

RAFFLES INSTITUTION

2015 Year 6 Preliminary Examination
Higher 1

CANDIDATE
NAME

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CIVICS
GROUP

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INDEX
NUMBER

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BIOLOGY

Paper 2

8875/02

16th SEPTEMBER 2015

2 hours

Additional materials: Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your index number, CT group & name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions.

Section B

Answer **either ONE** question.

At the end of the examination, **hand in your essay 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	/ 9
2	/12
3	/9
4	/10
Section B	
5 or 6	/20
Total	/60

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



Section A

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

- 1 Meristematic root tissue from a barley seedling was prepared and its chromosomes were observed under a microscope. **Fig. 1.1** shows a cell from the root tissue at the metaphase stage of mitosis.



Fig. 1.1

Fig. 1.2 shows the changes in amount of DNA at different stages of the barley life cycle.

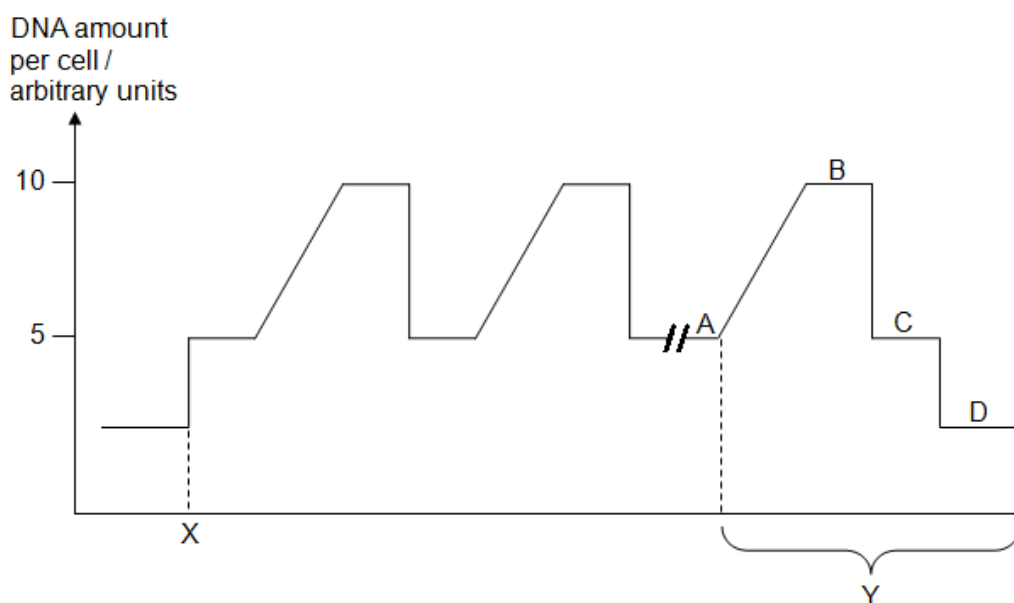


Fig. 1.2

- (a) Mark out clearly with an arrow, ↓, on **Fig. 1.2**, the part of the graph which corresponds to the stage shown in **Fig. 1.1**. [1]

Accept all part of line except the corners

- (b) With reference to **Fig. 1.2**, state which of the stages, from A to D,

- (i) has/have the **same** number of chromosomes as shown in **Fig. 1.1**; [1]

A and B

- (ii) has/have a **different** number of chromosomes as shown in **Fig. 1.1**. [1]

C and D

(c) Explain how stages in **Y** lead to variation. [4]

1. Crossing over* between non-sister chromatids* of homologous chromosomes/bivalents/homologous pair takes place during prophase I*;

Or

where equivalent portions of non-sister chromatids* of homologous chromosomes break and rejoin during prophase I*

2. gives rise to new combination of alleles* / mixing of alleles from both parental chromosomes which creates genetic variation in gametes;
A: new linkage groups in place of new combination of alleles
3. Independent assortment* of homologous chromosomes/bivalents/homologous pair at metaphase plate during metaphase I* and their subsequent separation during anaphase I

OR

Homologous chromosomes are arranged independently of other homologous pairs at metaphase plate during metaphase I* and their subsequent separation during anaphase I

4. results in 2^n possible (types of) gametes where n is the number of homologous pairs

OR

Gametes with different combinations of parental (maternal and paternal) chromosomes

(d) Explain the significance of the event occurring at **X**. [2]

1. X refers to fertilization*;
(point 1 is essential)
2. random fusion of gametes* results in greater variation/varied offspring with different genotypes and phenotypes;
3. Restoration of the diploid number of chromosomes

[Total : 9]

2 Fig. 2.1 shows DNA replication.

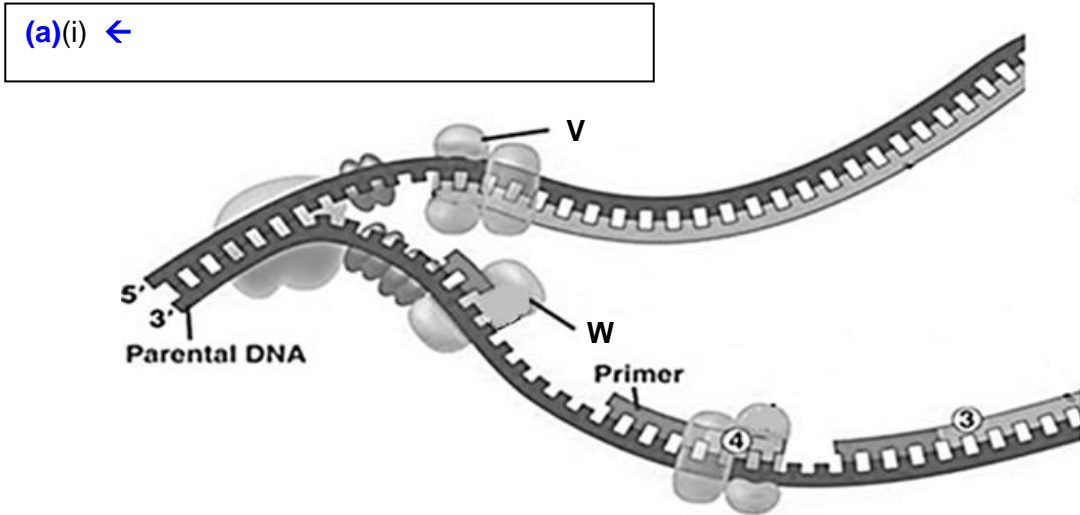


Fig. 2.1

(a) (i) Use an arrow to show the direction of replication of the leading strand in the box provided in Fig. 2.1. [1]

(ii) What do 5' and 3' on the DNA molecule represent? [2]

1. 5' represents the end (of strand of nucleotide) with carbon 5 on deoxyribose/pentose sugar having free phosphate group
2. 3' represents end (of strand of nucleotide) with carbon 3 on deoxyribose/pentose sugar having free hydroxyl group

(iii) Name the following molecules. [1]

V: DNA polymerase

W: Primase R: RNA primase

Note:

RNA primase forms DNA primer

DNA primase forms RNA primer

(iv) Describe the role of two named enzymes that are required for DNA replication. [2]

(role is needed, not description of how)

1. Helicase
Unzips the DNA double helix/ separates the two DNA strands by breaking hydrogen bonds between the complementary base pairs.
2. Topoisomerase
Breaking and rejoining DNA strands to relieve overwinding strain ahead of replication fork
3. DNA Polymerase
Addition of free deoxyribonucleotides/elongation of the new DNA strand by

- formation of phosphodiester bond between nucleotides.
4. DNA ligase
form phosphodiester bonds to join the Okazaki fragments sealing the nicks.
 5. Primase (*Reject RNA primase*)
to synthesise the RNA primers to provide free 3'OH for DNA Polymerase to elongate the new DNA strand

Fig. 2.2 shows transcription.

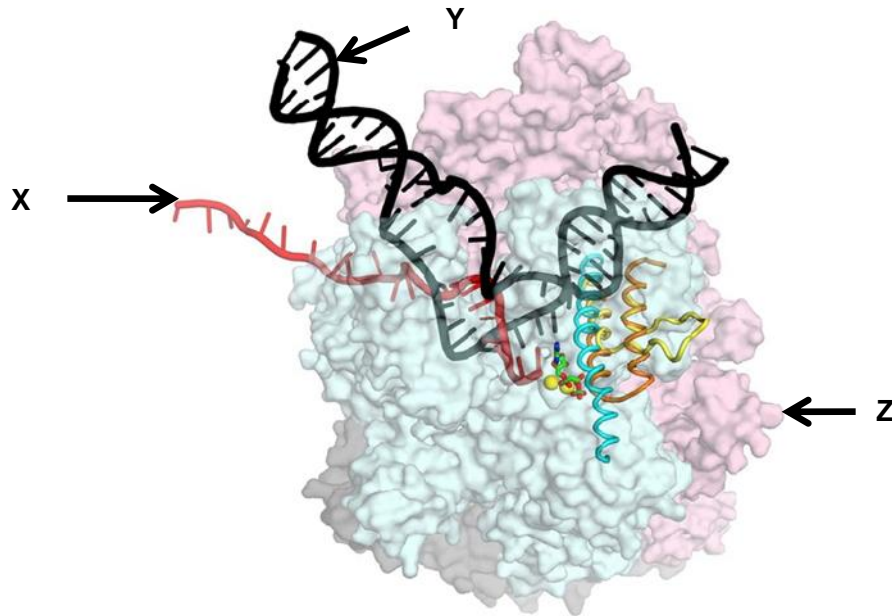


Fig. 2.2

(b) Name the following molecules [2]

X **mRNA_ / rRNA / tRNA**

Y **DNA.**

(c) Describe how the structure of molecule Z is adapted to its role in transcription. [2]

1. molecule Z = RNA polymerase,
2. which has a specific active site* which is complementary in shape/conformation* and charge to substrate such as DNA template and ribonucleotides;
3. catalyzing the formation of phosphodiester bond* elongating the RNA

(d) Describe how a silent mutation can result in no change in protein structure. [2]

1. single base substitution mutation (involves a replacement of a DNA nucleotide with a different nitrogenous base)
2. Change in codon resulting in same amino acid incorporated in polypeptide chain due to

degeneracy of the genetic code (R: wobble)

OR

3. Any mutation (e.g. insertion, deletion, substitution) in introns
4. which will be spliced out in post-transcriptional modification
5. Same primary structure and hence no change in secondary and tertiary structure

(1 and 2 OR 3 and 4) + 5

[Total :12]

3(a) Fig. 3.1 shows a series of aerobic and anaerobic reactions.

Each \bigcirc represents a carbon.

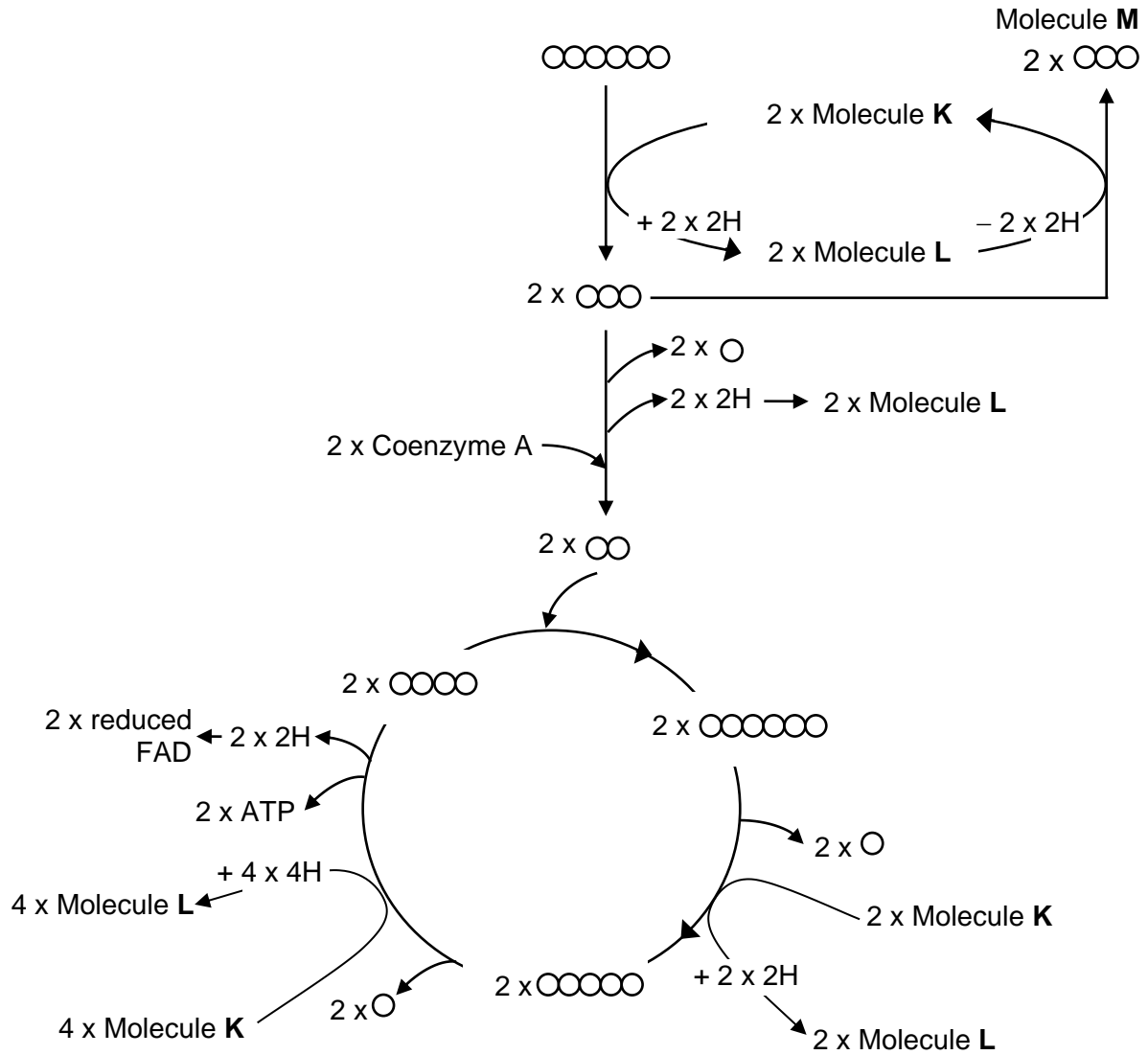


Fig. 3.1

Fig. 3.2 shows an electron micrograph of a mitochondrion.

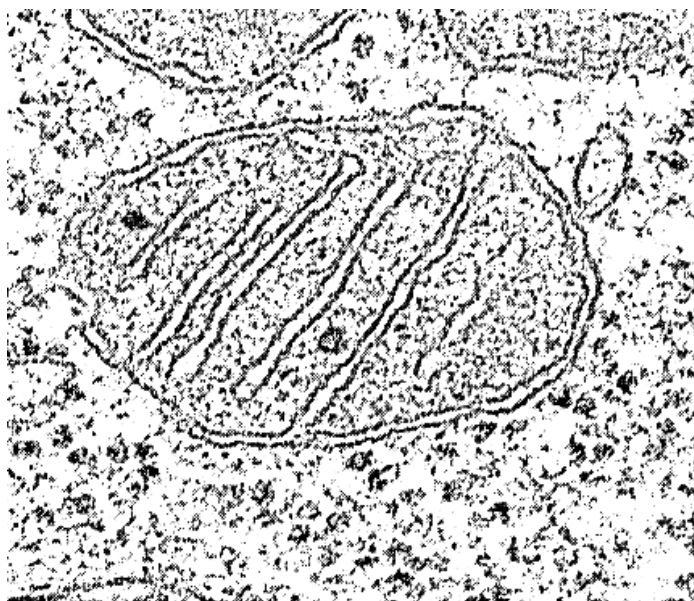


Fig. 3.2

With reference to **Fig. 3.1**,

- (i) Using an 'X', mark a point on **Fig. 3.2** clearly, showing where Molecule **M** is produced. [1]

Mark 'X' anywhere outside the mitochondria (mitochondria)

M = Lactate

- (ii) Name Molecule **L**. [1]

L = NADH / reduced NAD^+

- (iii) In aerobic conditions, explain how Molecule **L** is converted to Molecule **K**. [2]

1. Oxygen is the final electron acceptor reoxidising the electron carriers of the Electron Transport Chain*
2. So NADH (Molecule **L**) can continue to donate electrons and protons the ETC, thus regenerating NAD^+ *(Molecule **K**)

- (iv) The mitochondrion has two major compartments. Suggest the significance of compartmentalisation within the mitochondrion. [1]

1. Enzymes and substrates of Krebs cycle are kept in close proximity/ confined within the matrix increasing rate of reaction.
2. Optimal conditions e.g. pH for enzymes of Krebs cycle can be maintained within matrix for higher rate of reaction.
3. Intermembrane space has a high concentration of protons / a proton gradient can be set up across inner membrane so ATP can be produced via chemiosmosis.

- (b) Fig. 3.3 shows the absorption spectrum of one type of photosynthetic pigment from a plant and the rate of photosynthesis of the plant in different colours of light.

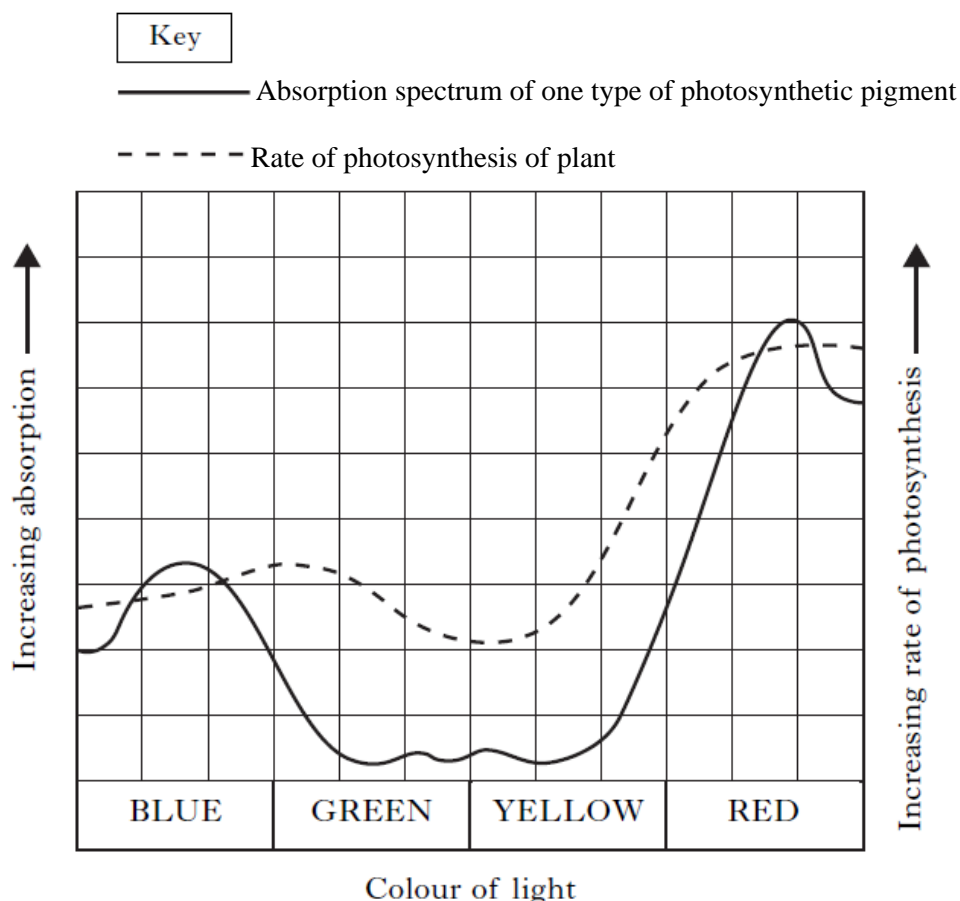


Fig. 3.3

- (i) Leaves of this plant contain more than one type of photosynthetic pigment. Use evidence from the graph to justify this statement. [1]

1. Photosynthesis occurs in green and yellow light though little light is absorbed by the single photosynthetic pigment in these wavelengths (green and yellow).
2. Photosynthesis occurs in all colours but the pigment absorbs mainly blue and red light.

Note: variations accepted as long as mention absorption spectrum vs action spectrum

- (ii) Plants typically have several photosynthetic pigments. Describe the role of accessory pigments in photophosphorylation. [1]

1. Widen the absorption spectrum / widen action spectrum
2. by channelling light energy of different wavelengths to chlorophyll a/main photosynthetic pigment/reaction centre

Spirogyra is a photosynthetic green alga which grows as a long strand of cells. A strand of *Spirogyra* was placed into water containing aerobic bacteria. Different parts of the strand were exposed to different colours of light. After a period of time, the bacteria had moved into the positions shown in **Fig. 3.4**.

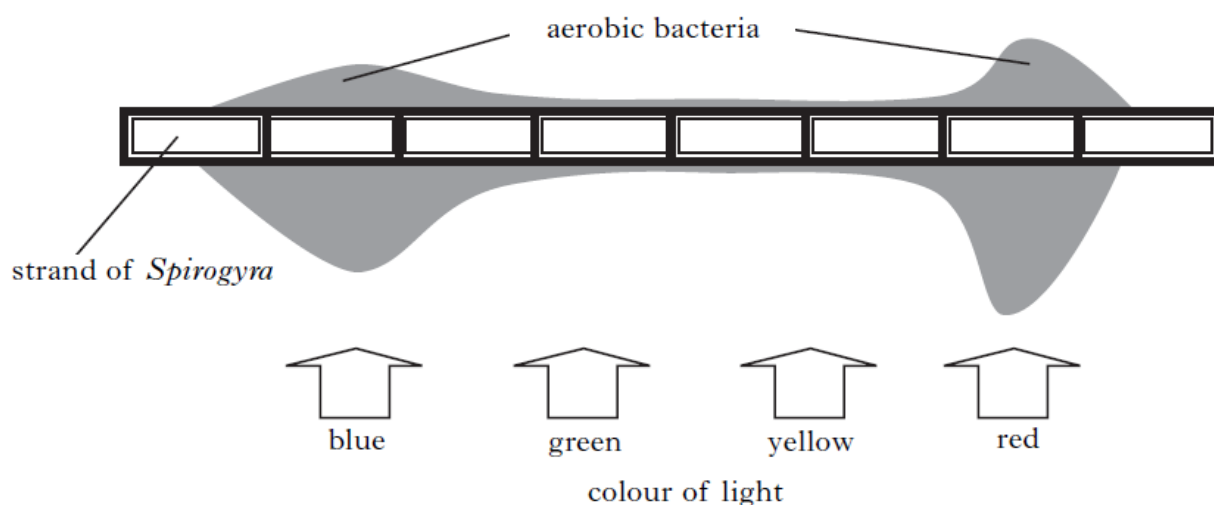


Fig. 3.4

(c) Explain the distribution of aerobic bacteria shown in the diagram. [2]

1. Photosynthesis occurs at higher rates in the regions with red and blue light
2. Producing more oxygen thus attracting aerobic bacteria

Accept reverse arguments

Eg:

3. Photosynthesis occurs at higher rates as indicated by more oxygen produced
4. Thus at red, blue light thus attracting aerobic bacteria

[Total : 9]

- 4 (a) **Fig. 4.1** shows the bacterium, *Agrobacterium tumefaciens*, and its ability to cause crown gall disease in certain plants. T-DNA, which is a part of the Ti plasmid, is integrated into the plant host chromosome upon infection by the bacteria. Scientists have manipulated the natural ability of the bacterium, and used it to transfer desirable genes into the cells of crop plants.

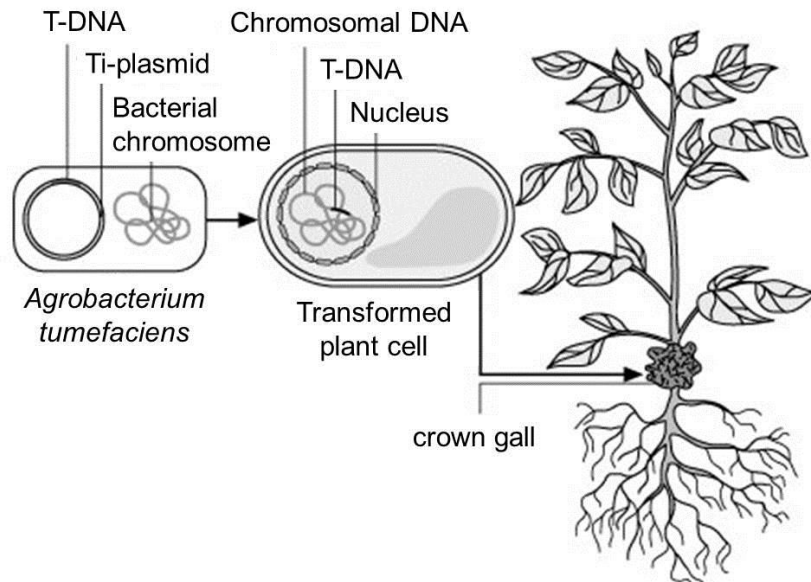


Fig. 4.1

(i) Explain how the Ti plasmid can be used to introduce a desirable gene into the cells of a crop plant. [3]

1. Digest Ti plasmid with a restriction enzyme and cut out the desirable gene using the same restriction enzyme*,
2. Complementary stick ends produced would anneal by complementary base pairing through formation of hydrogen bonds.
3. DNA ligase* then seals the nicks through formation of phosphodiester bonds between adjacent nucleotides of both strands
4. to form a recombinant plasmid.
5. Transformed *Agrobacterium* carrying the recombinant plasmid would infect a cell of the crop plant, and the section of desirable gene may be integrated into the genome / chromosome of the host plant cell.

(ii) With named examples, describe **two** potential benefits of transferring new genes into crop plants. [2]

1. Increase yield
Pest-resistant crop (e.g. Bt corn) by inserting Bt toxin gene from Bacillus thuringiensis into corn
OR
Herbicide resistant crops (e.g. Roundup Ready soybean) insertion of herbicide / glyphosate resistance gene from bacteria into soybean.

2. Improve quality

Improved nutritional quality (e.g. golden rice) by genes from daffodil and *Erwinia* / genes that produce enzymes required for the synthesis of beta-carotene inserted into rice plant

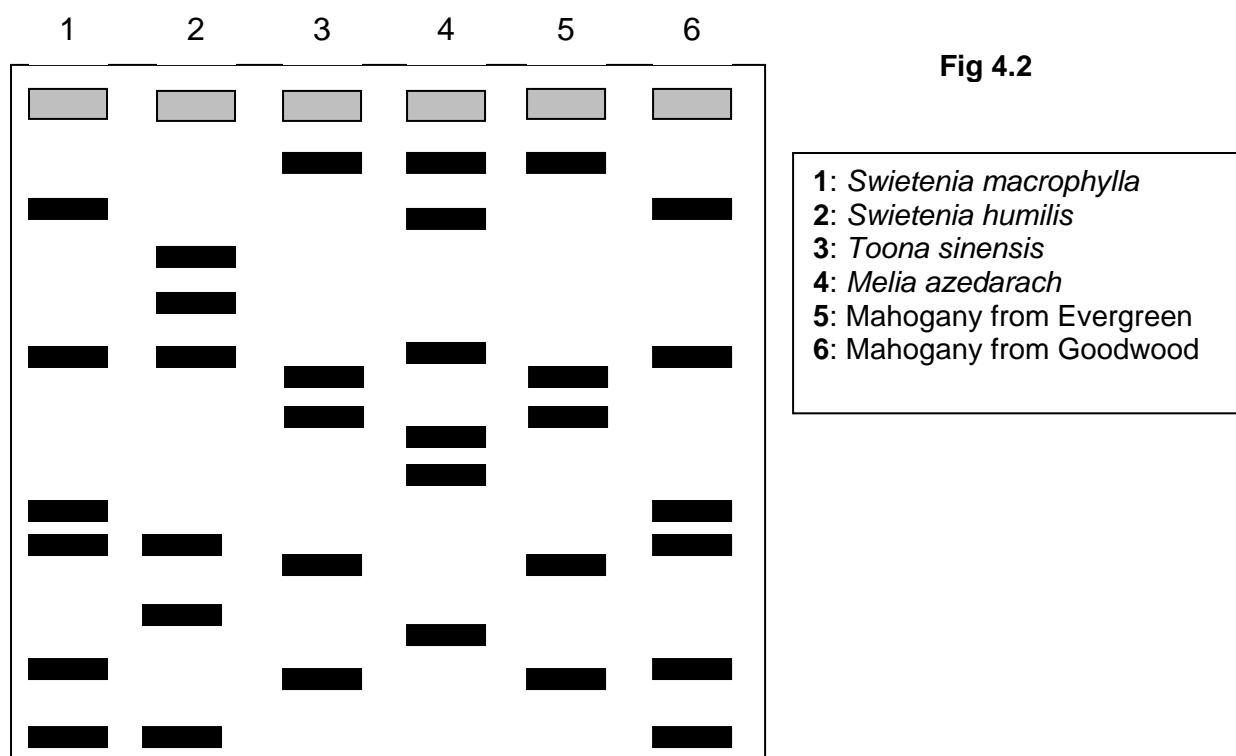
OR

Delayed ripening (e.g. Flavr Savr tomatoes) by inserting antisense gene for polygalactonurase enzyme

- (b) Wood from “big leaf mahogany”, *Swietenia macrophylla*, is prized for its beauty, durability and colour. Thus, it is highly valued in the furniture industry. Regulations with regards to the logging of *Swietenia macrophylla* have been put in place to curb excessive logging, greatly limiting the supply of big leaf mahogany in the furniture industry.

Some furniture suppliers claimed to produce furniture using mahogany from *Swietenia macrophylla* and fetch high prices for their products, when they used other variants of mahogany, e.g. *Toona sinensis*, *Melia azedarach*.

Molecular methods can be used to determine the type of mahogany used. Big leaf mahogany from two furniture companies, Evergreen and Goodwood were tested. *Cytochrome c* gene from the wood were amplified using PCR, subjected to restriction enzyme digest and resulting fragments were separated using gel electrophoresis. Samples of various known mahogany were also tested. **Fig. 4.2** shows the results of gel electrophoresis.



- (i) Explain how gel electrophoresis is used to produce the different positions of the bands shown in **Fig 4.2** [3]
1. These fragments of DNA are pipetted into the wells at the top of the gel in a position furthest from the positive electrode/anode;

2. Negatively-charged DNA; migrates out of well towards direction of positive electrode/anode when subjected to an electric field / current;
3. Fragments migrate through agarose gel matrix, made up of a meshwork of polysaccharides;
4. Meshwork impedes movement of longer fragments more than shorter fragments;
5. Longer fragments migrate slower compared to shorter fragments resulting in the different positions of the bands depicted in Fig 5.2

- (ii) Which of the two companies are selling furniture made from big leaf mahogany? Explain. [2]

1. Goodwood
2. Because all the 6 bands in lane 6 are in the same position as that in lane 1 which runs the product that contain *Swietenia macrophylla*

[Total : 10]

Section B Answer EITHER 5 OR 6.

Write your answers on the separate answer 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.

- 5 (a) Explain the importance of mitosis in growth, repair and asexual reproduction. [6]
5(a) Explain the importance of mitosis in growth, repair and asexual reproduction.[6]

1. Mitosis produces 2 daughter nuclei, each of which has the same number and same types of chromosomes as the parent cell.
2. The chromosomes in both nuclei were derived from the parental chromosomes by semi-conservative DNA replication resulting in production of genetically identical daughter cells

Growth

3. Mitosis takes place during growth of a multi-cellular organism. Growth is defined as an increase in number of cells or size of cells.
4. As one mitotic division results in 2 cells and two results in 4 cells etc. In this way mitosis gives rise to cell multiplication hence results in growth of the organism

Repair

5. When an organism is injured, wounds usually causes the production of chemicals that stimulate cell division to grow over the injured area.
6. An example of mechanical factor is abrasion which removes cells from skin surfaces and this stimulates the cells beneath to divide more rapidly.

Asexual reproduction

7. A type of reproduction where an organism replicates itself without the

- production of eggs or without fertilisation. Thus asexual reproduction takes place when a single parent **produces offspring genetically identical** to itself.
8. Many animal and plant species propagate by asexual means involving mitotic divisions of cells.
 9. Asexual reproduction is an advantage in stable environments where the offspring receive a set of genes from the parent who has survived and reproduced under the same conditions. With this set of genes, the offspring will be suitably adapted to the same conditions that have allowed the parent to thrive. In these ideal conditions, the population can reproduce very rapidly.
 10. e.g. vegetative reproduction in plants (e.g. strawberry)

At least 1 from each category to get full 6 marks

- (b) Describe the structure and role of tRNA. [6]

Structure:

1. Transfer RNA (tRNAs) are small (~4S, S = Svedberg, a measure of sedimentation rate of particles during centrifugation), containing only about 80 nucleotides.
2. Exists in a single-stranded form but segments of a tRNA molecule can **fold** in such a way that they form complementary base pairs with each other.

All tRNAs have a common structure

3. It folds back upon itself and held in shape by hydrogen bonding between complementary base pairs at certain regions to form a 3D L-shaped structure (in diagrams it is simplified into a cloverleaf (2D) structure.) → it has 3 loops.
4. On one of the loops, 3 specific unpaired triplet bases form an anticodon that binds to a specific mRNA codon via complementary base-pairing.
5. On another loop, 3' end with CCA stem is the attachment site for a specific amino acid that corresponds to the anticodon.
6. The process of attaching one amino acid to the 3' CCA stem is called tRNA activation.

Function:

7. tRNAs bring in specific amino acids in a sequence corresponding to the sequence of codon in mRNA to the growing polypeptide.
8. Aminoacyl tRNA synthase catalyse tRNA activation of attaching specific amino acid to specific tRNA
9. tRNA facilitate translation due to its ability to bind to a specific single amino acid, and
10. ability of its anticodon to base-pair with the mRNA codon

- (c) Explain the ways in which islands favour the formation of new species. [8]

1. Islands are geographically isolated* as they are surrounded by water that acts as a physical barrier preventing interbreeding.
2. This results in the disruption of gene flow*,

3. The islands due to their differing habitats / environments, present many niches for the species to fill – idea of adaptive radiation;
4. e.g. of differences. Soil type – sandy or clayey, availability of water, availability of shade, plant types, food types
5. Thus the (common) ancestral species on different islands were exposed to **different selection pressures*** and natural selection act on them;
6. There exist variation in the population and those with advantageous characteristics/best adapted to the local conditions are more likely to survive, reproduce and pass on their alleles to the next generation;
7. As the different populations evolve/change independently from each other, their allele frequencies change and they accumulate different genetic mutations over time;
8. Allele frequencies change due to natural selection and genetic drift/founders effect (which are random events that are due to chance);
9. Over hundreds and thousands of generations/ long periods of time, accumulation of genetic differences led to each population on different islands becomes **reproductively isolated***;
10. Eventually they can no longer **interbreed*** to produce **viable, fertile*** offspring
11. hence new species are formed through allopatric speciation;

6 (a) Compare glycosidic bonds in carbohydrates with peptide bonds in protein. [5]

Similarities

- 1) Both glycosidic bonds and peptide bonds are **covalent bonds***
- 2) In the formation of both glycosidic bond and peptide bond, condensation reaction occurs / water is formed

R: Both the bonds join monomers of biological molecules to form polymers

Differences

	Point of Comparison	Glycosidic bonds	Peptide bonds
4	Monomer	glycosidic bonds are formed <u>between monosaccharides</u>	peptide bonds are formed <u>between amino acids</u>
	OR		
	Product	Many glycosidic bonds in carbohydrates linked monosaccharides to form <u>polysaccharides</u>	many peptide bonds in protein linked amino acids to form <u>polypeptides</u>
5	Bonds formation between functional groups	formed between <u>hydroxyl</u> groups of two different monosaccharides	formed between the <u>amino group</u> of an amino acid and the <u>carboxyl group</u> of another amino acid

6	Types of bonds	<u>Several / different</u> types of glycosidic bonds can be formed e.g. α (1,4) or (1,6) <u>glycosidic bond</u>	<u>One</u> type of peptide bond is always formed between 2 amino acids
7	Branched vs linear	Could result in the formation of <u>branched</u> α (1,6) or <u>linear</u> α (1,4) polymer.	Results only in <u>linear</u> polymer.

NB: at least 1 similarity and 1 difference to get full marks

(b) Using a named example, relate the structure of a fibrous protein to its functions. [7]

- 1) An example of a fibrous protein is collagen*
- 2) Collagen is a structural protein that provides support e.g. collagen is found in skin, bones, blood vessels etc
- 3) A tropocollagen* molecule consists of three* helical polypeptide* chains wound around each other like a rope
- 4) Repeating tripeptide unit: Glycine-X-Y in each polypeptide chain, where X is usually proline* and Y is usually hydroxyproline*.
- 5) Glycine*, the smallest amino acid results in a compact coil / tight triple helix.
- 6) Bulky and relatively inflexible proline* and hydroxyproline* residues confer rigidity of the molecule.
- 7) Hydrogen bonds* are formed within each helical polypeptide chain and this stabilise each polypeptide chain which helps with providing support
- 8) Hydrogen bonds* are also formed between adjacent polypeptide chains and this increases tensile strength* which provides it with the ability to resist snapping due to stretching
- 9) Insoluble due to:
large molecular size of tropocollagen molecule
OR
hydrogen bonds* formed between adjacent polypeptide chains make collagen which contributes to the function of providing structural support.
- 10) Cross-linking* involving lysine* residues of adjacent tropocollagen molecules
- 11) results in the formation of fibrils / parallel bundles / idea of fibres which greatly increases tensile strength*.
- 12) Staggered/overlapping arrangement of tropocollagen minimizes points of weaknesses along the length of the fibrils contributes to structural support.

(c) Explain how primary, secondary and tertiary structures of a protein affect the functions of a proteinaceous enzyme [8]

Structure

1. Primary structure refers to the unique sequence and number of amino acids in a polypeptide linked by peptide bonds*
2. Secondary structure refers to the regular coiling and folding/pleating of the polypeptide held by hydrogen bonds* between CO and NH groups of the polypeptide backbone;
3. In alpha helix*, hydrogen bonds* form between CO and NH groups 4 a.a. apart, forming a 3D helical structure
OR
In beta pleated sheet*, hydrogen bonds* form between CO (or NH) group of one region/segment and NH (or CO) group of an adjacent region/segment of a single polypeptide chain, forming a flat/pleated sheet;
4. Tertiary structure refers to the folding of polypeptide into a specific conformation, held by bonds between R-groups* of structural amino acids within same polypeptide
5. Tertiary structure is maintained by hydrophobic interaction, hydrogen bonds, ionic bonds, disulfide bridges*
6. To give rise to globular proteins* like enzymes.
7. Whereby R groups of catalytic amino acids and contact amino acids are brought close together in the active site
8. R groups of contact/binding residues bind reversibly with substrate to position it in the correct orientation for catalysis to occur.
9. R groups of catalytic residues present within active site catalyze conversion of substrate to product.
10. Enzymes have specific active site* that is complementary in shape and charge* to its substrate*

(The 3D conformation of the active site is dependent on the primary, secondary and tertiary structure of the protein.)

-- END OF PAPER --

