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JURONG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE NAME

CLASS

BIOLOGY 8875/02

Paper 2 Core Paper **26 August 2016**

Additional Materials: Answer Paper **2 hours**

READ THESE INSTRUCTIONS FIRST

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

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

Section B
Answer any **one** question on the answer paper provided.
Circle the question number of the question attempted.

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

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

For Examiner's Use	
Section A	
1	
2	
3	
4	
Section B	
5 / 6	
Total	

This document consists of **12** printed pages and **2** blank pages.

[Turn over

Section A

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

1 Fig. 1.1 shows the effect of increasing temperature on the activity of an enzyme required in the synthesis of proteins.

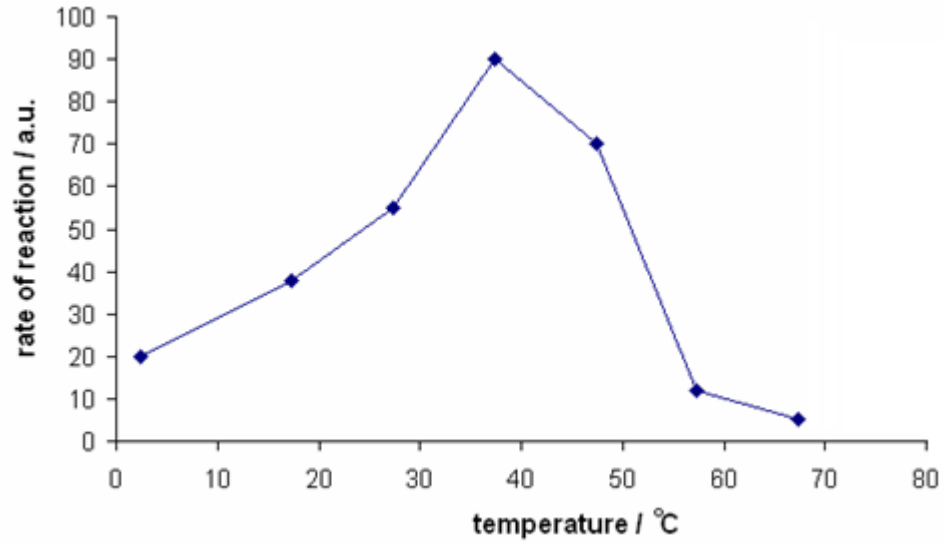


Fig. 1.1

(a) With reference to Fig. 1.1, describe and explain the effect of increasing temperature above 37^{0}C for this enzyme. [3]

1. **As temperature increases from <u>37ºC to 67ºC</u>, rate of reaction decreases from <u>90a.u. to 5a.u</u>.;;**
2. **despite enzymes and substrates having <u>increased kinetic energy</u> and <u>higher frequency of collisions</u>, <u>rate of reaction decreases</u>;;**
3. **because heat has <u>broken the hydrogen bonds and hydrophobic interactions</u> within the secondary and tertiary structures of enzyme and (polypeptide unfolds,) causing a <u>loss of</u> the (precise) <u>three-dimensional conformation of enzyme's (active site)</u> and enzyme denaturation occurs;; A: loss of (tertiary) structure/shape**
4. **Loss of 3D conformation of active site results in substrate not being able to fit into enzyme active site, rate of formation of enzyme-substrate complexes decreases, hence rate of reaction decreases;;**
   [max 3]

   Reject:
   Less successful collision frequency, hence lower rate of formation of enzyme-substrate complexes. The enzymes and substrates collide more often because of higher kinetic energy due to higher temperatures, but due to denaturation and loss of enzyme active site complementarity with substrate, ES complex formation is low.

Fig 1.2 shows an event occurring during synthesis of the enzyme.

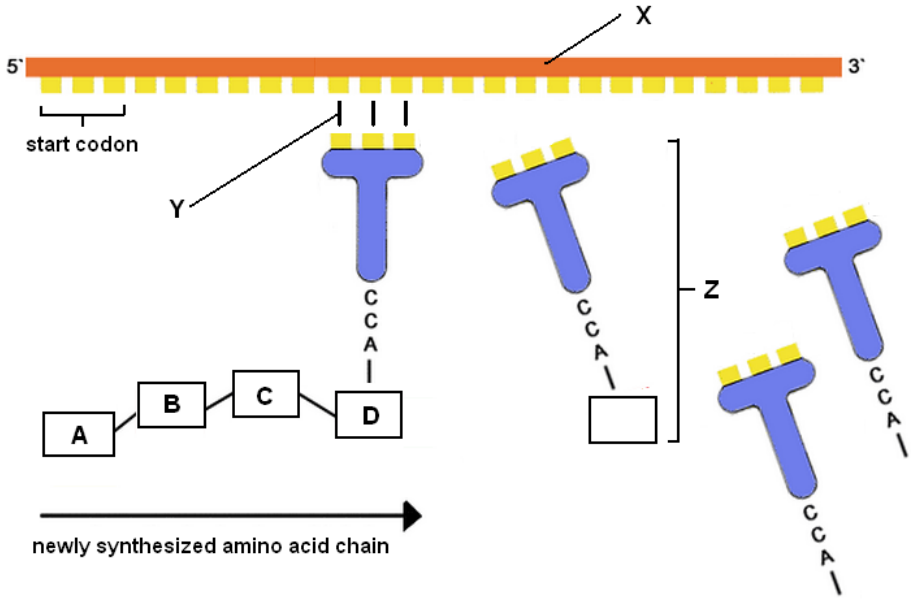


Fig. 1.2

(b) With reference to Fig. 1.2,

(i) identify [1]:

Molecule **X**: **mRNA;**

Bond **Y**: **Hydrogen bond;**

(ii) state the sequence of DNA bases (including the 5' and 3' orientation) coding for amino acid **A**; [1]

1. **3' TAC 5';;**

(iii) describe how molecule **Z** is formed. [2]

1. **A <u>specific amino acid</u> is joined/<u>attached to (the 3'end of) tRNA</u>/CCA stem of tRNA;;**
2. **forming <u>aminoacyl-tRNA</u>, catalysed by a <u>specific aminoacyl-tRNA synthetase</u>;;**
3. **ATP is required;;**
   (penalise once for no "specific")

Fig 1.3 shows the structure of a release factor consisting of a polypeptide made up of 722 amino acids. It is involved in the termination stage of protein synthesis in eukaryotes.

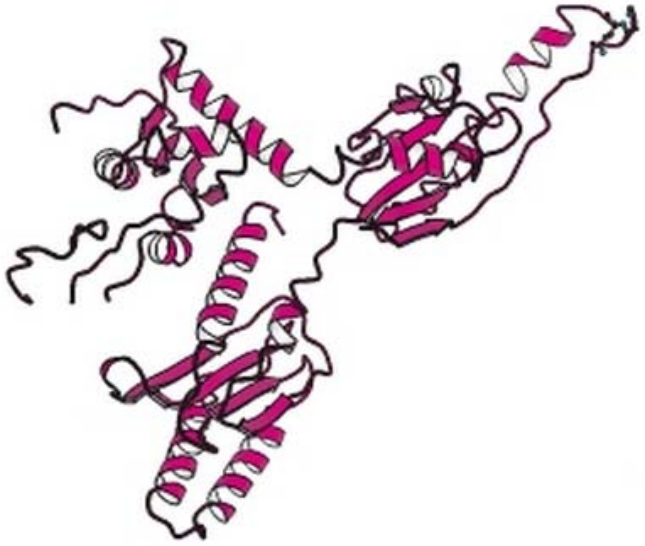


Fig. 1.3

(c) Using your biological knowledge,

(i) describe the termination stage of protein synthesis; [3]

1. **<u>Stop codon</u> (e.g. UAA, UAG and UGA) on <u>mRNA</u> encountered by the <u>ribosome</u>, ribosome stops translocating;;**
2. **<u>Protein release factor</u> would <u>recognise and bind to the stop codon</u> on the mRNA;;**
3. **<u>Addition of water molecule causes hydrolysis/cleavage of the ester linkage</u> of the fully-translated <u>polypeptide from the tRNA,</u> <u>releases polypeptide from ribosome</u>;;**

(ii) suggest why it is important for the release factor to be similar to tRNA in structure. [1]

1. **So that it can fit into the A site of the large ribosomal subunit;; OR**
2. **So that it can recognize and bind to the stop codons;;**

[Total: 11]

2 A pure-breeding variety of tomato plant, variety A, produced red fruits with green bases even when ripe.

Plants of variety A were crossed with another pure-breeding variety, B, with orange fruits which have no green bases when ripe. The F_1 generation plants all had red fruit with green bases.

(a) Define what is meant by a pure breeding plant. [1]

1. A plant that is homozygous at all gene loci OR produces only offspring of the same variety when it is self-pollinated;;

(b) Using the symbols,

G/**g** to represent allele for green-based or non green-based fruit
R/**r** to represent allele for red or orange fruit;

state the genotypes of variety **A** and **B.** [1]

1. A: RRGG B: rrgg ;;

(c) (i) Plants from the F_1 generation were crossed to variety B and the offspring were recorded:

red fruit, green base	55
red fruit, non-green base	56
orange fruit, green base	54
orange fruit, non-green base	55

Draw a genetic diagram to show that the expected phenotypic ratio of offspring phenotypes is 1:1:1:1. [4]

Parental phenotype **red fruit with green base** **X** **orange fruit with non-green base**
Parental genotypes **RrGg** **X** **rrgg** **;;**
Gametes;;

	RG	Rg	rG	rg
rg	**RrGg**	**Rrgg**	**rrGg**	**rrgg**

Offspring genotypes **RrGg** **Rrgg** **rrGg** **rrgg** **;;**

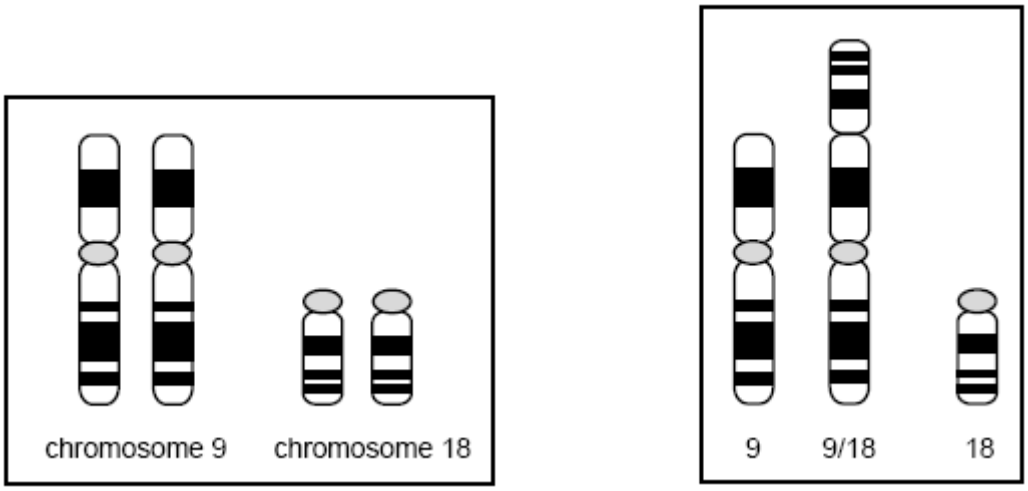
Offspring phenotypes **red fruit, green base** **red fruit, non green base** **orange fruit, green base** **orange fruit, non green base**
Phenotypic ratio **1 : 1 : 1 : 1** **;;**

(ii) State the name of this type of cross. [1]

1. **Test cross;;**

The genes for fruit base colouration and fruit colour were found on chromosome 9 and 18 of the tomato plant genome respectively.

It was found that prolonged exposure of plants to a chemical, ethyl methanesulfonate (EMS) led to plants with chromosomal abnormality. Fig 2.1 shows the karyotypes of a normal plant and plant that has been exposed to EMS. Plants exposed to EMS tend to have fruits with pale colour without any base colour.



Normal plant Plant exposed to EMS

Fig. 2.1

(d) With reference to Fig. 2.1, suggest why plants treated with EMS had fruits with pale colour without base colour. [2]

1. **Translocation of chromosome 18 to chromosome 9;;**
2. **Results in non-functional gene product/protein for fruit colour and fruit base colour;;**
3. **Only one copy of allele to code for fruit colour and fruit base, giving rise to less gene product and thus lighter fruit colour;;**

[Total: 9]

3 Hawaiian honeycreepers are a family of small birds native Hawaiian Islands. Fig. 3.1 shows the evolutionary relationships of Hawaiian honeycreepers and its distribution at various islands. All species of Hawaiian honeycreepers evolved from a single ancestral species, which arrived on the islands long ago. Each species has a unique beak shape.

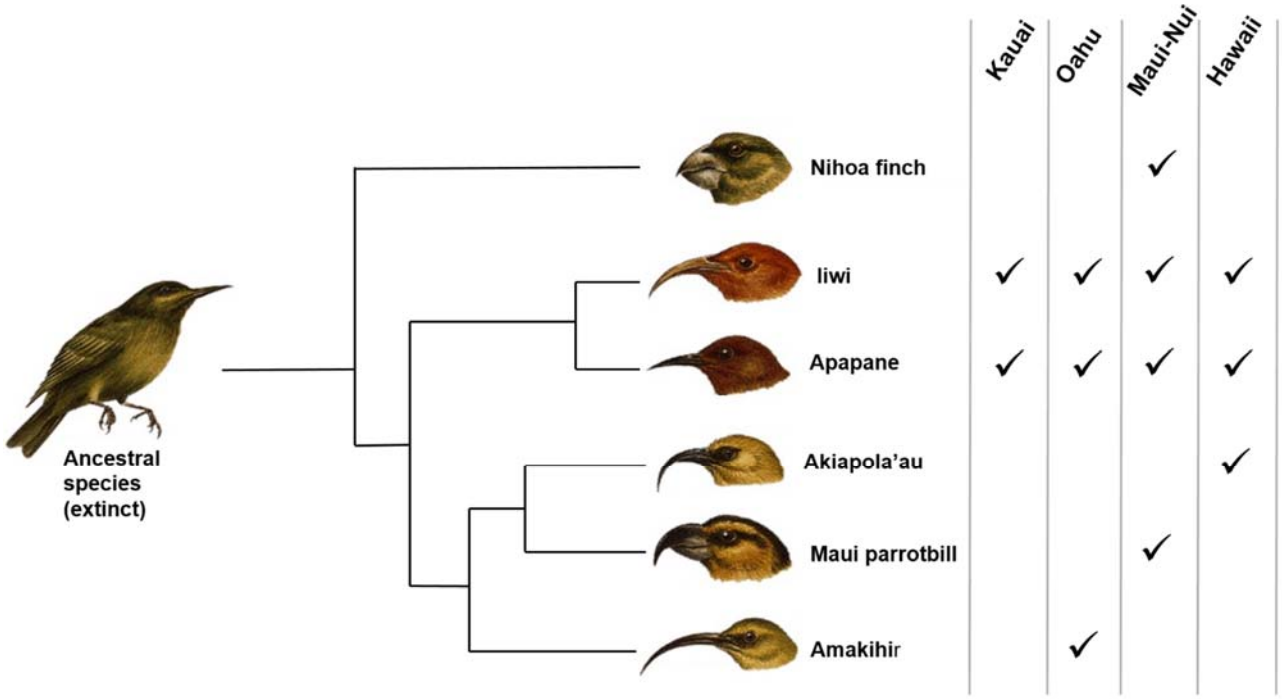


Fig. 3.1

(a) Explain how natural selection leads to different beak shape in Hawaiian honeycreepers on different islands. [5]

1. **Spontaneous mutations result in variations of beak shape within populations of Hawaiian honeycreeper;;**
2. **Selection pressure is the <u>types of food available</u> on each island i.e. insects/seeds/nectar;;**
3. **Individuals with beak shapes best adapted to feeding on particular food type will be selected for/at selective advantage;;**
4. **and survive to maturity, mate, passing on their advantageous alleles to their offspring;;**
5. **resulting in a change in allele frequency in the population over time leading to evolution;;**

(b) Although most species only inhabit one island, some species such as Iiwi and Apapane can thrive on all the four islands.

With reference to the evolution of beak shape, suggest why this is possible. [1]

1. **Each species has a beak shape that is adapted to certain selection pressure/ type of foods and this <u>same selection pressure be found in all the four islands</u>;;**

(c) The beak shapes in Fig. 3.1 is an example of anatomical homology and can be used as an evidence of evolution.

(i) Explain what is meant by 'homology'. [1]

1. <u>Similarity</u> in characteristics resulting from <u>common ancestry</u>;;

(ii) Describe with example, one other type of homology used to support evolution. [2]

1. **Molecular homology are similarities in DNA nucleotide / amino acid sequences of homologous genes that are derived from a common ancestor;;**
2. **Examples of homologous genes in different animals are β chain haemoglobin genes/cytochrome oxidase genes (any one) which are derived from a common ancestor;;**
   OR
3. **Embryological homology refers to similar patterns of embryological development that indicate they share a common ancestor;;**
4. **For example, all vertebrate embryos have structures called pharyngeal pouches in their throat regions at some stage in their development;;**

[Total: 9]

4 Plants in the milkweed family are an important food source of the Monarch butterfly larvae. During corn pollen shedding, corn pollen can fall on the leaves of milkweed plants when they occur in or near cornfields. Any Monarch larvae that feed on these plants are potentially exposed to corn pollen. A study was carried out to determine if pollen from Bt corn could be harmful to the larvae of the Monarch butterfly. The results are shown in Table 4.1.

Table 4.1

	Pollen density/grains per cm^2	**Average length of larvae/mm**	**Mortality rate after 5 days of exposure/%**
Larvae feeding on leaves coated with Bt pollen	0	27.4	10.0
	14	26.9	10.6
	75	26.5	11.3
	200	24.0	40.2
Larvae feeding on leaves coated with non-Bt pollen	0	27.8	10.5
	14	27.1	10.7
	75	26.9	10.0
	200	27.5	10.5

(a) With reference to Table 4.1, describe the effects of Bt pollen density on the mortality rate of the larvae after 5 days of exposure. [2]

1. **0-75 grains per cm^2, % mortality remains roughly constant at 10.6 – 11.3%;;**
2. **200 grains per cm^2, % mortality increases from 11.3 to 40.2%;;**

(b) Discuss the extent to which the results in Table 4.1 confirm that growing Bt corn is harmful to the larvae of the Monarch butterfly. [2]

1. **Growing Bt corn is not harmful to the larvae of the monarch butterfly;; / harmful only at high concentration;;**
2. **Only concentration as high as 200 grains per cm^2 to cause larvae to die/ result in high mortality rate;;**
3. **At the other pollen density i.e. 14 and 75 grains per cm^2 of, mortality rate is about the same for larvae feeding on both types of pollen;;**
4. **Larvae feeding leaves coated with pollen from Bt corn and those coated with pollen free of Bt did not show much difference in average length;;**
   [Max 2]

(c) Other than potential environmental impact mentioned in (b), discuss the ethical issues involved in the production of genetically modified (GM) food. [2]

1. **Tampering with nature by mixing genes among species may evoke strong responses from naturalists as many view this as going against natural way of life;;**
2. **Labelling issues - where consumers may not have information to make an informed choice;;**
3. **Improper use of animals - violation of animal rights / cruelty to animals /results in animal deformity;;**
4. **Accountability of biotechnological and agricultural firms with respect to GMOs;;** ***[max 2]***

The polymerase chain reaction (PCR) is a molecular technique which amplifies a section of DNA from a minute starting amount.

(d) Using your biological knowledge,

(i) explain why the nucleotide sequence of the DNA primers is critical to its function in PCR; [2]

1. **Primer has to be <u>complementary</u> to the <u>3' regions</u> of the target sequence to be amplified;;**
2. **Ensures <u>specificity</u> – only the sequence of interest is amplified;;**
3. **Provides <u>free 3'-OH end</u> for *Taq* polymerase to add free DNA nucleotides to;;**

(ii) explain how the ability of Taq polymerase to function at high temperature is an advantage in PCR. [2]

1. ***Taq* polymerase can withstand high temperature hence it will not denature at high temperature, so it can be used in PCR during the denaturation stage (95^{o}C);;**
2. **Allows technique to be fully automated;;**
3. **As there's no longer the need to replace the enzyme after every cycle;;**

PCR is also used as part of the protocol for detecting DNA sequences from GM foods. PCR can be used to amplify specific DNA sequences which are unique to GM foods. The PCR products can then be used for analysis to identify these unique sequences.

(e) Suggest how PCR can be used to detect these unique sequences in GM foods. [1]

1. **Primers that are <u>complementary to foreign gene / sequence</u> have to be designed for PCR e.g. bacterial *Bt* gene in Bt corn plants / Chinook salmon growth hormone gene and ocean pout promoter sequence in GM salmon / bacterial and daffodil genes in Golden Rice plants / antibiotic-resistance selectable marker genes;;**

[Total: 11]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

5 **(a)** Describe the specific roles of the cell surface membrane components. [8]

A. <u>Phospholipids [1]</u>

1. Phospholipids form a <u>phospholipid bilayer</u> which act as a <u>selectively permeable</u> membrane;; [1]

B. <u>Proteins [max 3]</u>

2. Transport – Act as (hydrophilic) channel proteins for facilitated diffusion of polar molecules and ions;;
3. Act as carrier proteins for active transport by which hydrolysing ATP to actively pump substances across the membranes;;
4. Act as enzymes;;
5. Act as receptors in signal transduction;;
6. For cell to cell adhesion;;
7. Attachment to the cytoskeleton and Extracellular Matrix (ECM);;

C. <u>Glycoproteins [max 1]</u>

8. Cell-cell recognition − the carbohydrate chain (oligosaccharides) function as a marker that distinguish one cell from another;;
9. Cell-cell adhesion – For binding cells together into tissues;;
10. Receptor sites for chemical signals (e.g. hormones);;

D. <u>Cholesterol [max 3]</u>

11. Acts like a plug, reducing the escape or entry of polar molecules across the membrane;;
12. Increases flexibility and stability of membranes;;
13. At (relatively) warm temperatures, cholesterol restrains the movement of phospholipids / makes the membrane less fluid / additional interactions with phospholipids, prevent cell membrane from breaking;;
14. At (relatively) low temperatures, cholesterol hinders the close packing of phospholipids / makes the membrane more fluid;;
15. lowers the temperature required for the membrane to solidify, prevent cell membranes from breaking up;;

(b) Describe how substances can be brought across a membrane by facilitated diffusion, active transport, endocytosis and exocytosis. [8]

A. Facilitated Diffusion [max 2]
1. **Involves carrier protein or channel proteins;;**
2. **Allows polar molecules and ions to pass though membrane;;**
3. **Occurs down a concentration gradient / Does not involve energy;; (needed for full credit)**
4. **Substance is brought in by a change in conformation of a carrier protein;;**
5. **Substance passes through a hydrophilic channel for channel proteins;;**

B. Active Transport [max 2]
6. **Involves carrier proteins;;**
7. **Allows polar molecules and ions to pass though membrane;;**
8. **Occurs against a concentration gradient;; (needed for full credit)**
9. **Requires energy in the form of ATP;;**
10. **Substance is brought in by a change in conformation of a carrier protein;;**

Endo/Exo-cytosis
11. **Also known as 'bulk transport' requires energy in the form of ATP;;**

C. For endocytosis, [max 2]
12. **It is a process by which materials are brought into the cells (materials are too large or too hydrophilic to enter via diffusion);;**
13. **The plasma membrane invaginates to envelope the materials;;**
14. **The invagination becomes sealed off to form a endocytic vesicle (which moves into the body of the cell);;**

D. For exocytosis, [max 2]
15. **It is a process by which materials are released from cells;;**
16. **A vesicle containing the material moves towards the surface of the cell;;**
17. **Its membrane fuses with the plasma membrane and becomes part of it;;**
18. **The vesicles then open to the exterior and its content leave the cell;;**

(c) Distinguish between non-cyclic and cyclic photophosphorylation. [4]

Features	Non-cyclic photophosphorylation	Cyclic photophosphorylation
Conditions under which process occurs	Non-cyclic photophosphorylation takes place when plants require ATP and NADPH	Cyclic photophosphorylation takes place when plants require only ATP
Photosystem involved	Both photosystem I and II are involved	Only photosystem I are involved
Pathway of electrons	Electrons travel along a non-cyclic pathway e.g. from special chlorophyll a of PS II to PS I and to $NADP^+$	Electrons travel along a cyclic pathway e.g. from special chlorophyll a of PS I back to PS I $^+$
First electron donor	First electron donor is water	First electron donor is special chlorophyll a of PSI
Last electron acceptor	Last electron acceptor is $NADP^+$	Last electron acceptor isspecial chlorophyll a of PSI
Products	Products are ATP, NADPH and oxygen	Product is only ATP
ETCs involved	Two different ETCs are involved	Only one ETC is involved – the ETC between PSII and PSI

Each comparison =1 mark **[max 4]**

[Total: 20]

6 **(a)** Describe the structure and function of the rough endoplasmic reticulum and chloroplast. [8]

Rough ER

1. **Consists of a network of sheets;;**
2. **Ribosomes are present on the membrane of the rough ER;;**
3. **Rough ER membrane is continuous with the outer membrane of the nuclear envelope;;**
4. **hence the space between membranes of the nuclear envelope is continuous with the cisternal space of the ER;;**
   max 2 marks

5. **Site of protein synthesis – proteins destined for secretion out of the cell via exocytosis or for incorporation into membranes are synthesised by ribosomes attached to the rough ER;;**
6. **The proteins are transported through the pore in the ER membrane into the ER lumen, where biochemical modification takes place / proteins may be modified by enzymes in the ER lumen that add carbohydrate chains (or lipids) to them – glycosylation;;**
7. **Forms part of the intracellular transport system which isolates and transports the synthesised/modified proteins to other compartments within the cell by transport vesicles budding off from the ER membrane;;**
   max 2 marks

Chloroplast

8. **Enclosed by double membranes/outer and inner membranes, separated by an extremely narrow fluid-filled space – intermembrane space;;**
9. **Presence of thylakoids/grana;;**
10. **The thylakoid membrane contains photosynthetic pigments OR electron transport chain/electron carriers OR ATP synthase/stalked particles (any one);;**
11. **Stroma contains a matrix with 70S ribosomes, double-stranded circular DNA and enzymes (any two);;**
    max 2 marks

12. **Site of photosynthesis – synthesis of simple organic materials (hexose sugars) from inorganic materials (water and carbon dioxide) using light as the source of energy trapped by photosynthetic pigment;;**
13. **The light-dependent reactions of photosynthesis occur on the thylakoids while the light-independent reactions occur in the stroma;;**
14. **Involved in the synthesis of amino acids, fatty acids, purines and pyrimidines;;**
    max 2 marks

(b) Describe how the chromosomes behave during mitotic cell cycle. [8]

Interphase

1. **Chromosome exist as the uncoiled and diffused form called chromatin;;**
2. **During S phase, semi conservative DNA replication occurs and each chromatin consist of two chromatids joined by the centromere;;**

Prophase

3. **Chromatin shorten and thicken/condense and become distinct structures called chromosomes;;**

Metaphase

4. **Spindle fibres from each pole of the cell are attached to one of the two chromatids of each chromosome at the centromere region;;**
5. **Spindle fibres pull on the centromere, arranging the chromosomes in a single row on the metaphase plate (equator of the spindle);;**

Anaphase

6. **Centromere divides and sister chromatids separate at centromere, forming daughter chromosomes;;**
7. **Shortening of microtubules occurs and spindle fibres attached to the centromeres pull the daughter chromosome to the opposite poles of the cell with centromere leading the way;;**

Telophase

8. **Daughter chromosomes reach the opposite poles;;**
9. **Chromosomes uncoil, lengthen and become indistinct to form chromatin again;;**

(c) Identify the causative factors which increase the chances of cancerous growth and explain how uncontrolled cell division can lead to cancer. [4]

Causative factor of cancers

1. **Cancer is caused by changes in the genes which control division;;**
2. **Proto-oncogenes are converted to oncogenes and the tumour suppressor genes are less active;;**
3. **resulting in dysregulation of checkpoints of cell division and causing the cell to divide uncontrollably;;**

Mutation of the two genes are caused by:

4. **Exposure to ionising radiation e.g. X-ray, UV ray (any one);;**
5. **Exposure to chemical carcinogens e.g. asbestos, benzene (any one);;**
6. **Infection by viruses e.g. hepatitis B virus, human papilloma virus (any one);;**
7. **Genetic susceptibility;;**
8. **Lifestyle e.g. smoking;;**
9. **Long life;;**

Max 1 marks for Pt. 3-8

How uncontrolled cell division leads to cancer

10. **(During uncontrolled cell division,) Cells that should not divide begin to go through repetitive and very rapid cell cycles;;**
11. **Forming a lump of cells known as tumours;;**
12. **Cancer cells usually fail to differentiate into specialised cell for the function of the tissue they grow in;;**

[Total: 20]