

RAFFLES INSTITUTION

2018 Year 6 Preliminary Examination
Higher 1

BIOLOGY

8876/01

Paper 1 Multiple Choice

25th September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name and shade your Index Number on the Answer Sheet in the spaces provided unless this has been done for you.

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

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

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

Calculators may be used.

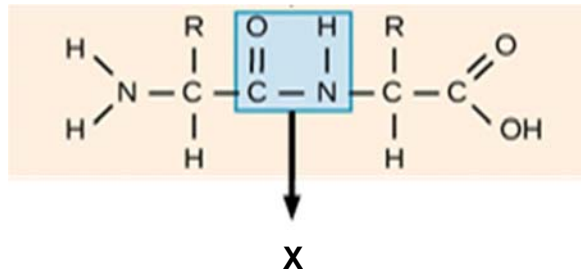
(Erase all mistakes completely. Do not bend or fold the OMR Answer Sheet).

This document consists of **21** printed pages.



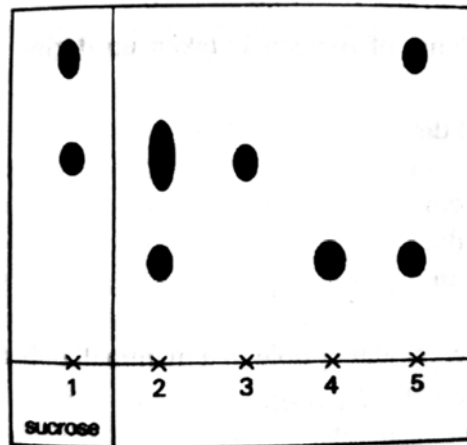
Raffles Institution
Internal Examination

1. The diagram shows a molecular structure.



What is enclosed by the box X?

- A Phosphodiester bond
 - B Glycosidic bond
 - C Ester bond
 - D Peptide bond
2. Five disaccharides were each hydrolysed and the products were separated by chromatography. The chromatogram produced is shown in the diagram.

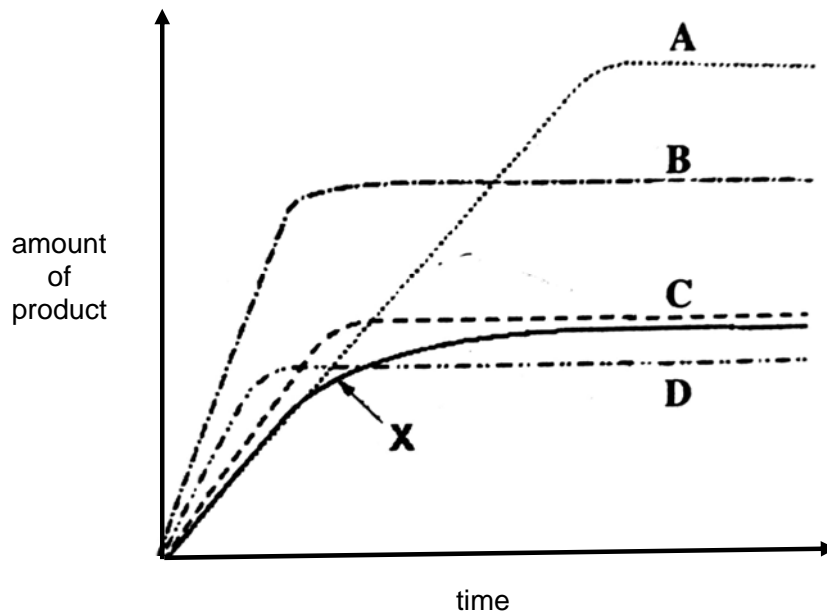


If lane 1 represents the products of the hydrolysis of sucrose, which results were obtained from the hydrolysis of lactose and maltose?

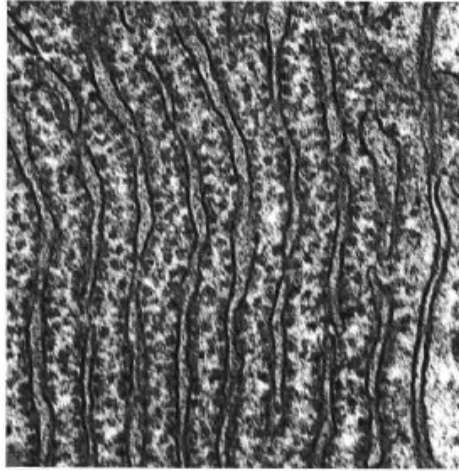
	lactose	maltose
A	2	3
B	2	4
C	5	2
D	5	3

3. An essential feature of a competitive inhibitor is its ability to _____.
- A activate an operator gene
 - B modify a substrate
 - C occupy an active site
 - D same shape as active site
4. Line X shows the activity of an enzyme at 20°C. Lines A to D show the effect of different conditions on the activity of the enzyme.

Which line shows the effect of increasing the temperature by 10°C and adding extra substrate?

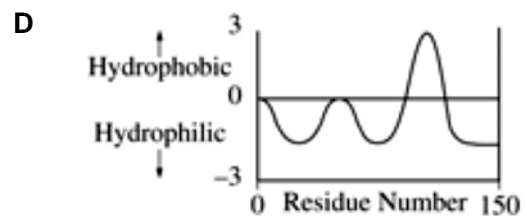
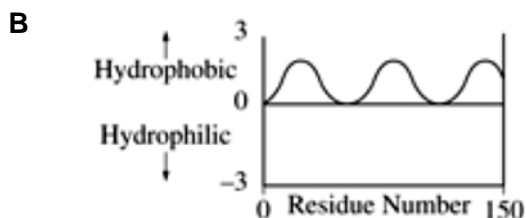
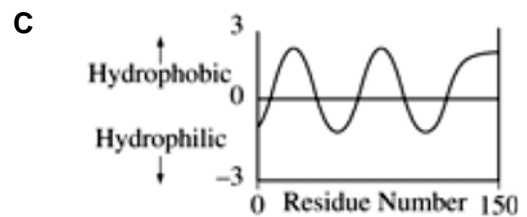
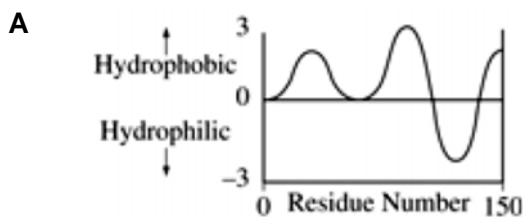


5. The electron micrograph shows part of an organelle in a cell.



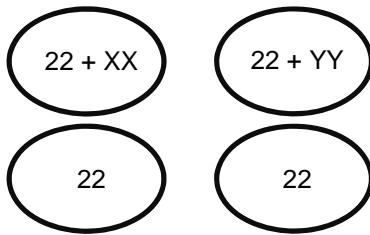
What describes a function of the cisternae in the organelle shown?

- A Moving protein to places where they are covered by phospholipid membranes for secretion outside the cell
- B Producing proteins and covering them with phospholipid membranes for secretion outside the cell
- C Producing proteins, covering them with phospholipid membranes and moving them for use inside the cell
- D Producing ribosomes and proteins and storing them in phospholipid membranes for use inside the cell
6. Glycophorin, an integral membrane protein, has a single transmembrane α helix. Which of the following plots most likely represents glycophorin?

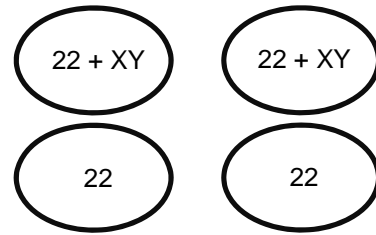


7. A human cell with 44 autosomes, and sex chromosomes X and Y, suffers a non-disjunction at the first meiotic division. Which of the following set of gametes could result?

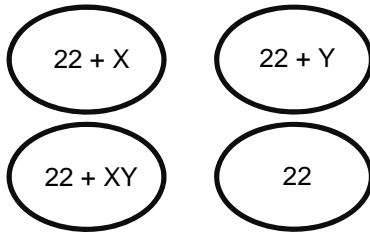
A



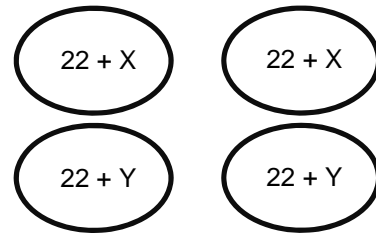
C



B



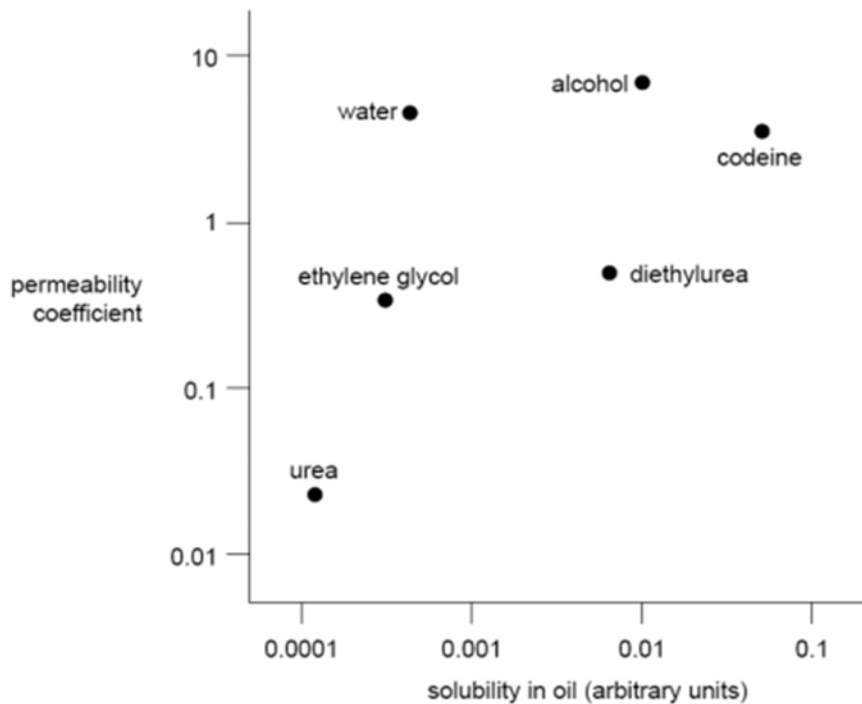
D



8. Which of the following is **not** a function of mitosis?

- A Growth of multicellular organisms.
- B Repair of multicellular organisms.
- C Reproduction of single-celled organisms.
- D Increase in size of single-celled organisms.

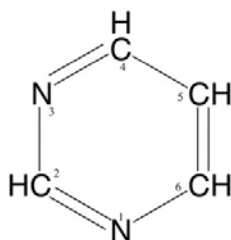
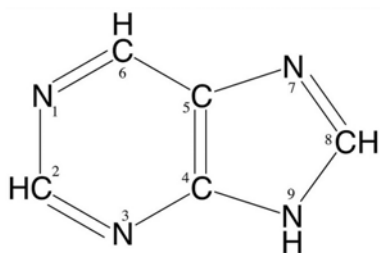
9. Materials are constantly exchanged between a cell and its surroundings. The ease with which a molecule passes through a plasma membrane can be represented by a permeability coefficient. The graph below shows the permeability coefficients for a range of molecules plotted against their solubility in lipid.



From the graph you can conclude that

- A water is more lipid-soluble than alcohol.
- B a cell gets rid of urea more slowly than excess water.
- C drugs like alcohol and codeine enter cells more slowly than ethylene glycol.
- D ethylene glycol passes through the plasma membrane more easily than diethylurea.
10. Which of the following statements is **not** true of mutations in a diploid organism?
- A Chances of encountering a recessive lethal allele in a population of diploid organism is higher compared to that of haploid organisms.
- B All somatic mutations alter the organism's phenotypes.
- C Some mutations causes the loss in regulation of the cell cycle.
- D Some loci are more prone to mutation than others.

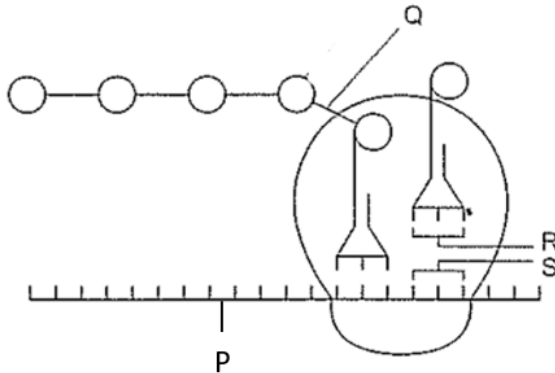
11. The structures of purine and pyrimidine are shown below.



Which of the following correctly shows the numbers of carbon atoms in the corresponding nucleic acid?

	Molecule	Number of carbons in the molecule
A	DNA strand with the sequence ATCGAAA	33
B	mRNA molecule with the sequence AUCGAAA on 1 strand	30
C	DNA molecule with the sequence ATCGAAA on 1 strand	33
D	DNA strand with the sequence ATCGAAA	68

12. The diagram below shows the process of translation in a prokaryotic cell.



Which of the following correctly identifies the bonds?

	P	Q	between R and S
A	Peptide	Phosphodiester	Hydrogen
B	Hydrogen	Disulfide	Phosphodiester
C	Phosphodiester	Peptide	Hydrogen
D	Hydrogen	Hydrogen	Peptide

13. The active messenger RNAs (active mRNAs) in tissue cells can be isolated by passing the homogenised cell contents through a fractionating column. The column has short lengths of uracil nucleotides attached to a solid supporting material. Molecules of mRNA that can pass through the column are quickly broken up into small pieces and cannot be translated.

The active mRNAs that attach to the column can be collected subsequently by an appropriate treatment.

Which statements correctly describe active mRNA?

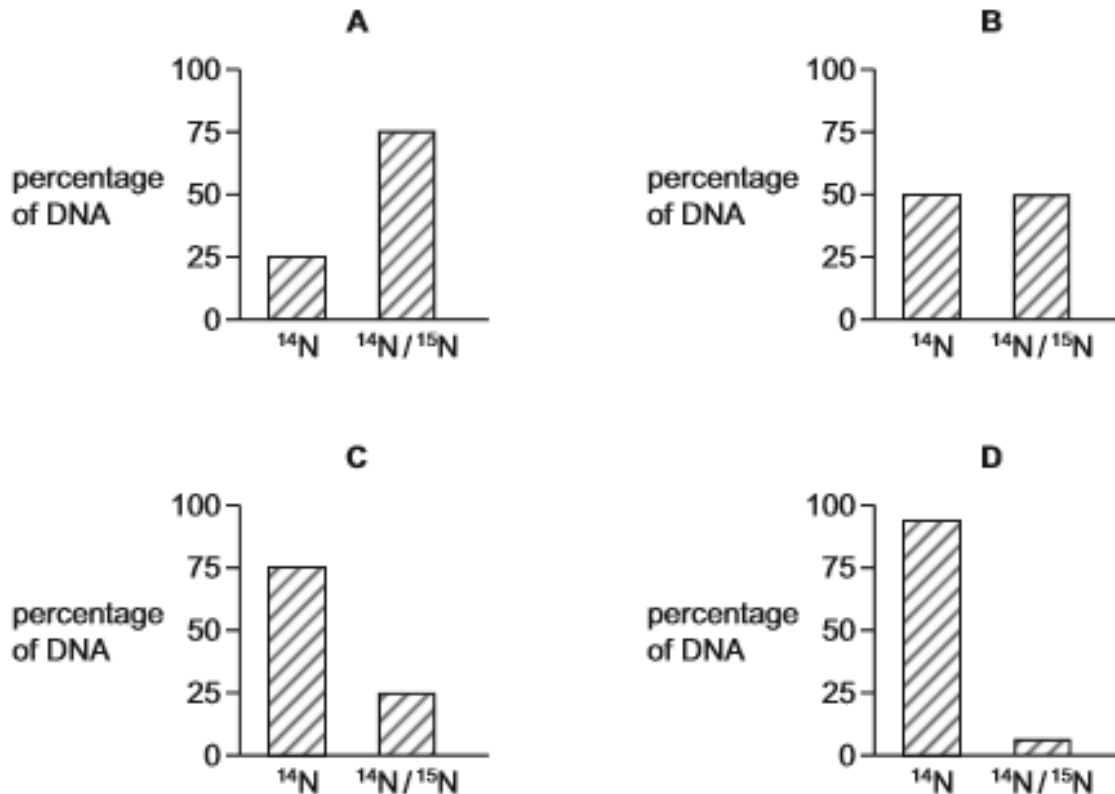
- 1 Active mRNAs are held to the fractionating column by bonds between adenine and uracil bases.
- 2 Active mRNAs can be released from the fractionating column by breaking hydrogen bonds.
- 3 Only mRNAs with polyadenine tailing can be translated.
- 4 Polyadenine tailing stabilises mRNA and prevents it from being broken up.

- A 1 and 2
 B 1, 2 and 3
 C 3 and 4
 D 1, 2, 3 and 4

14. Bacteria were grown in a medium containing ^{15}N . After several generations, all the DNA contained ^{15}N . Some of these bacteria were transferred to a medium containing the common isotope of nitrogen, ^{14}N . The bacteria were allowed to divide once. The DNA of some of these bacteria was extracted and analysed. This DNA was all hybrid DNA containing equal amounts of ^{14}N and ^{15}N .

The bacteria were allowed to divide two more times.

What would be the percentages of ^{14}N and ^{15}N labelled DNA in these bacteria?



15. A geneticist determines that a particular human disease is caused by a gene mutation. The mutant allele contains a substitution of cytosine to adenine at position 334. The DNA sequence for bases 301 to 351 from the non-template strand of the normal allele is shown.

5'- ATG TTA CGA GGT ATC ATA CGA ACG GAG CGC GAA CTA GTT ACT CCC ATA AAA - 3'

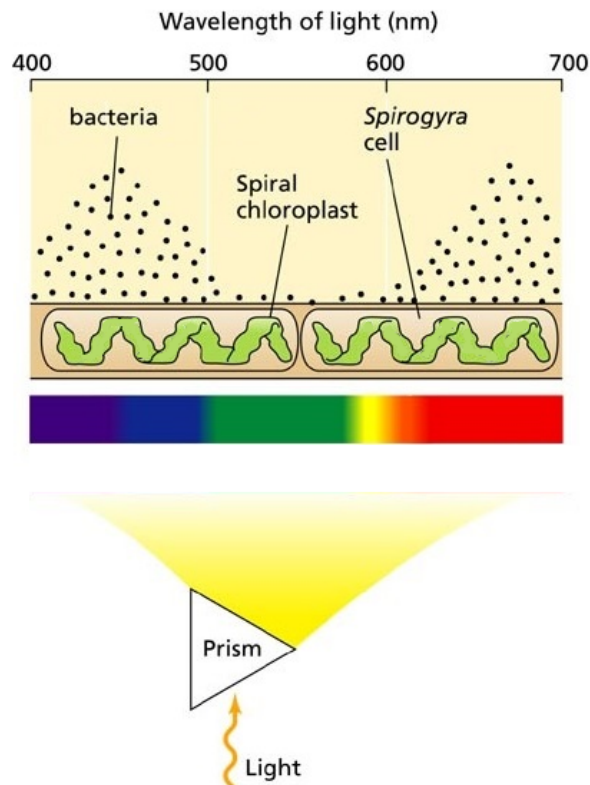
Which of the following statements best describes a consequence of this mutation?

- A** A nonsense mutation has occurred resulting in no protein product being formed.
- B** The mutant protein contains fewer amino acids than the normal protein.
- C** A missense mutation has occurred resulting in a non-functional protein.
- D** There is no change in length of amino acid sequence due to the mutation occurring outside of the coding region.

16. In 1882, the German botanist T.W. Engelmann performed an ingenious experiment to investigate the effects of different wavelengths of light on the rate of photosynthesis for a suspension of alga *Spirogyra* (a filamentous microorganism containing long, spiral chloroplasts).

In his experiment, a prism was placed between the light source and the alga filament to produce and scatter all colours of the light across the alga filament evenly. Then, aerobic bacteria were added to the alga filament suspension. All the other variables were kept constant.

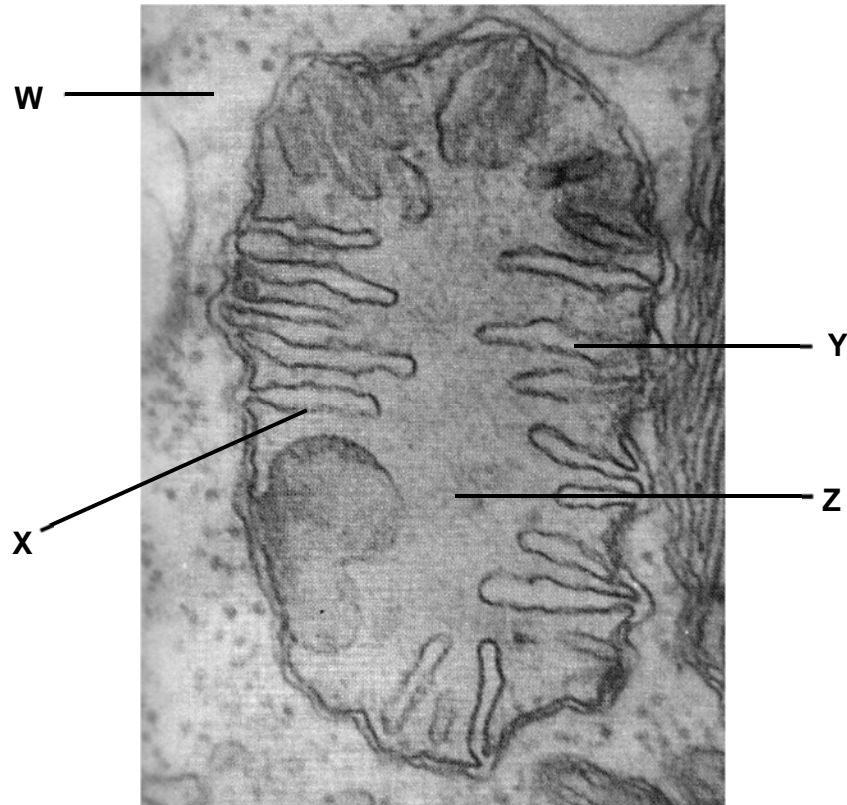
After exposure to light for a certain period of time, the bacteria were found to move towards and accumulate at specific lengths along the alga filament as shown below.



Which of the following conclusion(s) can be drawn from the above experiment.

- I The directional movement of the bacteria is due to oxygen released from *Spirogyra*.
 - II Green light is least absorbed, whereas red and blue wavelength of light is efficiently used for photosynthesis.
 - III NADPH is the reducing power that drives the formation of glyceraldehyde-3-phosphate.
- A** II only
B I and II only
C II and III only
D All of the above

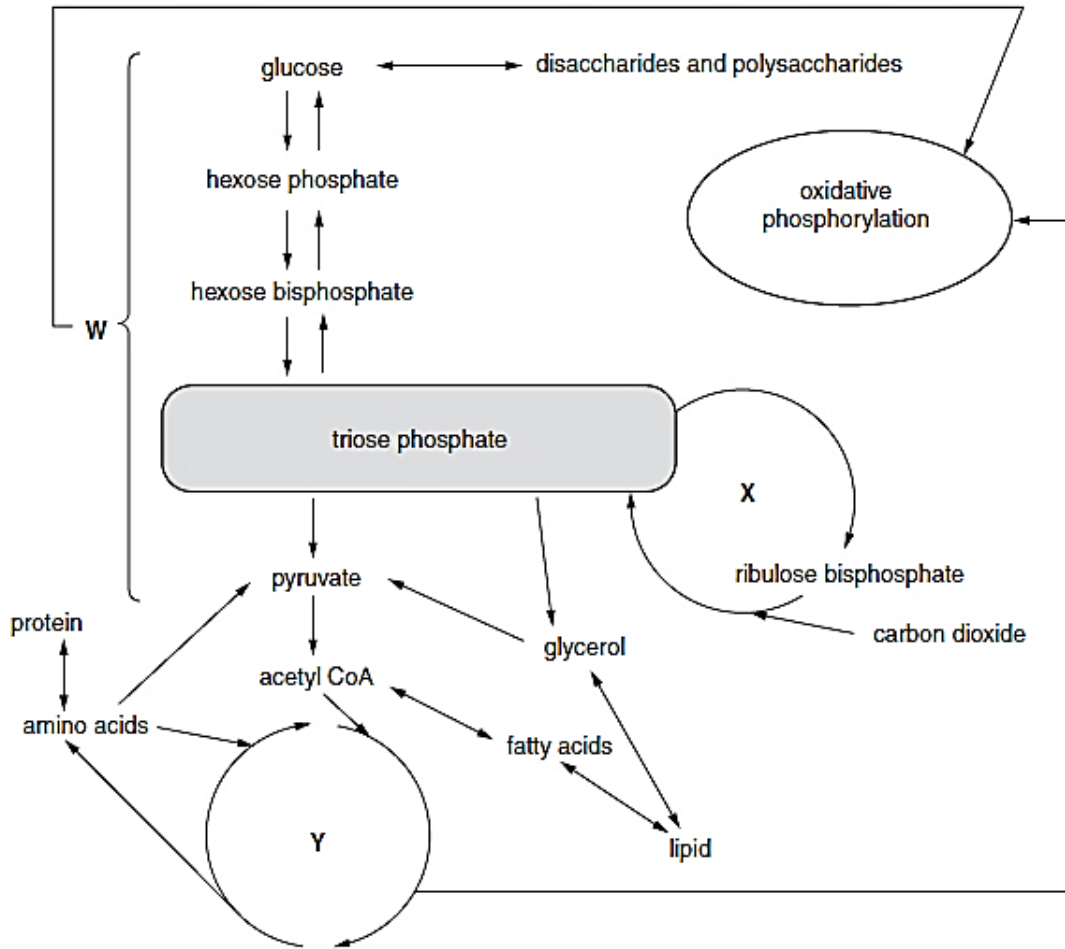
17. The figure below shows an electron micrograph of an organelle.



Which of the following correctly matches the following processes with the corresponding structures?

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

18. The diagram represents some of the reactions that take place in a leaf cell.



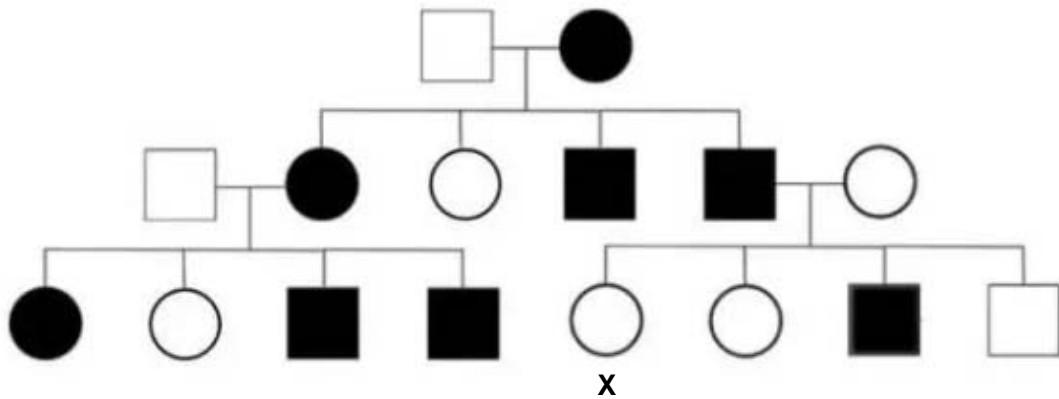
Which statement explains why the three reaction pathways **W**, **X** and **Y** are able to work independently of one another in the same leaf cell?

- A **X** occurs only in the absence of light unlike both **W** and **Y**.
- B **W**, **X** and **Y** are separated by membranes, allowing for the formation of separate proton gradients to synthesise ATP.
- C **W**, **X** and **Y** are separated by membranes, allowing for the maintenance of different conditions for enzymes to function.
- D **W**, **X** and **Y** are different pathways, each with their own biochemical reactions.

19. A metabolic poison inhibits liver enzymes that convert lactate to other compounds for metabolism. Which row illustrates the events that occur in an exercising athlete who accidentally consumed the metabolic poison?

	lactate accumulation	NAD production	ATP production	pH of blood
A	no	no	no	increased
B	no	yes	yes	decreased
C	yes	no	no	increased
D	yes	yes	yes	decreased

20. The pedigree below shows the inheritance of Marfan syndrome which affects connective tissues in the body.



Individual X is homozygous at the loci for the disease gene. What is the genetic basis of inheritance of the disease?

- A** Autosomal dominant
- B** Autosomal recessive
- C** Sex-linked dominant
- D** Sex-linked recessive

21. A scientist was studying the inheritance of coat colour and tail shape in mice.

Coat colour is controlled by the *A/a* gene locus, where allele *A* codes for black coat colour, whereas tail shape is controlled by the *B/b* gene locus, where allele *B* codes for a kinked tail.

A black mouse with straight tail was crossed with an albino mouse with kinked tail. The cross produced the following offspring:

- 7 black mouse with kinked tail
- 7 black mouse with straight tail
- 8 albino mouse with kinked tail
- 5 albino mouse with straight tail

Based on the information above, what is the genotype of the parent mice that gave rise to the above results?

- A** $AAbb \times aaBB$
- B** $Aabb \times aaBb$
- C** $AaBb \times aabb$
- D** $AAbb \times aaBB$

22. Border collie dogs can have “stand up” ears, “flop down” ears or “mid way” ears. Ear type is controlled by a single gene.

A true breeding “stand up” ears Border collie was crossed with a true breeding “flop down” ears Border collie.



“stand up” ears



“flop down” ears

All the Border collies in the F_1 generation had “mid way” ears.

Based on the information given, which of the following statement(s) is/are valid.

- 1 The basis of inheritance for ear type is codominance, where the heterozygotes will have “mid way” ears.
- 2 The cross of two border collies with “mid way” ears will give rise to offspring with a phenotypic ratio of 1 : 2 : 1.
- 3 Ear type phenotype is controlled by one gene locus and three alleles.
- 4 The genotype of a border collie with “stand up” ears can only be determined by crossing with a border collie with “mid way” ears.

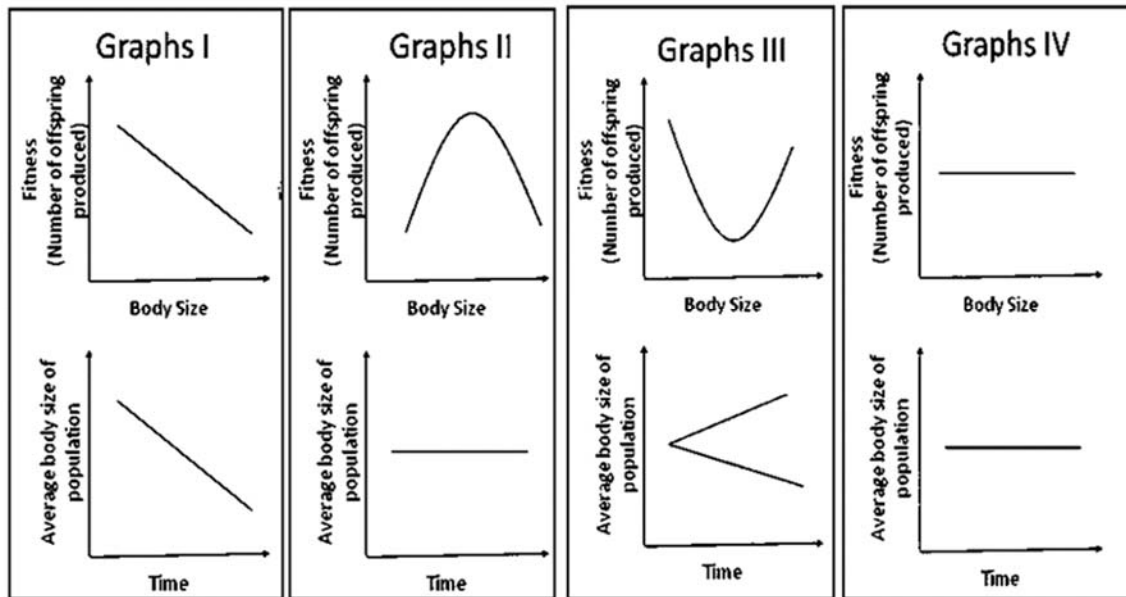
- A 2 only
- B 3 only
- C 1 and 2 only
- D 1, 2 and 4 only

23. Totipotency is demonstrated when _____.

- A cancer cells give rise to heterogeneous cell types
- B a stem cell can differentiate into placental cells and all cells in an organism
- C a hematopoietic stem cell differentiates into a lymphocyte
- D an embryonic stem cell divides and differentiates

- 24.** The use of induced pluripotent stem cells (iPSCs) overcome some of the following issues involving the use of other types of stem cells. Which issue below constitutes an ethical issue?
- I Embryonic stem cells are harvested from the blastocyst, which have the potential to develop into an adult and its use takes away a life.
 - II Stem cells are difficult to harvest from an individual as they are present in smaller proportions and are indistinguishable from non-stem cells.
 - III The use of embryonic stem cells in stem cell therapy may result in life threatening tissue rejection in the patient.
 - IV Consent on the use of embryonic stem cells is currently given by the parents but the potential being had no say.
- A** II and III
 - B** I and IV
 - C** I, III and IV
 - D** All of the above

25. The different forms of natural selection can be distinguished according to their effect on the body size of the pink salmon (*Onchorhynchus gorbuscha*).



Which of the following describes the correct form of natural selection for each of the following sets of graphs?

	Graphs I	Graphs II	Graphs III	Graphs IV
A	Directional selection	Stabilising selection	Disruptive selection	No selection
B	No selection	Directional selection	Disruptive selection	Stabilising selection
C	Stabilising selection	Directional selection	No selection	Disruptive selection
D	Disruptive selection	No selection	Stabilising selection	Directional selection

26. Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperms, and they selectively kill developing male embryos.

In the 1960s in Samoa, the proportion of male blue moon butterflies fell to less than 1% of the population. However, by 2006, the proportion of males was almost 50% of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

- I *Wolbachia* acts as a selective agent.
- II The selective killing of male embryos is an example of artificial selection.
- III When infected with *Wolbachia*, male embryos that are homozygous for the recessive allele of the suppressor gene die.
- IV All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.
- V The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

- A I and IV
- B II and III
- C I, III and V
- D II, IV and V

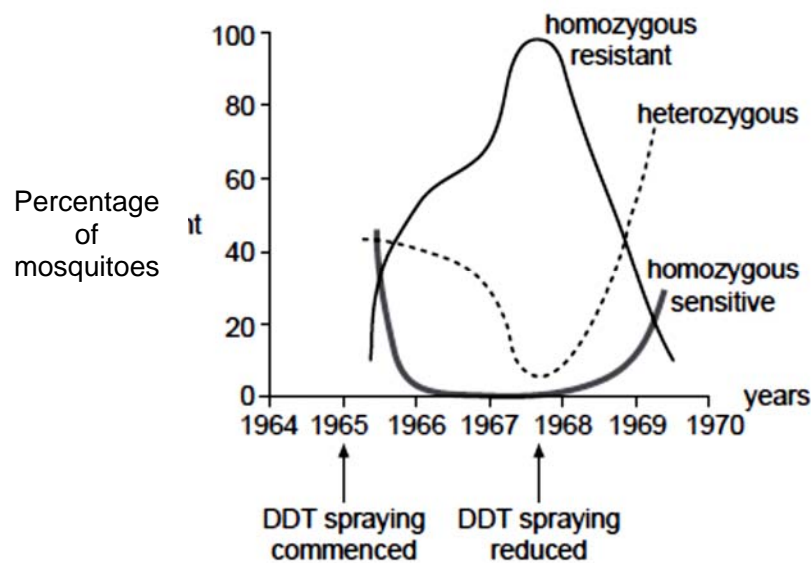
27. In the mid-1960s, DDT was widely used as an insecticide against mosquitoes. The sensitivity to insecticide in mosquitoes is determined by a single gene that has two alleles.

allele 1 : resistant to DDT

allele 2 : sensitive to DDT

Over several years, genotypic frequencies were measured in a population of mosquito larvae.

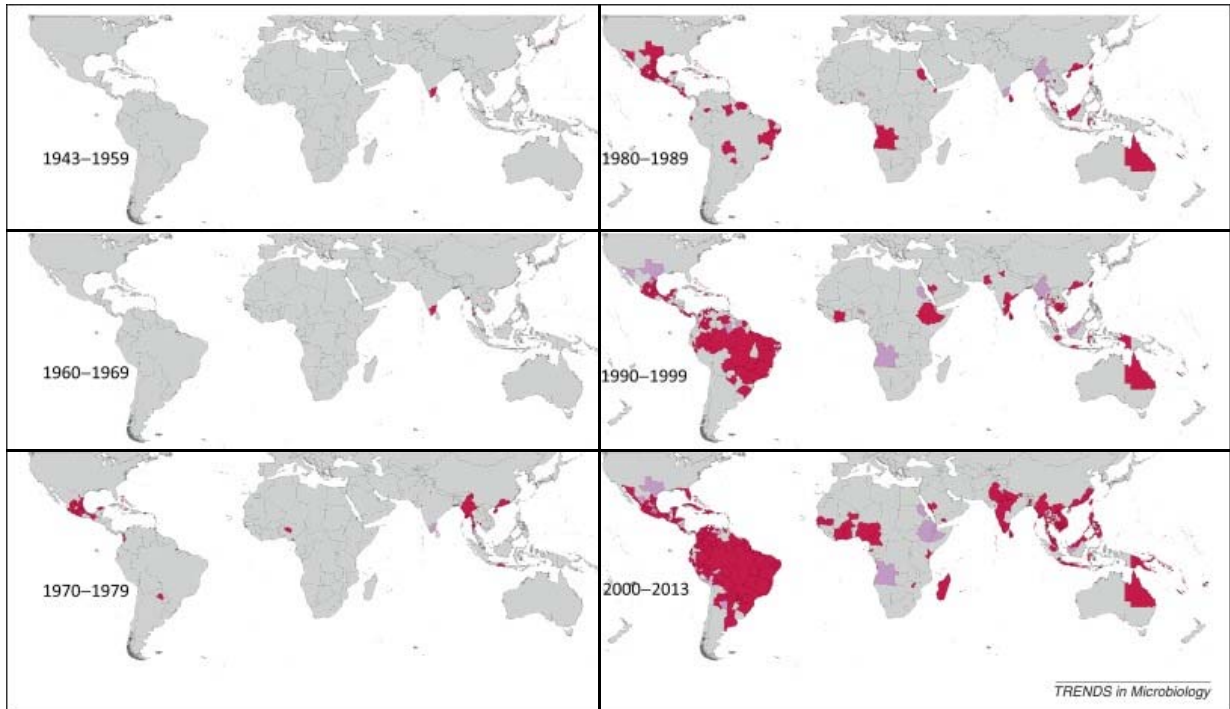
The graph below shows the results.



Analysis of the graph reveals that in the population, _____.

- A allele 1 confers a selective disadvantage in the absence of DDT.
- B heterozygote advantage is demonstrated after DDT spraying is reduced.
- C mutant allele 1 emerged as a result of the use of DDT in 1965.
- D only one copy of allele 1 is required for resistant phenotype.
28. Which of the following describes a positive feedback loop concerning climate change?
- A Increased atmospheric temperature result in melting of sea ice which decreases the amount of sunlight reflected back into space
- B Increased burning of fossil fuels increases atmospheric CO₂ concentration, enhancing the greenhouse effect
- C Melting of glaciers causes an increase in sea levels
- D Increase in atmospheric temperature causes many species to move towards increased altitudes to stay within their optimum temperature range

29. The diagram below shows the distribution of confirmed cases of dengue fever from 1943 to 2013.



Which of the following explain(s) the observed changes in distribution?

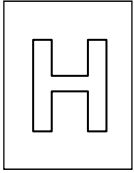
- I Increased global human traffic
 - II Increased global temperatures allows mosquitoes to survive better at increased latitudes
 - III Increased global temperatures allow mosquitoes carrying the dengue virus to move northwards
 - IV Increased global temperatures increases the replication rate of the dengue virus in mosquitoes
 - V Increased global temperatures reduces the replication rate of the dengue virus in humans
- A** II and V only
- B** II, III and IV only
- C** I, II and IV only
- D** All of the above

30. In the recent decades, human activities have contributed significantly to the increase in greenhouse gases, resulting in global warming.

Which of the following are not examples of such human activities?

- A Burning of fossil fuels
- B Conversion of land for agriculture
- C Increase consumption of meat
- D Overfishing

- End of Paper -



RAFFLES INSTITUTION
2018 Year 6 Preliminary Examination

Higher 1

CANDIDATE
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INDEX
NUMBER

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BIOLOGY

8876/02

Paper 2 Structured and Free-response Questions

13th September 2018

2 hours

Candidates answer on the Question Paper.
 Additional Materials: Writing paper.

READ THESE INSTRUCTIONS FIRST

Write your index number, CT group & name in the spaces at the top of this page.
 Write in dark blue or black pen.
 You may use a HB pencil for any diagrams or graphs.
 Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES

Section A

Answer **all** questions in the spaces provided on the Question Paper.6

Section B

Answer any **one** question in the writing paper provided.

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

You may lose marks if you do not show your working or if you do not use appropriate units

At the end of the examination, **hand in your essay question SEPARATELY.**

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

For Examiner's Use	
SECTION A	
1	/12
2	/9
3	/11
4	/7
5	/6
SECTION B	
6 or 7	/15
Total	/60

This document consists of **12** printed pages.



Raffles Institution
Internal Examination

[Turn over

SECTION A
Answer **all** questions.

- 1 Phosphofructokinase (PFK) is an allosteric enzyme made of 4 subunits and controlled by many activators and inhibitors which regulates glycolysis. PFK phosphorylates fructose-6-phosphate to form fructose-1,6-bisphosphate. This enables the cell to increase or decrease the rate of glycolysis in response to the cell's energy requirements. For example, a high ratio of ATP to ADP will inhibit PFK and glycolysis.

Fig 1.1 shows the effect of low ATP on Phosphofructokinase (PFK) activity.

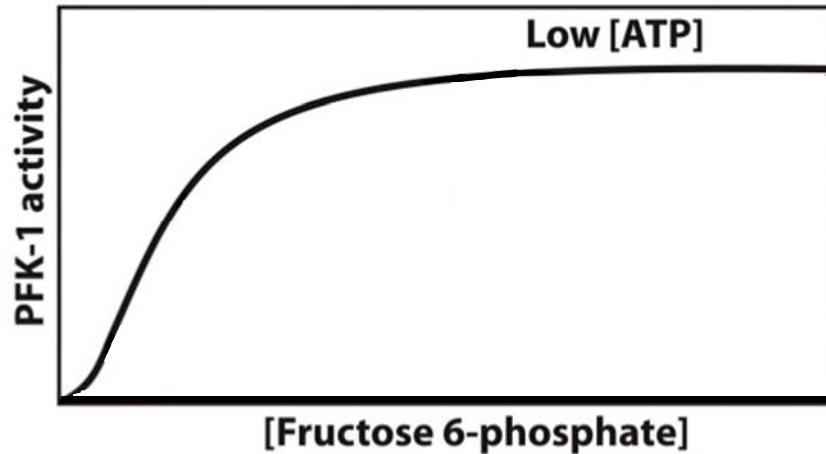


Fig 1.1

- (a) (i) On Fig. 1.1, draw a graph to show the effect of high ATP on PFK activity. [1]
(ii) Explain the graph you have drawn.

.....

 [3]

- (iii) Name a molecule that will act as an allosteric activator of PFK.
 [1]

2 During meiosis, the cell divides to produce gametes.

(a) Discuss the role of centromere in the production of gametes.

.....

.....

.....

.....

.....

.....

.....[3]

(b) Most human traits as well as medical conditions are under genetic influence.

A gene is found to control a rare disease, Wiskott–Aldrich syndrome (WAS) which is characterised by eczema, low platelet count and immune deficiency.

Another gene that controls hair type has 2 alleles. 1 allele results in straight hair, another codes for curly hair. Presence of both results in wavy hair.

In **couple 1**, a normal female with straight hair married a wavy-haired male suffering from WAS. Predicted phenotypic ratio of their offspring is as follows:

	WAS	Hair
Female	All normal	1 wavy : 1 straight
Male	All normal	1 wavy : 1 straight

For **couple 2**, a wavy-haired female suffering from WAS married a wavy-haired normal man. Predicted phenotypic ratio of their offspring is as follows:

	WAS	Hair
Female	All normal	1 curly : 2 wavy : 1 straight
male	All affected	1 curly : 2 wavy : 1 straight

(i) What is the mode of inheritance of the WAS disease?

.....[1]

(ii) Use suitable symbols to represent the alleles of the gene controlling WAS disease.

.....[1]

(iii) Use a genetic diagram to explain the results of **couple 2**.

[4]

[Total : 9]

- 3 **Fig. 3.1** shows the results of experiments investigating the effect of different light intensities on the rate of photosynthesis of cucumber plants measured as $\text{mm}^3 \text{CO}_2$ uptake per cm^2 leaf area per hour. The experiments were carried out at different temperatures and carbon dioxide concentrations.

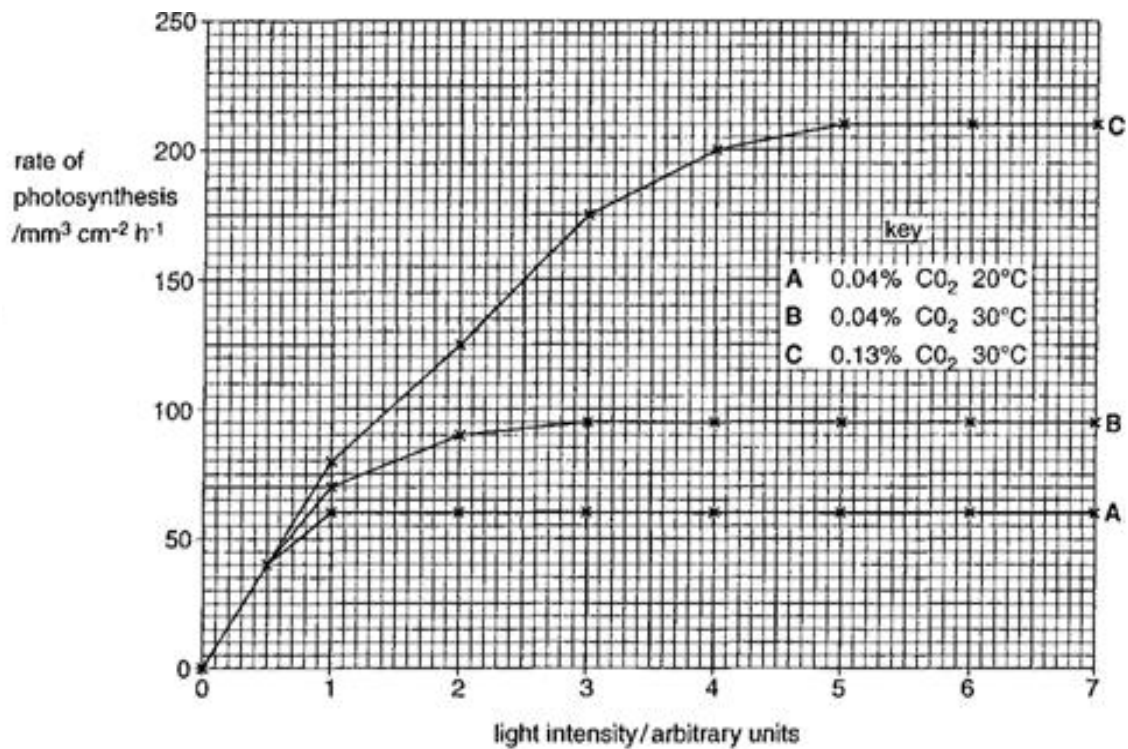


Fig 3.1

(a) (i) With reference to Fig. 3.1, state the best conditions for the growth of cucumber.
.....[1]

(ii) With reference to Fig. 3.1, explain reasons for the difference between curves B and C.
.....
.....
.....
.....
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.....[3]

(b) Fig. 3.2 shows the absorption spectra of various leaf pigments and the action spectrum for photosynthesis.

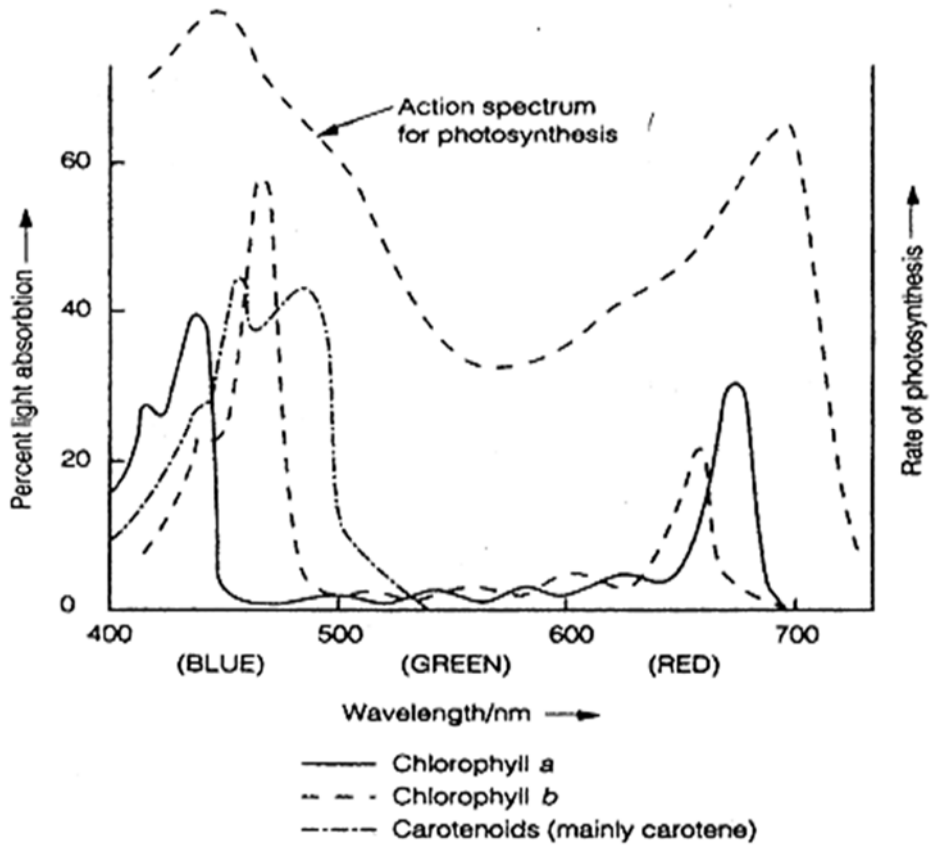


Fig. 3.2

With reference to Fig. 3.2,

(i) explain why most plants are characteristically green.

.....
.....
.....
.....[2]

(ii) explain the shape of the action spectrum.

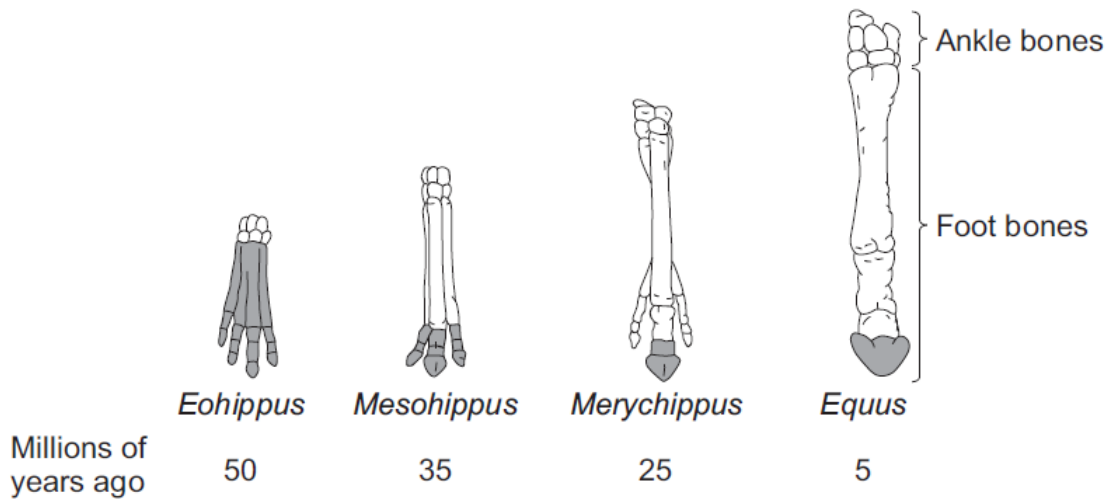
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.....
.....[3]

(c) In conducting experiments to obtain the action spectrum for photosynthesis, explain why the use of organic solvents such as acetone or ether is necessary to extract photosynthetic pigments.

.....
.....
.....
.....[2]

[Total: 11]

- 4 Fig. 4.1 shows changes in the foot bones of four ancestors of modern horses over the past 50 million years.



Key: The shaded bones are the bones which touched the ground.

Fig. 4.1

- (a) Describe two changes in the foot bones of horses that have taken place over the past 50 million years.

.....

[2]

- (b) *Eohippus* lived in swampy areas with soft mud. Since then, the ground in the habitat has become drier and harder. All of the horse ancestors were preyed upon by other animals.

- (i) Explain **one** advantage to *Eohippus* of the arrangement of bones in its feet.

.....
[1]

is an important indicator of changes in global climate because warmer air and water temperatures are reducing the amount of sea ice present.

Fig. 5.1 shows Arctic sea ice extent for the months of September and March of each year from 1979 through 2016. September and March are when the minimum and maximum extent typically occur each year.

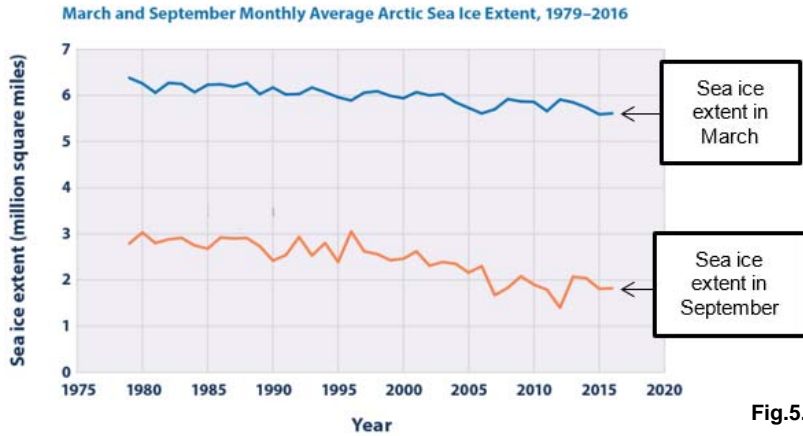


Fig.5.1

Fig. 5.2 shows the start and end of the sea ice melt season.

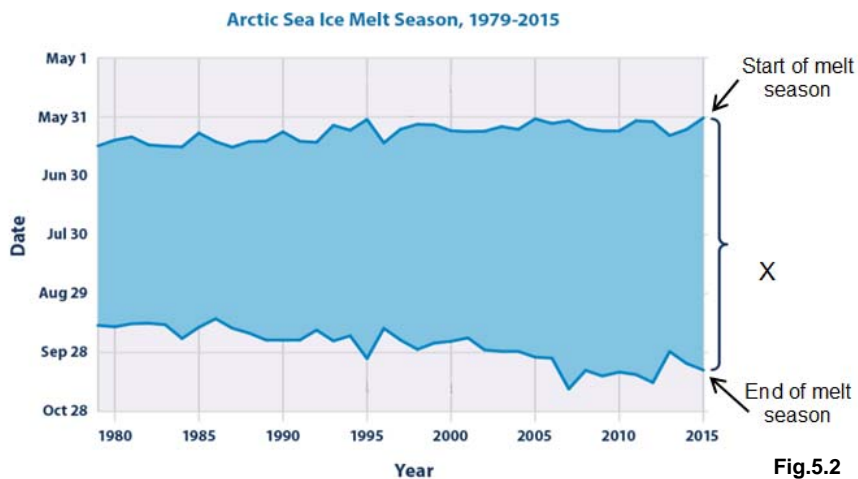


Fig.5.2

Fig. 5.3 shows the distribution of Arctic sea ice extent by age group during the week in September with the smallest extent of ice for each year.

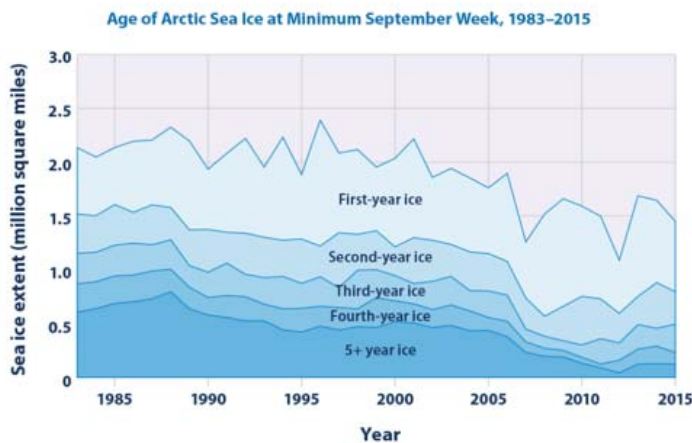


Fig.5.3

- (a) With reference to Fig. 5.1, suggest why the sea ice extent in March is different from that in

September.

.....
.....[1]

- (b)** With reference to Fig. 5.2,
(i) identify what **X** denotes.

.....[1]

- (i)** Describe how **X** changes from 1979 to 2015.

.....
.....[1]

- (ii)** Explain how this is linked to the changes in sea ice extent as shown in Fig. 5.1 and Fig. 5.3.

.....
.....
.....
.....
.....
.....
.....[3]

[Total: 6]

Section C

Answer one question in this section.

Write your answers on the separate writing paper provided.
Your answers should be illustrated by large, clearly labeled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections (a), (b) etc., as indicated in the question.

6 (a) Account for the importance of hydrogen bonds in biological organisms. [7]

(b) Describe the main features of replication of DNA. [8]

[Total: 15]

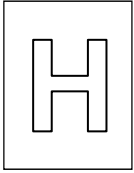
OR

7 (a) Discuss the diverse roles of membranes in a cell. [7]

(b) Describe the major properties of enzymes and discuss their mode of action. [8]

[Total: 15]

End of Paper



RAFFLES INSTITUTION
2018 Year 6 Preliminary Examination Suggested Answers

Higher 1

CANDIDATE
NAME

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CIVICS
GROUP

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INDEX
NUMBER

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BIOLOGY

8876/02

Paper 2 Structured and Free-response Questions

13th September 2018

2 hours

Candidates answer on the Question Paper.
 Additional Materials: Writing paper.

READ THESE INSTRUCTIONS FIRST

Write your index number, CT group & name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use a HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO NOT WRITE IN ANY BARCODES

Section A

Answer **all** questions in the spaces provided on the Question Paper.6

Section B

Answer any **one** question in the writing paper provided.

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

You may lose marks if you do not show your working or if you do not use appropriate units

At the end of the examination, **hand in your essay question SEPARATELY.**

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

For Examiner's Use	
SECTION A	
1	/12
2	/9
3	/11
4	/7
5	/6
SECTION B	
6 or 7	/15
Total	/60

This document consists of **10** printed pages.



Raffles Institution
Internal Examination

[Turn over

2018 Prelim H1 Answers:

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

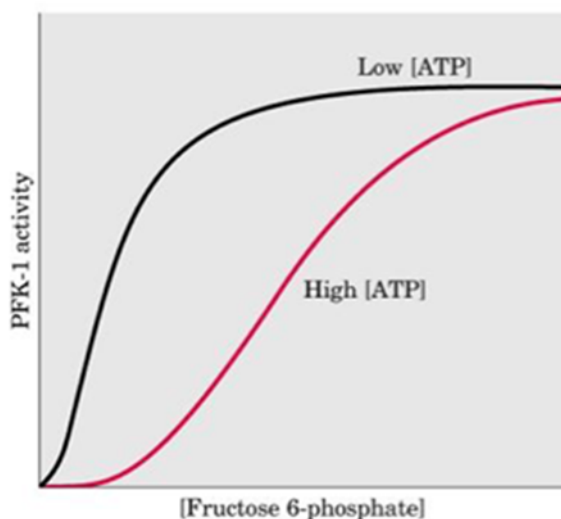
2018 Prelim H2 Suggested Answers

SECTION A

Answer **all** questions.

1

- (a) (i) On Fig 1.1, draw a graph to show the effect of high ATP on PFK activity [1]



- (ii) Explain the graph you have drawn. [3]

- 1) High levels of ATP inhibits PFK activity by lowering its affinity for fructose 6-phosphate.
- 2) ATP acts as an allosteric inhibitor which binds to an allosteric site which inhibits the PFK activity
- 3) $[V_{max}]$: inhibition can be overcome by high substrate concentrations;
- 4) [idea of cooperativity] binding of substrate to 1 subunit changes conformation of other subunits such that it becomes easier for substrate to bind;

- (iii) Name 1 molecule that will act as allosteric activator of PFK activity.[1]

AMP/ADP

(b)

(i) Describe the structure of PFK. [4]

- 1) PFK has a quaternary* structure made up of 4 polypeptide chains
- 2) Each of which has primary* structure which is the number and sequence of amino acid
- 3) The secondary* structure of PFK is made up of alpha helix and beta pleated sheets (name at least 1)
- 4) The tertiary* structure of PFK is formed by interaction of R groups of amino acid namely hydrogen bond, hydrophobic interaction, disulfide bond and ionic bond within the same polypeptide
- 5) The overall conformation of PFK is maintained by its primary, secondary and tertiary structure in addition to the interaction among the 4 polypeptide chains

(ii) Explain how a change in pH affect the PFK activity.[3]

- 1) Affects ionisation of R groups* of aa.
- 2) A change in pH will disrupt the ionic and hydrogen bond* that maintain the 3D conformation of active site of PFK
- 3) which will result in a change in 3D conformation of active sites* , no longer complementary in shape and charge to substrate / substrate cannot fit, hence
- 4) less enzyme-substrate complex* formed hence reducing the PFK activity

[Total : 12]

2
(a)

Discuss the role of centromere in the production of gametes.[3]

1. They allow (proteins called kinetochore proteins, and subsequently) spindle fibres, to attach; (MUST HAVE)

2a. resulting in proper alignment of chromosome singly in on equator in metaphase ;

2b. so that sister chromatids / daughter chromosome can be equally separated to opposite poles during Anaphase;

3a. resulting in proper alignment of bivalents on equator in metaphase ;

3b. so that homologous chromosomes can be equally separated to opposite poles during Anaphase 1;

(b)

(i) What is the mode of inheritance of the disease WAS? [1]
Sex-linked recessive

(ii) Use suitable symbols to represent the alleles of the gene controlling the disease WAS[1]

X^W : Dominant allele that codes for no WAS on X chromosome

X^w : recessive allele that codes for disease WAS on X chromosome;

Must show both alleles

Must have X chromosome on symbol

(iii) Use a genetic diagram to explain the results of couple 2. [4]

[1] parental phenotype and genotype;

P phenotype: wavy-hair female WAS sufferer x wavy-hair normal male ;

P genotype: $X^wX^wH^S H^C$ x $X^WYH^S H^C$

Gametes (n): X^wH^S X^wH^C x X^WH^S YH^S X^WH^C YH^C

[1] all correct gametes (circled) in P and F₁ gen

		Male gamete			
		X^WH^S	YH^S	X^WH^C	YH^C
Female gametes	X^dH^S	$X^wX^wH^S H^S$ Normal Straight hair female	$X^wYH^S H^S$ WAS sufferer, straight hair male	$X^wX^dH^S H^C$ Normal wavy hair female	X^wYH^S WAS suf wavy hair

	X^dH^C	$X^W X^w H^S H^C$ Normal wavy hair female	$X^w Y H^S H^C$ WAS sufferer, wavy hair male	$X^W X^d H^C H^C$ Normal curly hair female	$X^w Y H^C H^C$ WAS sufferer, curly hair male
--	----------	---	--	--	--

[1] Punnett square with correct genotypes and related phenotypes (marker to note, don't need phenotype)

offspring genotypic ratio	$X^W X^d H^S H^S$	$X^W X^w H^S H^C$	$X^W X^w H^C H^C$	$X^w Y H^S H^S$	$X^w Y H^S H^C$	$X^w Y H^C H^C$
offspring phenotypic ratio	Normal Straight hair female	Normal wavy hair female	Normal curly hair female	WAS sufferer, straight hair male	WAS sufferer, wavy hair male	WAS sufferer, curly hair male
	1	2	1	1	2	1

[1] Correct F_2 genotypic and phenotypic ratio

[Total : 9]

3

- (a) (i) With reference to **Fig. 3.1**, state the best conditions for the growth of cucumber. [1]
0.13% carbon dioxide, 30°C, above 5 arbitrary units of light;
- (ii) With reference to **Fig. 3.1**, explain reasons for the difference between curves B and C. [3]
- Curve B reaches a plateau at rate of photosynthesis of $95 \text{ mm}^3 \text{ cm}^{-2} \text{ h}^{-1}$ at lower light intensity of 3 units, whereas Curve C reaches a higher maximal rate of photosynthesis of $210 \text{ mm}^3 \text{ cm}^{-2} \text{ h}^{-1}$ at higher light intensity of 5 units; (idea of : max rate being different, with values)
 - due to presence of higher CO_2 concentration at 0.13 (graph C);
- OR
- Curve B: reaches max rate at light intensity of 3 units, while Curve C reaches max rate at light intensity of 5 unit
 - light intensity is no longer a limiting factor as any further increase in light intensity does not affect rate of photosynthesis. Hence, CO_2 concentration becomes limiting;
- (max 2 from 1 and 2 or 3 and 4)
- Plant C achieve higher rates of photosynthesis as compared to B, because higher CO_2 / substrate concentration during **carbon fixation*** in Calvin cycle.
 - results in **higher frequency of effective collision*** with enzyme Rubisco (and RuBP), thus **more enzyme-substrate complexes*** being formed;
- (b) With reference to **Fig. 3.2**,
- (i) explain why most plants are characteristically green [2]

1. Percentage of green light absorbed by (all 3 pigments – marker discretion) is very low at less than 5%;
2. Green light is reflected / transmitted;

For reference: Blue ~ 490–450 nm, red ~ 635-700 nm

(ii) explain the shape of the action spectrum. [3]

1. Peak(s) of action spectrum/ highest rate of photosynthesis, correspond to absorption peak(s) (Idea of : action spectrum = sum of absorption of all pigments) ;
2. Light absorbed by different photosynthetic pigments is used for photoactivation/ photosynthesis
3. thus higher percentage of light absorption leads to higher rate of photosynthesis in red and blue light; (idea of : chl a peak corresponding to action spectrum peak)
4. carotenoids / chl b absorbed at blue and red light, broadening the range of wavelength that can be used for photosynthesis
5. Region between 500 to 600 nm (R: green) is not an exact match between absorption and action spectra due to role of other accessory pigments

(c) In conducting experiments to obtain the action spectrum for photosynthesis, explain why use of organic solvents such as acetone or ether is necessary to extract photosynthetic pigments. [2]

1. Chlorophyll pigments are membrane-bound (A: thylakoid and chloroplast membranes);
2. Only organic solvents can dissolve the membrane, that is composed of a phospholipid bilayer;

[Total: 11]

4

(a) Describe two changes to the bones in the feet of horses that have taken place over the past 50 million years.[2]

1. The bones became larger/longer/thicker;
2. The number of bones became fewer/idea of fewer toes or bones fused;
3. Fewer bones touched the ground/lower surface area in contact with the ground;

(b)

(i) Explain **one** advantage to *Eohippus* of the arrangement of bones in its feet.[1]

1. With a larger surface area (inference of data) in contact with the ground, it can distribute its weight and not sink into the soft mud/ can escape predators (advantage);

Must have context specific info and clear advantage.

(ii) Based on the information given, explain how the changes in the arrangement of the foot bones of horses support Darwin's theory of evolution by natural selection.[4]

1. It shows descent with modification from a common ancestor;
2. There was variation in the size/number/arrangement of foot bones in the population; (context specific)
3. The environment changed from swampy to hard and firm ground; (envt change,

- quote)
4. They faced selection pressure of predation; (idea of selection pressure, quote)
 5. Natural selection selected for individuals who had larger/fewer foot bones as they are; (selected traits)
 6. Able to run faster on firm ground to avoid predation; (suggest why trait is an advantage)
 7. Those who survive, are able to reproduce and pass on their alleles for larger/fewer bones to the next generation;

[Total: 7]

5

- (a) With reference to **Fig. 5.1**, suggest why the sea ice extent in March is different from that in September. [1]

March – maximum sea ice after sea water freezes in the winter/colder months
September – minimum sea ice after melting in the summer/hotter months

- (b) (i) Identify X shown in **Fig. 5.2**. [1]
X: duration of sea ice melt;
- (i) Describe how X changes from 1979 to 2015. [1]
1. X increased by about a month from 1979 to 2015
 2. Sea ice melt season is starting earlier and ending later, melt season spanning from mid june to mid sept in 1979, to late may to late sept in 2015;
- (ii) Explain how this is linked to the changes in sea ice extent as shown in Fig. 5.1 and Fig. 5.3. [3]
1. Longer sea ice melt season results in more ice melting, lowering minimum sea ice extent observed in September; (Fig. 5.1)
 2. This also means that less time is available for formation of sea ice in the winter months;
 3. Resulting in a consistent decrease in maximum sea ice extent seen in March (Fig. 5.1);
 4. Longer duration of sea ice melt resulted in less ice remaining frozen past the melt season;
 5. As seen in the decrease in the amount / proportion of multi-year old ice (Fig. 5.3);
 6. Which implies thinning of ice cover over the years;

Section C

Answer one question in this section.

Write your answers on the separate writing paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

6 (a) Account for the importance of hydrogen bonds in biological organisms. [7]

Ref to H2 answers

(b) Describe the main features of replication of DNA. [8]

1. Replication of DNA is semi-conservative* where both of the original strands of the double helix separate* and act as templates* for the synthesis of two new strands;
2. This gives rise to new/daughter DNA molecule which consists of one original and one newly synthesised strand;
3. replication of DNA begins at the origin of replication* where enzyme helicase* will bind and unzip* the DNA molecule by breaking hydrogen bonds* between complementary base pairs;
4. separated strands of DNA interact with the single stranded DNA binding proteins* so that it will remain single stranded and can serve as a template* for replication;
5. Topoisomerase* relieves "overwinding" strain ahead of replication forks by breaking, swivelling and rejoining DNA strands;
6. enzyme primase* catalyses the synthesis of a short RNA primer;
7. Complementary base pairing of free deoxyribonucleotide triphosphates (dNTP) such as dATP, dTTP, dGTP and dCTP with the nucleotides on the template occurs;
8. Purines Adenine and Guanine base pairs with pyrimidines Thymine and Cytosine respectively;
9. DNA polymerase* catalyses the formation of phosphodiester bond* linking DNA nucleotides;
10. and the new DNA strand is synthesised in the 5' to 3' direction*;
11. RNA primers* will then be removed and replaced with DNA by another DNA polymerase;
12. one of the daughter strands known as the leading strand* will be synthesised continuously;
13. the other strand known as the lagging strand* is synthesised discontinuously, giving rise to Okazaki fragments*;
14. DNA ligase* catalyses the formation of phosphodiester bond* between the Okazaki fragments;

R: If use ATGC without spelling the full word. Molecule of DNA refers to double stranded helix. Strand refers to a single polynucleotide. No exceptions accepted

OR

7 (a) Discuss the diverse roles of membranes in a cell. [7]

Ref to H2 answers

(b) Describe the major properties of enzymes and discuss their mode of action. [8]

Properties of enzymes

1. Most enzymes are globular proteins which are soluble and can be transported
2. Enzymes have active sites which are complementary in shape and charge to substrates
3. Enzymes can be denatured by temperatures and pH
4. Enzymes are required in small amount and can be reused

5. Enzymatic reactions can be inhibited by competitive or non-competitive inhibitors which slows down the rate of reaction of enzymes
6. Enzymatic reactions can be regulated by end-product inhibition

Mode of action of enzymes

7. Enzymes have an **specific* active site*** which is **complementary in shape/conformation and charge*** to the substrate;
8. **Effective collisions between enzyme and substrate form a temporary enzyme-substrate complex***;
9. Based on the **lock and key*** hypothesis, **enzyme** is the **lock*** and **substrate** is the **key*** (lock and key hypothesis) Or
10. Based on the **induced fit*** hypothesis, substrate **induces a change in shape** in enzyme active site so that **active site is a more precise fit for substrate** for effective catalysis.
11. Enzyme-substrate complex held together by **weak interactions e.g. hydrogen, ionic bonds, hydrophobic interactions***
12. **Catalysis** - Enzyme **lowers the activation energy*** barrier by
13. Aligning substrates next to each other (close proximity) in active site for reaction to occur (any one of following elaboration)
 - Strain on bonds to be broken / distorts the substrate and reduces activation energy to achieve transition state
 - Orientates substrate such that its bonds are exposed to attack
 - Provide a favorable microenvironment
 - R-groups of amino acid residues in active site participate in direct catalysis – e.g. Acid-base catalysis
14. **Products no longer fit active site** and are **released** → enzyme is **unchanged** and **can be used again**;