VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2017

NAME : _____

CT CLASS : _____

H2 BIOLOGY **9744/1**

Paper 1 Multiple Choice **1 hour**

Additional material: Multiple choice answer sheet

READ THESE INSTRUCTIONS FIRST

Write your name, exam number on the answer sheet provided.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

There are **30** questions in this paper. Answer all questions. For each question there are four possible answers A, B, C and D.
Choose the **one** you consider correct and record your choice **in soft pencil** on the separate answer sheet.

Read the instructions on the answer sheet very carefully.

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

The use of an approved scientific calculator is expected, where appropriate.

1 Which of the following is a false statement regarding centrioles and ribosomes?

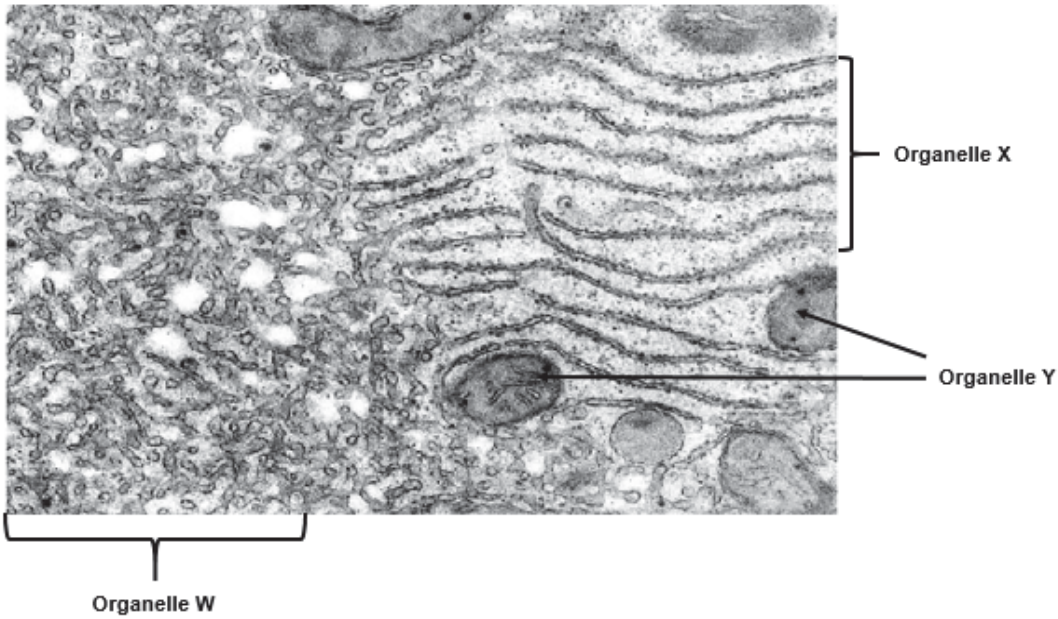
A Both are non-membrane bound organelles.

B Only centrioles are present in a cell undergoing mitosis.

C Both are present in dividing and non-dividing animal cells.

D Under high temperature, both will be denatured as they have a proteinaceous component.

2 Fig 2 shows three cell organelles W, X and Y.



Which of the following statements about these organelles is true?

A Only organelle Y contains RNA.

B Only organelle W contains carbohydrates and phospholipids.

C Organelle X has 80S ribosomes whereas organelle Y has 70S ribosomes.

D Organelles X and Y have double membrane whereas organelle W has a single membrane.

3 Which set of factors shown below will produce the **least** fluid cell surface membrane?

A	● High proportion of cholesterol ● High temperature
B	● Low proportion of phospholipids with saturated fatty acids ● High temperature
C	● Low proportion of phospholipids with unsaturated fatty acids ● Low temperature
D	● High proportion of phospholipids with unsaturated fatty acid ● Low temperature

4 Fig 4 shows a repeating unit found in a biomolecule.

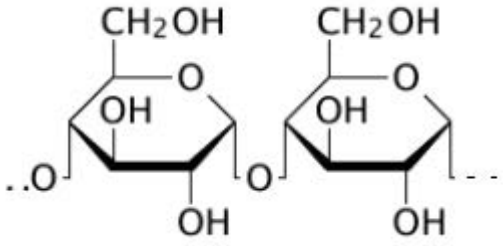


Fig 4

In which of the following biomolecules, would one expect to find the above repeating unit?

X Absent
√ Present

	Cellulose	**Glycogen**	**Amylose**	**Collagen**
A	X	X	√	X
B	√	X	√	X
C	√	X	X	√
D	X	√	√	X

5 Fig 5 below is an electron micrograph of a stained fiber of deoxyhemoglobin S (HbS).

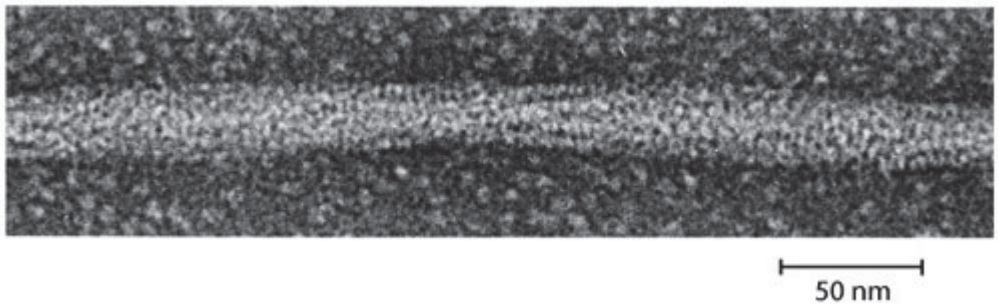


Fig 5

[From G. Rykes, R.H. Crepeau, and S.J. Edelstein. *Nature* 272(1978):509.]
Source: http://www.nslc.wustl.edu/sicklecell/part2/molecular.html

Which of the following statements is true?

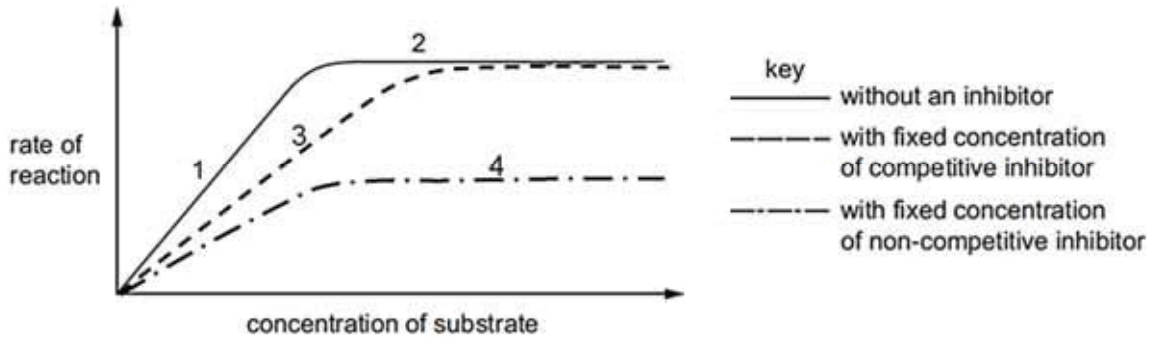
A Mutation in the red blood cell results in the production of HbS which precipitates out as long rigid fibers under low oxygen concentration.

B The long HbS molecule is insoluble due to its large molecular size and this results in the sickling of red blood cells.

C The aggregration of HbS molecules, under low oxygen concentration, causes the fiber to be precipitated out of solution, resulting in the sickling of red blood cells.

D Under low oxygen concentration, HbS molecules form a triplex helix structure, causing the cell membrane of the red blood cells to be more rigid and hence they sickled.

6 The graph shows the effect of increasing the concentration of substrate on the rate of enzyme catalysed reaction.



What is limiting the rate of the enzyme-catalysed reaction at 1, 2, 3 and 4 on the graph?

	1	2	3	4
A	enzyme concentration	substrate concentration	competitive inhibitor	non-competitive inhibitor
B	enzyme concentration	substrate concentration	non-competitive inhibitor	competitive inhibitor
C	substrate concentration	enzyme concentration	competitive inhibitor	non-competitive inhibitor
D	substrate concentration	enzyme concentration	non-competitive inhibitor	competitive inhibitor

7 Many people are opposed to the use of embryonic stem cells on ethical grounds. Researchers have come up with a way of developing embryonic stem cells from a patient's cells. The cultured embryonic cells can then be used to treat the patient. Fig 7 shows the process.

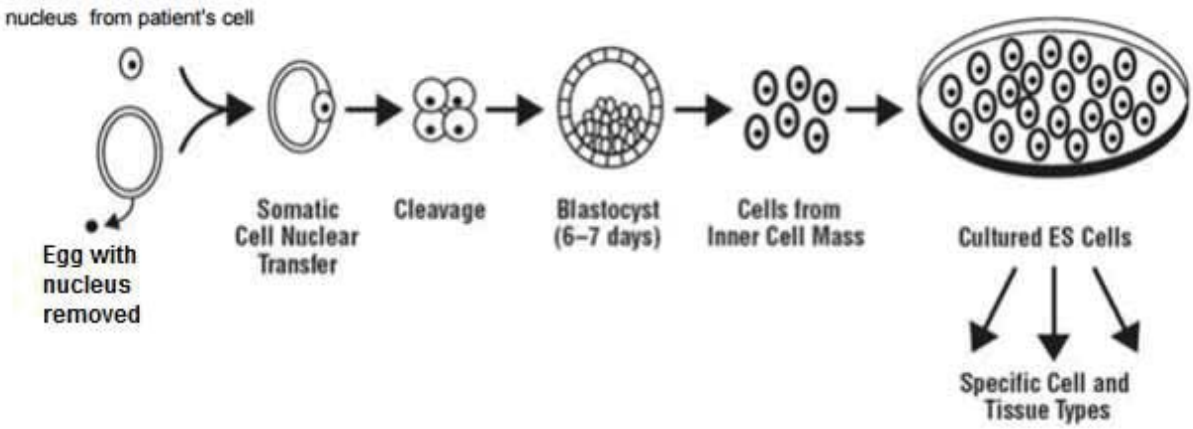


Fig 7

http://media.www.dailyvanguard.com/media/storage/paper941/news/2004/02/26/News/Is.Cloning.Ethical-2612583.shtml

Which of the following options is true?

1 The patient will not show any immune response when the specific cell types developed from the embryonic stem cells are introduced into the patient.

2 No embryo is destroyed in the process of harvesting the embryonic stem cells.

3 The cultured embryonic stem cells can be used for reproductive cloning.

4 The moral concern of the embryo being an individual is not an issue as the embryonic cells come from the patient.

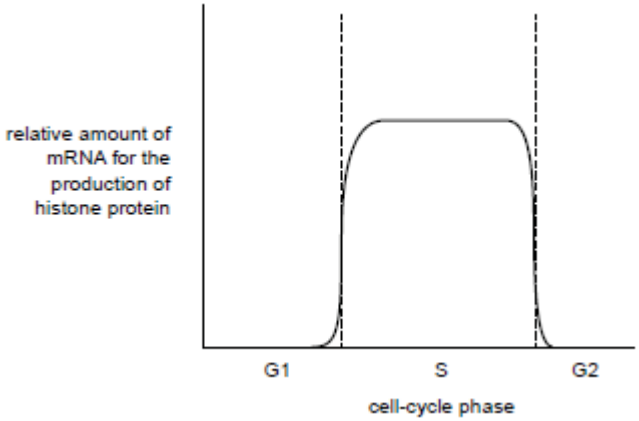
A 1 only

B 1 and 4 only

C 2 and 3 only

D 1, 2, 3 and 4

8 The graph below shows the relative amount of mRNA for the production of histone protein at different times throughout a cell cycle.



Using your knowledge of the cell cycle and the information in the graph, it is correct to state that

A DNA replication occurs most actively in the G1 phase.

B histone genes are highly active throughout the cell cycle.

C histone protein synthesis occurs simultaneously with DNA synthesis.

D histone protein is not present in the cell during the G1 and G2 phases.

9 The following are descriptions of different regions of chromosomes.

1 Non-coding sequences are only located within the genes.

2 The ends of the chromosomes can be lengthened using a RNA template.

3 Sequences found in the middle of the chromosomes are always integral to the positioning of spindle fibres.

4 Each chromosome comprise of tight packing of several DNA molecules around histone proteins and scaffold proteins.

Which of the statements above apply only to a eukaryotic chromosome?

A 2 only

B 1 and 3 only

C 3 and 4 only

D All of the above

10 The sequence below depicts the template strand of a hypothetical gene. The exons are in bold type.

3′ **TAC AAA** CCG GCC **TTT GCC AAA** CCC AAC CTA **AAT ATG AAA ATT** 5′

An allele for this gene codes for a polypeptide with only five amino acids. This is caused by a mutation in one of the exons.

Which of the following describes the change(s) that results in the formation of the shorter polypeptide?

A Deletion of one adenine

B Addition of two cytosine

C Substitution of thymine with adenine

D Addition of cytosine and removal of adenine

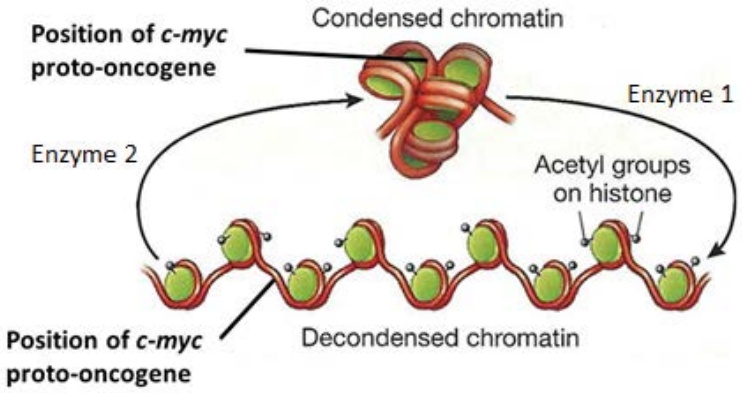
11 The following events occur during transcription.

P. Bonds break between complementary bases.
Q. Bonds form between complementary bases.
R. Phosphodiester bonds form.
S. Free nucleotides pair with complementary nucleotides.

Which options correctly depicts the frequency of the events occurring in the nucleus?

	Occurs once	**Occurs twice**
A	P, R, S	Q
B	Q, R, S	P
C	R, S	P, Q
D	P, S	Q, R

12 The *c-myc* proto-oncogene on chromosome 8 codes for the c-myc protein, a transcription factor that promotes cell proliferation. In cells that are induced to differentiate, the gene is expressed at a very low level. The figure below shows the involvement of two enzymes in regulating the expression of this gene.



Which one of the following statement is true?

A A hyperactive enzyme 2 can lead to tumor formation.

B Enzyme 1 is only functional in both stem cells and cancerous cells.

C Enzyme 2 can be recruited by methylation of *c-myc* gene.

D Both enzymes 1 and 2 carry out chemical modification on the DNA molecule.

13 Which of the following mechanism can reduce the amount of polypeptides produced from a given mRNA molecule?

A Addition of ubiquitin to the mRNA

B Increasing the region of DNA methylation

C Preventing activators from binding to enhancers

D Inhibiting the activity level of poly(A) polymerase

14 Fig. 13.1 represents the changes in the quantity of DNA in two types of cell divisions that occur in different types of cells of an organism. Fig. 13.2 shows the entire set of homologous chromosomes in a diploid sex cell of this organism before it undergoes the type of nuclear division that leads to **P**.

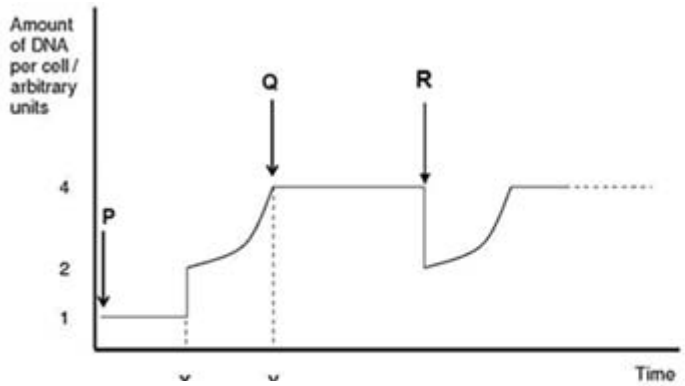


Fig. 13.1

Fig 13.2

Identify the correct combination of outcomes within a cell in this organism at **P**, **Q** and **R**.

	At **P**	At **Q**	At **R**
A		Diploid set of homologous chromosomes, each with identical sister chromatids.	Diploid set of homologous chromosomes, each a single DNA molecule.
B		Diploid set of homologous chromosomes, each with identical sister chromatids.	Haploid set of chromosomes, each a single DNA molecule.
C		Diploid set of homologous chromosomes, each a single DNA molecule.	Haploid set of chromosomes, each a single DNA molecule.
D		Tetraploid sets of homologous chromosomes, each a single DNA molecule.	Diploid set of homologous chromosomes, each a single DNA molecule.

15 Which of the following statements are true of HIV and influenza virus?

1	Genetic material with the same sense
2	Uncoating occurs after fusion of envelope with host membrane
3	Viral particles contain specific enzymes that are not found in the host cells
4	Replication of viral genetic material takes place in the nucleus immediately upon infection
5	Changes in the genome are due to the lack of proofreading mechanism only

A 1 and 4 only
B 2 and 3 only
C 1, 4 and 5 only
D 2, 3 and 5 only

16 In mice, hair colour pigment is expressed by the B/b locus. The dominant allele B codes for black colour hair while the recessive allele b codes for brown colour.

Banding of hair colour is caused by the A/a locus. The dominant agouti allele A causes banding on hairs such that the coat appears paler in colour. Black hair appears grey and brown hair appears beige. The recessive allele a does not cause banding so that the coat is a continuous colour.

What are the likely genotypes of the two parents if the offspring phenotypic ratio of black: grey: beige: brown offspring is 3:3:1:1?

A AaBb and AaBb
B AaBb and aaBb
C AaBb and Aabb
D AABb and aaBB

17 A farmer is interested in selling white squash as a novel vegetable bred two white squashes together and obtained all white squashes in the F1 generation. He then performed a self-cross of one of these F1 offspring and found that the F2 offspring can be grouped into three different colours of squash as shown below.

White squash	234
Yellow squash	58
Green squash	18

Which of the following is the best explanation for the inheritance of fruit colour in squash?

A Fruit colour is controlled by one gene with multiple alleles.

B Fruit colour is controlled by one gene that showed incomplete dominance.

C Fruit colour is controlled by two genes that showed independent assortment.

D Fruit colour is controlled by two epistatic genes that did not assort independently.

18 In a common genetic condition afflicts children, the mutant allele differs from the wild-type allele by a single nucleotide substitution. This substitution eliminates a *NheI* restriction site so that the mutant allele is not cut by the restriction enzyme, *NheI*. A pedigree of a family exhibiting this condition is shown in Fig. 17.1.

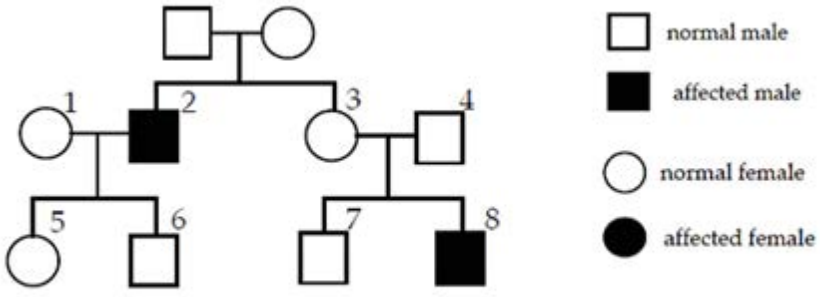


Fig 17.1

The DNA from four individuals in the pedigree were isolated and subjected to polymerase chain (PCR) reaction. This technique amplifies a 1000 bp portion of their DNA that includes the *NheI* site that is affected by the mutation. The PCR products are then digested with *NheI* and analysed. The DNA fragments from the digest are run on an agarose gel and the results are shown in Fig. 17.2.

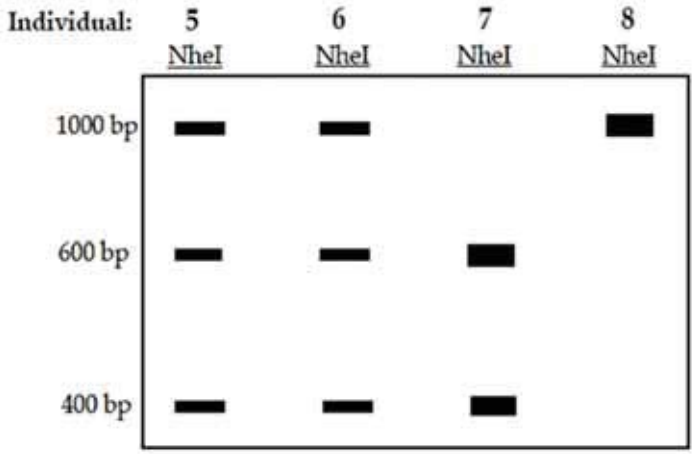


Fig. 17.2

Based on the data in Fig. 17.1 and Fig. 17.2, identify the correct mode of inheritance and the probability of Individuals 3 and 4 having a daughter who will be affected.

	Mode of inheritance of disease	**Probability**
A	autosomal dominant	0.125
B	autosomal recessive	0.25
C	X-linked dominant	0
D	X-linked recessive	0.5

19 Tyrosinase is an enzyme that catalyses the conversion of the amino acid tyrosine into the black pigment melanin. It is responsible for the black fur colour of some rabbits.

group of rabbits kept at 30 °C resulted in 90% of the rabbits with light fur colour. A second group of rabbits kept at 10 °C resulted in 90% of the rabbits with black fur colour.

Which hypothesis is supported by these results?

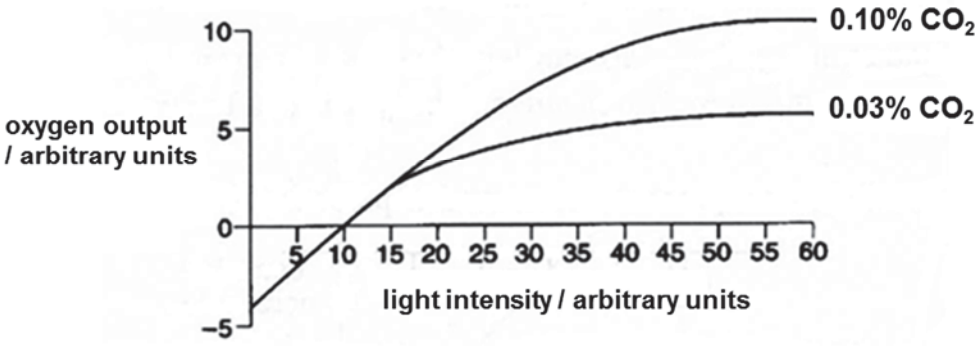
A An inhibitor is present in rabbit skin cells that can bind strongly to tyrosinase when the external temperature is 30 °C.

B At 10 °C external temperature there are fewer tyrosinase-tyrosine complexes formed and less melanin is produced.

C Tyrosinase is an enzyme that is coded for by a gene that is switched off when the external temperature is 10 °C.

D Tyrosinase is a temperature-sensitive molecule that is only activated when the external temperature is 30 °C.

20 The graph shows the oxygen output of a green plant at different light intensities in two separate setups with different concentrations of carbon dioxide in the surrounding air.



What can be deduced from the graph above?

I At 10 arbitrary units of light intensity, the rate of photosynthesis is equivalent to the rate of respiration.

2 Concentration of carbon dioxide limits the rate of photosynthesis when light intensity exceeds 15 arbitrary units.

3 Enzymes catalysing carbon fixation are saturated at high light intensities (above 30 arbitrary units) in both experiments.

4 Oxygen output can be used to quantify the rate of photosynthesis due to their role as final acceptor of protons and electrons.

A 1 only

B 1 and 2 only

C 3 and 4 only

D 2, 3 and 4 only

21 Which of the following statements show a difference between cyclic and non-cyclic photophosphorylation?

A Cyclic photophosphorylation involves PSI and PSII only whereas non-cyclic photophosphorylation involves PSI, PSII and NADP.

B Light energy is required to boost electrons in cyclic photophosphorylation whereas for non-cyclic photophosphorylation, the energy comes from photolysis of water.

C Only non-cyclic photophosphorylation produces protons which is required for the generation of the proton gradient for ATP synthesis.

D Oxygen is produced in non-cyclic photophosphorylation only.

22 Two respirometers (one shown in Fig 22) were set up to investigate the rate of respiration in spiders. To one setup, the spiders were fed a diet containing a drug before the experiment. For this setup, the drop of fluid remained stationary after a short distance from the starting position. Distance moved is shorter than the control setup.

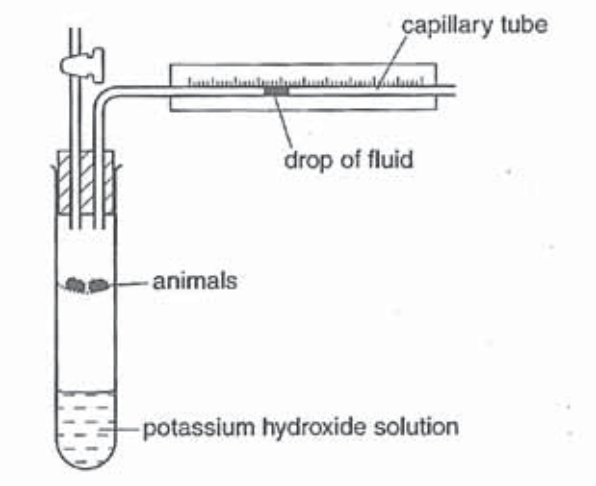


Fig 22

What could be a possible explanation for this observation?

A The oxygen content in the boiling tube was depleted.

B A mutation occurred that causes the ATP synthase to become hyperactive.

C A drug was introduced that act as an ion channel on the mitochondrial membrane.

D Inhibitor of the electron carriers in the electron transport chain was added to the animal's diet.

23 ARHI has been identified as a tumor-suppressor gene and is of significant importance in modulating cell growth and apoptosis. It was proposed that in cancerous cells, ARHI gene expression was decreased. Expression of ARHI is proposed to be related to acetylated STAT3.

To study how the expression of ARHI is affected by acetylation of STAT3, cultures of normal ovarian epithelial cells and ovarian cancer cells were analysed. The results are shown in Fig 23.1 and 23.2 below.

Fig 23.1 shows the extent of methylation in normal and cancer ovarian cultures. For Fig 23.2, amount of protein present is indicated by the density and thickness of the band.

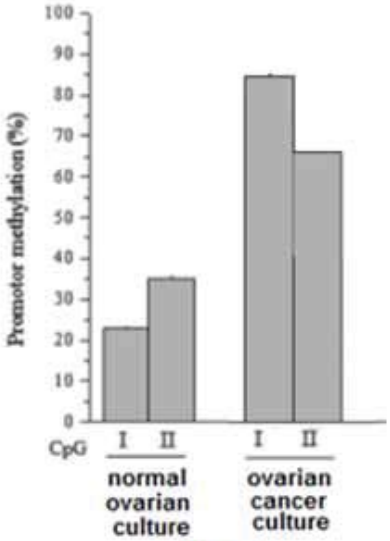


Fig 23.1

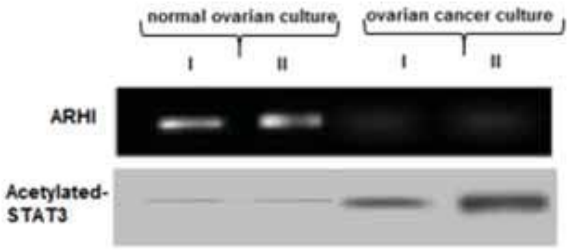


Fig 23.2

From the information given, which of the following is true?

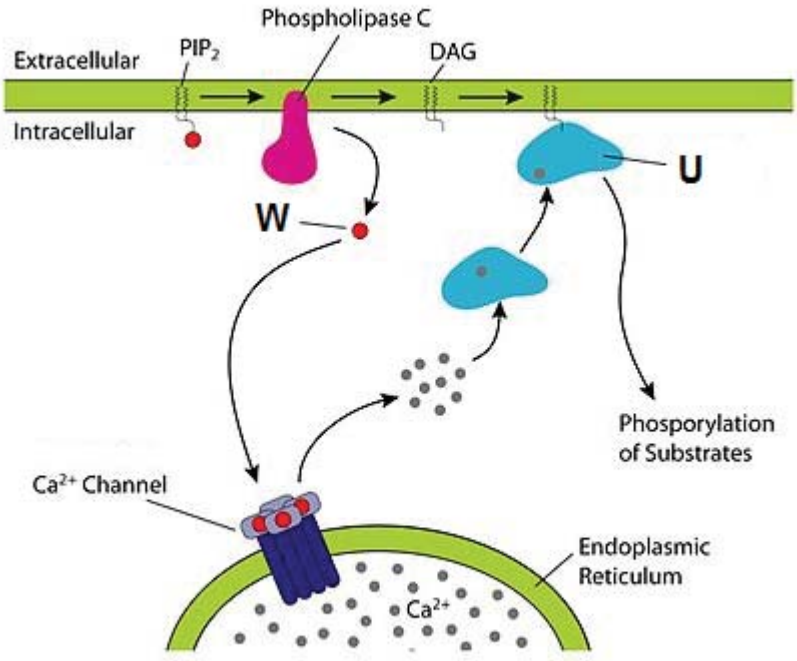
A Normal ovarian cells show lower methylation of the ARHI promoter which increases the accessibility of the ARHI gene, resulting in the synthesis of acetylated STAT3 which promotes apoptosis.

B Acetylation of STAT3 results in increased accessibility of ARHI gene, resulting in ARHI being expressed in normal ovarian cells.

C Elevated acetylated STAT3 in ovarian cancer cells results in hypermethylation of the AHRI promoter, decreasing its expression.

D Lower methylation of the ARHI gene in normal ovarian cells results in ARHI being expressed as the gene is loosely coiled around the acetylated STAT3.

24 The figure below shows a signaling pathway involving calcium ions.



Which of following is true about molecules W and U?

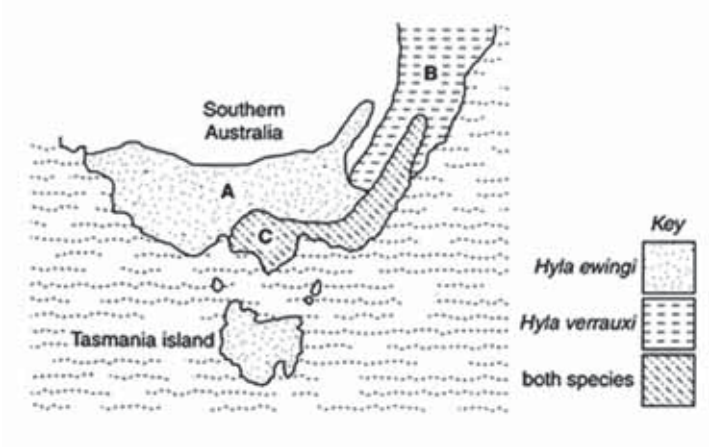
A Both molecules W and U are made up of amino acids.

B Only molecule W is expected to be produced in large number.

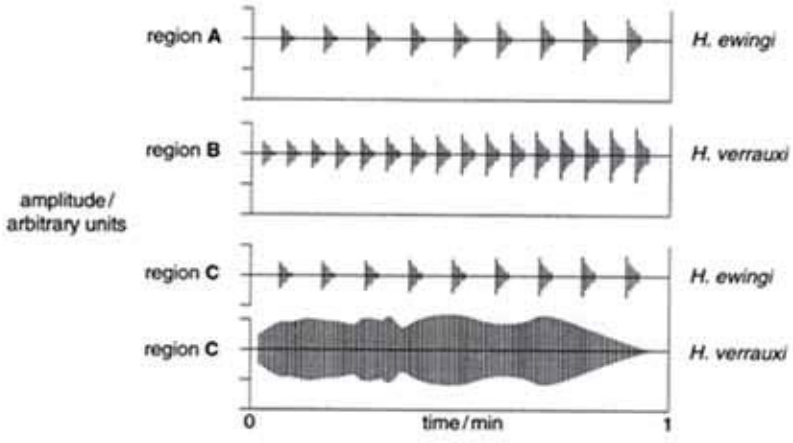
C Increased production of both W and U occurs in response to the binding of ligand.

D Removal of molecule W from the cell will result in the inability of ligand to bind to the receptor.

25 *Hyla ewingi* and *Hyla verrauxi* are two closely related species of tree frogs from southern Australia.



DNA sequence comparisons show a high level of homology and interbreeding can occur to produce viable offspring. Mate selection is based on females responding to the frequency of mating calls emitted by male frogs. The following data shows the pulse frequency and amplitude in the mating calls of *H. ewingi* and *H. verrauxi* from the regions **A**, **B** and **C**.



The distinct mating call observed in region C involves events shown below:

I Sexual selection by females of *Hyla verrauxi* selects for males with a continuous calls over males that emit a discontinuous call.

II Female *Hyla verrauxi* tree frogs preferred mates that emit calls of higher amplitude.

III Males of both species in region C compete for mates.

IV Variations in amplitude occur in male mating calls present in population of *Hyla* frogs.

V The genes that code for continuous high amplitude calls are passed down to future generations and become established in the population of *H. verrauxi.*

What is the correct sequence of events that leads to the distinct profile of male mating call of *H verrauxi* in region C?

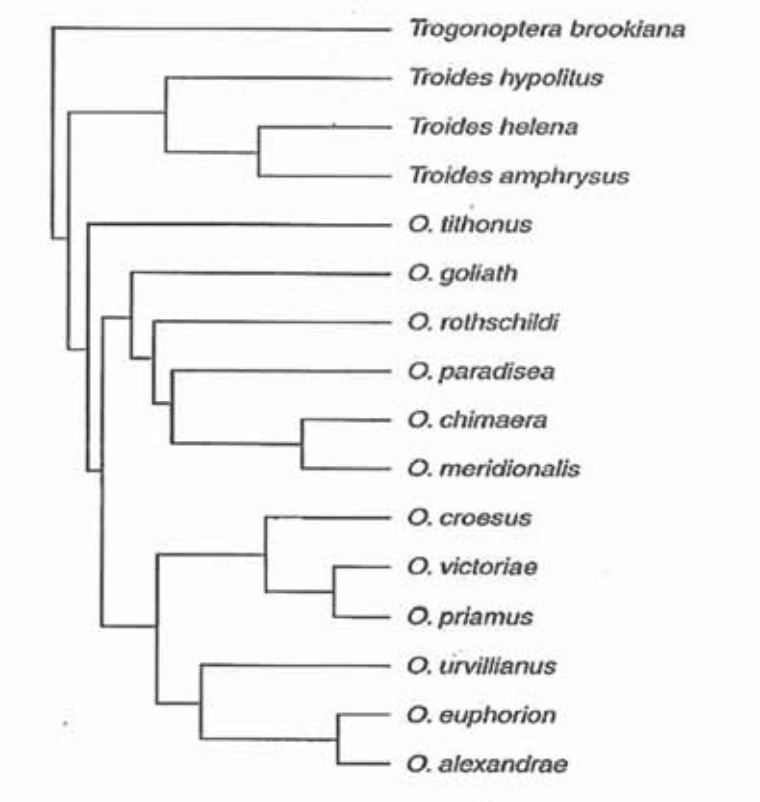
A III → I → IV → II → V

B I → II → IV → III → V

C IV → I → V → III → II

D II → IV → V → I → III

26 The figure is a phylogenetic tree of three genera of butterflies *(Orniithoptera*, *Trogonoptera* and *Troides)* that was constructed based on the comparison of the nucleotide sequences of the gene *ND5* that is located in the mitochondrial genome.



Based on the phylogenetic tree, what conclusions can be drawn regarding the relationships of these three genera?

1 The three genera *Orniithoptera*, *Trogonoptera* and *Troides* form a monophyphyletic clade.

2 *O. victoriae* shares fewer identical nucleotides in the ND5 gene with *O. alexandrae* than with *O. goliath.*

3 *Troides hypolitus* shares both ancestral and shared derived traits with *Troides helena* and *Troides amphyrysus.*

4 *Trogonoptera brookiana* diverged from the common ancestor much earlier than *O. alexandrae* so it is now extinct.

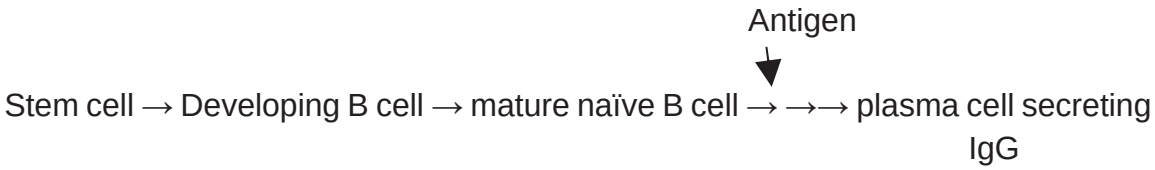
A 1 only

B 1 and 3 only

C 2 and 4 only

D 2, 3 and 4 only

27 The flow chart below shows the development of a B cell.



Which of the following statements below are true of the different cells above?

I	In a developing B cell, somatic hypermutation produces different mature naïve B cells with different BCR (B cell receptor).
II	The mature, naïve B cell will be expressing both IgM and IgD on its cell surface membrane.
III	From one stem cell, it is possible to obtain many different mature naïve B cells each specific for a different antigen.
IV	The plasma cell will contain all the genes present in the stem cell.

A I and II only

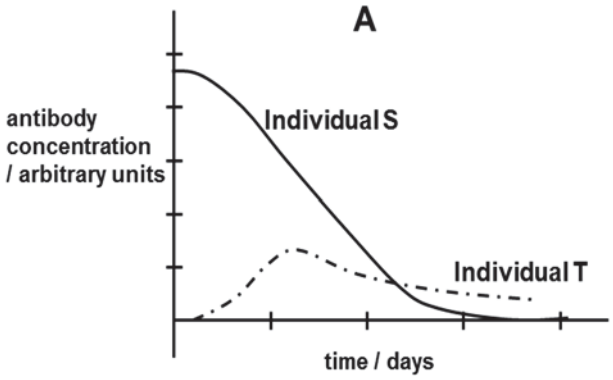
B I and III only

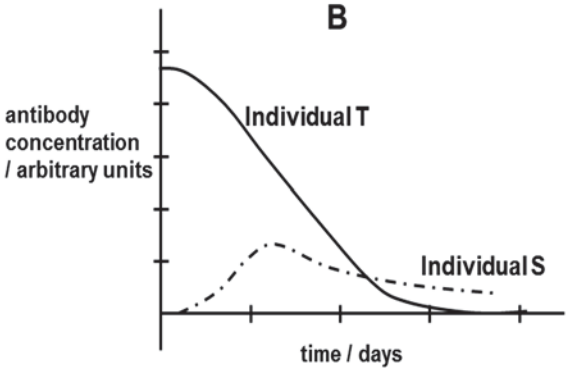
C II and III only

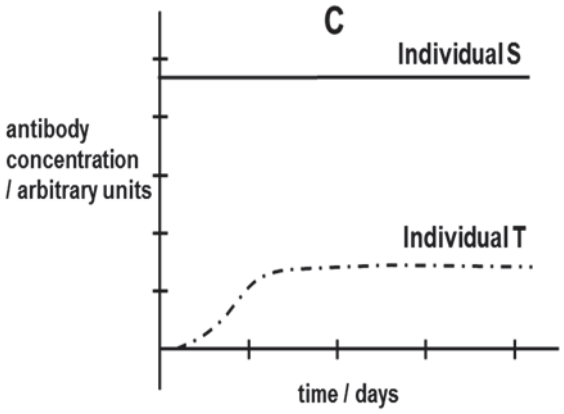
D III and IV only

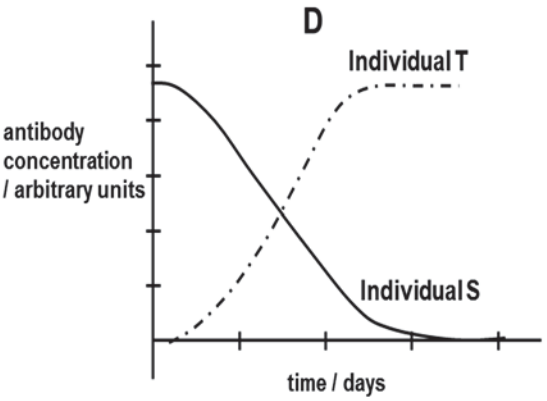
28 Two individuals took part in a study to investigate the effectiveness of two different types of immunisation. Individual S received an injection of antibodies against tetanus and Individual T received a tetanus vaccination.

Which of the options below shows correctly the changes to the antibody concentration in the blood of S and T?

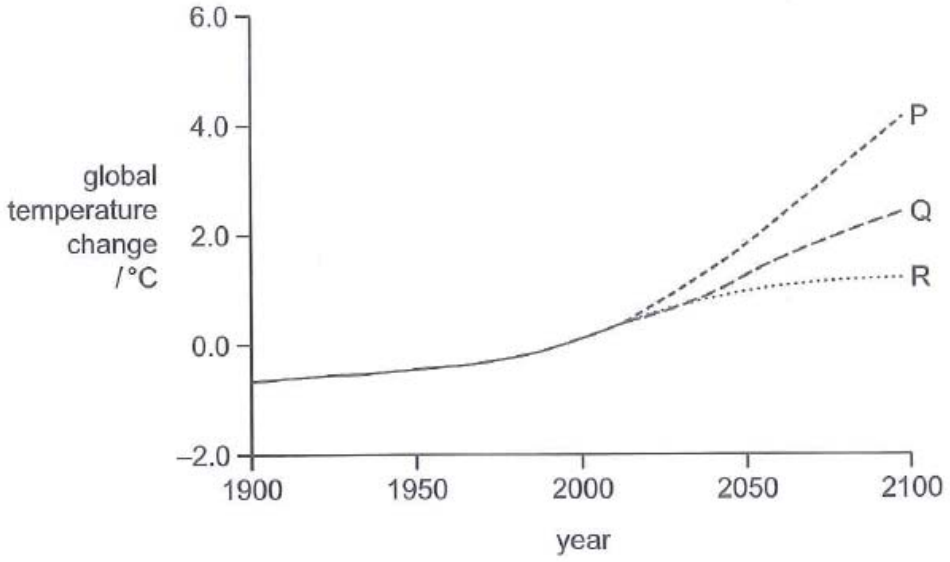








29 The graph shows the predicted change in global temperatures using three different models, P, Q and R. Model Q assumes that no new factors act to influence the rate of climate change.



The predictions based on models P and R can be explained using some of the following statements.

1 An increased global temperature and reduced rainfall will lead to an increase in forest fires.

2 Permanently frozen soil and sediment in the Arctic will begin to thaw as global temperatures increase.

3 Rising sea temperatures will cause increased growth of photosynthetic algae.

4 Rising sea temperatures will reduce the solubility of greenhouse gases in the oceans.

Which of these statements support predictions of P and R?

	Statements that support prediction **P**	Statements that support prediction **R**
A	1, 2 and 4	3
B	1 and 3	2 and 4
C	2	1, 3 and 4
D	3 and 4	1 and 2

30 Rice crops in Japan are damaged by the green rice leafhopper *(Nephotettix cincticeps),* a pest that reduces crop yield.

In a study of the effect of climate change on crop damage by the green rice leafhopper, it was found that an increase in winter temperatures caused an increase in crop damage, while an increase in summer temperatures caused a decrease in crop damage.

Which of the following are possible explanations for these findings?

1 Increased temperatures in the summer cause a rise in metabolic rate that results in the pests reproducing more rapidly.

2 Increased temperatures in the summer raise the metabolic rate above the range that the pests can tolerate.

3 Increased temperatures in the winter disrupt the pests' life cycle and result in fewer being able to reproduce.

4 Increased temperatures in the winter allow more pests to survive and results in an increase in the pest population.

A 1 and 3 only

B 1 and 4 only

C 2 and 3 only

D 2 and 4 only

VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2017

NAME : _____

CT CLASS : _____

H2 BIOLOGY **9744/2**

Paper 2 Structured Questions **2 hours**

READ THESE INSTRUCTIONS FIRST

Write your Name and CT Class on the cover page of this paper.
Write in dark blue or blue pen.
You may use a soft pencil for any diagrams or graphs.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the spaces provided on the question paper.

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

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

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total	

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1 Fig.1 shows an electron micrograph of an organelle. There are two distinct groups of vesicles (Boxes B and C) associated with this organelle.

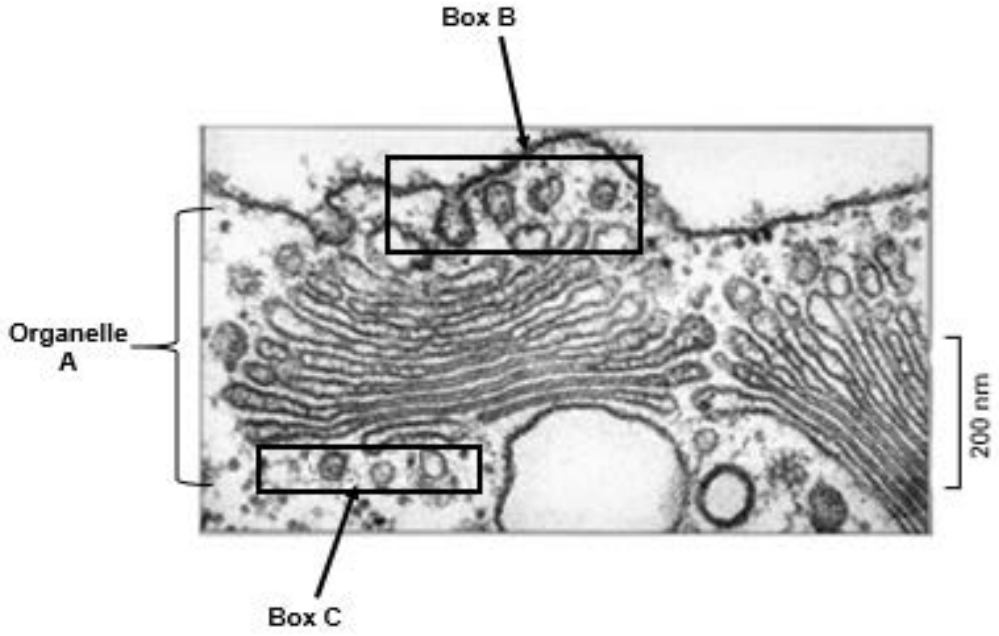

Fig. 1

Source:https://ib-biology2010-12.wikispaces.com/Cell+Images

(a) (i) Identify Organelle A.

Support your answer with one observable feature, other than vesicles, shown in Fig 1.

Organelle A:

[2]

(ii) Describe the differences in the role of the vesicles in Boxes B and C.

[4]

In Angelman syndrome, a severe and rare neurodevelopmental disorder, it has been reported that the lack of ubiquitin protein ligase E3A (*UBE3A*) expression leads to a disruption of structure and function of Organelle A.

(b) Suggest how the lack of *UBE3A* expression can lead to a disruption in the structure and function of Organelle A.

[3]

(c) State two characteristics, one in structure and one in chemical property that you would expect to see in ubiquitin protein ligase.

[2]

[Total:11]

2 An experiment to determine the effect of Compound K, a metabolite derived from ginseng, on the expression of a gene (*RUNX3*) was carried out using a culture of human colorectal cancer cells. *RUNX3* gene codes for a transcription factor.

Cells were treated with Compound K for 72 hours. Samples of cells were removed at specific time intervals. These cells were then lysed and the mRNA and proteins analysed.

Fig 2 shows the changes in the HDAC (Histone Deacetylase) mRNA and HDAC protein over the 72 hour period. The thickness of the band is an indication of the concentration of the mRNA and proteins.

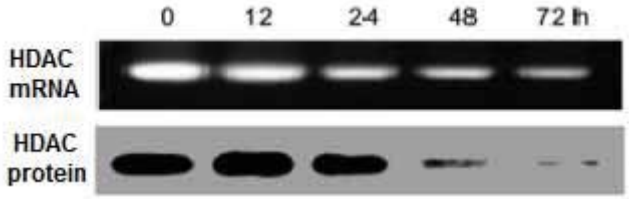

Fig 2

(a) Explain the similarity in the pattern seen in both HDAC mRNA and HDAC protein.

[2]

(b) **(i)** What information about the gene expression of *RUNX3* in the colorectal cancer cells can one conclude from the data at the beginning of the experiment? Explain your answer.

[3]

(ii) Suggest one way how your answer in **(i)** can affect the cell.

[3]

(c) With reference to the data shown in Fig 2, suggest how Chemical K can bring about the change in the HDAC mRNA and protein.

[2]

(d) Suggest why HDAC mRNA instead of the HDAC gene was analysed in this experiment.

[2]

[Total:12]

3 Diauxic growth is a two-phase growth response observed in a culture of bacteria of *E. coli.* This phenomenon (Fig. 3) was discovered by Jacob and Monod who were awarded the Nobel prize for their ground breaking study of how gene expression is regulated in prokaryotic organisms. They studied how glucose and lactose impact the growth of *E. coli*. Substrates X and Y are the two different sugars that are introduced to the bacteria culture medium at the same time, to serve as carbon sources.

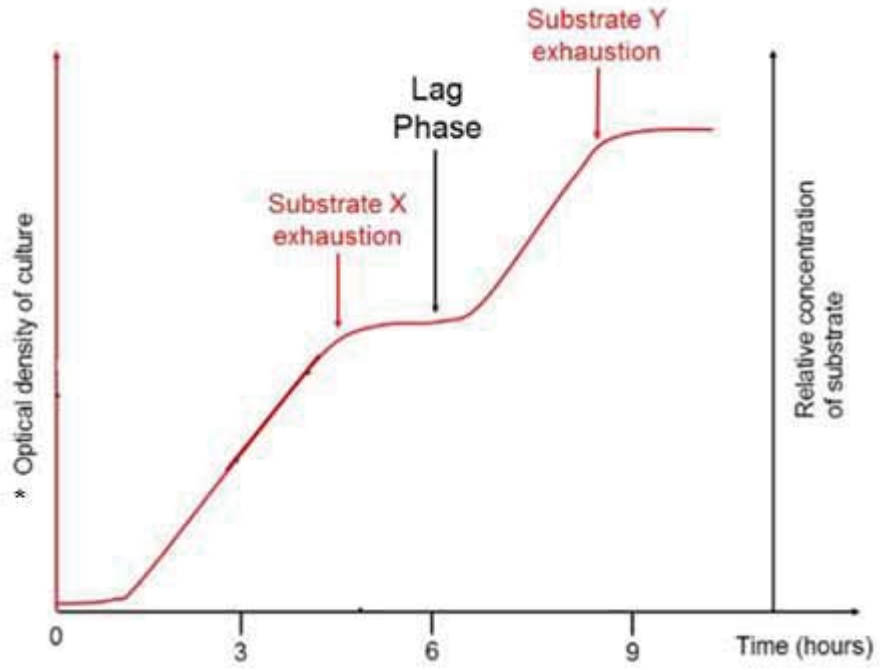

Fig. 3

*Note: Optical density, measured in a spectrophotometer, is used as a measure of the concentration of bacteria in a suspension.

(a) **(i)** Identify substrates **X** and **Y**.

X: .....

Y: ..... [2]

.....

(ii) Using your knowledge of gene expression in bacteria, explain how Fig. 3 supported their conclusion that the *Lac* operon is under dual control.

[4]

(b) On Fig. 3, draw separate graphs to show the change in the concentration of the two substrates over time. Label your graphs clearly. [2]

(c) Eukaryotes are structurally different from prokaryotes and hence exhibit differences in their control of gene expression.

Explain two such differences.

1.

2.

[4]

[Total:12]

4 Wild-types freshwater snails, *Physa heterostropha* have pigmented shells. When two pure-breeding albino snails were crossed and their F1 selfed, the F2 generation consists of 48 pigmented snails and 35 albino snails.

(a) What do you understand by the term pure-breeding?

[1]

(b) Using appropriate symbols, draw a genetic diagram to explain the results obtained.

Symbols:

[1]

[6]

[Total:8]

5 Cells X and Y are two types of cells taken from a healthy individual and cultured in media that is similar to the actual conditions in the body.

Fig. 5 illustrates the change in the telomere lengths of these cells with increasing rounds of cell division. M1 represents the Hayflick limit where cells will leave the cell cycle (replicative senescence) while M2, termed crisis, is characterised by widespread cell death, although some cells that survive M2 will be able to continue dividing.

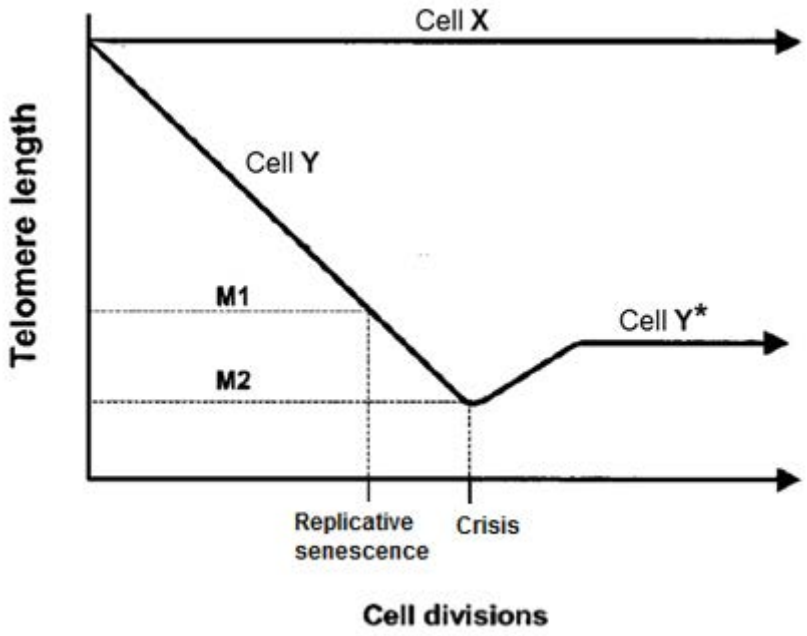

Fig. 5

(a) (i) Account for the decrease in the telomere length of Cell Y.

[4]

(ii) Explain why there is a limit to the number of times Cell Y can divide.

[2]

(b) Outline how Cell X is able to maintain its telomere length.

[3]

(c) With reference to Fig 5, explain how the change in telomere length resulted in Cell Y* after M2.

[2]

(d) Describe the importance of centromeres in cell division.

[2]

[Total:13]

6 Metformin has been used for the treatment of Type II diabetes where the skeletal muscles are resistant to insulin stimulation. It is transported into the cell by specific protein carrier.

Fig 6 shows how metformin influence the cellular activity involved in the signal transduction pathway. AMPK is a kinase that is involved in energy sensing and is activated by AMP(adenosine monophosphate) which is the one of the products of ATP hydrolysis.

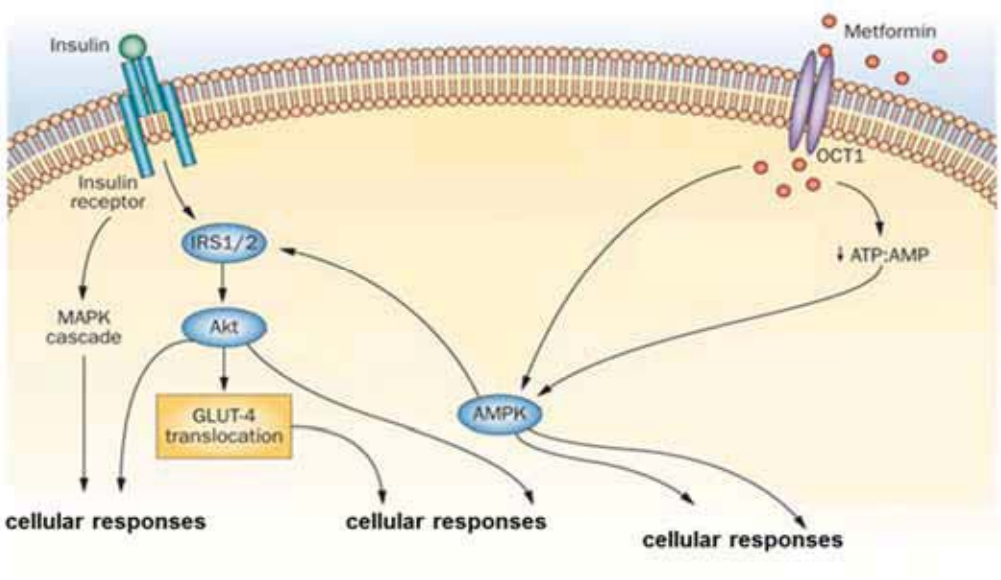

Fig 6

source: http://www.nature.com/nrendo/journal/v8/n8/fig_tab/nrendo.2012.106_F1.html?foxtrotcallback=true

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

[4]

(b) Akt is known to stimulate other cellular responses in the insulin signaling pathway.

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

[3]

(c) Metformin was found to induce a decrease in NADH oxidation in the mitochondria.

(i) Suggest how metformin can lead to a decrease in the ATP:AMP ratio in the mitochondria.

[3]

(ii) Suggest two ways in which ATP can still be produced in the mitochondria.

[2]

[Total: 12]

7 The Hawaiian Islands are some of the most isolated islands in the world. It is made up 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. 7 shows 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. 7A shows the skulls and mandibles while Fig. 7B shows the wing and leg bones of the giant Hawaiian goose and nene.

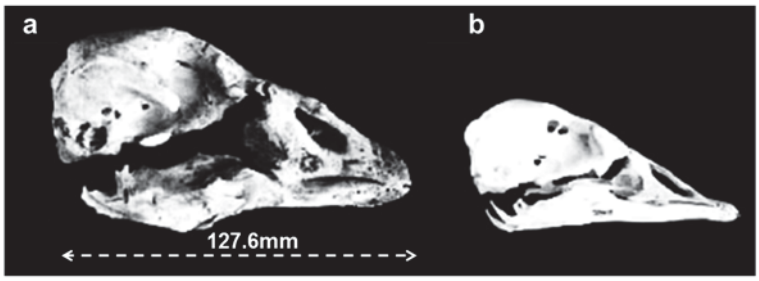

Fig. 7A. Skulls and mandibles of (a) giant Hawaiian goose and (b) nene.

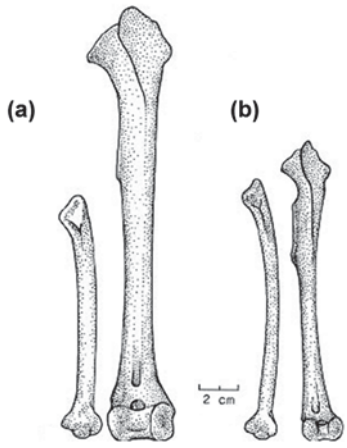

Fig. 7B. Wing (left) and leg bones (right) of (a) giant Hawaii goose and (b) nene.

(Source: https://www.researchgate.net/figure/11540628_fig2_Fig-3-Left-ulna-and-tibiotarsus-a-B-canadensis-maxima-USNM-555497-b-giant)

(a) With reference to Fig7A and 7B, discuss whether these fossils can be used to support Darwin's theory of evolution.

[3]

(b) Using your knowledge of anatomical homology, explain how these differences came about.

[5]

(c) Explain why molecular data is able to overcome the limitations of this fossil study.

[4]

(d) Based on the fossils, state one species concept that can be used to determine whether the Hawaiian goose and nene belong to the same species.

[1]

[Total:13]

8 The immune response consists of innate and adaptive responses.

(a) What is the importance of the innate immune response?

[3]

Fig 8 shows the changes to the variable regions of B cell receptors over time. CDR1-3 are specific regions in the variable regions that are important for the attachment of antigen. Changes in the base sequence are indicated by the darkened vertical lines.

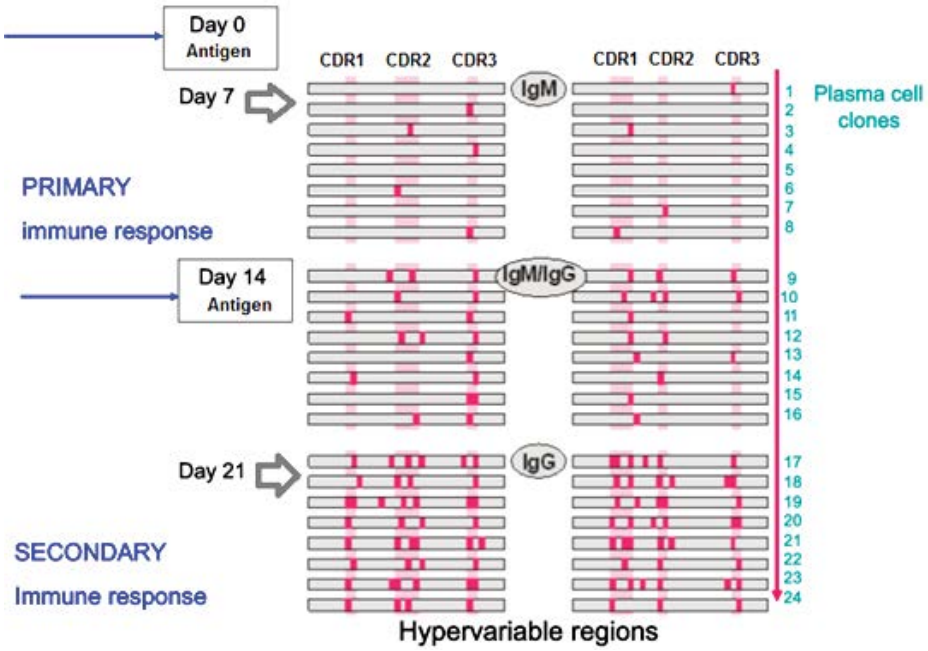

Fig 8

http://slideplayer.com/slide/7421892/

(b) Explain the significance of these changes over time.

[4]

(c) State how a B cell is able to produce two types of B cell receptor (Ig M and Ig D) at same time.

[1]

[Total:8]

9 In Rio de Janeiro, Brazil, dengue epidemics first appeared during the 1980s, according to city authorities. In 2002, the city reported 145,779 cases, in 2008 there were 120,917 cases, and by June 2012 there were over 68,000 cases.

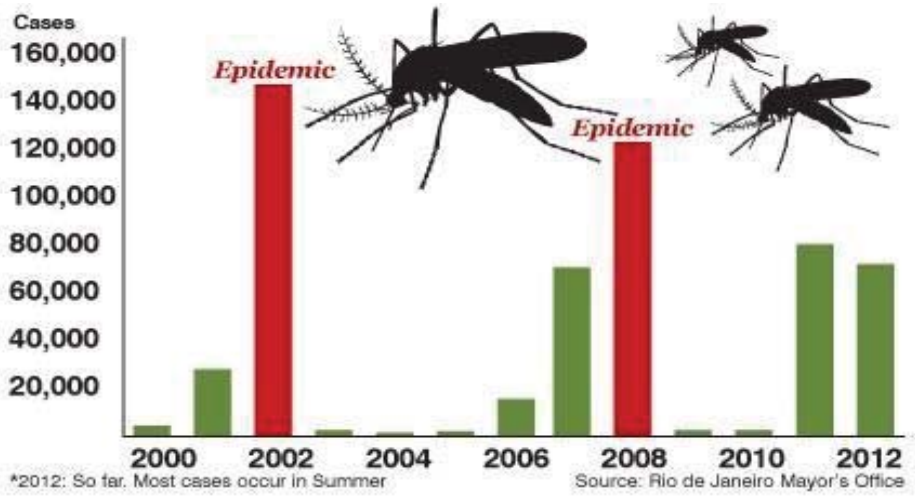

Fig 9 Cases of dengue fever report in Rio, Brazil

(a) **(i)** Describe the pattern of resurgence of dengue shown in Fig.9.

[2]

(ii) Suggest three possible ways in which climate change can result in the pattern described in part (i).

[3]

(b) Adhering to all WHO recommendations, Singapore has dramatically reduced the percentage of households with *Aedes* mosquitoes since the inception of its vector control programme in 1996. However, the incidence of dengue fever has recently increased.

Suggest why the vector control programme might not have worked as initially intended.

[2]

(c) To suppress the wild *Aedes aegypti* mosquito population responsible for dengue outbreaks in Singapore, British company Oxitec has created special genetically modified (GM) mosquitoes of the same species which have a self-limiting gene that kills off their larvae. They have achieved success with such GM mosquitoes released into the wild.

(i) Describe two advantages of this strategy.

[2]

(ii) Discuss the possible impact of these advantages on the natural ecosystem.

[2]

[Total: 11]

VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2017

NAME : _____

CT CLASS : _____

H2 BIOLOGY **9744/3**

Paper 3 Longer Structured and Free-response Questions **2 hours**

READ THESE INSTRUCTIONS FIRST

Write your Name and CT Class on the cover page of this paper.
Write in dark blue or blue pen.
You may use a soft pencil for any diagrams or graphs.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided on the question paper.

Section B
Answer any one question on the writing paper provided.
Indicate the question number of the essay that you have attempted in the box on the left.

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 the 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	
1	
2	
3	
Section B	
Total	

Section A

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

1 Huntington's disease (HD) is a rare neurodegenerative disease. Fig. 1.1 shows a pedigree of HD across three generations (**I** to **III**).

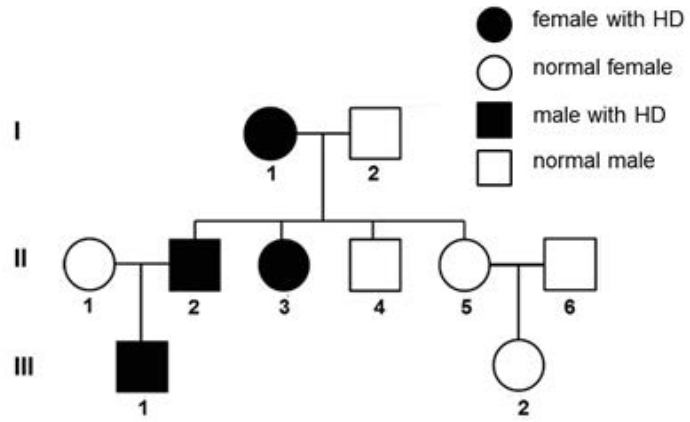

Fig. 1.1

(a) With reference to Fig. 1.1, account for the mode of inheritance of the disease.

[3]

HD strikes in adulthood when disease symptoms appear between the ages of 30 and 50 in 90% of cases. The disease involves the progressive loss of particular nerve cells in the brain leading to loss of motor control and a decline in cognitive function.

HD is caused by alteration in the Huntingtin (*HTT*) gene located on human chromosome 4. The genetic alteration is an increase in the number of repeats of three nucleotide bases (CAG) in the first exon of the HTT gene. This CAG triplet is normally repeated about 20 times, but an approximate doubling in the number of repeats to 40 or more results in the expression of the disease. The number of CAG repeats also correlates with age of onset of HD and severity of disease.

(b) The CAG repeat codes for the amino acid glutamine.

(i) Explain the likely effect of the abnormal increase in CAG repeats on HTT protein structure and function.

[3]

(ii) Suggest possible reasons why individuals having number of repeats ranging from 21-39 do not develop the disease.

[2]

(c) The genetic test for HD involves taking a small sample of DNA from the individual, to look for abnormally expanded CAG repeats, through polymerase chain reaction (PCR).

(i) Explain why PCR can be used for the diagnosis of HD.

[2]

(ii) Explain how gel electrophoresis was used to detect the band patterns of the offspring in Fig.1.1.

[4]

Fig. 1.2 shows the pedigree of a male parent who developed HD when he was 40 years old. The results of electrophoresis of PCR fragments of some of the individuals are shown. The age onset of HD is shown in brackets below the individuals who developed HD.

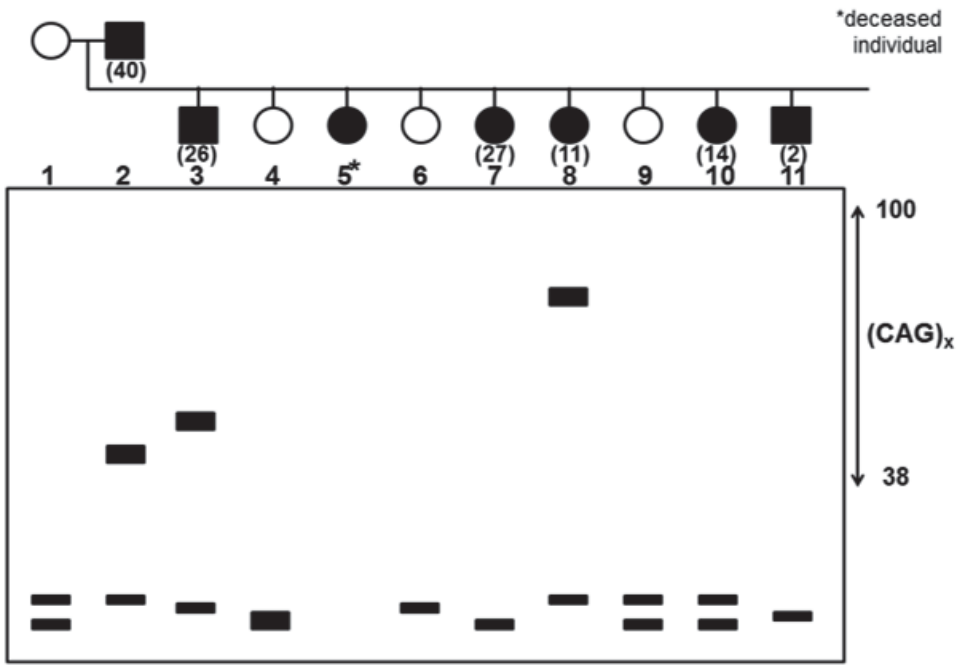

Fig. 1.2

(d) Based on the information you have been given, draw in the band patterns (in Fig. 1.2) for individuals #6, #10 and #11. [2]

(e) Individuals with 6-35 CAG repeats will be unaffected. Offspring of individuals with 36-39 repeats are at increased risk for HD.

Suggest how this increased risk can occur.

[2]

[Total: 18]

2 In many multicellular organisms, such as mammals, the time taken for the mitotic cell cycle varies considerably between different tissues, but is very carefully controlled in each cell.

(a) Explain how the loss in the control of the cell cycle can lead to cancer.

[3]

(b) Most mammals possess an internal defence mechanism that can target and destroy cancerous cells.

Outline how such a mechanism is activated to be effective in its function.

[4]

The effectiveness of anti-cancer drugs may be determined by growing different tumours in culture. The effectiveness of two drugs on two human tumours (A and B) from different tissues was assessed.

The two drugs, T138067 and vinblastine, were added to the tumours in culture on days 5, 12 and 19. The volumes of the tumours were compared with the volumes of tumours that were not treated with any drugs. The results are shown in Fig. 2.

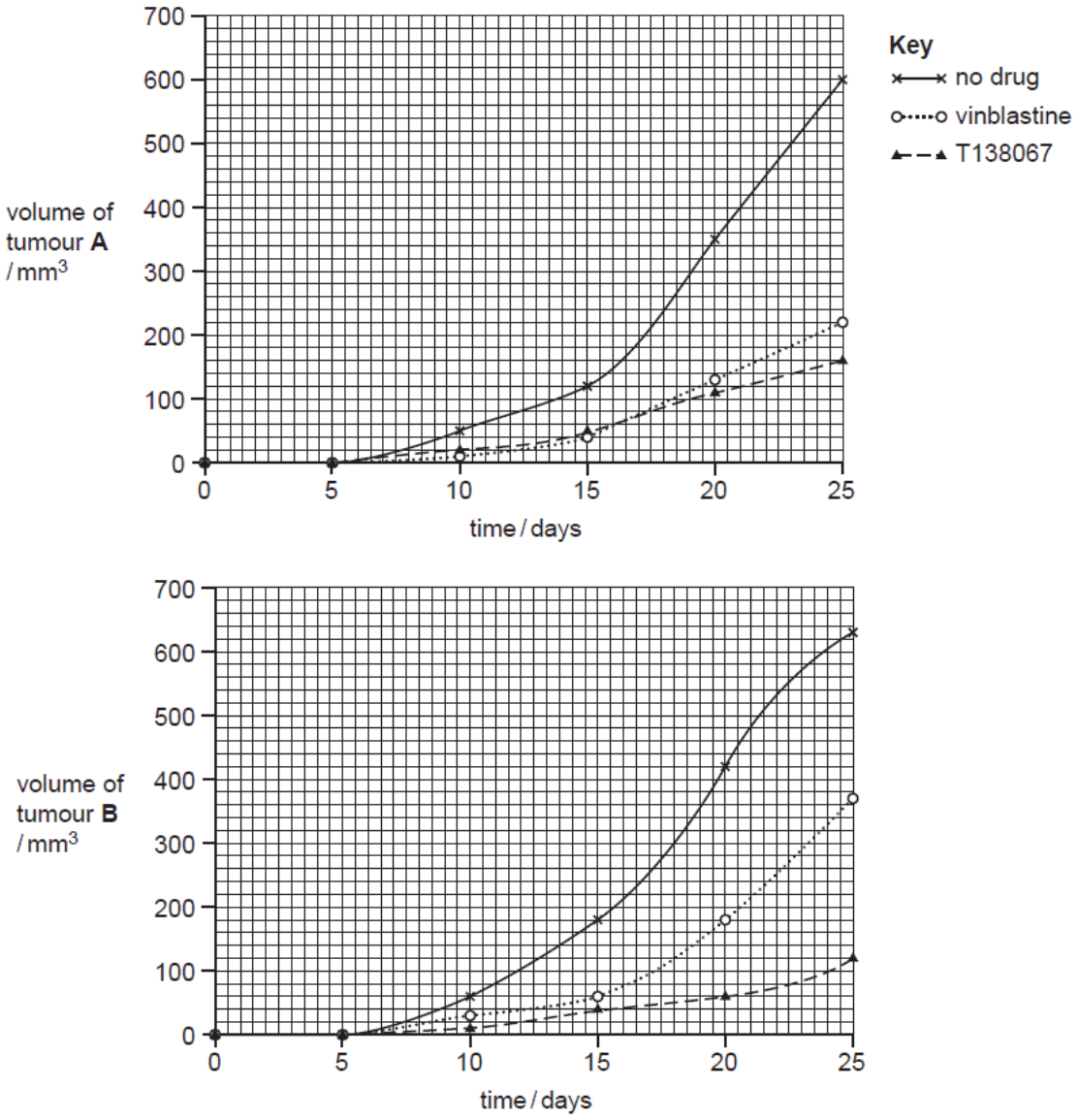

Fig. 2

(c) **(i)** Use the data in Fig. 2 to compare the effectiveness of the two drugs used to treat the tumours.

[4]

(ii) Both Vinblastine and T138067 were able to bind to tubulin.

Explain the effects of Vinblastine and T138067 as anti-cancer drugs.

[3]

(iii) Suggest why the same tumor cells may respond differently to these two drugs?

[3]

[Total: 17]

3 Fig. 3.1 shows the rate of carbon dioxide uptake by Barley and Sugarcane at a range of carbon dioxide concentrations.

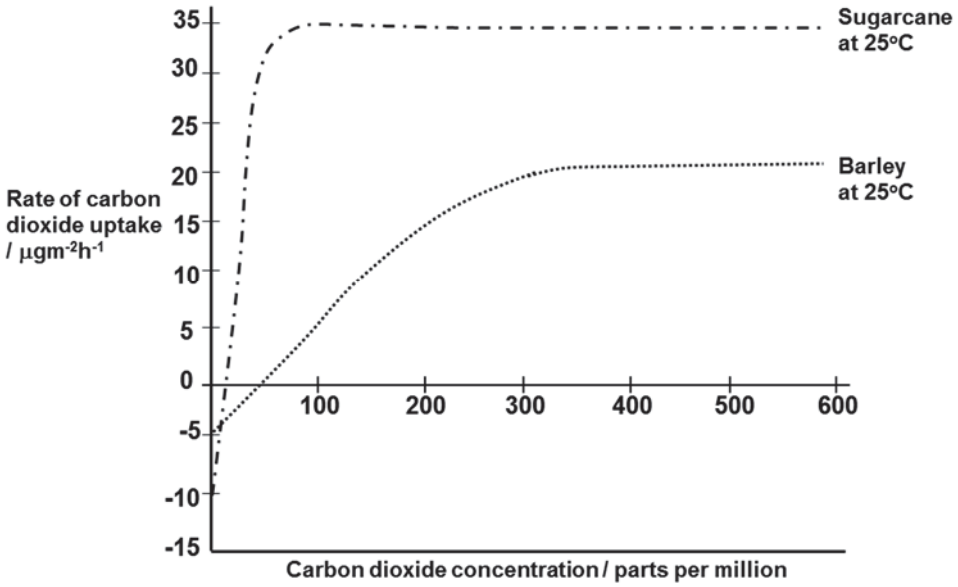

Fig 3.1

(a) With reference to the curve for Barley, explain the meaning of limiting factor.

[3]

Plants, in general, utilise either the C3 or C4 photosynthetic pathways. C3 plants (eg. barley) produce triose phosphate as their first product in Calvin cycle. The enzyme ribulose bisphosphate carboxylase (Rubisco) is a key enzyme in the C3 pathway.

C4 plants (eg. sugarcane) produce oxaloacetate (OAA), a 4 carbon compound, as their first product. This reaction is catalysed by Phosphoenolpyruvate carboxylase (PEPC). Photosynthesis for these C4 plants then continues in much the same way as C3 plants.

The K_m values for carbon dioxide for Rubisco and PEPC is shown below.

K_m CO_2 for Rubisco = 12 μM
K_m CO_2 for PEPC = 2 μM

Fig 3.2 below shows morphological differences in the leaf of a C3 and C4 plants.

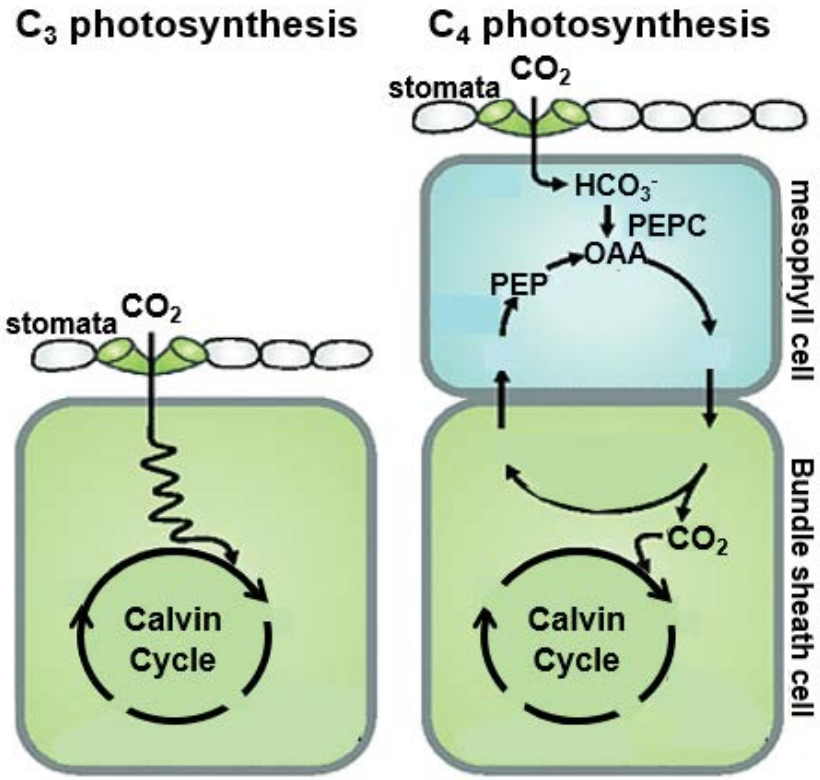

Fig 3.2

(b) Based on the morphological differences shown in Fig 3.2 and the K_m values for both enzymes, suggest reasons for the difference in rate of CO_2 uptake for Sugarcane (C4 plant) and Barley (C3 plant) shown in Fig 3.1.

[5]

(c) Suggest another structural difference in the leaf morphology between C3 and C4 plants.

[1]

Table 3.3 shows the mass of water absorbed by six crop plants, three of which are C3 and three of which are C4.

crop	C3 or C4	mass of water absorbed per gram dry mass produced /g
rice	C3	682
potato	C3	575
wheat	C3	542
maize	C4	350
sorghum	C4	304
millet	C4	285

Table 3.3

(d) In view of all the information that is given above, discuss the likely impact of predicted changes in carbon dioxide concentration, global temperatures and rainfall patterns on the distribution of C3 and C4 plants.

[6]

[Total: 15]

Section B

Answer **one** question in this section

Write your answer on the writing paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

4 **(a)** Discuss the effectiveness of a live, attenuated vaccine against an RNA virus. [13]

(b) Discuss the various ways in which the concentration of an enzyme in a cell can be regulated. [12]

[Total: 25]

5 **(a)** Describe the functions of various components found in the plasma membrane and explain, using named examples, why there is a different composition of these components in membranes of different cells and organelles. [13]

(b) Hyperglucagonemia is a condition where there is excess glucagon secretion. Using your knowledge of how glucagon works and how HIV infects a cell, explain how drugs can be used to target the different stages in each condition. Highlight in your answer, similarities in the mechanism of the drugs. [12]

[Total: 25]

2017 JC2 Prelim Practical Examination
Apparatus List
(Blue font – for teachers only)
Question 1

Reagents		
1	Hard-boiled egg (stained red) (Egg white with congo red)	Dish
2	Hot water (40˚C)	Thermostatically controlled water bath
3	Buffer solution (pH 2)	In vials All buffers are bought
4	Buffer solution (pH 4)	
5	Buffer solution (pH 6)	
6	Buffer solution (pH 8)	
7	Buffer solution (pH X) (pH 6)	
8	Solution K1 (4% trypsin)	
9	Distilled water	
Apparatus		
1	5 x test tubes	Plastic bag
2	5 x syringes	
3	5 x rubber bungs	
4	Labels	
5	Scalpel	
6	Forceps	
7	Thermometer	
8	Ruler	

Question 2

Reagents		
1	Extract P (1% starch and 20% sucrose)	In vial
2	Distilled water	In wash bottle
3	Benedict's reagent	To be shared by 2 students on the same bench
4	Hydrochloric acid	
5	Sodium hydrogen carbonate	
6	I_2/KI solution	
Apparatus		
1	1 x Visking tubing (soaked)	Teacher's bench
2	1 x boiling tube	
3	1 x rubber band	
4	3 x test-tubes	
5	1 x 1ml syringe	
6	1 x 10ml syringe	
7	1 x 50ml beaker	
8	1 x glass rod	
9	Bunsen burner, wire gauze, tripod stand, lighter	
10	Paper towels	
11	Test tube holder	
12	Slide DB	To be shared by 2 students on the same bench
13	Stage micrometer	
14	Microscope	

Apparatus used for Question 1 and Question 2

Apparatus		
1	1 x 250ml beaker	
2	1 x test-tube rack	
3	Stopwatch	
4	White tile	

VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2017

NAME : _____

CT CLASS : _____

H2 BIOLOGY **9744/4**

Paper 4 **2 hours 30 minutes**

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1. Write your name and CT group in the spaces at the top of this page.
2. Write in dark blue or black pen. You may use an HB pencil for any diagrams or graphs.
3. Answer all questions in the spaces provided on the Question Paper.
4. Students with the microscope and slide **must start with Question 2b first.**
5. 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.
6. At the end of the examination, fasten all your work securely together. The number of marks is given in brackets [ ] at the end of each question.

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **13** printed pages, excluding the cover page.

[Turn over

Answer **all** questions.

1. K1 is an extract prepared from the digestive tract of a small mammal. You are required to investigate the ability of this extract to bring about the breakdown of protein at varying pH, and determine the pH of an unknown solution through your observations.

Proceed as follows:

1. You have been supplied with a source of protein in the form of coagulated ('hard-boiled') egg which have been stained red.

2. Label five test-tubes **A, B, C, D** and **E** respectively. Prepare a beaker to act as a water-bath. The temperature of the water should be about 40˚C. It is not necessary to maintain this temperature.

To tube **A** add 2 cm^3 of K1 and 1 cm^3 of buffer, pH **2**.
To tube **B** add 2 cm^3 of K1 and 1 cm^3 of buffer, pH **4**.
To tube **C** add 2 cm^3 of K1 and 1 cm^3 of buffer, pH **6**.
To tube **D** add 2 cm^3 of K1 and 1 cm^3 of buffer, pH **8**.
To tube **E** add 2 cm^3 of K1 and 1 cm^3 of buffer of unknown pH, **X**.

3. Using a ruler and a scalpel, cut five pieces of egg of dimensions **2 cm in length, 0.5 cm wide and 0.5 cm in depth**. Place a piece of the egg in each of tubes **A, B, C, D** and **E**.

4. Place the five tubes in the water-bath at about 40˚C for 20 minutes while you continue with the rest of the question. Gently shake the tubes at five minute intervals during this time.

5. After 20 minutes, return to tubes **A, B, C, D** and **E**. Place a rubber bung in tube **A** and shake the tube vigorously ten times. Repeat this procedure on tubes **B, C, D** and **E.**

6. Allow the contents of the tubes to settle and then observe them carefully.

(a) **(i)** Record your observations in a suitable format in the space below, noting particularly any differences that you observe in the appearance of the contents of the five tubes. [6]

(ii) Based on your observation in (a) (i), estimate the pH of buffer **X**. [1]

(b) State the conclusions that you can draw, at this stage, about the action of K1 on the protein at different pH. Explain how your observations allow you to make these conclusions. [4]

(c) **(i)** Discuss two sources of error, other than temperature, that may have affected the accuracy of your results. [2]

(ii) Suggest improvements to reduce the sources of error that you have identified in **(c) (i).** [2]

(d) In a separate experiment, the effect of pH on potato catalase activity was studied using the following setup (shown in **Fig. 1**).

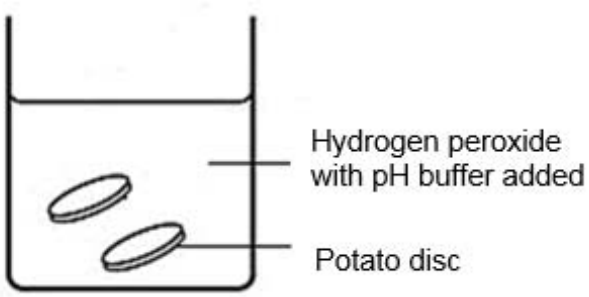


Fig. 1

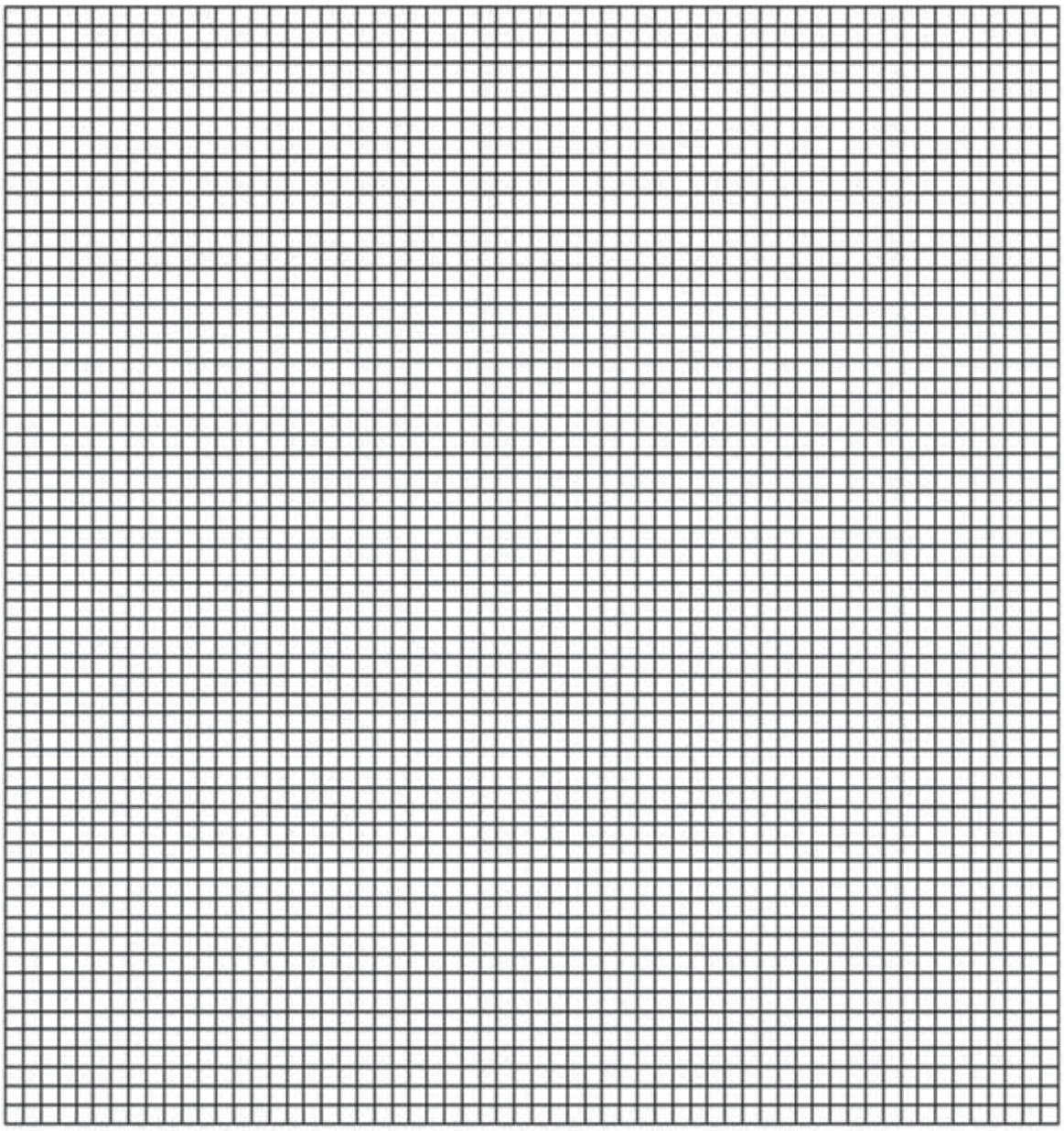
Equal volume of hydrogen peroxide solution was added with buffer solution of varying pH into five beakers. Two potato discs were placed together into each beaker and the time taken for each disc to rise was recorded. Results obtained are shown in **Table 1**.

Table 1

pH buffer	Time taken for potato disc to rise / s		Rate of reaction / s^{-1}
	Disc 1	Disc 2	
4	58	63	
5	43	47	
6	41	42	
7	39	40	
8	44	49	
9	56	63	

(i) Calculate the rate of breakdown of hydrogen peroxide for each pH and record your answers in **Table 1**. (Working is not required) [1]

(ii) Plot a graph showing the effects of varying pH buffer on the rate of breakdown of hydrogen peroxide in the grid provided below. [4]



(iii) Explain how one can determine that the time taken for potato discs to rise at two different pH is significantly different from each other? [3]

[Total: 23]

2. **(a)** You are provided with an extract **P** from plant cells which contains a mixture of different carbohydrates.

You are required to identify which carbohydrates present in **P** can pass through the Visking tubing.

Proceed as follows:

1. Using the apparatus and reagents provided, carry out relevant tests to identify all the carbohydrates present in extract **P**.

(i) Use the space below to record the tests that you have performed, your observations and conclusions in a suitable format. [4]
Details of the tests are not required.

2. Prepare the Visking tubing by tying a knot at one end of the tubing.

3. Add 10 cm^3 of solution **P** into the Visking tubing and wash the outside of the tubing with water.

4. Place the Visking tubing into a boiling tube. Fold the open end over the top of the tube and secure it with a rubber band.

5. Add distilled water into the boiling tube. Leave the setup for 10 minutes.

6. After 10 minutes, remove the Visking tubing from the boiling tube and test the contents in the boiling tube for any carbohydrate molecules using the reagents provided.

(ii) What do your results indicate about the property of the Visking tubing? Explain your answer. [3]

(iii) Explain how you can modify the experiment to determine the rate of diffusion of the carbohydrate that you have identified in **(a) (ii)** above. [3]

(b) Slide **DB** shows a stained longitudinal section of a young root tip.

Examine **DB** carefully using low and high power objectives of your microscope. Note the occurrence and distribution of different kinds of cells in this section.

(i) Make a plan drawing of the entire section, within the outline drawn in **Fig. 2** below to show the different **regions**. These regions result from differences in the *shapes, sizes* and *structure* of the cells as well as in the frequency of mitosis.
Do not draw individual cells. Ignore the cells that make up the root cap region.

Annotate your drawing as fully as possible to describe the features of the cells in each region that you map. [5]

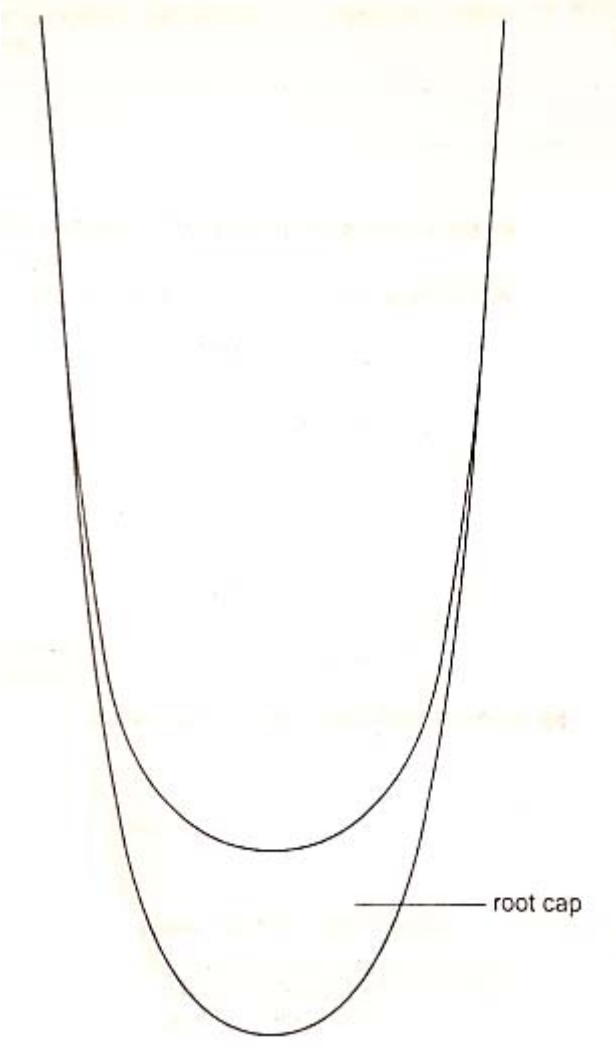


Fig. 2

(ii) In the space below, draw to the **same scale**, two cells that are at different stages of mitosis. Identify the stages and label the distinctive features of each stage in your drawings. [5]

[Total: 20]

Name: _____ **CT Group**: _____

3. Yeast cells have transport proteins in their cell membranes for the uptake of nutrients from the surroundings. There are separate transport proteins for glucose and for maltose. When exposed to both glucose and maltose, the transport protein for maltose is down-regulated and is not produced.

Plan an investigation to find out whether or not the yeast transport proteins for glucose and maltose function at the same rate. The hypothesis is that the rate of uptake of glucose is higher than the rate of uptake of maltose.

You are provided with the following materials, which you can choose from. You may not use any additional materials and apparatus.

- an unlimited supply of 10% yeast suspension
- an unlimited volume of 10 g dm^{-3} glucose solution
- an unlimited volume of 10 g dm^{-3} maltose solution
- Benedict's solution
- dilute hydrochloric acid
- sodium hydrogen carbonate
- distilled water
- beakers and flasks of different sizes
- stop watch
- colorimeter and cuvettes
- centrifuge and centrifuge tubes
- thermometer
- thermostatically-controlled water baths
- pipettes and pipette fillers
- burettes and burette stands
- filter funnels and filter paper
- syringes
- Bunsen burner
- glass rods
- test-tubes and boiling tubes

Your plan should have a clear and helpful structure to include:

- an explanation of the theory to support your practical procedure
- a description of the method used including the scientific reasoning behind the method
- how you will record your results and ensure that they are as accurate and reliable as possible
- proposed layout of results tables and graphs with clear headings and labels
- relevant risks and precautions taken
- The correct use of scientific and technical terms

[Total: 12]

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BIOLOGY DEPARTMENT
JC2 PRELIMINARY EXAMINATIONS 2017
HIGHER 2 9744/1 Answers

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

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HIGHER 2 9744/2 Propose answers

1 Fig.1 shows an electron micrograph of an organelle. There are two distinct group of vesicles (Boxes B and C) associated with this organelle.

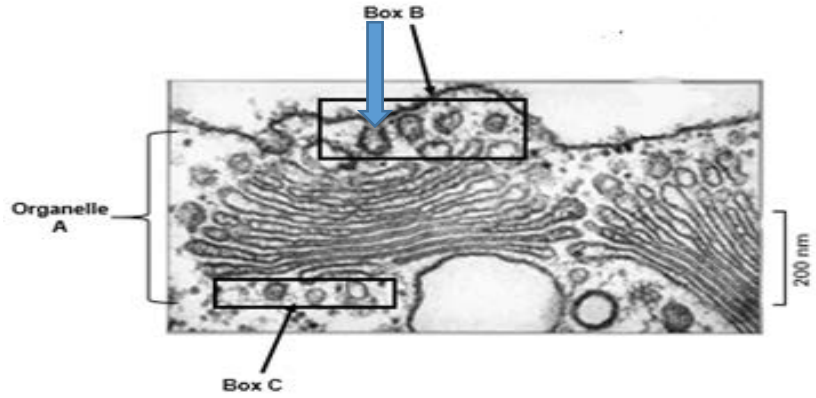


Fig. 1

(a) (i) Identify organelle A. Feature
Golgi body/ golgi apparatus;;

A stack of membranes with swollen ends;;

(ii) Describe the differences in the role of the vesicles that fuse with the forming face and the vesicles that are formed at the maturing face. [4]

- Box C: [2m]
- vesicles contain proteins and/or lipids;
- transported from rER and sER;
- that will undergo chemical **modification** within the golgi body;
- **examples** of modification: glycolysation, phosphorylation etc

- Box B: [2m]
- Packaging and transport fn: Vesicles containing modified products will be transported to the cell membrane;
- where they **fuse** and **release** the products to the outside of the cell/via exocytosis;

(b) Suggest how the lack of E3A expression can lead to a disruption in the structure and function of the Organelle A.

- Lack of gene expression means that the enzyme E3A is not **produced**/ transcribed and translated;;
- Proteins that are tagged by ubiquitin, are meant for **degradation**;;

- These proteins are either **damaged/abnormal/excess**;;
- Removal of these proteins help to maintain the normal functions of the GA (idea of);; (A: reverse argument)

(c) State two characteristics, one in structure and one in chemical property that you would expect to see in ubiquitin protein ligase. [2]

Structure: globular / specific 3D configuartion
Chemical ppty: solubility in water;;

2 (a) Explain the **similarity in the pattern** seen in both HDAC mRNA and HDAC protein. [2]

- HDAC mRNA is the **template** for the **translation** /synthesis of HDAC protein;;
- Decrease in mRNA concentration lead to a decrease in concentration of HDAC protein;;

(b) (i) What information about the gene expression of *RUNX3* can one conclude from the data at the beginning of the experiment? Explain your answer. [3]

There are 2 possible answers to this question.

Possible answer 1

- *RUNX3* gene is silenced/ down regulated;;
  (Note: this last mark is only awarded if student's answer shows that there is an attempt to link *RUNX3* gene expression to HDAC levels shown in Fig 2.1)
- How does HDAC down regulate *RUNX3* expression:
  - Remove acetyl groups from lysine residues of histones;
  - Increase positive charge of histones;
  - Results in negatively *RUNX3* gene being more tightly coiled around histones;
  - Promoter less accessible to transcription factors and RNA polymerase;
- Data: Highest HDAC mRNA and protein;

Possible answer 2

- *RUNX3* gene is upregulated;;
  (Note: this last mark is only awarded if student's answer shows that there is an attempt to link RUNX3 gene expression to HDAC levels shown in Fig 2.1)
- How does RUNX3 **up**regulate HDA
  - RUNX3 TF binds to promoter of **HDAC gene;**
  - Recruits RNA pol or formation of transcription initiation complex for transcription;
  - Up regulation HDAC gene expression (idea of);
  - highest HDAC mRNA and protein concentration;

  A: RUNX3 TF act as activator (attaches to enhancer region); to allow correct positioning of TIC/ stabilise the TIC; through looping mechanism;

(ii) Suggest one way how your answer in (i) can affect the **cell**. [3]

Down regulation of RUNX3:

- *[What is RUNX3]* RUNX3 is a TSG Or TF coded by RUNX3 binds to/activates other TSG;;
- *[what is its function/ function of other genes]* Involved in halting cell cycle/ repair DNA damage/send cells to apoptosis;;
- *[impact –leading to cancer]*Reduced expression leads to accumulation of DNA damage/ cells not able to stop at the appropriate checkpoints/ do not undergo apoptosis, resulting in cancer;;

Upregulation of RUNX3:

- *[What is RUNX3]* RUNX3 codes for the TF for HDAC gene;
- HDAC protein deacetylates/ silence TSG;;
- *[what is its function/ function of other genes]* Involved in halting cell cycle/ repair DNA damage;;
- *[impact –leading to cancer]*Reduced expression leads to accumulation of DNA damage/ cell cycle out of control, resulting in cancer;;
  (Described eg. cells not able to stop at the appropriate checkpoints, leading to uninhibited growth.)

- RUNX3 is a protooncogene or codes for the TF for proto-oncogenes;;
- Results in increase/upregulate expression of genes that promote cell growth and proliferation;;
- *[impact –leading to cancer]* Increased expression leads to increase cell proliferation / cell cycle out of control, resulting in cancer;;

(c) With reference to the data shown in Fig 2, suggest **how** Chemical K can bring about the change in the HDAC mRNA and protein. [2]

- {Change} Decrease HDAC mRNA and protein;

- Any one of the ways below:
  1. Act as a repressor (specific TF) that binds to the silencer;
  2. Prevents TIC assembly;
  3. Down regulate HDAC expression

Or

  4. Breakdown mRNA/Decrease stability of mRNA;
  5. Reduce half life;
  6. Less mRNA and hence less HDAC protein being synthesised;

Or

  7. Cause DNA methylation of HDAC gene;
  8. At CpG regions;
  9. Silence the gene/ recruit histone acetylase;

Or AVP (1 1/2m)

(d) Suggest why HDAC mRNA instead of the HDAC gene was analysed in this experiment. [2]

Answers must provide reason for both HDAC mRNA and HDAc gene.

- Fixed copies/ concentration of the HDAC gene (idea of);;
- Gene may not be expressed/ idea of cannot study expression;;

- Differential expression of the gene can be seen using the mRNA;;
- Chemical K affects transcription and hence its effect can only be seen by observing changes in mRNA concentration;;

3 **(a)** **(i)** Identify substrates **X** and **Y**.[2]

X: glucose;

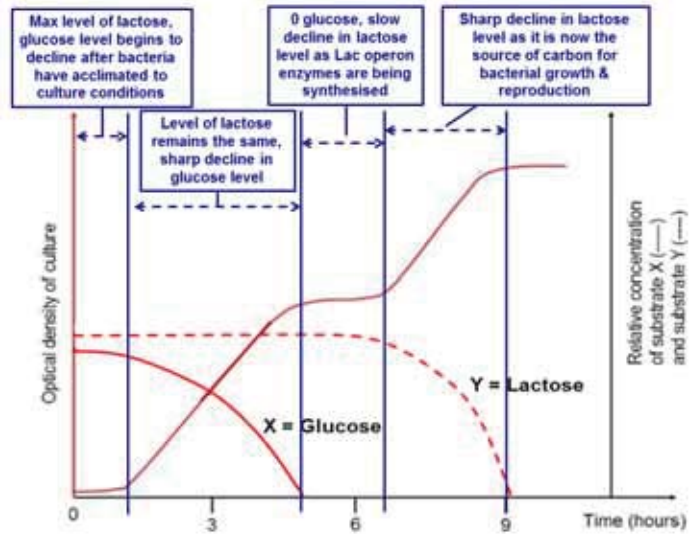
Y: lactose;

(ii) Using your knowledge of gene expression in bacteria, explain how Fig. 3 supported their conclusion that the *Lac* operon is under dual control. [4]

- Evidence #1 – first growth phase: When glucose and lactose are both present, glucose is used preferentially (A! first/ preferred respiratory substrate) for bacteria to grow and reproduce;;
- Lac operon is under negative control and the gene coding for beta-galactosidase that breaks down lactose into glucose and galactose is not expressed;;
- Evidence #2 – second growth phase: when glucose is depleted, lac operon is active and under positive control, so expression of the gene for beta-galactosidase is upregulated;;
- Evidence #3 – Lag phase: bacterial growth levels / plateaus out: time needed for activation of CAP by cAMP when adenylyl cyclase inhibition is removed after glucose is depleted and cAMP levels increase/ time needed for the expression of lac operon;;

(b) On Fig. 3, draw separate graphs to show the change in the concentration of the two substrates over time. Label your graphs. [2]

Answer:



Each curve for glucose and for lactose must show:

- Decreasing trend <u>but with glucose being used first</u> @½ m
- Shape of curve to consist of plateau and linear segments @½ m
- A! decreasing trend for glucose from time 0. (FYI – During the lag phase, bacteria are adapting to growth conditions, so that individual bacteria are maturing and not yet able to undergo binary fission. During the lag phase, synthesis of RNA, enzymes and other molecules occurs. As the cells are metabolising, there is some usage of glucose.)

(c) Eukaryotes are structurally different from prokaryotes and hence exhibit differences in their control of gene expression.

Explain two such differences. [4]

Any two below (note: from perspective of eukaryotic genes):

- Chromatin modelling – acetylation/deacetylation Or methylation/demethylation of CpGs in eukaryotic promoters;; to compact chromatin by wrapping high mw DNA/ large eukaryotic genome around histones to fit into space of nucleus;;
- Post-transcriptional – 5' capping and polyA tail addition;; for protection from exonucleases / facilitate transport out of nucleus through nuclear pores to the cytoplasm;;
- Post-transcriptional – alternative splicing of pre-mRNA occurs;; to produce more than 1 type of mature mRNA/ protein product from one gene / to generate more types / diversity of proteins than no. of genes in genome (to perform all the functions necessary for cell to survive/ in response to different stimuli);;
- Translational - through addition of long polyA tail;; to maintain stability of mature mRNA in the cytoplasm as templates for translation of more protein;;
- Post-translational – protein modification;; to activate/ inactivate proteins in response to appropriate signals/ control activity of synthesised proteins;;
- A! Transcriptional – In eukaryotes, one promoter controls the expression of one gene (instead of several functionally related genes);; because eukaryotic genes are not organised into operons (explanation);;

- A! presence of many control elements distal from gene;; allowing for combinatorial control of expression;;

4 (a) What do you understand by the term pure-breeding? [1]

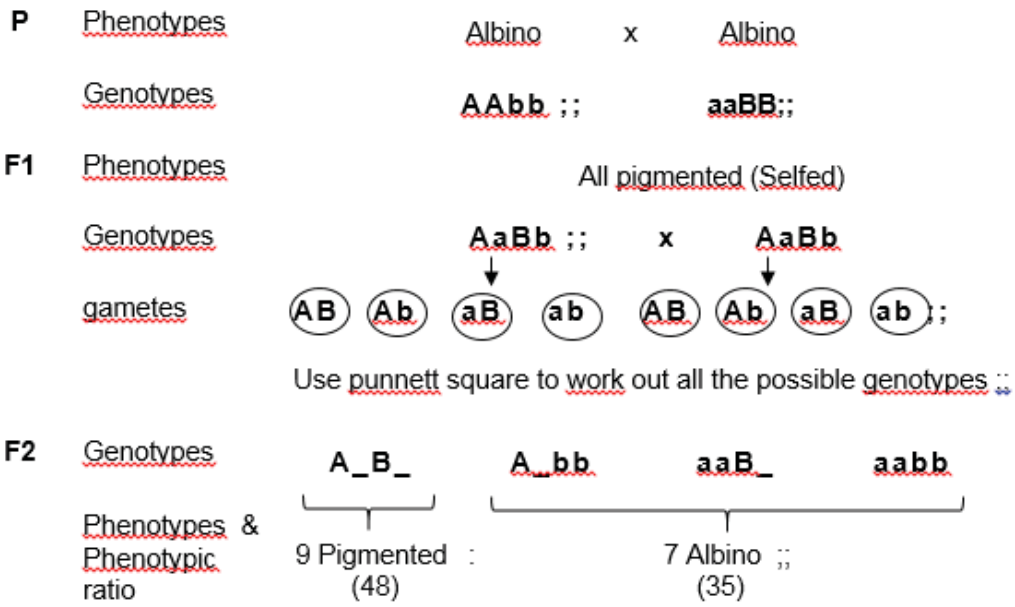
- An organism is said to be pure bred when it is homozygous at the gene loci that is being investigated/under study;;

(b) Using appropriate symbols, draw a genetic diagram to explain the results obtained.

Let A be the dominant allele that codes for an enzyme that converts a precursor to an intermediate pigment (white or albino) and a be the recessive allele that codes for a non-functional enzyme

Let B be the dominant allele that codes for an enzyme that converts the intermediate to a coloured pigment and b be the recessive allele that codes for a non-functional enzyme
At least 1 copy of each dominant allele must be present for the production of coloured pigment.

Genetics Diagram:



5 (a) (i) Account for the decrease in the telomere length of Cell Y. [4]

1) during DNA replication;
2) when the last **RNA primer is removed/excised;**
3) at the **3' end of parental template strand** / **5'end of daughter strand**;
4) it is **not replaced by** corresponding **DNA** sequence;

5) as **DNA polymerase cannot add new nucleotides; without an existing 3'OH end;**
6) idea of resulting daughter DNA strand being shorter than the parental DNA strand;
7) ref to **end replication problem**;

(ii) Explain why there is a limit to the number of times Cell Y can divide (Hayflick's limit). [2]

1) idea of ends of chromosomes **shortening into critical genes** / telomeres **shortening to a critical length**;
2) cells will **halt the cell cycle**;
3) and subsequently cell will **undergo apoptosis**;
4) idea of protecting integrity of genes being passed to daughter cells;
5) idea of preventing accumulation of mutations;

(b) State how Cell X is able to maintain its telomere length. [1]

- presence of an active enzyme **telomerase** to regenerate telomeres;;

(c) (i) With reference to Fig 5, explain how the change in telomere length resulted in Cell Y* after M2. [2]

1) (describe change) telomere length increases slightly then remains constant;
2) failure of cell Y to undergo apoptosis;
3) as the cell can continue to proliferate;
4) idea of mutation;
5) leading to **activation** of telomerase activity / **increased** expression of telomerase which can regenerate length of telomeres;;

(ii) State one external factor that can contribute to the formation of Cell Y*. [1]

- UV radiation/ X ray / ionising radiation;;
- Chemical carcinogens eg. tobacco;;
- Viruses (eg. retroviruses);;

(d) Describe the importance of centromeres in cell division. [3]

1) site where sister chromatids attach to each other;
2) acts as site for specific attachment of kinetochore / kinetochore assembly;
3) Which allows for attachment of microtubules/ spindle fibers;
4) During metaphase / metaphase I / metaphase II;
5) Allow the equal (@proper) separation of sister chromatids and homologous chromosomes;
6) allow genetically identical daughter cells to be formed;
7) prevent non-disjunction / occurrence of aneuploidy or polyploidy;

6 (a) Explain how metformin can be used to decrease the blood glucose level in patients with Type II diabetes. [4]

1) Metformin enters cell via OCT1 / facilitated diffusion through protein channel;
2) Metformin binds to and activates AMPK;

3) Metformin induces decreased ATP:AMP ratio / induces hydrolysis of ATP to AMP;
4) which phosphorylates and activates IRS1/2 and Akt;
5) leading to increased GLUT-4 translocation;
6) by inducing vesicles containing GLUT-4 transporters to fuse with the plasma membrane;
7) increased numbers of GLUT-4 transporters proteins on membrane;
8) allowing increased glucose uptake into the cell;
9) idea of activation of other cellular enzymes (eg. glycogen synthase)

(b) Akt is known to stimulate other cellular responses in the insulin signaling pathway.

Suggest how activation of Akt can lead to different cellular responses. [3]

- **acts as relay protein / secondary messenger** that can **bind to other proteins / enzymes;;** (@ activate other relay proteins)
- that leads to **activation / inactivation of proteins/kinases** that take part in **other signalling transduction pathways/ signal cascades**;;
- leading to **activation of other enzymes** that can **catalyse different cellular reactions**;; (accept specific examples)
- **acts as transcription factors** that can **upregulate/downregulate expression of different genes**;;
- idea of signal amplification;
- idea of activating other kinases in the same signal transduction pathway;

(c) Metformin was found to induce a decrease in NADH oxidation in the mitochondria.

(i) Suggest how metformin can lead to a decrease in the ATP:AMP ratio in the mitochondria. [3]

1) by inhibiting oxidative phosphorylation / chemiosmosis;
2) Reduced electrons being donated to ETC;
3) Resulting in less electron transfer along the ETC;
4) thus lesser energy released;
5) to pump the protons across the inner mitochondrial membrane;
6) lower proton gradient established across the inner mitochondrial membrane; / decreased proton motive force;
7) less ATP generated by ATP synthase;

(ii) Suggest two ways in which ATP can still be produced in the mitochondria. [2]

- **Substrate level phosphorylation** in **Krebs cycle**;;
- Use of **reduced FAD** in **oxidative phosphorylation / oxidation of reduced FAD**;;

7 (a) With reference to Fig7A and 7B, discuss whether these fossils can be used to support Darwin's theory of evolution. [3]

- Explanation of Darwin's theory of evolution – idea of **descent from a common ancestor with modification** to adapt to different environmental conditions/ selective pressures;; (the premise of their discussion)

Can be used:

- Same basic structure of skulls and wing and leg bones indicate shared ancestry;
- Leg bones of giant Hawaii goose is much longer and stouter (idea of) than nene;; (modified to suit a land-bound type of locomotion/ loss of flight)
- Skull and the mandibles show significant differences in size;; (modified to adapt to differences in the types of food they eat/ to different types of food available)

Cannot be used:

- Lack of an 'ancestral' fossil for comparison, so difficult to determine if the 2 sets of bones are "modified" from a common plan;;
- Differences in structure of wing bones are not significant, so inconclusive about modification to adapt to different selective pressures for locomotion (i.e. flight vs flightless);;

(b) Using your knowledge of anatomical homology, explain **how** these differences came about. [5]

- There was existing variation in the population of ancestral birds from East Asia that landed on the two different islands;;
- were subjected to different selection pressures; in the two different islands
- Those that were best adapted to the selective pressure on a particular island were selected for, survived and reproduced;;
- Passing down advantageous genes / alleles to offspring;
- Change in allele frequency over time;
- accumulation of independent mutations;
- With ref to structure of skulls, leg bones:
  - difference in size: e.g. longer leg bones allow the birds to run away from predators faster/ chase after prey faster;;
  - smaller skull - decrease weight for flight/ larger jaw for feeding;;

(c) Explain why molecular data is able to overcome the limitations of this fossil study.[4]

- Definition of molecular data: e.g. DNA and/or proteins;;
- Different species of Hawaiian waterfowl exhibit different bone morphology, as shown by nene and giant Hawaiian goose (idea of closely related species showing distinct morphological features);;
- May be used to confirm that the major phenotypic differences between nene and giant Hawaiian goose may be due to small genetic differences;; (although this sounds like bullet 1, it is not - it illustrates the effect of master regulatory genes such as key TFs)
- Molecular data are unambiguous and objective, side steps the problem of analogous structures/ Overcome the problem of ambiguity between homologous and analogous structures;;
- Or idea of molecular methods are not dependent on subjective judgments / observations) Molecular data being easily converted to numerical form for analysis;;
- A! can use extensive regions of genome (coding and non-coding) OR idea of using many gene/ amino acid sequences for comparison;;
- AVP;;

4 max

(d) Based on the fossils, state one species concept that can be used to determine whether the Hawaiian goose and nene belong to the same species. [1]

Any one

- Genetic (based on DNA analysis of DNA/protein extracted from fossil samples);;
- Ecological (based on structure of mandibles, long legs – clues about the niches they occupy and the competition for similar/ dissimilar resources for e.g. if the mandibles are very similar, they are likely to feed on and thus compete for similar types of food);;

8 The immune response consists of innate and adaptive responses.

(a) What is the importance of the innate immune response? [3]

- Body's first line of defence against pathogens;;
- External mechanisms: physical barriers such as the skin and mucus prevents entry of pathogens;;
- Internal mechanisms: consist of cellular defences, plasma proteins, inflammatory responses that respond immediately to invasion from pathogens to contain (and get rid) the infection;;

(b) Explain the significance of these changes over time. [4]

- Somatic hypermutation;;
- **Point Mutations** produce B cells with membrane Ig having **altered antigen-binding sites;;**
- Producing B cells with <u>higher affinity (B cell) receptors</u> (which will survive, proliferate and mature into plasma cells);;
- In this way, antibodies are generated that have increasingly higher affinity during an immune response;;
- This provides progressively better protection against the pathogen;
- This mechanism is termed **affinity maturation**;;

(c) State how a B cell is able to produce IgM and IgD at the same time. [1]

- **Alternative splicing** of the pre-mRNA;;

9 (a) (i) Describe the pattern of resurgence of dengue shown in Fig.9.1. [2]

- cyclical;;
- QV

(ii) Suggest three possible ways in which climate change can result in the pattern described in part (i). [3]

- Higher temperatures in summer due to climate change leads to faster pathogen development and shorter life cycles for mosquito vectors;;
- Global warming of many regions previously not suitable as habitats for mosquitoes now results in more widespread breeding of the vectors;;
- Climate change resulting in higher precipitation in some areas lead to ponding and more breeding places and also longer breeding seasons for the vector since these pools will take long to dry up with frequent returns of rain;;
- Changes in agricultural practices like crop rotation or choice of crop, planting more rice to take advantage of the ready supply of water from more rain will help in providing more breeding grounds for mosquito vectors;;
- Crop rotation patterns together with higher frequency of extreme weather conditions may culminate to create the cyclical pattern observed in the epidemic outbreaks.
- Climate change resulting in higher wind patterns can also bring vectors to higher regions previously inaccessible to them;;

(b) Suggest why the vector control programme might not have worked as initially intended. [2]

- Climate change resulting in changes in mosquito's phenology, shorter life cycles and more adaptable to wider range of habitats, making vector control methods less effective;;
- A new mutated serotype/strain of Dengue virus emerged which might reproduce faster in the mosquito's salivary glands, extending their period of infection, reducing the impact of vector control;;
- Mosquito populations outside of the homes have become resistant to the pesticides used and are able to survive the thermal fogging treatments and still lay sufficient eggs to replenish their numbers;;
- A shift in dengue virus transmission from the household to other sites, such as schools and workplaces;;

[2 max]

(c) **(i)** Describe two advantages of this strategy. [2]

Advantages

- Biological control (idea of) measures using GM mosquitoes are more target specific than current use of pesticides, which kill off other species of insects like useful honey bees/ natural ecosystem not affected;;

- Even with mating cycles shortened, the self-limiting gene becomes established faster in the population, as the larva die off and adult vector numbers will be drastically reduced and the disease spread impeded;;
- without the use of pesticides, there will be no negative impact on environment, humans etc;;
- Minimal manpower needed to implement and sustain the suppression. Male mosquitoes will live a while to mate with many wild females, unlike the fogging attempts that has to be repeated every few days as mosquitoes evade the fumigated areas and return afterwards.

(ii) Discuss the possible impact of these advantages on the natural ecosystem. [2]

- With the demise of the *Aedes aegypti* species in the community, since the GM mosquitoes are **target specific**, other mosquito species will flourish at their expense and the eventual **extinction** of *Aedes aegypti* might actually be observed in the area tested with GM male releases;;
- Diseases carried by other mosquito species could become the next vector borne disease outbreak if another species succeeds in fulfilling the niche once filled by *Aedes aegypti*
- Without mosquitoes, thousands of plant species would lose a group of pollinators. Adults depend on nectar for energy (only females of some species need a meal of blood to get the proteins necessary to lay eggs).
- Some fishes depend on mosquito larvae for food and so their main food source could be removed without adult laying more eggs in the water
- Many species of insect, spider, salamander, lizard and frog would also lose a primary food source.

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JC2 PRELIMINARY EXAMINATIONS 2017
HIGHER 2 9744/3 Answers

Note: A: Accept; R: Reject

1 Huntington's disease (HD) is a rare neurodegenerative disease. Fig. 1.1 shows a pedigree of HD across three generations (**I** to **III**).

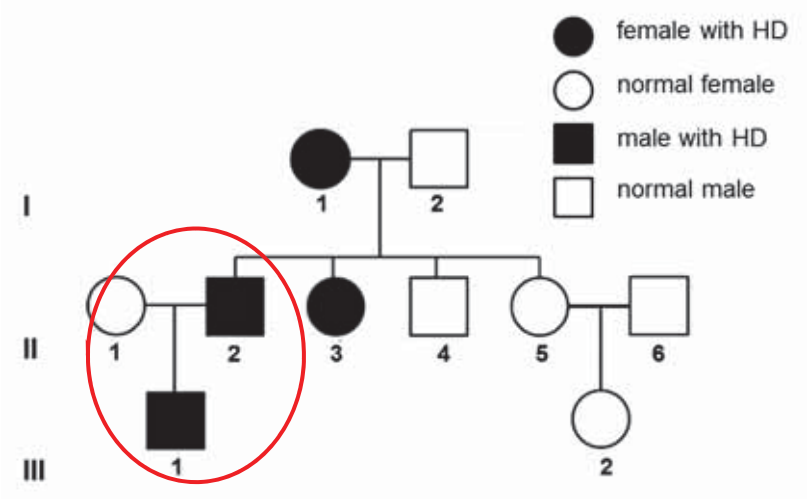

Fig. 1.1

(a) With reference to Fig. 1.1, account for the mode of inheritance of the disease. [3]

- HD is inherited in an **dominant** manner;
- every generation has affected offspring as long as one parent is affected (**I**1);;
- a single defective allele is sufficient for trait;

- Inherited in an **autosomal** manner;
- male and female offspring are similarly affected;
- an affected male parent (**II**2) can produce an affected son (**III**1);;

(b) (i) Explain the likely effect of the abnormal increase in CAG repeats on HTT protein structure and function. [3]

- Production of an abnormally **long polypeptide** / longer than the normal polypeptide (R! premature termination since length of CAG repeats is associated with disease); /
- Alters **primary structure** of polypeptide;
- disrupts the **R group interactions** such as hydrogen bonding, ionic, hydrophobic interactions and disulfide bridges;;
- essential for correct/ extensive folding into tertiary structure with specific 3D shape;;/ idea of 3D shape/conformation or tertiary structure is affected;;
- normal function of protein is lost/ abnormal protein is made; *Max 3m*

(ii) Suggest possible reasons why individuals having number of repeats ranging from 21-39 do not develop the disease. [2]

- Insertion mutation of multiples of 3 that code for chain of 20 glutamines (A! less than 40 glutamines) do not drastically affect 3D shape/ structure and thus function of the protein;;
- Slight effect on protein function but not drastic enough to develop disease;;
- A chain of more than 40 glutamines affect interactions between R groups that lead to folding into specific tertiary structure of the protein to affect normal function and cause HD;;

(c) **(i)** Explain why PCR can be used for the diagnosis of HD. [2]

- PCR makes use of specific primers that flank the region of the HTT gene/ exon 1 that contains the CAG repeats;;
- to **amplify** the **different fragment lengths** to allow for differentiating between normal and mutant allele;;

(ii) Explain how gel electrophoresis was used to detect the band patterns of the offspring in Fig.1.1. [4]

- During electrophoresis, negatively charged DNA fragments migrate through a gel towards the positive electrode;;
- under an electric field;
- agarose gel acts as a molecular sieve;
- Larger fragments (i.e. has more CAG triplets) move slower compared to shorter fragments;;
- Gel is stained with methylene blue and observed under white light;; / ethidium bromide and observed under uv light;;

(d) Based on this information, draw in the band patterns (in Fig. 1.2) for individuals #6, #10 and #11. [2]

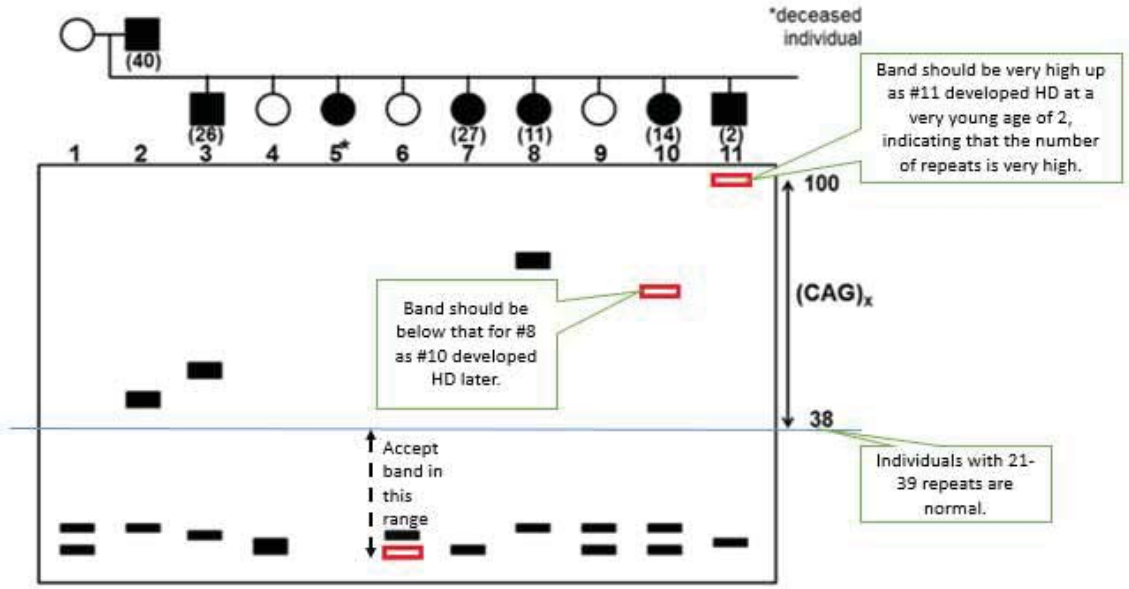

Fig. 1.2

(e) Individuals with 6-35 CAG repeats will be unaffected. Offspring of individuals with 36-39 repeats are at increased risk for HD.
Suggest how this increased risk can occur. [2]

- As the altered HTT gene is passed from one generation to the next, the size of the CAG trinucleotide repeat may increase in size due to **errors in DNA replication** of CAG repeat region **during formation of gametes**;;
- Since trait is dominant, they are at risk of having children who will develop HD when affected gamete with >40 repeats fuses with a healthy gamete;;

2 **(a)** Explain how the loss of control in the cell cycle can lead to cancer. [3]

- Loss of control means that the checkpoints regulating the stop and go signal of the cell cycle is lost;
- **Failure to halt cell cycle** /Cells continue to divide even if they have not properly completed the previous stage;

- **Even when** DNA is mutated (R: cells are damaged);
- Leads to an **accumulation of mutations**;
- Which includes **loss of function mutation** in **several TS genes**;;
- And **gain of function mutation** in *at least* **one proto-oncogene**;;
- causing cell to undergo uncontrolled cell division;
- cells cannot repair DNA damage; they evade apoptosis; grow in the absence of growth factor; loss of contact inhibition etc etc
- Ref to cancer development being a **multistep process**; [max 3m]

(b) Outline how such a mechanism is activated to be effective in its function. [4]

1) (cancer-derived) **peptides** presented **via MHC1** on surface of cancerous cells;
2) **Naïve cytotoxic T cells** with **receptors specific** to peptides recognize and bind; (idea of specific binding by cytotoxic T cells)
3) cancerous cells **recognized by macrophages / dendritic cells** (@ other examples of immune cells);
4) and **engulfed via phagocytosis;**
5) Presentation of peptides via **MHCII to naïve T helper cells;**
6) which **activates of T helper cells** (ref **clonal selection)**;
7) T helper cells **release cytokines**;
8) cause **activation of cytotoxic T cells (ref clonal selection)**;
9) Which target cancerous cells and perform **direct killing**;
10) Via release of **granzyme and perforin**;

(c) **(i)** Use the data in Fig. 2 to compare the effectiveness of the two drugs used to treat the tumours. [4]

- (similarity) Both drugs are effective for treatment of tumor A and B;
- total volume decreased compared to control;
- Vinblastine and T138067 are both equally effective against tumor A / T138067 is slightly more effective than Vinblastine against tumor A;
- QV;; eg. After 25 days, size of tumor A decreased from 600mm^3 to 220mm^3 when vinblastine was added; while size decreased from 600mm^3 to 160mm^3 when T138067 was added;
- T138067 is more effective for treatment against tumor B than Vin;
- QV;; eg. After 25 days, size of tumor B decreased from 620mm^3 to 360mm^3 when vinblastine was added; while size decreased from 600mm^3 to 120mm^3 when T138067 was added;
- Idea that Vinblastine is more effective against tumor A than tumor B;
- Idea that T138067 is more effective against tumor B than tumor A;

(ii) Both Vinblastine and T138067 were able to bind to tubulin.
Explain the effects of Vinblastine and T138067 as anti-cancer drugs. [3]

1) idea of preventing the polymerisation of tubulin / idea of tubulin being important component of spindle fibre;
2) thus prevent formation of spindle fibre
   Alternative: prevent shortening of spindle fibres;
3) spindle fibres cannot attach properly to chromosome during metaphase;
4) sister chromatids cannot be separated equally during anaphase; (reject if students describe as separation of chromosomes)
5) idea of **preventing mitosis** (nuclear division) **from occurring**;
6) idea of reduced number of cancer progeny cells formed / new cancer cells cannot be formed / new cancer cells are not viable;

(iii) Suggest why the same tumor cells may respond differently to these two drugs? [3]

- difference in uptake due to presence of different receptors to take in the drug;;
- difference in efflux of drug due to presence of different transporter proteins that can export the drug out of cell;;

- difference in stability of drug as it may be degraded to different extent (idea of susceptibility of drug to degradative enzymes);;
- different affinity of the drug to binding with tubulin leading to different extent of responses;;
- AVP;;

3 **(a)** With reference to the curve for Barley, explain the meaning of limiting factor. [3]

Definition of limiting factor: (Any one below)

- As a factor that is closest to its minimum value and changing the concentration (or idea of) of this factor will change the rate of reaction/ rate of CO2 uptake;; (A: if students make reference to either an increase ot decrease) **OR**
- as a factor that will directly affect the rate of reaction/ rate of CO2 uptake if its value is changed;;
- From CO2 concentration of <u>0 to 350ppm;</u>
  - increase [CO2], increases the rate of CO2 uptake;
  - CO2 is the limiting factor;
- From CO2 concentration of 350ppm onwards;
  - Increase in [CO2], does not bring about further increase in uptake/ rate remains constant;
  - CO2 is no longer limiting/ some other factors (or named factor) is limiting;

(b) Based on the morphological differences shown in Fig 3.2 and the K_m values for both enzymes, suggest reasons for the difference in rate of CO_2 uptake for Sugarcane (C4 plant) and Barley (C3 plant) shown in Fig 3.1. [5]

What are the differences?

- Much higher rate of CO2 uptake at low CO_2 concentrations
- QV/ quote gradient (steeper for sugarcane cf barley);
- Achieving a max of 35ugm^{-2}h^{-1} at very low CO2;
- At less than 100ppm of CO_2;
- Much higher than CO_2 uptake of 20ugm^{-2}h^{-1} in C3 plants;
- Higher enzyme saturation levels of PEPC compared to Rubisco;

Explanation:

- Presence of PEPC in C4 plants but not in C3;
- PEPC helps incorporate and concentrate CO_2 for use in Calvin cycle in bundle sheath cells;
- Lower Km value of PEPC implies that it has a higher affinity for carbon dioxide while Rubisco has a lower affinity since it has a higher Km 0f 12µM;;
- Presence of mesophyll cells that house PEPC, a morphological feature not observed in C3;
- Calvin cycle occurs deeper within cell, inside bundle sheath and away from Oxygen being exchanged near stomatal region;
- PEPC has no affinity for Oxygen, unlike Rubisco which can also bind to Oxygen other than just CO_2;
- Rubisco can bind to Oxygen and undergo photorespiration;
- Reduces contact with Oxygen by having Calvin cycle deeper inside cell layers; [5max]

(c) Suggest another structural difference in the leaf morphology between C3 and C4 plants. [1]

- C4 plants have thicker leaves;;

(d) In view of all the information that is given above, discuss the likely impact of predicted changes in carbon dioxide concentration, global temperatures and rainfall patterns on the distribution of C3 and C4 plants. [6]

- Climate change will raise global temperatures;
- Due to increased carbon dioxide levels serving as greenhouse gases;

- Rainfall patterns will be erratic with floods in some areas and drought in others;

Carbon dioxide rising:

- C4 plants can reach maximum photosynthetic capacity even at low carbon dioxide concentration;
- having higher levels will help them attain maximum capacity in shorter time compared to C3 plants;

OR

- C4 plants are more adapted to low carbon dioxide concentration than C3 plants ;
- C4 plants will, have reduced advantage / be at a disadvantage, over C3 plants with respect to higher atmospheric carbon dioxide concentration ;

Increased global temperatures:

- Increased enzyme activity due to raised temperatures possible to benefit both C3 and C4;
- Beyond optimal temperature however, both C3 and C4 plants will decline as enzymes become denatured;
- C4 plants will be better adapted to high temperatures as PEPCase might have a higher optimal temperature;
- Both C4 and C3 plants may spread to higher latitudes as temperatures are cooler up there;
- Increased temperature beyond optimum can also force the stomata to close more to reduce transpiration losses so water stress becomes a problem;

Water stress with changing rainfall patterns:

- C4 plants well adapted to, water stress / lack of water ;
- C4 absorb less water per gram of dry mass produced and so are better adapted to dry conditions;
- C4 plants likely to increase in hot dry areas;
- C4 crop plants will continue to be cultivated in places with high temperatures and low rainfall ;
- C4 crops will make more efficient use of irrigation ;
- higher rainfall will benefit C3 plants ;
- rising temperatures in some places will be linked to lower rainfall ;
- ref. to competition between C3 and C4 plants with respect to, water supply / [CO2]
- e.g. C4 plants thought to have evolved in (current) low carbon dioxide atmosphere
- and C3 plants when the carbon dioxide levels were higher (further back in the past);

[6 max]

Essay Questions

4(a) Discuss the effectiveness of a live, attenuated vaccine against an RNA virus. [13]

1. Define live attenuated vaccine in the context of natural acquired immunity @1m max
   - Live attenuated vaccine is the preparation of a ***weakened form/ less or non-pathogenic variants** of the disease-causing pathogen will stimulate the body's immune system (idea of active immunisation) / recognise it as foreign;;
   - to destroy the attenuated version, and "remember" it so that the immune system will more rapidly recognise and destroy the natural pathogens that it encounters later;;
2. Define purpose of using live attenuated type and its link to effectiveness @2m max
   - as attenuated virus are able to replicate in host cell and not degrade, it can induce lifelong immunity as it continues to thrive in the body;;
   - replication of the weakened pathogen does not cause symptoms/ disease yet is able to stimulate natural immune response in vaccinated person; (award only once);
   - no need for booster shots will be required in order to revive immunity in the individual;;
3. Explain primary and secondary immune response to vaccination @3m max

- in *first exposure to the vaccine or primary response, there is a lag phase and a low amount of antibody produced against the vaccine;;
- Mainly IgM antibodies are secreted with low potency;;
- in *secondary response when the body encounters the natural virus pathogen that the vaccine is intended to protect against, the pool of memory B cells remaining from primary response will be activated to divide and differentiate more rapidly and potently;;
- To develop into plasma cells that produce high levels of antibodies of different classes due to class switching that has started in primary response;;
- Together with somatic hypermutation and affinity maturation will produce plasma cells that secrete antibodies with higher specificity and affinity for the natural virus pathogen;;

4. Explain sequence of events activated by vaccine: (i) innate, (ii) humoral and cell-mediated arms of adaptive immunity, and (iii) immunological memory @3m max
   - Antigen presenting cells (APCs) in the body will engulf extracellular virus in the blood stream or infected body cells;; (students were not penalised for missing out infected cells)
   - *APCs will present the processed antigenic protein to the helper T cells via MHC class II molecules;;
   - *Activated $CD4^+$ Helper T cells will produce cytokines that activate naive B cells to develop into plasma cells which will secrete antibodies specific to the antigen;;
   - *$CD8^+$ Cytotoxic T cells to perform direct killing of virus-infected cells after altered infected cells present processed antigen peptide through MHC class I molecule;;
   - *Memory B cells and T cells remain in the body for future encounter of the same pathogen;;
5. RNA viruses and high rate of mutation (ref lack of proof reading capacity of virus RNA polymerase or reverse transcriptase of retroviruses) @2m max
   - *Errors in genome replication by virus RNA-dependent RNA polymerase are not corrected (name at least one virus enzyme responsible for this);;
   - missense mutations result in changes in codons in mRNA;;
   - changes in primary structure of virus proteins, including virus surface proteins;;
6. Structural change in **viral surface glycoproteins** that act as antigens @1m max
   - *altered primary structure leads to altered folding into tertiary structure with alteration of 3D shape; (award once as it overlaps with point 9)
   - *change in epitopes/ antigenic determinants that are no longer recognised by antigen binding site of antibody raised in immune response to vaccine;;
7. Link to challenge of vaccine design due to constant change in RNA viral antigens @2m max (check with point 10)
   - constant mutations in virus surface proteins lead to continuous change in epitopes/ antigenic determinants;;
   - antibody raised in immune response to vaccine now have antigen binding site that is specific to original epitope can no longer bind altered epitope;;
   - unable to eliminate new strains of RNA virus that evolve from the original strain, so there is loss of immunity;;

AVP wrt effectiveness of live attenuated vaccine (capped at 4m max in total);;

- live attenuated virus mutates within the body into virulent / pathogenic form to cause full-blown disease;;
- weakened virus causing full-blown disease in people with weak immune systems;;
- reference to herd immunity awarded ½ m as this applies to vaccination in general;
- reference to antigenic shift in influenza virus leading to new subtypes;;

***essential points**

4b Discuss the various ways in which the concentration of an enzyme in a cell can be regulated. [12]

Overview:

1 Enzymes are proteins and their concentration in a cell is regulated by controlling/regulating gene expression;;

Regulation of enzyme production in Eukaryotes [9 max]

2 *Presence or absence of enzyme*: [3m max]

- Chromatin remodelling - level link to accessibility of promoter of gene to transcription factors and RNA polymerase, formation of transcription initiation complex (TIC);;
- Via histone acetylation (description) – idea of gene expression: eg. decrease binding of negatively charged DNA to positively charged histones, resulting in DNA being more loosely coiled around histones)
- DNA methylation;; (gene silencing: CpG rich regions required for binding of TF and recruiting of histone deacetylases)

3 *Increase concentration of enzyme or Up regulation*: [2m]

- Enhancer and activator; with idea of stabilising transcription initiation complex to increase transcription; (R: RNA pol)

4. *Decrease concentration of enzyme or Down regulation*:

- Silencer and repressor with idea of blocks assembly of TIC/ prevents release of RNA polymerase from TIC to decrease transcription/ blocks assembly of RNA pol;;

5 Translational level: controlling the Half-life of mRNA [3m max]

- The longer the half-life of an mRNA, the more stable it is and hence the more times it can serve as a template for the translation of the enzyme;; (idea of :The mRNA can allow the synthesis of more proteins if it remains in the cytoplasm for a longer period of time)
- This is done by
  - Presence of 5' cap and 3' poly A tail prevents digestion from 5' and 3' exonucleases respectively;;
  - Longer poly A tail, longer half life; (offers more resistance to 3' exonuclease)
  - Specific proteins that bind to the 3' UTR to mark the mRNA for rapid degradation;;
  - Certain hormones can stimulate or retard the rate of degradation of mRNA, thereby decreasing or increasing its availability for translation to protein;

6 Initiation of translation [1m]

- Masking of mRNA by specific proteins to 5"UTR of mRNA prevents ribosome binding;;

7 Biochemical modification to make functional enzyme; [2m max]

- Enzymes may have to undergo certain post-translational modification to form functional enzymes through the addition of any of a number of these biochemical: [any 2, 1 max]
  - Glycosylation - Addition of carbohydrates;
  - Phosphorylation – Addition of phosphate groups;
  - Acetylation / Methylation – Addition of acetate or methyl group;
  - Proteolytic cleavage;

8 Enzyme degradation [decrease enzyme concentration] [1m]

- Ubiquitinylation involves the addition of ubiquitin which marks the enzyme for degradation by proteasome;;

9 Presence of growth factor/ signalling molecule that

- cause the activation of transcription via cell signalling pathway;; [1m]

Regulation of enzyme production in Prokaryotes [4 max]

9 via operons;

10 Presence of **substrate/ inducible operon** (eg. lactose for lac operon); [3m]

- In the absence of lactose: active repressor binds to operator to prevent binding of RNA

pol to promoter, no transcription;;
- Presence of lactose: repressor inactivated (or description) by allolactose binding to active repressor, hence transcription of structural genes or named example;;
- Upregulation: by the binding of cAMP-CAP complex to the CAP binding site upstream of promoter;;

11 Presence of **end product/ repressible operon** (eg. tryptophan for trp operon) [2m]
- In the absence of tryptophan: inactive repressor cannot bind to operator to prevent binding of RNA pol to promoter, transcription;;
- Presence of tryptophan: tryptophan active inactive repressor, binding to promoter, hence transcription of structural genes or named example;;

12 AVP

Activity: Note: here the reference is about **functional** enzyme [2m max]
- End product inhibition/ allosterism explained;;
- Optimal condition: pH eg. lysosome;;
- Enzyme inactivation at high temperatures eg. Himalayan rabbits

QWC (Quality of Witten Expression)
To be awarded if students write on regulation in both prokaryotes and eukaryotes.

5a Describe the functions of various components found in the plasma membrane and explain, using named examples, why there is a different composition of these components in membranes of different cells and organelles. [13]

Components of membrane and their functions:

(1) Phospholipids
- Forms bilayer due to amphipathic nature
- Barrier to water-soluble substances
- Provides fluidity to membrane;
- compartmentalisation;

(2) Cholesterol
- Regulates fluidity of membrane
- Maintain mechanical stability of membrane
- Reduces uncontrolled leakage of polar molecules / ions

(3) Proteins
- transport proteins - Allow water-soluble ions, glucose, amino acids etc to be transported in and out of cell
- enzymes – catalyse chemical reactions on the membrane eg. adenylyl cyclase
- receptor – allows for specific binding of signalling ligand
- structural support – proteins attached to cytoskeleton to provide framework to cell
- energy transducers eg. ATP synthase

(4) Carbohydrates (@glycoproteins or glycolipids)
- Form H bonds with water and stabilizes membrane
- Cell-cell recognition / cell communication
- Cell-cell adhesion

Significance of different components:

<u>In different organelles</u>
- Eg mitochondrion and chloroplast;
- Require proteins (electron carriers) to be arranged in order;
- To facilitate electron transfer along electron transport chain;
- Idea of carrying out chemiosmosis;
- Eg. nucleus

- Require opening such as nuclear pores to be present in the membrane;
- Eg. rER; more protein channels for newly synthesized proteins to enter lumen;
- Eg. chloroplasts; photosynthetic pigments on thylakoid membrane for absorption of light;
- Eg. lysosome; more proton pumps to maintain acidic internal environments;

In different cells

- Ref different cell types contains different amount and types of glycoproteins and glycolipids;
- idea of similar cell types can adhere together to form tissues;
- Ref cells receiving signalling ligand / specific example of effector cells etc;
- Require specific protein receptors to be present on cell membrane;
- To allow specific signalling ligand to recognize and bind;
- For signal to be received and transmitted;
- Ref cells that produces / synthesized proteins for extracellular use / cells that perform secretory functions etc;
- Contains more transporter proteins on the plasma membrane;
- Ref immune cells eg. B cell/macrophage/ T helper cell etc
- To contain specific receptor eg. BCR with specific antigen binding sites;
- That enable it to bind to specific antigen;
- Ref cells in organisms living in areas of higher temp (accept reverse)
- Higher % of saturated fatty acids in phospholipids;
- For greater stability of the membrane;
- AVP

5b Hyperglucagonemia is a condition where there is excess glucagon secretion. Using your knowledge of how glucagon works and how HIV infects a cell, explain how drugs can be used to target the different stages in each condition. Highlight in your answer, similarities in the mechanism of the drugs. [12]

Similarities: (3max)

- Bind to **specific receptors** on **cell surface membrane**;;
- Due to **complementary** binding/fitting to relevant **receptors** on specific **target** cells;;
- Drug can also act as **competitive inhibitor**/ structural analog to relevant receptors on target cells;
- **Block the binding** of glucagon or HIV and hence limit the propagation of the diseases;
- Drug can also enter the cell and work by inhibiting **intracellular** cell processes;
- Eg. involving **enzymes**;
- Drug can be steroid based to facilitate entry into cell;
- Drug can be administered in liposomes to ensure quick delivery to target cells via bloodstream;

Examiner's comments:
Despite prompting from the question, this part was barely discussed. Many offered only a sweeping statement about the two drugs to be similar in action of targeting receptors as some sort of competitive inhibitor. Some mentioned the common target of intracellular enzymes but most never mentioned about the common mode of drug entry into the cell.

Differences: (9 max)
Other targets

	Glucagon	**HIV**
Target Receptor	G-protein linked receptors	CD4 /CCR5 receptors
Target Cell Type	liver cells	T helper cells

Molecular shape specificity	Similar to glucagon	Can be similar to T helper cell surface receptors or bind directly to gp120 /41 on HIV
Target other cellular pathways Eg. enzymes	**GTPase enzyme** activity used to hydrolyze its bound GTP to back GDP, inactivating the G-protein once again	Drug that inhibits HIV **reverse transcriptase** activity will prevent viral DNA transcription from RNA
Target other cellular pathways Eg. enzymes	**Phosphodiesterase** which inactivates cAMP by converting it to AMP can be used to reduce the number of second messengers.	Drug that inhibits HIV **DNA polymerase** activity will prevent doubled stranded HIV DNA from being made
Target other cellular pathways Eg. enzymes	Inhibitor to cellular responses preventing the breakdown of glycogen polymers to glucose -1-phosphate by **glycogen phosphorylase**	Drug that works against **HIV integrase** will prevent incorporation of viral DNA into host cell
Target other cellular pathways Eg. enzymes	--	**HIV protease** inhibitors prevent the assembly of the capsid coat around the viral RNA and enzymes to form nucleocapsids.
Target other cellular pathways	--	Drugs can be co-receptor analogs deployed to reduce the efficiency of co-receptor binding
Target other cellular pathways	--	Drugs designed to prevent uncoating, by preventing the fusion of the membranes via steric hinderance of the hairpin formation
Regulation of release	Glucagon release can be inhibited at the (α cells) of pancreas	Prevent release of HIV by blocking the formation of new virions so that they cannot bud off to infect new T cells

Victoria Junior College
Biology Department
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Question 1

(a) (i) Record your observations in a suitable format in the space below, noting particularly any differences that you observe in the appearance of the contents of the five tubes. [6]

- Independent variable must be either contents of tube OR pH in the first column;
- Column heading;
- Observations of contents of tubes – (½ for extent of fragmentation, ½ for colour / clarity of solution)

Tubes	pH buffer used	Observations of the contents of the tubes
A	**pH 2**	Egg remained whole / minor fragmentation; Solution **remained** clear and colourless;
B	**pH 4**	Egg remained whole / minor fragmentation; Solution **remained** clear and colourless;
C	**pH 6**	Egg fragmented slightly (idea of more fragmentation compared to tube A and B); Solution changed from clear colourless to cloudy with a tinge of red;
D	**pH 8**	Egg fragmented to a greater extent / more extensive fragmentation (compared to tube C); Solution changed from clear colourless to cloudy red;
E	**pH X**	Egg fragmented slightly (idea of more fragmentation compared to tube A and B); Solution changed from clear colourless to cloudy with a tinge of red;

(ii) Based on your observation in (a) (i), estimate the pH of buffer X. [1]

- pH 6;;

(b) State the conclusions that you can draw, at this stage of the procedure, about the action of K1 on the protein at different pH. Explain how your observations allow you to make these conclusions. [4]

- K1 is an **enzyme** (protease);
- as it is **sensitive to pH changes**;
- K1 enzyme work optimally at **pH8**; (accept ECF based on students' table)
- Idea of **more extensive breakdown of egg** observed in tube D;
- **causing more red dye released** into the solution from egg in tube D;
- When pH goes below its optimum pH, the **conformational shape of enzyme changes**;
- Specific bonds affected - H bonds, ionic bonds, hydrophobic interactions;
- Less ideal for binding of substrate or idea of less ES complexes formed;

- **denaturation** of enzyme;
- Idea of decrease in rate of enzyme reaction;

(c) (i) Discuss two sources of error, other than temperature, that may have affected the accuracy of your results. [2]

- Inconsistency of the shaking action of the tubes; different extent of fragmentation / leakage of stain into the solution may be due to the different strength in shaking;
- Idea of interval of pH too broad as the optimal pH is between the pH interval
- Idea of pH range not extensive enough as the optimal pH may be above pH 8;;
- Staining of egg is not homogenous; affecting the leakage of the stain into the solution;
- Imprecise cutting of egg; leading to different surface area for enzyme to work on;
- Determination of colour and clarity of content is subjective and may deviate amongst individuals;
- Procedures lack the use of a control to show that the effects of breakdown of egg is due to action of K1;

(ii) Suggest improvements to reduce the sources of error you have identified in (c) (i). [2]

- Standardize the method and force for shaking of tubes by using mechanical shaker / vortex;
- Reduce the interval of pH eg. use pH 4, 5, 6, 7, 8
- Extend the range of pH to above 8 eg. use pH 4 to 14
- Use a standardised mold / core borer to cut the egg;
- Use a colorimeter to measure absorbance of light by the contents of the tube;
- Set up a control tube, replacing K1 with same amount of distilled water for all pH and repeat the experiment;

(d) The following experiment in **Fig. 1** was set up to investigate the effect of pH on the activity on the enzyme catalase on potato.

pH buffer	**Time taken for potato disc to rise / s**			**Rate / s^{-1}**
	Disc 1	**Disc 2**	**Average**	
4	58	63	60.5	0.0165
5	43	47	45	0.0222
6	41	42	41.5	0.0241
7	39	40	39.5	0.0253
8	44	49	46.5	0.0215
9	56	63	59.5	0.0168

(i) Plot a graph showing the effects of varying pH buffer on the rate of breakdown of hydrogen peroxide in the grid provided below. [4]

- Correct X and Y axis label with units;;
- Scale;;
- Points plotted;;
- Best fit graph plotted;;

(ii) Explain how one can determine that the time taken for potato discs to rise at two different pH is significantly different from each other? [3]

- Repeat the experiment several times (eg. 5-6 times) for each of the two pH;
- Calculate the average time taken for discs to rise at each pH;
- Conduct the T test;
- if $P < 0.05$, then reject the null hypothesis;
- there is significant difference in the timing for discs to rise at the two different pH;
- any difference observed not by chance;
- (accept if students explain $P > 0.05$)

Question 2

(a) You are provided with an extract **P** from plant cells which contains a mixture of different carbohydrates.

You are required to identify which carbohydrates present in **P** can pass through the Visking tubing.

(i) Use the space below to record the tests that you have performed, your observations and conclusions in a suitable format. [4]
Details of the tests are not required.

R= reject; A= Accept

Test for Biomolecules	**Observations (Record: change from ___ to ___)**	**Conclusions**
I_2 / KI test for Starch A: iodine test R: starch test	I2/KI **turned from brown or yellow to blue black;** Accept: dark blue, but not blue	**Starch present**;
Benedict's test for reducing sugar; (R: B's test for monosaccharides/ glucose as it cannot distinguish between mono and disaccharides. Only detect reducing property)	Contents **remained clear blue**; (Note: Record **both colour and clarity**)	**Reducing sugar absent**; (R: glucose)
Acid hydrolysis followed by Benedict's test (R: Non-reducing sugar test)	Contents **turned from clear blue to opaque orange/brick-red**; R: cloudy (R: • opaque blue or opaque green – Tr's results is brick red/orange, opaque)	**Non-reducing sugars present**; (R: sucrose, disaccharide) Note: This test is used to determine the presence of NRS only. It **cannot** provide identity of the NRS.

(ii) what do your results indicate about the property of the Visking tubing? Explain your answer. [3]

- Property: **semi-permeable/ selectively permeable/ partially permeable**;

- **Pore size** that only allow small molecules (to diffuse through);
- Non-reducing sugars are able to diffuse through the pores because of their **small** size but starch molecules are too **large** to pass through;;
- Idea of movement (of non-reducing sugars) down a **concentration gradient**;
- Evidence:
  - NRS: blue with tinge of red, cloudy;
  - Starch: remained yellow/brown;

(iii) Explain how you can modify the experiment to determine the **rate of diffusion** of the carbohydrate that you have identified in (a) (ii) above. [3]

- *Sampling (S)*

1. Taking samples at regular time intervals;
2. 5 time intervals or stated; (A: idea of more than 1 time eg. over 10 mins)

- *Method (M)*

3. **Fix volume** of sample;
4. Conduct acid hydrolysis and B's test;
5. Measurement: comparing colour change/ colour and clarity Or measure absorbance/ transmittance using a colorimeter Or determine time taken for first colour change;
6. determine concentration: by comparing against a colour standard; of known concentration of NRS;

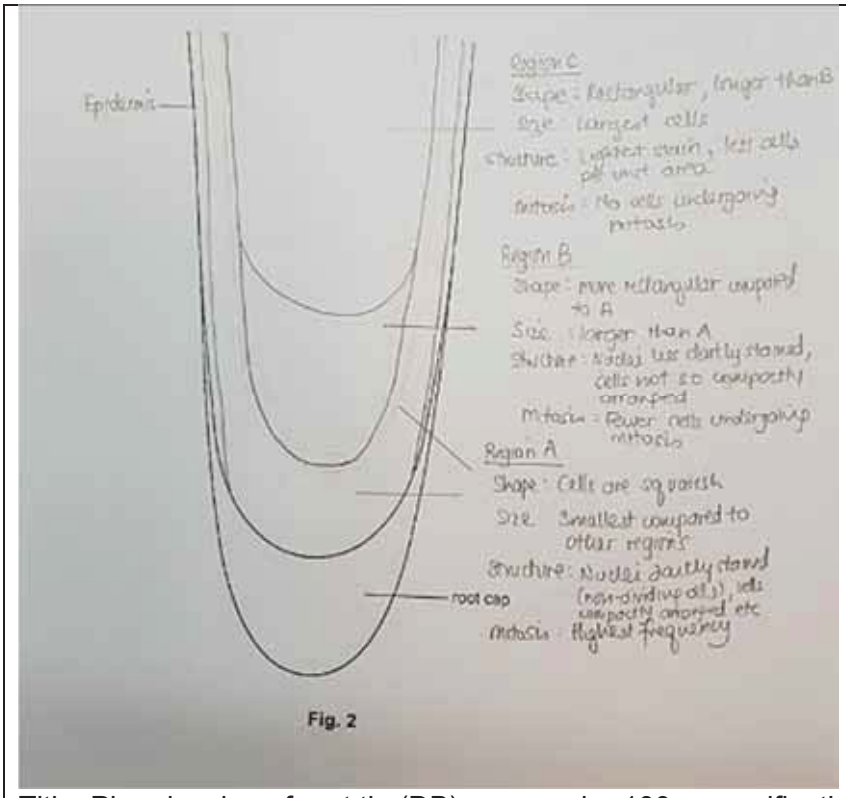
- *Rate (V)*

7. Plot graph of y against (sampling) time;
8. calculate rate by dividing concentration over time;
9. Rate taken from gradient;

{max 3m}

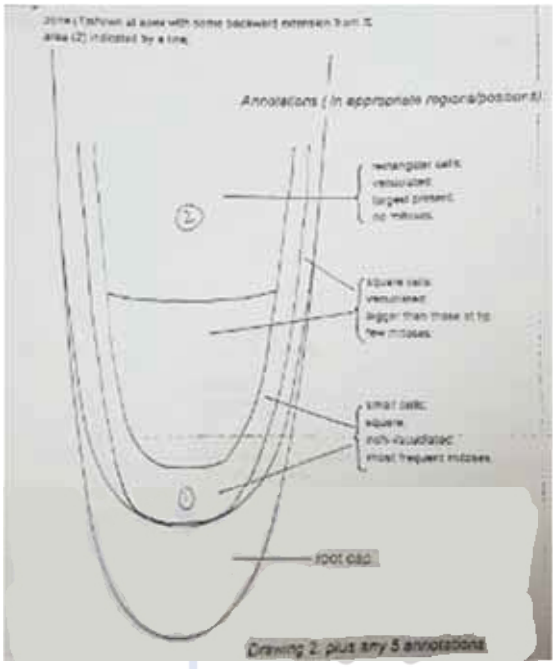
(b) (i) Make a plan drawing of the entire section, within the outline drawn in Fig. 2.1 below to show the different **regions**. These regions result from differences in the ***shapes, sizes* and *structure* of the cells** as well as in the **frequency** with which different stages **of mitosis** are visible.

Annotate your drawing as fully as possible to describe the features of the cells in each region that you map. [5]



Title: Plan drawing of root tip (DB) seen under 100x magnification
(Note: You are not expected to draw the epidermis)

Marking points:
1) Number of layers/zones: at least 3 (not more than 4)
2) Shape and proportion of the 3 layers;
3) Annotation for each layer: 1m x 3 layers (annotation include shape, size and special features eg. dividing cells, position of nucleus etc)
1. Title;
2. Magnification;



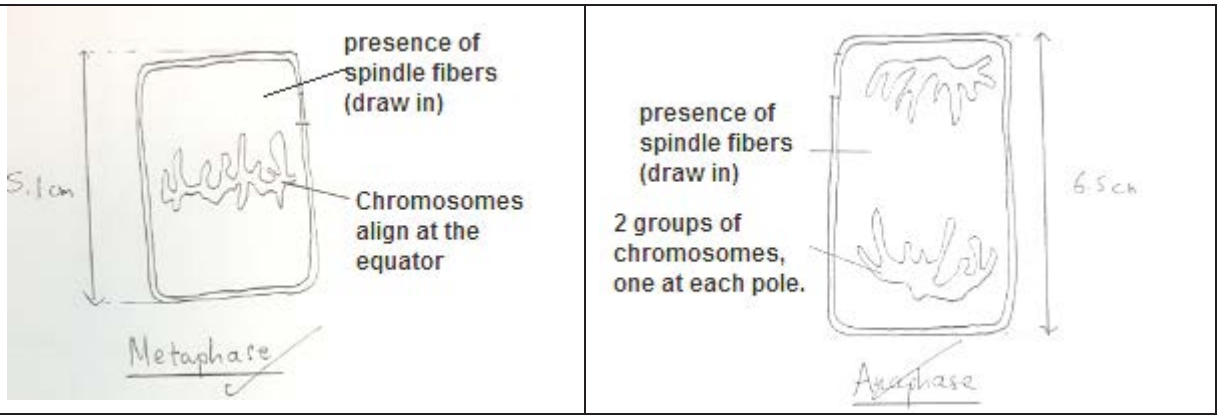
Another possible plan drawing (J2000)

(ii) In the space below, draw to the **same scale**, two cells that are at different stages of mitosis. Identify the stages and **label the distinctive features** of each stage in your drawings. [5]

Mark scheme
1) Same scale: i.e. cells must be relatively the same size and correct shape and proportion;;
2) Distinctive features of each stage 1m x2

3) Outline : clear, no shading, cell wall drawn as double lines;;
4) Magnification;;

Students" work



Question 3
Proposed mark scheme
Theoretical Consideration [2 max]

1. a) Rate of uptake of glucose is higher than rate of uptake of maltose because glucose is the **main respiratory substrate**;
   b) Hence **more transport proteins** of glucose present on cell surface membrane OR transport proteins have higher affinity for glucose so increased uptake occurs;
   c) Uptake is limited by the number of transport proteins;

2. Outline of strategy and theory supporting it:

a) Method of following the uptake of glucose and maltose **separately**: taking samples at intervals from the suspension and calculating uptake; (A! if students refer to taking one sample after a fixed period of time.)

b) Using Benedict's test to determine the concentration of glucose / maltose / reducing sugars left in the yeast suspension;

3. Hypothesis: Rate of glucose uptake > rate of maltose uptake by their respective transporters at the same concentration.
   Predicted results: At every sugar concentration, change in absorbance/time will be higher for glucose (i.e. sharper gradient and higher saturation plateau).

Procedure [7 max]

4. Specify at least 5 different concentrations of glucose and of maltose (e.g. 0, 2, 4, 6, 8, and 10 gdm^{-3}) and use of dilution table (glucose / maltose concentrations, vol. of distilled water, and vol. of 10gdm^{-3} glucose / maltose stock solutions must be shown);

5. Factors to be kept constant; @ ½ mark each

a) Temperature (specify a temp. in the range 30 – 40°C)

b) Fixed vol. of 10% yeast suspension

c) Appropriate ratio of sugar solution : yeast suspension (from 5:1 to 10:1 vol./vol. such as 10 cm^3 sugar solution to 1 cm^3 yeast suspension)

d) Pre-incubation of sugar solutions (e.g. 2-5min) to attain temp. of water bath;

6. Logical sequence of procedure steps:

a) Yeast mixed with sugar solution;

b) Sampling of glucose or maltose at fixed intervals (specify at least 5 regular time intervals e.g. 0, 5, 10, 15, 20 minutes);

c) Filtered / centrifuged to remove yeast;

6. Description of Benedict's test for the presence of glucose / maltose (e.g. boiling water bath for 2-5 minutes); colour and clarity;

7. Description of use of colorimeter; for determining the concentration of glucose / maltose based on absorbance value (note absorbance units is in A);

8. Showing calculation of quantity of sugars taken in, based on difference between initial and final concentration.

9. Description of a control: same conditions (e.g. use same vol. / vol. ratio using 10gdm^{-3} glucose / maltose (how) but using boiled and cooled yeast (what) to show that functional transport proteins are required for the uptake of sugar (why);;

10. Repeats and replicates (repeat the whole experiment twice with replicates incorporated in the write up);;

Results [2]

11. Table: use of correct headings and processed to average absorbance value of glucose / maltose and rate of uptake of glucose / maltose;;

12. Plot graph (Y axis: rate of uptake of sugar / A min^{-1}, X axis: concentration of sugar / gdm^{-3}) that show the kinetics of both glucose and maltose;;

Risk consideration [1]

What, why, how: Benedict's solution irritates the skin, wearing of gloves and goggles to avoid contact; AVP: yeast solution, HCl if it is used