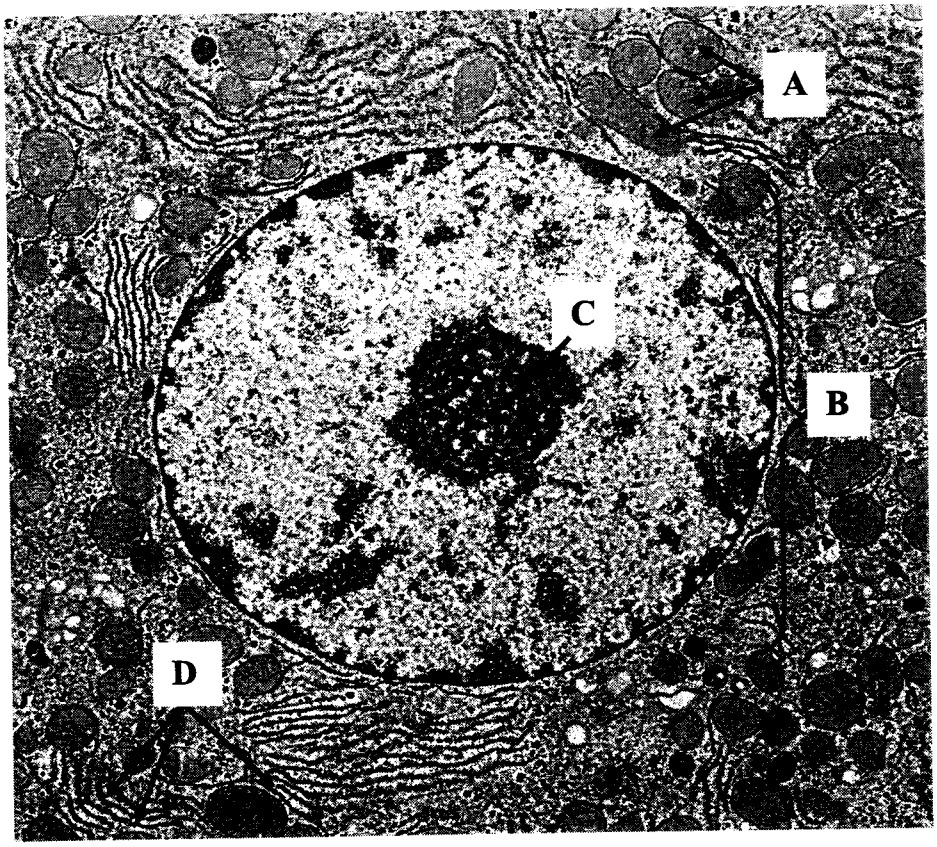

Fig 1

(a) Compare the structure of organelles A and B. [3]

(b) How are structures C and D involved in the synthesis of ribosomes? [3]

(c) Give one piece of evidence visible from Fig 1, which suggests that

(i) the cell is able to provide energy for many metabolic activities, [1]

(ii) the cell is actively synthesising proteins for use within the cell. [1]

Some bacteria secrete exotoxins out of the cell. Exotoxins are a group of soluble proteins that are capable of altering host cell physiology.

(d) Given that bacteria do not have membrane-bound organelles, suggest how the secretion of proteins in hepatocyte differs from that of bacteria. [1]

Total: [9]

Question 2

Sialidase is one of the many hydrolytic enzymes found within a lysosome. Fig 2 shows the structure of sialidase, which is a hydrolytic enzyme that is capable to digesting sialyloligosaccharides. Sialyloligosaccharides are acidic oligosaccharides that are usually made up of α-glucose with sialic acid residues linked by (2→3) and (2→6) glycosidic bonds.

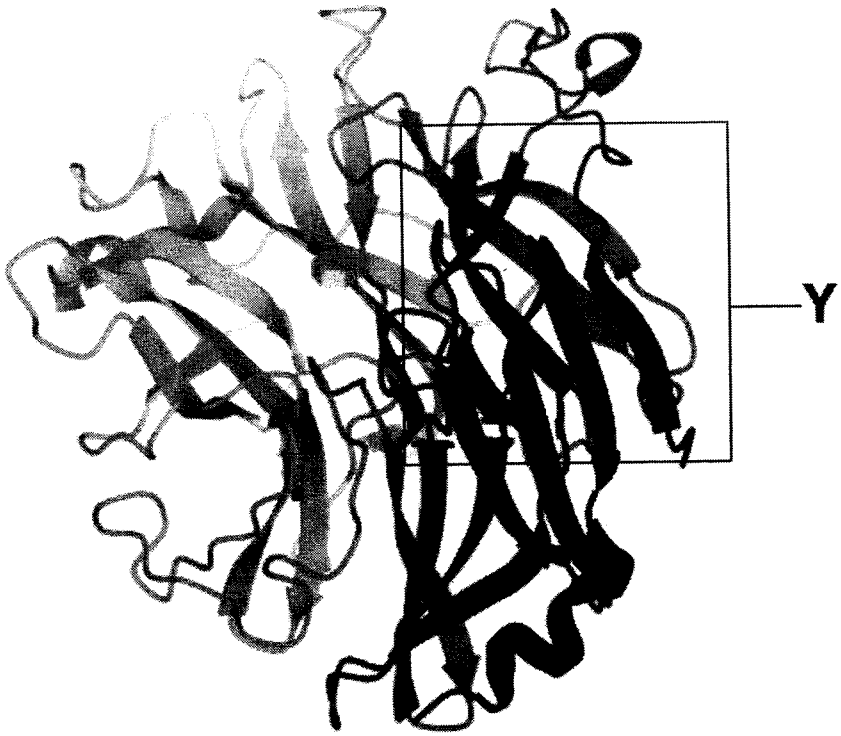

Fig 2

(a) Name structure Y and describe how it is formed. [3]

(b) Compare the structure of sialidase and its substrate. [2]

Lysosomal enzymes, such as sialidase, are only active over a narrow range of pH, with an optimum of pH 5. The pH of the cytoplasm is 7.2. The internal pH of lysosomes is maintained by concentrating H^+ ions in the lysosome.

(c) Describe how H^+ ions could be moved across the lysosomal membrane. [2]

(d) Explain why enzymes from a leaky damaged lysosome may not destroy the cell contents. [2]

(e) Suggest why the lysosomal membrane is not destroyed by the enzymes in the lysosome. [2]

Total: [11]

Question 3

Fig 3.1 shows cells of an organism in various stages of mitosis.

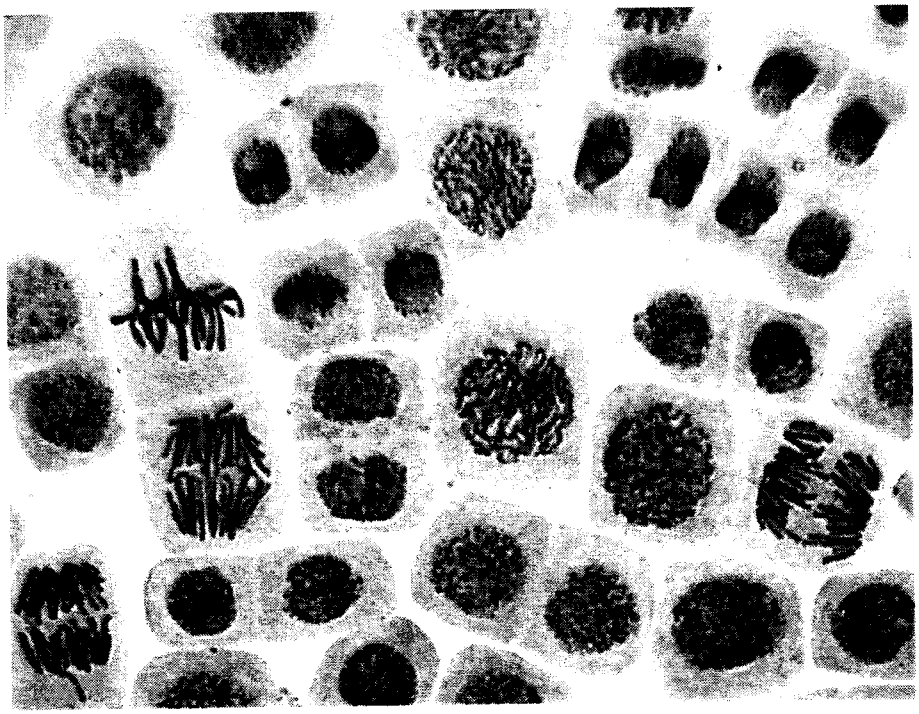

Fig 3.1

(a) On Fig 3.1, use labels and label lines to indicate one cell in prophase and anaphase. [1]

(b) Describe how the mitotic cell cycle is controlled to ensure the production of daughter cells that are genetically identical to parental cells. [3]

Cancer occurs when the cells escape the control mechanism that normally limits their proliferation, and thus leads to uncontrolled proliferation of cells. This results in tumorigenesis.

There are different types of chemotherapeutic drugs to treat cancer. One example is cisplatin, which is used for the treatment of testicular and ovarian cancer. Each cisplatin molecule forms two chemical bonds with a DNA molecule. Fig 3.2 shows two ways in which cisplatin can bind to the DNA molecule.

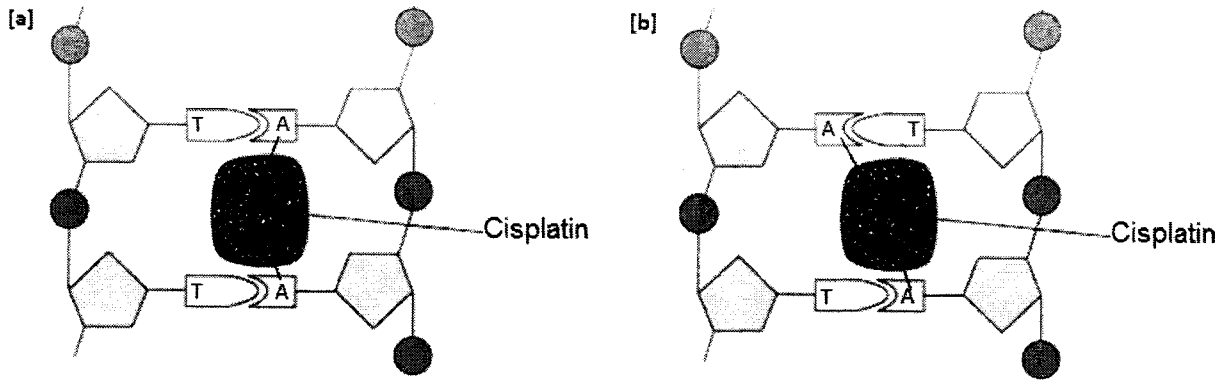

Fig 3.2

(c) **(i)** State precisely the cell cycle phase that cisplatin acts on. [1]

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(ii) Explain how cisplatin inhibits the division of cancer cells. [3]

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While cisplatin is one of the most powerful drugs for testicular and ovarian cancer, it can interfere with the function of normal cells and cause severe side effects. Hence, scientists have been creating alternative drugs in attempts to find treatments without side effects. One approach is to develop light-activated drugs.

With a team of researchers, Thorn-Seshold developed a method for optically controlling microtubule inhibitor drugs. The strategy involves identifying a fixed structural element, which is required for a drug's biological activity, and then replacing that element with a flexible hinge that swings open or shuts in response to blue light. Hence, blue light can be used to switch the hinged drug on and off with single-cell precision.

(d) **(i)** State two functions of microtubule in a normal, non-dividing cell. [2]

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(ii) Explain how interfering with the function of microtubules helps to treat cancer. [3]

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(iii) Suggest how the change in the flexible hinge of the drug can be optically controlled. [2]

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Total: [15]

Question 4

Fig 4 shows a DNA replication fork.

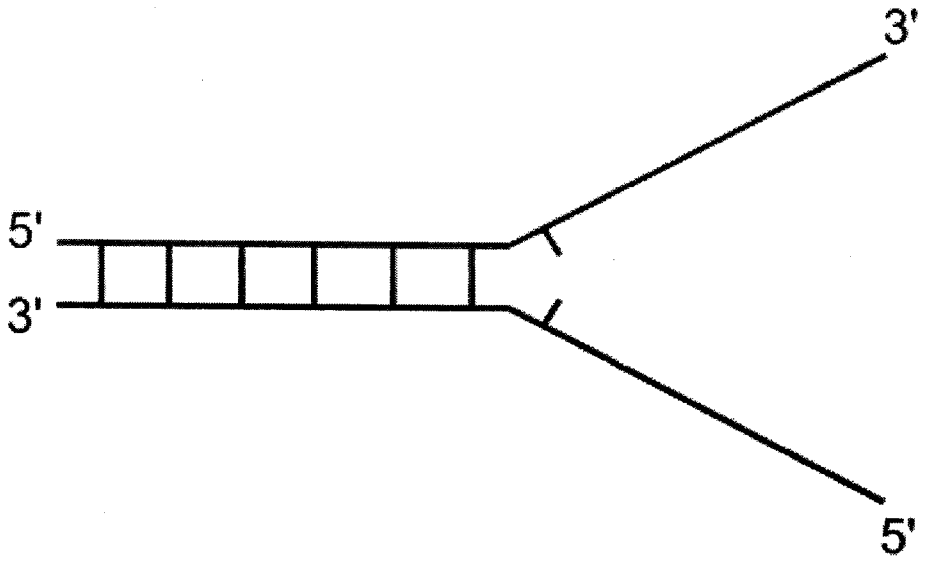

Fig 4

(a) (i) Using two arrows (→), draw the newly-synthesized Okazaki fragments on Fig 4. [1]

(ii) Explain why synthesis of DNA occurs both continuously and discontinuously during DNA replication. [2]

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(b) Outline the steps that occur to produce a complete DNA molecule after the formation of Okazaki fragments. [3]

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(c) Describe the importance of complementary base pairing in DNA replication. [1]

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Total: [7]

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Question 5

In the 1950s, Erwin Chargaff determined the relative quantities of the four bases in DNA in different organisms. His results provided important evidence for the model of DNA proposed by James Watson and Francis Crick in 1953. Table 5.1 shows the relative quantities of the four bases in bacteria, yeast and an unknown.

Table 5.1

Sample	Percentage of adenine	Percentage of thymine	Percentage of guanine	Percentage of cytosine
Escherichia coli	24.7	23.6	26.0	25.7
yeast	31.3	32.9	18.7	17.1
unknown	24.0	31.2	23.3	21.5

(a) Explain why the result of the unknown differs from those of yeast and bacteria? [2]

Protein synthesis in both eukaryotic and prokaryotic cell is a multi-step process.

(b) Suggest how protein synthesis in eukaryotes will be affected when there is a mutation to the TATA region on DNA. [2]

Fig 5 shows the base sequence on a segment of mRNA coding for Ras protein, with their corresponding amino acids.

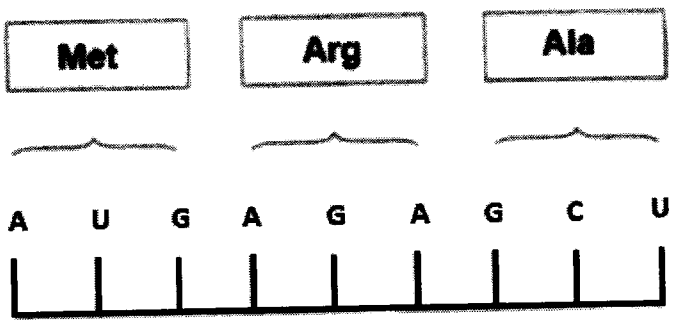

Fig 5

mRNA sequences from ten closely related species of rats were analysed. It was found that some regions are highly conserved. However, the third base position of many codons is least conserved. For example, amino acid arginine can be coded by AGA and AGG codons.

(c) **(i)** Explain why the third base position of this codon is less conserved than the first and second positions. [2]

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(ii) The codons in the mRNA sequence do not overlap. Suggest an advantage of this. [1]

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Some genetic drugs are short sequences of nucleotides. They act by binding to selected sites on DNA or mRNA molecules and preventing the synthesis of disease-related proteins. The two types of drugs include:

1 Antisense drugs made from ribonucleotides that bind to mRNA.
2 Triplex drugs made from deoxyribonucleotides that bind to DNA forming a triple-helix.

Table 5.2 below shows the sequence of bases on the part of a molecule on mRNA.

Table 5.2

Sequence of part of mRNA	Sequence of part of antisense drug
A	
C	
G	
U	
G	

(d) Complete Table 5.2 to show the base sequence on the antisense drug that binds to this mRNA. [1]

Total: [8]

Question 6

Fig 6 shows a type of virus called a T2 phage. It consists of a protein coat enclosing a DNA molecule. This DNA causes the bacterial cell to make new copies of the T2 phage.

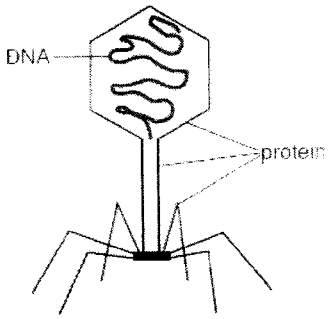

Fig 6

(a) (i) State two ways in which the structure of the protein coat of T2 differs from the structure of its DNA. [2]

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(ii) List three features of a bacterium that T2 does not share. [3]

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(iii) Describe what happen after T2 phage genome enters bacterium host to complete its life cycle. [3]

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(b) T2 phages were used in experiments in 1952 to find out whether protein or DNA is the genetic material responsible for inheritance. The protein molecules in the coat were labelled with a radioactive isotope of sulphur, ^{35}S and the DNA inside was labelled with a radioactive isotope of phosphorus, ^{32}P.

(i) Name the bond in protein that joins two sulphur atoms. [1]

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(ii) Name the part of the deoxyribonucleotide to which phosphorus atoms are bonded. [1]

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Total: [10]

Question 7

Fig 7 shows a segment of the *Escherichia coli* chromosome that contains the *lac* operon.

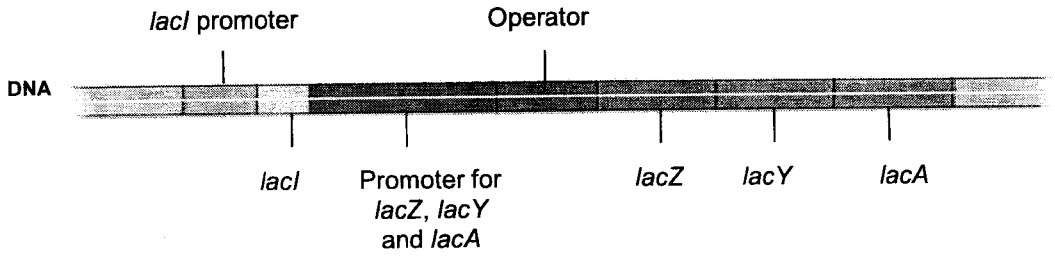

Fig 7

(a) With reference to Fig 7,

(i) identify one coding and one non-coding DNA sequence, [1]

Coding DNA: .....

Non-coding DNA: .....

(ii) describe three differences between the organisation of eukaryotic and prokaryotic genes. [3]

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The gene activity of the *lac* operon in four different *E. coli* strains was measured and the results are shown in Table 7.

Table 7

***E. coli* strain**	**Genotype**	**Presence (✓) or absence (×) of β-galactosidase activity**	
		Lactose present	**Lactose absent**
E1	$I^+ O^+ Z^+$	✓	×
E2	$I^- O^+ Z^+$	✓	✓
E3	$I^+ O^c Z^+$	✓	✓
E4	$I^S O^+ Z^+$	×	×

Key	
+	wild type
-, c, s	mutant

(b) Using information from Table 7, account for the activity of β-galactosidase in strains E2 and E3 in terms of the expression of LacI protein and its binding to the operator region. [2]

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(c) The activity of β-galactosidase in E4 was due to a single-base substitution mutation in the lacI gene, resulting in a change in the LacI protein. [3]

Explain how this mutation could have resulted in the change.

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Total: [9]

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Question 8

In *Drosophilia* flies, the gene for wing shape is found on chromosome 2. Allele C for curly wing is dominant to allele c for normal wing.

Female flies are homogametic while males are heterogametic. The gene for eye colour is found on the X chromosome. Allele for red eyes is dominant to the allele for white eyes.

(a) (i) Fill in the blanks using suitable symbols. [1]

	Female fly	**Male fly**
Eye colour	White	Red
Wing shape	Curly wing, heterozygous	Curly wing, heterozygous
Genotype		

(ii) Draw a genetic diagram showing the phenotypes of the offspring and the expected phenotypic ratio when these two flies are crossed. [4]

(b) 240 offspring were obtained from this cross and the table below shows the number of offspring for each phenotype.

Red-eyes, curly wings female	83
Red-eyes, normal wings female	41
White-eyes, curly wings male	78
White-eyes, normal wings male	38

	Probability				
Degrees of freedom	**0.90**	**0.50**	**0.10**	**0.05**	**0.01**
2	0.21	1.39	4.61	5.99	9.21
3	0.58	2.37	6.25	7.81	11.34
4	1.06	3.36	7.78	9.49	13.28
5	1.61	4.35	9.24	11.07	15.09
6	2.20	5.35	10.64	12.59	16.81

Formula for χ^2 calculation

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} \qquad v = c - 1$$

where Σ = 'sum of...' O = observed 'value'
v = degrees of freedom E = expected 'value'
c = number of classes

Complete the table to obtain the calculated χ^2 value and state what conclusion may be drawn from the result. Show all the necessary workings and calculations. [5]

Classes	*Observed number (O)*	*Expected ratio*	*Expected number (E)*	$(O - E)^2$	$\frac{(O - E)^2}{E}$
Red eyes, curly wings female					
Red-eyes, normal wings female					
White-eyes, curly wings male					
White-eyes, normal wings male					
					$\sum\chi^2 =$

Total: [10]

Question 9

2,4-dinitrophenol is a chemical that is toxic to mitochondria. When added to mitochondria, this chemical allows electron transport to occur but prevents the phosphorylation of ADP to ATP. The chemical achieves this by breaking the essential link between electron transport and ATP synthesis. This toxin causes mitochondria to produce heat instead of ATP. The greater the amount of toxin added, the faster is its action.

(a) If mitochondria are poisoned with 2,4-dinitrophenol, by what process could a plant cell produce more ATP? [1]

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(b) A researcher wanted to study cellular respiration in insect cells. She cultured some muscle cells from the common field cricket, *Teleogryllus oceanicus*, and then studied the effects of adding 2,4-dinitrophenol to these cells. An agricultural company was interested to fund this research. [1]

Suggest why an agricultural company might want to fund research on the effects of this toxin on field crickets.

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The experiment is summarized in Table 9. Temperature observations in each trial were made at equal time intervals.

Table 9

Observations made at equal time intervals	Temperature / °C		
	Control (no 2,4-dinitrophenol)	Trial 1 (2,4-dinitrophenol added)	Trial 2
1 (start)	28	28	28
2	27	28	29
3	28	29	
4	29	31	
5	28	36	
6	28	23	
7	27	21	

(c) Explain why the temperature went down after the fifth observation in trial 1. [1]

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(d) Trial 2 had twice the concentration of 2,4-dinitrophenol added. [2]

Complete Table 9 by writing temperatures in the spaces provided to predict the trend.

(e) Another researcher suggested adding pyruvate to the cells at the beginning of the experiment to cancel out the effects of this toxin. [2]

Explain what effect adding pyruvate would have on cancelling out the effects of this toxin.

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Total: [7]

Question 10

Fig 10 shows the action of the hormone insulin on liver cells to regulate the concentration of blood glucose.

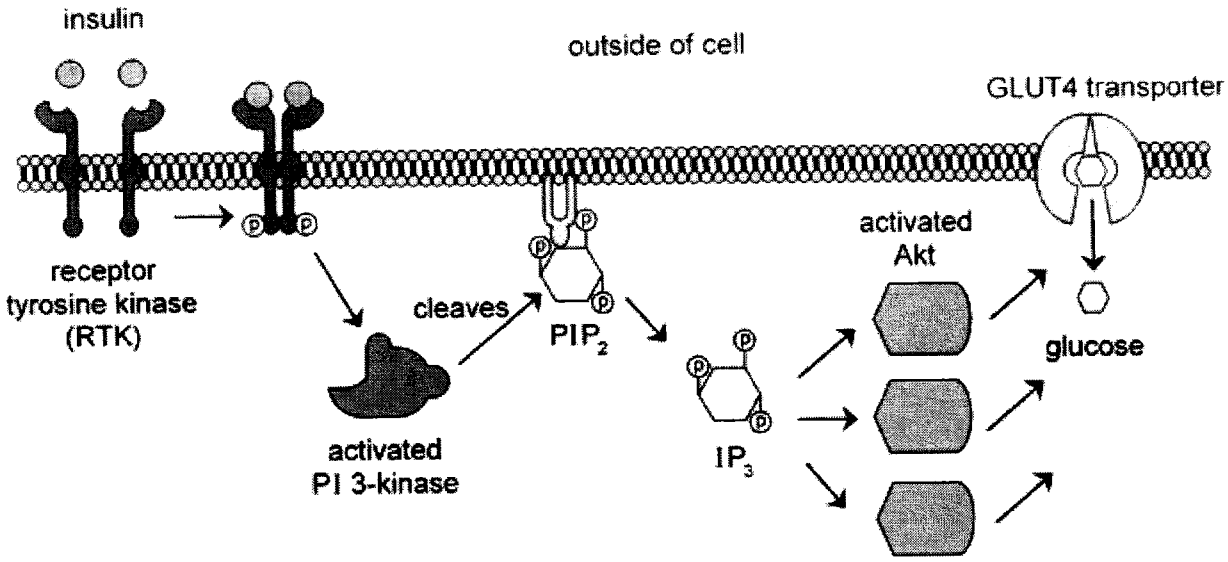

Fig 10

(a) Outline the process of insulin-receptor interaction. [4]

(b) Describe the nature of IP_3 and explain its significance in insulin signalling. [3]

(c) Explain how GLUT4 transporters regulate the concentration of blood glucose. [2]

Total: [9]

Question 11

Table 11 shows the range of optimal temperatures for the growth of some major crops in the state of Iowa, USA. These crops are generally grown in April and harvested in October where average temperatures are between 16°C and 28°C.

Table 11

Type of crop	Temperature/ °C		
	Optimal	Minimum	Maximum
Corn	22 - 25	20	32 - 34
Wheat	20 - 25	5	38
Soybean	25 - 28	10 -14	37 - 40

(a) With reference to Table 11 and your knowledge of enzymes, explain why Iowa is suitable for the growth of these crops. [2]

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(b) Suggest why corn productivity may be threatened by climate change. [3]

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Total: [5]

Name:		Centre/Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free-Response Questions
Additional Materials: Answer Booklet

22 September 2022
2 hours

READ THESE INSTRUCTIONS FIRST:

Write your class, index number and name 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.

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

Sections B
Answer any **one** free-response question in the Answer Booklet provided.

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

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

For Examiner's Use	
Section A / 50	
1	26
2	16
3	8
Section B / 25	
4 / 5	25
Total	75

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

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Section A: Long Structured Questions

Answer **all** questions.

Question 1

Fig 1.1 shows a male red deer, *Cervus elaphus*. Red deer are herbivores, browsing on low vegetation in forests and on waste land.

Fig 1.1

A history of wild red deer on the western European island of Ireland includes these facts:

- Red deer have lived in Ireland for at least 12 000 years.
- Originally, red deer could cross from the neighbouring island of Great Britain to Ireland over a land connection.
- A rise in sea levels at the end of the last Ice Age removed this land connection, separating the red deer on the two islands.

- In the 1800s, the number of red deer in Ireland decreased sharply after the main food crop for the human population failed for several consecutive years.
- In the 1900s, this decrease in the number of red deer continued as large areas of waste land were drained for agriculture.

- By 1960, red deer were nearly extinct in Ireland, restricted to one population, **A**, of 60 individuals.
- Since then, protection has allowed population **A** to increase to over 600 red deer.
- Several new red deer populations, **B**, **C** and **D**, have also been established in different parts of Ireland from individuals brought from Great Britain.

(a) (i) Use the information given to identify two causes of extinction that may have threatened the survival of red deer in Ireland. [2]

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(ii) Describe how the level of molecular similarity between the red deer in population **A** and population **B** can be investigated. [3]

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(iii) Explain why some red deer in population **A** show unique molecular features that are not found in any of the red deer in populations **B**, **C** and **D**. [3]

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The mitochondrial cytochrome *b* (cyt-b) gene sequences (1140 bp) of one subspecies of the European red deer (*Cervus elaphus* in Europe), three subspecies of the wapiti (*C. elaphus* in Asia and North America), and six subspecies of the sika deer (*C. nippon* in Japan) were compared. The wapiti was shown to be more closely related to the sika deer than to the European red deer. This is in conflict with traditional morphological results, which suggest a close sister group relationship between the wapiti and the European red deer.

(b) Suggest why the mitochondrial cytochrome *b* (cyt-b) gene is used to compare the phylogenetic relationships between the three subspecies of deer. [2]

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The domestic dog, *Canis familiaris*, is found worldwide. It is able to breed with all other members of the genus to form fertile hybrids.

Table 1 shows whether members of different species of the genus *Canis* are able to breed with each other.

Table 1

key: ✓ = able to interbreed ✗ = unable to interbreed ? = interbreeding unknown

	dingo	grey wolf	golden jackal	side-striped jackal	black-backed jackal	domestic dog
dingo	✓	?	?	?	?	✓
grey wolf	?	✓	?	?	?	✓
golden jackal	?	?	✓	✗	✗	✓
side-striped jackal	?	?	✗	✓	✗	✓
black-backed jackal	?	?	✗	✗	✓	✓
domestic dog	✓	✓	✓	✓	✓	✓

(c) Suggest why the members of the genus *Canis* could be described as one species. [2]

Using molecular techniques and comparing the genomic sequences, a phylogenetic tree of the members of the genus *Canis* was constructed, as shown in Fig 1.2.

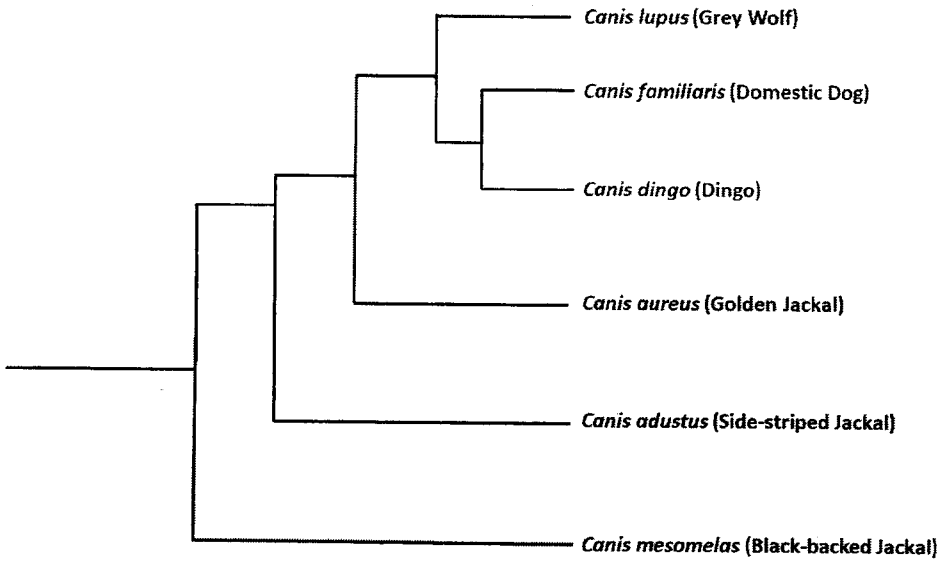

Fig 1.2

(d) (i) Explain why using molecular techniques is better than using the information of interbreeding to determine the evolutionary relatedness between the members of the genus *Canis*. [2]

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(ii) Explain which of the two remaining species of jackals is more closely related to the golden jackal. [1]

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The distribution of some of the species belonging to the genus *Canis* is shown in Fig 1.3.

The dingo and the grey wolf species have distinct ranges in Australia and Europe respectively.

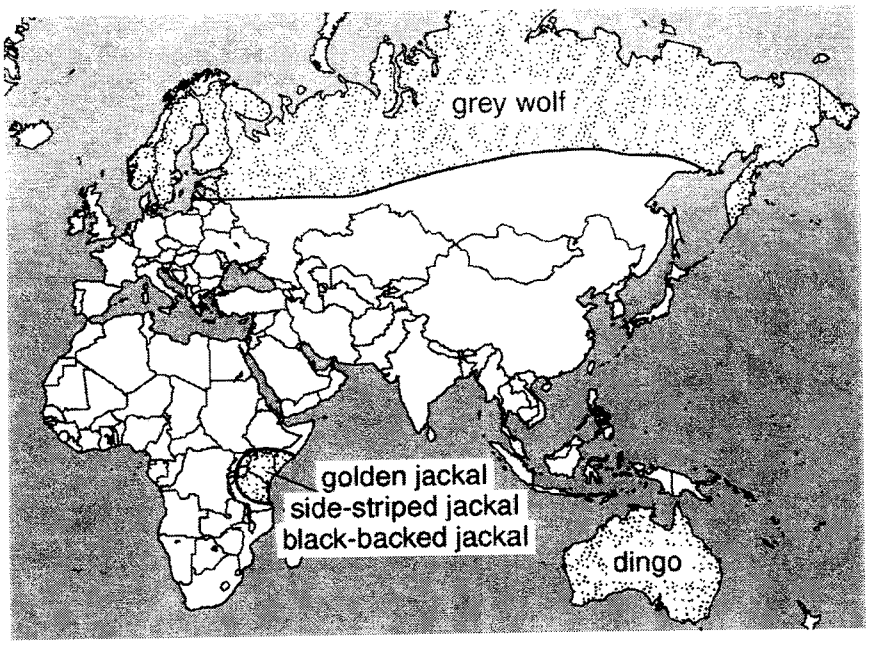

Fig 1.3

(e) Together with information from Fig 1.2 and Fig 1.3, explain how dingo could have evolved into a distinct species. [5]

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The Hawaiian Islands are some of the most isolated islands in the world. They are made up of islands that are formed at different times. The first birds to have flown to these islands probably arrived millions of years ago from East Asia.

Fig 1.4 and Fig 1.5 show the fossils of two extinct species of Hawaiian waterfowl found on two different islands. The giant Hawaiian goose was a flightless bird whereas the nene could fly. Until recently, the evolutionary relationships among Hawaiian waterfowl are known only from bone structures. Fig 1.4 shows the skulls and mandibles while Fig 1.5 shows the wing and leg bones of the giant Hawaiian goose and nene.

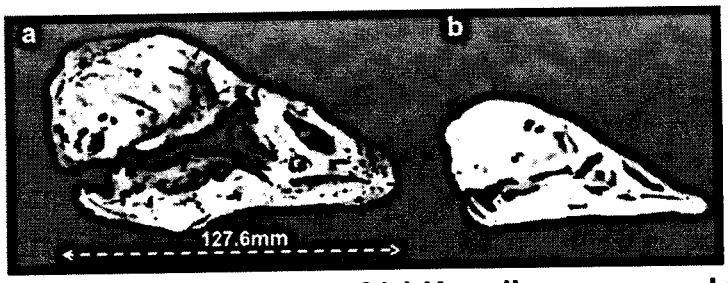

Fig 1.4 : Skulls and mandibles of (a) Hawaiian goose and (b) nene

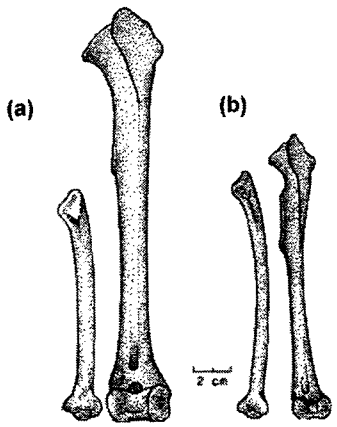

Fig 1.5 : Wing (left) and leg bones (right) of (a) giant Hawaii goose and (b) nene

(f) Based on the fossils, state two species concepts that can be used to determine whether the Hawaiian goose and nene belong to the same species. [2]

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(g) With reference to Fig 1.4 and Fig 1.5, discuss whether these fossils can be used to support Darwin's theory of evolution. [4]

Total: [26]

Question 2

A global strategy to tackle malaria involves the rapid diagnostic testing (RDT) of individuals who may have malaria. This involves testing human blood samples for the presence of proteins specific to *Plasmodium*. RDT test sticks make use of monoclonal antibodies (mAbs).

mAbs are antibodies that are all identical to each other. mAbs are produced *in vitro* by fusing a plasma cell with a cancer cell to produce a hybridoma, which divides repeatedly to form many genetically identical cells that all produce the same antibodies.

Table 2 contains information about two RDT test sticks.

Table 2

Test stick	*Plasmodium* protein tested for	Species of *Plasmodium* that produce the protein
1	pLDH (parasite lactate dehydrogenase)	*P. vivax* *P. falciparum* *P. ovale* *P. malariae*
2	HRP-2 (histidine-rich protein 2)	*P. falciparum* only

Some details of the design of these RDT test sticks are shown in Fig 2.1.

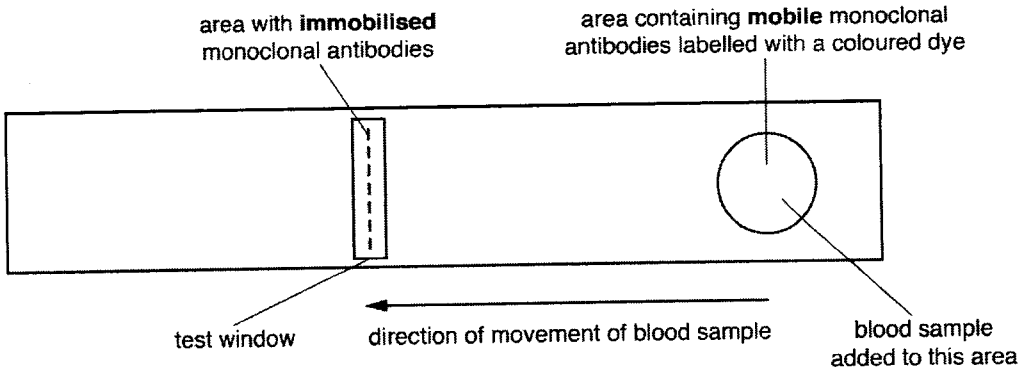

Fig 2.1

The **immobilised** monoclonal antibodies in the test window are not visible.

If the blood sample contains a *Plasmodium* protein that can be detected by the RDT test stick,

- the **mobile** monoclonal antibodies bind to one part of the protein,
- the **immobilised** monoclonal antibodies bind to another part of the protein,
- a coloured line in the test window indicates a positive result for the protein.

(a) With reference to Table 2 and Fig 2.1, [2]

(i) explain why test stick 1 and test stick 2 will contain different mobile monoclonal antibodies,

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(ii) explain what can be diagnosed for this person from a positive result for test stick 1 and a negative result for test stick 2. [2]

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(b) Outline the process during B-cell development that allow our immune system to produce antibodies that recognise a range of *Plasmodium* proteins. [4]

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Prokaryotic cells can potentially be used for antibody production. Fig 2.2 shows a possible experimental procedure for antibody production in bacteria cells.

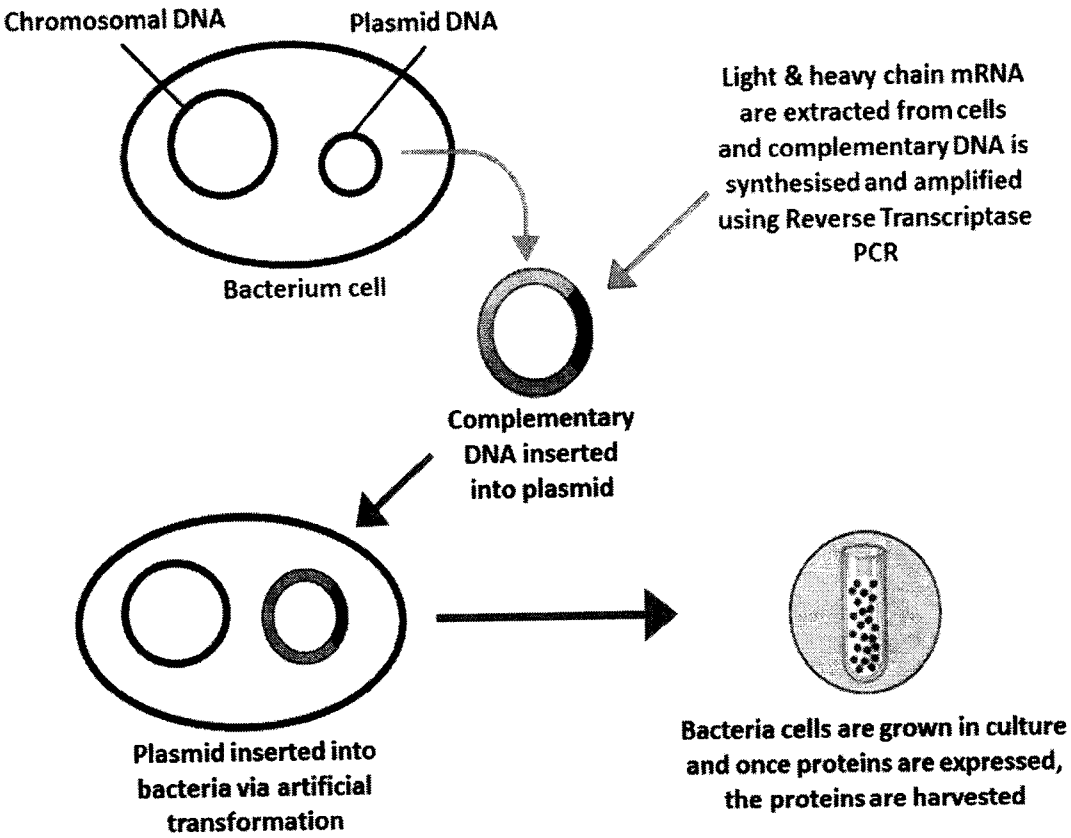

Fig 2.2

To obtain DNA sequences of the light and heavy chain genes, light and heavy chain mRNA are extracted from plasma cells and then DNA containing the gene sequences are produced using reverse transcription Polymerase Chain Reaction (PCR).

The procedure for reverse transcription PCR is as follows:

- The extracted mRNA is mixed with deoxyribonucleotides, reverse transcriptase and incubated at 65°C for 5 minutes.
- RNase is then added to the reaction mixture and incubated at 42°C for 50 minutes, then 70°C for 15 minutes.
- Primers, *Taq* polymerase and deoxyribonucleotides are then added. The first cycle of PCR is carried out at 72°C, before the normal three-stage PCR cycle is carried out for the next 40 cycles at temperature 95°C, 60°C and 72°C.

(c) For the reverse transcription PCR procedure, explain why

(i) extracted mRNA is mixed with deoxyribonucleotides and reverse transcriptase; [1]

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(ii) RNase is added to the reaction mixture and eventually incubated at 70°C for 15 minutes; [2]

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(iii) the first cycle of PCR is carried out at 72°C instead of the usual 95°C. [2]

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(d) Production of fully functional antibodies, which originate from eukaryotic cells, in prokaryotic cells is expected to be unsuccessful. [3]

Explain why production of fully functional antibodies in prokaryotic cells is expected to be unsuccessful.

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Total: [16]

Question 3

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

Fig 3 shows the relationship between the number of plant genera and the mean annual rainfall in seven countries.

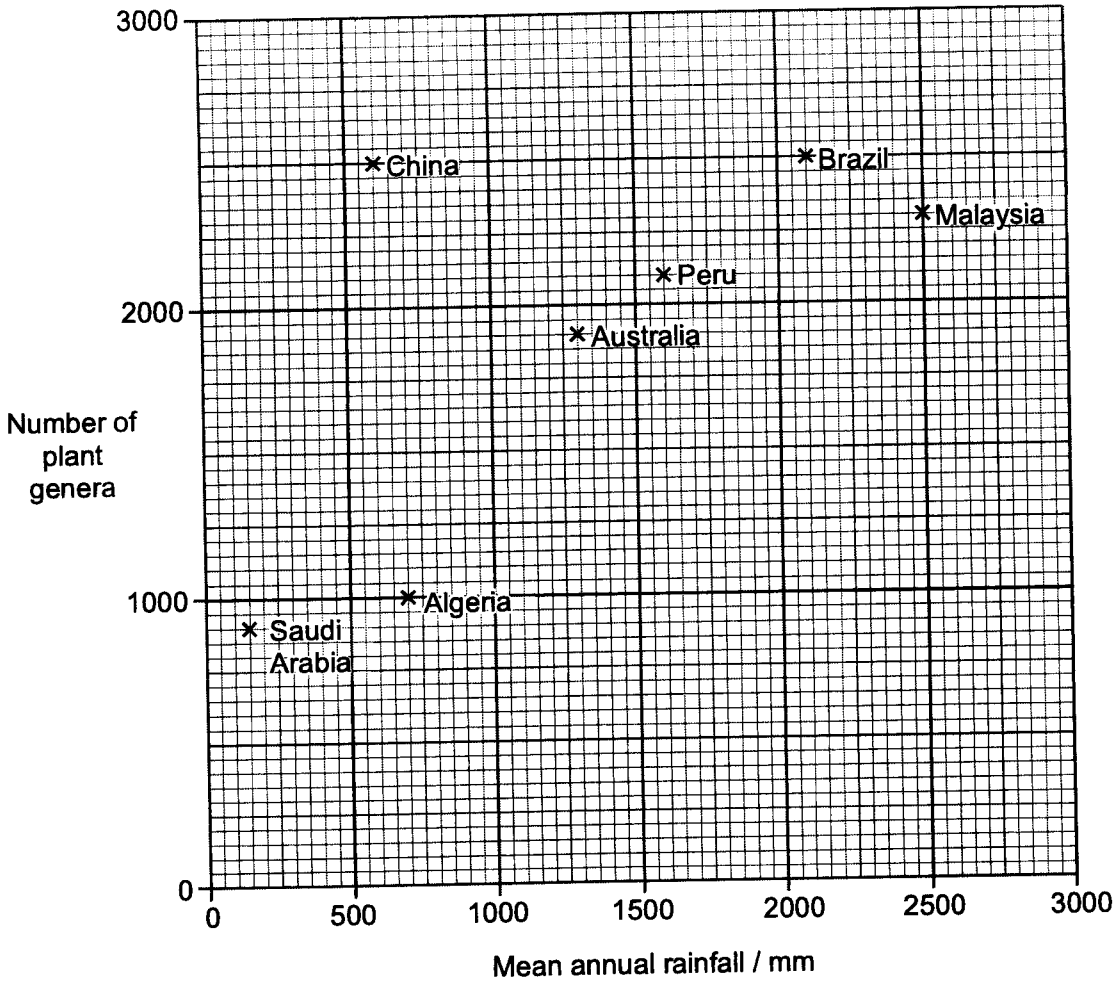

Fig 3

(a) (i) Describe the relationship between the number of plant genera and the mean annual rainfall in these seven countries. [2]

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(ii) Discuss how changes in rainfall can affect plant biodiversity. [3]

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(b) Suggest the benefits to humans of conserving plant species. [3]

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Total: [8]

Section B: Free-Response Questions

Answer **one** question.

Write your answers in the Answer Booklet provided.
Your answers should be illustrated by large, clearly labelled diagrams, wherever appropriate.

Your answer must be in continuous prose, where appropriate.
A **NIL RETURN** is required.

4 **a** In eukaryotes, a gene mutation can give rise to a new allele. Outline how the frequency of a gene mutation can increase in a population. Consider both prokaryotes and eukaryotes. [10]

b Describe how the structures of nuclei acids are adapted for protein synthesis. [15]

5 **a** Using named examples, outline the role of ATP in eukaryotes. [10]

b Eukaryotic cells contain various organelles that perform different specific functions. These organelles comprise membranes that have different compositions that are adapted to their specific roles. [15]

Describe the different structures of various membranes using named examples and explain how they are adapted to the role they perform in a eukaryotic cell.