Section A

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

1 Cellulose is the major structural component in plants. Fig. 1.1 shows part of the structure of cellulose in which alternate β-glucose monomers are rotated by 180° relative to one another. This allows for up to 40 parallel chains of this polymer to form microfibrils. These microfibrils are responsible for the physical properties of cellulose.

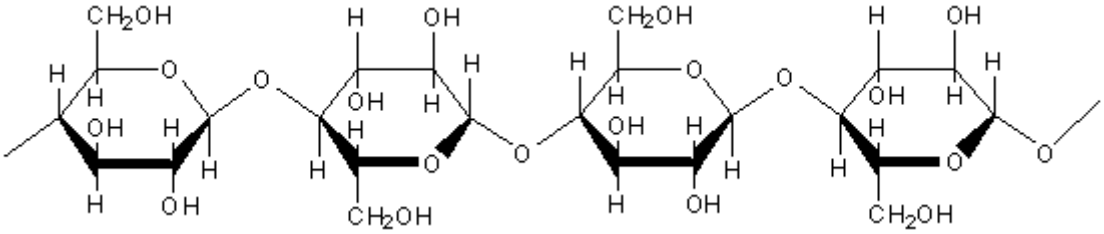


Fig. 1.1

(a) With reference to Fig. 1.1,

(i) identify the bond that is formed between the β-glucose monomers in cellulose.

_____[1]

(ii) Explain how the molecular structure of cellulose contributes to its physical properties.

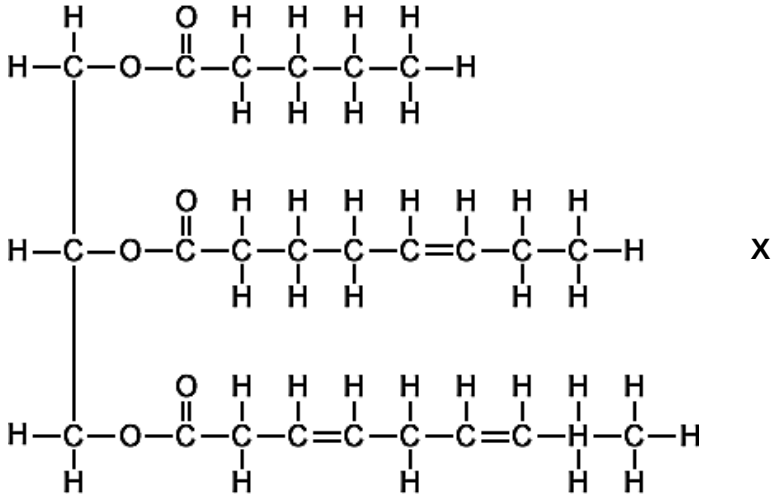
_____

_____

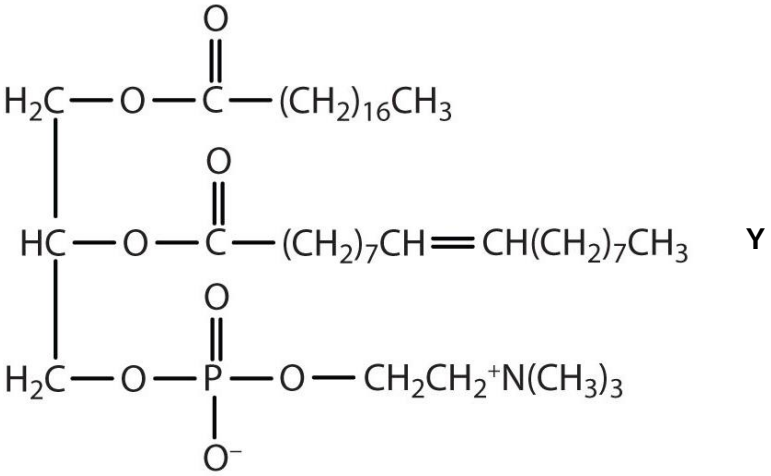
_____

_____ [2]

Fig 1.2 shows the structure of two lipid molecules, **X** and **Y**, which can be found in plant cells.



X



Y

Fig. 1.2

(b) With reference to Fig 1.2,

(i) describe **two** structural features which are similar between molecules **X** and **Y**.

_____

_____

_____

_____[2]

(ii) explain how the structure of molecule **Y** is related to the bilayer arrangement in a plant cell membrane.

_____

_____

_____

_____

_____

_____[3]

[Total: 8]

2 DNA is found mostly in the cell nucleus, but another type of nucleic acid, RNA, is common in the cytoplasm. Watson and Crick proposed that RNA must copy the *template* found in the nucleus and carry it out to the cytoplasm, where proteins are synthesized. Crick also predicted the existence of an "adaptor" molecule that reads the genetic code and selects the appropriate amino acids to add to a growing polypeptide chain. This proposed flow of genetic information is known as the "Central Dogma".

As it turned out, several types of RNA are involved in the utilisation of genetic information. In the nucleus, the code is "transcribed," or copied, into a messenger RNA (mRNA) molecule. In the cytoplasm, the mRNA code is "translated" into amino acids. Translation is orchestrated at the ribosome, itself partly composed of RNA, with transfer RNA playing the role of adaptor.

RNA is an intermediary between DNA and protein. (n.d.). Retrieved July 03, 2016, from http://www.dnaftb.org/21

(a) With reference to the information given above,

(i) explain what is meant by the term *template*.

_____

_____

_____

_____[2]

(ii) suggest how the structure of the adaptor molecule is suitable for its role.

_____

_____

_____

_____

_____

_____[3]

(b) Explain why the unwinding of the DNA double helix promotes transcription.

_____

_____[1]

(c) List **two** ways in which transcription differs from translation.

_____

_____

_____

_____[2]

Multiple copies of DNA molecules can be amplified using the Polymerase Chain Reaction (PCR) in the science lab. *Taq* polymerase is a thermostable DNA polymerase that is used in PCR. Fig. 2.1 shows the effect of increasing the temperature on the rate of reaction of the enzyme.

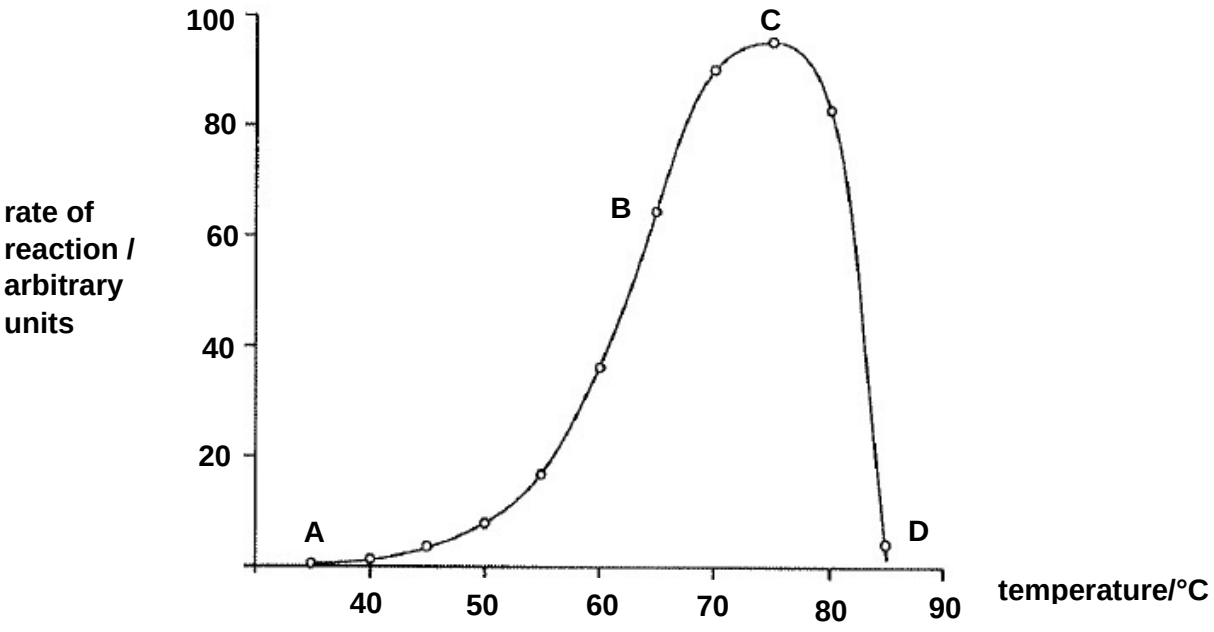


Fig. 2.1

(a) With reference to Fig 2.1,

(i) describe the curve between **A** and **B**.

_____

_____

_____

_____[2]

(ii) explain the change in reaction rate from **A** to **B**.

_____

_____

_____

_____

_____

_____[3]

(iii) Suggest how the structural features of *Taq* polymerase make it thermostable.

_____

_____

_____

_____[2]

[Total: 15]

3 Anoles are small, colour-changing lizards that are abundant in the Caribbean Islands. Hundreds of species live on the six islands of the Caribbean. Biologist, Jonathan Losos, has discovered the traits that enable dozens of anole species to adapt to different vertical niches in the forest of the islands.

While differences in limb length, body shape, and toepad size allow different species to flourish on the ground, on thin branches, or high in the canopy, changes in other characters, such as their colourful dewlaps, have played a key role in reproductive isolation and the formation of new species.

(a) Using this information,

(i) state the factor that was important in determining differences in limb length, body shape and toepad size.

_____[1]

(ii) state the process that resulted in the differences in limb length, body shape and toepad size.

_____[1]

(iii) explain how differences in limb length, body shape and toepad size between the populations may have arisen.

_____

_____

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_____[5]

The breeding behaviour of the *Anolis proboscis* is of interest as their reproductive rate is very low and the species is considered to be endangered. Study of one population is aimed at finding the father of a new offspring.

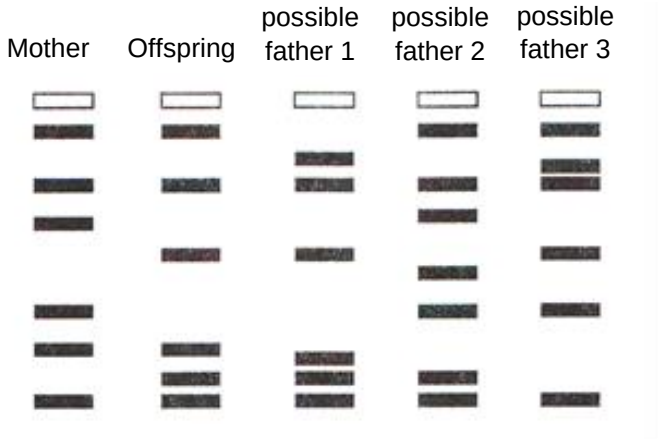


Fig. 3.1

(b) With reference to Fig. 3.1,

(i) state the most likely father of the offspring.

_____[1]

(ii) explain why the male identified in **(b)(i)** is more likely to be the father than either of the other males.

_____

_____

_____

_____

_____

_____[3]

[Total: 11]

4 The speed of feather growth is a sex-linked trait that found in chicks. The speed is either fast feathering or slow feathering. Slow feathering in chickens is caused by a dominant allele (referred to as *K*) on the Z chromosome. The sex chromosomes of a male bird are ZZ while the sex chromosomes in females are ZW.

Colour of the feathers is also controlled by another gene. When chickens with splashed white feathers are crossed with black-feathered birds, their offspring are speckled white and black (Andalusian).

When the Andalusian are crossed among themselves, they produced white, blue and black offspring in the ratio 1:2:1 respectively.

A farmer crossed a slow feathering, white splashed feathered female and a fast feathering Andalusian feathered male.

(a) Using the symbols *K* and *k* for speed of feathering and F^S for white and F^B for black,

(i) explain the inheritance of colour in the chickens.

_____

_____

_____

_____[2]

(ii) Draw a genetic diagram to show the cross between a slow feathering, white splashed feathered female and a fast feathering Andalusian feathered male. [4]

[Total: 6]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.

Your answer 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)** Explain the differences in the process of Polymerase Chain Reaction and DNA replication in nature. [6]

(b) Outline the structure and function of Golgi apparatus. [6]

(c) Discuss the ethical implications and benefits of the Human Genome Project. [8]

[Total: 20]

6 **(a)** Explain the need for the production of genetically identical cells and fine control of replication. [6]

(b) Outline the three phases of the Calvin cycle. [6]

(c) Discuss the ethical and social implications of genetically modified animals. [8]

[Total: 20]

1 Cellulose is the major structural component in plants. Fig. 1.1 shows part of the structure of cellulose in which alternate β-glucose monomers are rotated by 180° relative to one another. This allows for up to 40 parallel chains of this polymer to form microfibrils. These microfibrils are responsible for the physical properties of cellulose.

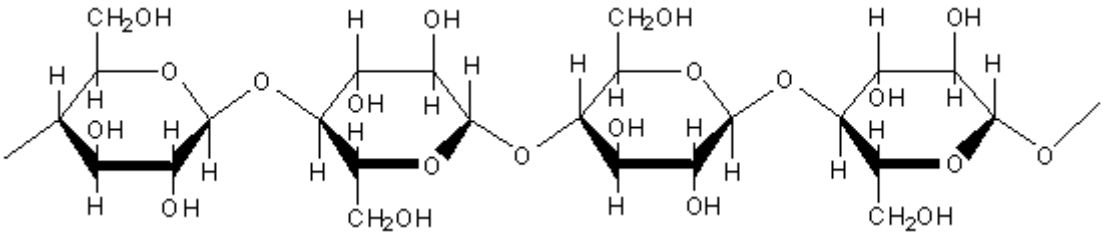


Fig. 1.1

(a) With reference to Fig. 1.1,

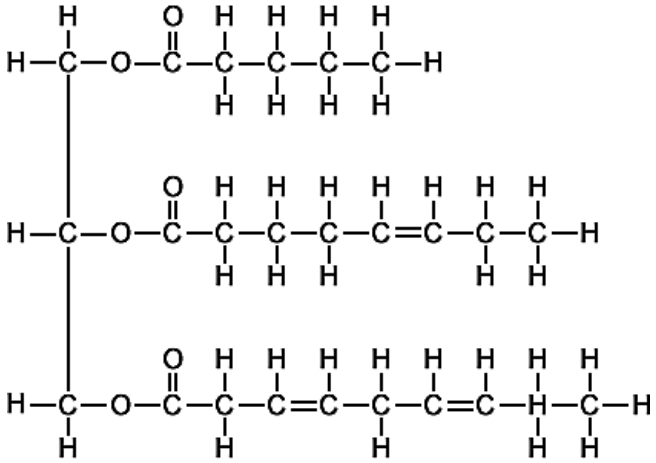
(i) identify the bond that is formed between the β-glucose monomers in cellulose.

β(1→4) glycosidic bond (**reject:** glycosidic bond, β glycosidic bond, 1→4 glycosidic bond etc.) [1]

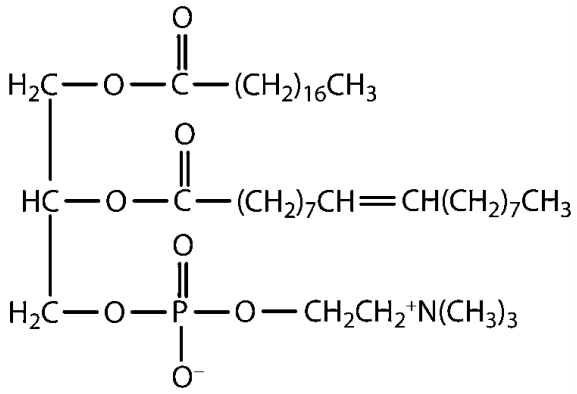
(iii) Explain how the molecular structure of cellulose contributes to its physical properties.

Physical property	**Relating molecular structure to physical property**
1. **high tensile strength**	▪ **Hydroxyl (OH) groups** project outwards from each linear cellulose chain, forming **hydrogen bonds** with neighbouring chains leading to **cross-linking** which results in microfibrils which bundle together to form strong **macrofibrils**.
2. **insoluble in water**	▪ **Cross-linking** between linear cellulose chains prevents access by water **because ALL hydroxyl groups are used to form hydrogen bonds**
3. **fully permeable**	• Cellulose has large **intermolecular spaces** between macrofibrils, permitting passage of water and solutes.

Fig 1.2 shows the structure of two lipid molecules, **X** and **Y**, which can be found in plant cell.



X



Y

Fig. 1.2

(b) With reference to Fig 1.1,

(i) describe **two** structural features which are similar between molecules **X** and **Y**.

1. Both molecule X (triglyceride) and molecule (phospholipid) contains a **glycerol molecule**.

2. Both molecules contain **at least 1 ester bond**. (Reject if student write three ester bonds as phospholipid only has 2 ester bond.)

3. Both molecules contain **at least 1 chain of hydrocarbon**. (Reject if student write three hydrocarbon chains as phospholipid only has 2 ester bond.)

4. Both molecules contain **1 chain of unsaturated hydrocarbon**.

Any **2**

(ii) explain how the structure of molecule **Y** is related to bilayer arrangement in a plant cell membrane.

The phosphate head is polar / hydrophilic thus able to form hydrogen bonds with water molecules in the aqueous environment. [1]

The fatty acid chains are long and non-polar / hydrophobic thus resulting them facing away from the aqueous environment to form the hydrophobic core.[1]

Unsaturated fatty acid chains contain carbon-carbon double bonds (C=C), resulting in the formation of kinks that prevents the close packing of phospholipids. [1]

[Total: 8]

2 DNA is found mostly in the cell nucleus, but another type of nucleic acid, RNA, is common in the cytoplasm. Watson and Crick proposed that RNA must copy the *template* found in the nucleus and carry it out to the cytoplasm, where proteins are synthesized. Crick also predicted the existence of an "adaptor" molecule that reads the genetic code and selects the appropriate amino acids to add to a growing polypeptide chain. This proposed flow of genetic information is known as the "Central Dogma".

As it turned out, several types of RNA are involved in the utilization of genetic information. In the nucleus, the code is "transcribed," or copied, into a messenger RNA (mRNA) molecule. In the cytoplasm, the mRNA code is "translated" into amino acids. Translation is orchestrated at the ribosome, itself partly composed of RNA, with transfer RNA playing the role of adaptor.

RNA is an intermediary between DNA and protein. (n.d.). Retrieved July 03, 2016, from http://www.dnaftb.org/21

(a) With reference to the information given above,

(i) explain what is meant by the term *template*. [2]

In the synthesis of RNA molecules, the template used is DNA.

The DNA base sequence is used to form complementary base pair using **free ribonucleotides.**

The template serves to ensure that the same genetic information is passed along every time a gene is copied.

(ii) suggest how the structure of the adaptor molecule is suitable for its role. [3]

3' CCA end/stem that the specific **amino acid** will be bind to

the other end of the tRNA is made up of **three bases known as an anticodon** that is **complementary to the codons of the mRNA**

the anticodons will **form hydrogen bonds** with the condons of the mRNA

(b) Explain why the unwinding of the DNA double helix promotes transcription.

RNA polymerase can bind to the promoter region/ TATA box. [1] [1]

(c) List two ways in which transcription differs from translation. [2]

Any two of the below, a complete comparison must be made

Feature	Transcription	Translation

Location	Occurs in nucleus	Occurs on ribosome in cytoplasm
Template	DNA antisense OR template strand used as a template to form mRNA	Sequence of triplet bases OR codons on mRNA read to form polypeptide
Enzyme	RNA polymerase II used for (i) unwinding of DNA helix (ii) elongation of mRNA (iii) phosphodiester bond formation	Catalytic site (peptidyl transferase) on large subunit of ribosome link amino acids by peptide bonds to form polypeptide
Bond	Phosphodiester bond used to link phosphate group of 1 nucleotide and ribose sugar of another	Peptide bond used to link adjacent amino acids
Direction of reading of genetic message	Antisense OR template strand of DNA is read in 3' to 5' direction to form RNA	Ribosomes move along mRNA from the 5' to 3' direction to read codons on mRNA.
Raw material	Free ribonucleotides	Amino acids
Product(s)	mRNA, tRNA, rRNA	Proteins

Multiple copies of DNA molecules can be amplified using the Polymerase Chain Reaction (PCR) in the science lab. Taq polymerase is a thermostable DNA polymerase that is used in PCR. Fig. 2.1 shows the effect of increasing the temperature on the rate of reaction of the enzyme.

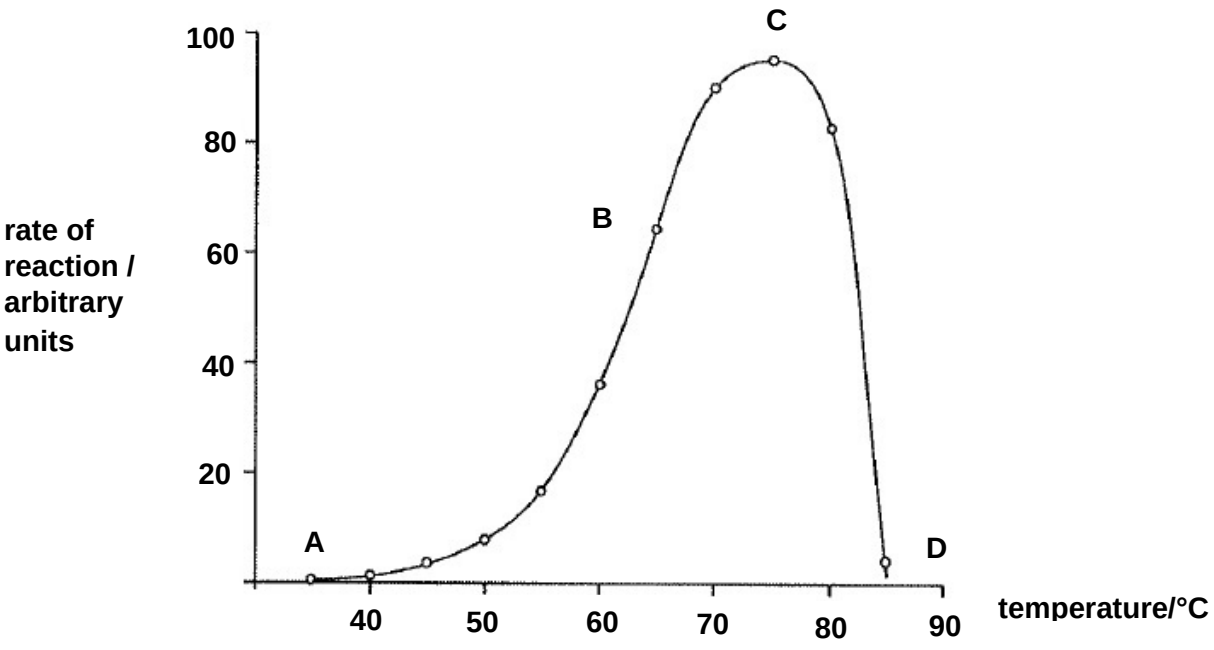


Fig. 2.1

With reference to Fig 2.1,

(a) **(i)** describe the curve between **A** and **B**. [2]

as temperature **increases from 35°C to 50°C**, the rate of reaction increases slightly from **0 arbitrary unit (A. U.) to approximately 15 A. U.**

as temperature increases from **50°C to 85°C,** the rate of reaction increases sharply from **15 A. U. to approximately 95 A.U. 0 arbitrary unit to 65 arbitrary units**

(ii) explain the reaction rate change from **A** to **B**.

- as temperature increases from 0°C to 65°C, Increase in temperature will lead to an increase in kinetic energy in both deoxyribonucleoside triophosphates (dNTP) and Taq polymerases
- Increases the rate of **effective collisions** between **dNTP and Taq polymerases**
- Increases the rate of formation of **enzyme-substrate complexes per unit time**
- Resulting in **an increase in the rate of enzymatic reaction**.

(iii) Suggest how the structural features of Taq polymerase make it thermostable.

- It is possible that the enzyme contains **high numbers of cysteine residues** which contains sulfhydryl groups, the oxidation between two sulfhydryl groups form **disulfide bonds which are strong covalent bonds**
- The enzyme might contain **many polar functional groups** that can form **hydrogen bonds or ionic bonds and the collective strength**

Note that the question asked for structural features instead of feature. [2]

[Total: 15]

3 Anoles are small, colour-changing lizards that are abundant in the Caribbean. Hundreds of species live on the six islands of Caribbean. Biologist Jonathan Losos has discovered the traits that enable dozens of anole species to adapt to different vertical niches in the forest of the islands.

While differences in limb length, body shape, and toepad size allow different species to flourish on the ground, on thin branches, or high in the canopy, changes in other characters, such as their colourful dewlaps, have played a key role in reproductive isolation and the formation of new species.

(b) Using this information,

(i) state the factor that was important in determining differences in limb length, body shape and toepad size.

Habitat / Environment / Places where the anoles live [1]

(students are expected to deduce this from second paragraph "…differences in limb length, body shape, and toepad size allow different species to **flourish on the ground, on thin branches, or high in the canopy**…")

(ii) state the process that resulted in the differences in limb length, body shape and toepad size.

Natural Selection (reject: selection / selection pressure etc.) [1]

(iii) explain how the differences in limb length, body shape and toepad size between the populations may have arisen.

There is **variation in alleles** that give rise to the distinct phenotypic differences between the population, i.e. differences in limb length, body shape, and toepad size. / OWTTE making ref to genotypic and phenotypic differences existing in the population [1]

There are differences in selection pressures in different habitats which results in anoles with **advantageous traits being selected for in that particular habitat**. [OWTTE concept of natural selection] [1]

Anoles with advantageous traits are able to survive until sexual maturity and reproduce to **pass on the advantageous alleles to their offspring**. / OWTTE about passing on the advantageous alleles [1]

Different habitats prevent interbreeding and gene flow between the different populations thus giving rise to distinct phenotypic differences. [1]

In addition, there can be **genetic drift** such as the founder effect whereby a small distinct phenotype of anoles that crawl, colonise and reproductively isolated in a new habitat. [1]

The breeding behaviour of the *Anolis proboscis* is of interest as their reproductive rate is very low and the species is considered to be endangered. Study of one population is aimed at finding the father of a new offspring.

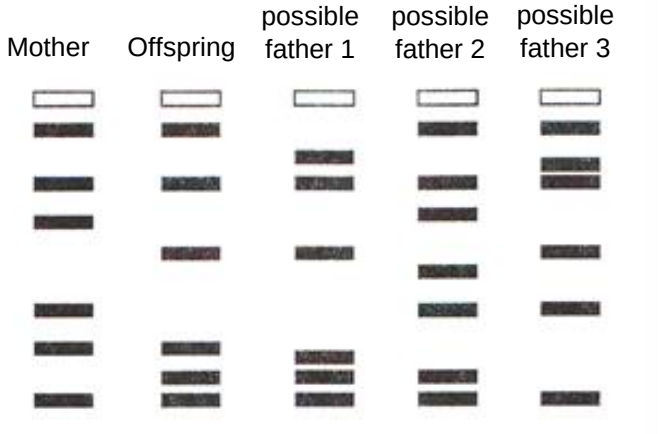


Fig. 3.1

(b) With reference to Fig. 3.1,

(i) state the most likely father of the offspring.

Father 1 [1]

(ii) explain why the male identified in **(i)** is more likely to be the father than either of the other males.

The DNA bands of the offspring must be **inherited from either the mother or the father.** [1]

The offspring's **second smallest bands and the third largest bands are absent in the mother's DNA profile** / banding pattern, therefore the offspring must have inherited from its father. [1]

Since **father 1 has both of the bands**, and not Father 2 and father 3, so father 1 is the correct father. [1]

[Total: 11]

4 The speed of feather growth is a sex-link trait that found in chicks. The speed is either fast feathering or slow feathering. Slow feathering in chickens is caused by a dominant allele (referred to as K) on the Z chromosome. The sex chromosomes of a male bird are ZZ while the sex chromosomes in females are ZW.

Colour of the feathers is also controlled by another gene. When chickens with splashed white feathers are crossed with black-feathered birds, their offspring are speckled white and black (Andalusian).

When the Andalusian are crossed among themselves, they produced white, blue and black offsprings in the ratio 1:2:1 respectively.

A farmer crossed a slow feathering, white splashed feathered female and a fast feathering Andalusian feathered male.

(a) Using the symbols K and k for speed of feathering and F^s for white and F^B for black,

(i) Explain the inheritance of colour in the chickens. [2]

Co dominance.

White and Black alleles are dominant and express equally.

(ii) Draw a genetic diagram to show the cross between a slow feathering, white splashed feathered female and a fast feathering Andalusian feathered male. [4]

Parental phenotypes:	Slow feathered White female	**X**	Fast feathered Andalusian male	
Parental genotypes:	Z^KW F^S F^S	**X**	Z^kZ^k F^S F^B	
Gametes produced:	Z^KF^S WF^S		Z^kF^S Z^kF^B	[1]

F_1 genotypes

Gametes	Z^KF^S	WF^S
Z^kF^B	$Z^KZ^kF^SF^B$ Slow feathering Andalusian male	$Z^kWF^SF^B$ Fast feathering Andalusian female
Z^kF^S	$Z^KZ^kF^SF^S$ Slow feathering White Male	$Z^kWF^SF^S$ Fast feathering White female

[2]

F_1 genotype:

$Z^KZ^kF^SF^B$ $Z^kWF^SF^B$ $Z^KZ^kF^SF^S$ $Z^kWF^SF^S$

F_1 phenotypes and phenotypic ratio: [1]

1 Slow feathering Blue Andalusian Male : 1 fast feathering Andalusian female 1 slow feathering white male 1 fast feathering white female

Essays

Question 5

(a) Explain the differences in the process of Polymerase Chain Reaction and DNA replication in nature. [6]

		PCR	DNA Replication	Explanation
1	Type of primer	Excess forward and backward DNA primers used	RNA primer required Additional step to remove RNA primer and replace it with DNA	No need to fill gap once primer removed
2	Replication segment	Only specific segment/sequences	Entire DNA molecule replicated	As specific primers used to

		of DNA molecule replicated		**flank the target sequence to be amplified.**
3	**Strand separation**	**High temperatures at 95^0 C**	**Enzyme <u>helicase</u> unwind DNA double helix**	High temperature to fully denature the DNA in vitro
4	**Synthesis of DNA strands**	**DNA replication forks (and the Okazaki fragments associated with lagging strand synthesis) do not occur in PCR.** **Both** daughter stands are synthesized **continuously**	**One** daughter strand is synthesized **continuously; while the other** daughter strand is synthesized **discontinuously as short Okazaki fragments**	PCR - As denaturation caused DNA double strands to unzip fully allowing primers to anneal whereas unzipping in DNA replication is slowly at the replication fork. **PCR because the template strands are single stranded (separated by heating) fragments, so there aren't any 'lagging strands'.**
5	**Enzyme and property**	**<u>Taq polymerase</u>** is used which does not have **proofreading ability**	**<u>DNA polymerase</u>** is used which has **proofreading ability**	Taq polymerase → thermostable and heat labile at the temperatures used in PCR thermocycling reactions. But has no proofreading properties.
6	**Use of DNA ligase**	**DNA ligase is not required**	**DNA ligase is required to catalyse the** formation of **phosphodiester bonds between Okazaki fragments to form a single DNA strand**	PCR as both daughter stands are synthesized continuously→ no need ligase

(b) Outline the structure and function of Golgi apparatus.

Maximum of 4 marks for functions only, at least 2 marks for structure

Structure	**Functions**

• Consists of a stack of flatten membrane-bound sacs also known as cisternae and a system of associated Golgi vesicles
 	
• Continuously formed at one end of the stack (forming face) & budding off as Golgi vesicles at the other (maturing face)
 	
  • ***cis*** **face** (the face nearest the nucleus and endoplasmic reticulum): where ER vesicles from ER fuse with GA to add its membrane to the forming face and deposit the contents into the Golgi cisternae
 	
  • ***trans*** **face** (the face nearest the membrane): where vesicles bud off from GA to export the content
	• **To chemically modify proteins and lipids synthesised at ER**: When proteins and lipids from rough and smooth ER vesicles move from *cis* to *trans* face of GA, oligosaccharides (short chains of carbohydrate) are attached to the proteins and lipids, forming glycoproteins and glycolipids respectively.
	
	• **To sort and packages proteins according to their identification tags:** GA may add identification tags such as phosphate groups and oligosaccharides to the products formed before sorting and directing them to appropriate parts of the cell.
	
	• **To form lysosomes:** Vesicles called lysosomes which contain hydrolytic enzymes bud off from *trans* face of GA
	
	• **To replace plasma membrane:** When secretory vesicles from GA fused with the plasma membrane to discharge their contents (exocytosis), the membrane from the vesicles offset the plasma membrane lost through endocytosis.
	
	• **To synthesise macromolecules:** GA is involved in the synthesis of mucin (a component of mucus) in mucus-secreting cells, hyaluronic acid (a substance that bind cells together) and material for new cell walls (carbohydrates) during plant cell division.
	
	• **To transport lipid**
	Lipids are digested to form fatty acids and glycerol in the small intestine. Fatty acids and glycerol are absorbed and resynthesised to lipids in SER. Lipids are then transported to GA. GA vesicles containing the lipids then fused with the plasma membrane and discharged the lipids into the lymphatic system.

(c) Discuss the ethical and benefits of the Human Genome Project. [8]

Max of four from ethical issues and 4 from benefits

Ethical issues

E1a. Ownership of personal genetic information
E1b. Difficult to determine who owns and controls the genetic information or who should have access to it OR
E1c. Legislation needed to ensure that there is no discrimination on the basis of genetic information; e.g. at work or for health insurance

E2a. Commercialisation of products
E2b. Difficult to determine who own genes and other pieces of DNA
OR
E2c. To ascertain if patenting DNA will limit the accessibility and development into useful products

E3a. Use of genetic information in reproductive decision making and reproductive rights
E3b. Concerns that prenatal genetic testing could lead to genetic manipulation or a decision to abort based on undesirable traits disclosed by the tests

E4a. Physiological impacts and stigmatisation
E4b. due to an individual's genetic differences, may affect the society's perceptions and treatment of an individual

E5a. Clinical issues including the professional education of doctors and other health service providers and patients; as well as public education
E5b. In genetic capabilities, scientific limitations, and social risks and implementation of standards and quality-control measures in testing procedures

E6a. Treatment versus enhancement of humans
E6b. No clear distinction between medical treatment and enhancement

Benefits

1 Molecular medicine (no marks for heading. Max 5 mks, @ 1 mk)
Allows elucidation of genes associated with human diseases OR understanding the genetic basis of diseases;

Allows early diagnosis OR detection of genetic diseases;
E.g. risk of breast cancer, diabetes and colon cancer;

Allows large scale studies on genetically homogenous populations to identify alleles linked to certain disease conditions;
Allows potential development of treatment of genetic and acquired disease by gene therapy;

2 Allows genetic testing for the presence of a faulty gene for a condition that may not develop for some years, including having presymptomatic genetic testing for Huntington disease and predictive testing for young-onset forms of Alzheimer disease;

3 Rational drug design OR pharmacogenomics: 'custom drugs' → knowing about which genes affect a person's response to a drug OR genetic differences affect the way we react

to a drug → possibility of tailoring drugs prescribed to fit a patient's pharmacogenomics profile for greater efficacy / to avoid dangerous side effects OR design of the most effective drug therapy and treatment strategies based on the specific genetic profile of a patient;

4 Pharmaceutical products such as medicine can be synthesized using readily available gene sequences; e.g. humulin and tissue plasminogen activator (TPA) given to after heart attack to dissolve blood clots;

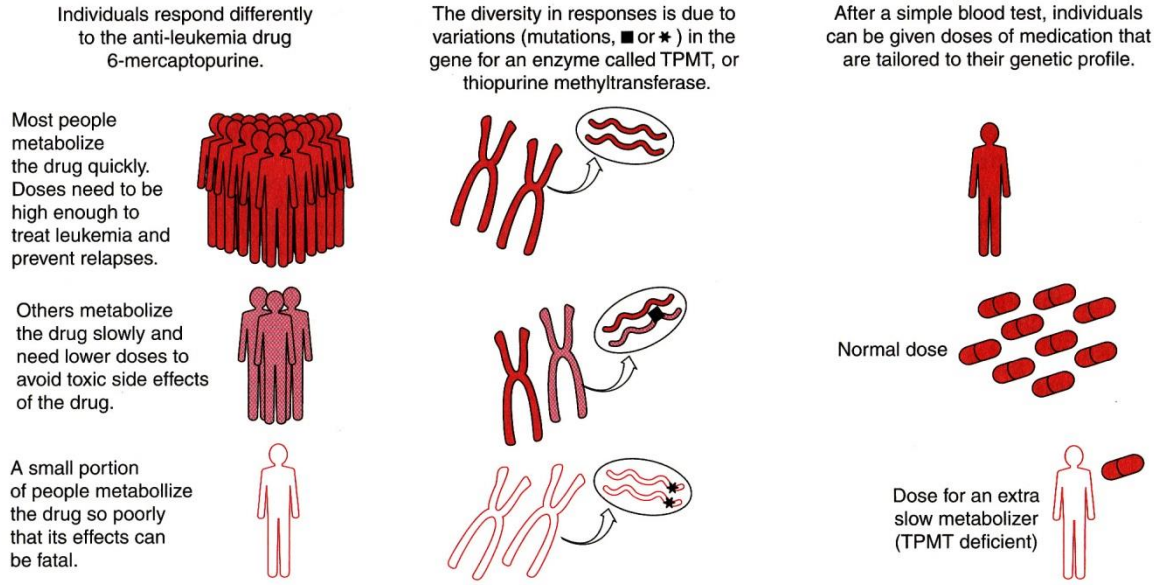


Figure 1: Pharmacogenomics. Different individuals with the same disease often respond differently to a drug treatment because of subtle differences in gene expression. The dose that works for one person may be toxic for another – a basic problem in conventional medicine.

5 DNA Forensics (max 3 mk, @ 1 mk)
Identify potential suspects whose DNA may match evidence left at crime scenes;
Exonerate persons wrongly accused of crimes;
Identify crime (e.g. 911 terrorist attack on World Trade Centre tower in New York City in 2001) and catastrophe victims (e.g. in the Asian tsunami in 2006);

Establish paternity and other family relationships;

6 Match organ donors with recipients in transplant programs;

7 Bioarchaeology, anthropology, evolution and human migration (max 1 mk, @ 1 mk)
Study human evolution (through germline mutations in lineages);
Study of migration of different population groups based on female genetic inheritance OR lineage and migration of males via Y chromosomes;

8 Risk assessment (*@ 1 mk*)
Assess health damage and risks caused by radiation exposure OR mutagenic chemicals OR cancer-causing toxins;

[Total: 20]

6 (a) Explain the need for the production of genetically identical cells and fine control of replication. [7]

1 To ensure **genetic stability** as cell replicates via mitosis
New daughter cells contain the **full set of chromosomes** and **identical hereditary information** as those of the parent cell.
There is no variation in genetic information and the chromosome number

2 Asexuel reproduction / vegetative propagation
Mitotic division is the means for some plant and animal to produce asexually

3 Growth
The number of cells within an organism increases by mitosis.
This is the basis of growth in multicellular organisms which originated from a single diploid zygote.

4 Cell replacement
Cells in the skin, vaginal and oesophageal lining are constantly sloughed off, dying and being replaced by new ones.
When damaged tissues are repaired, the new cells must be exact copies of the cells being replaced so as to retain normal functions of cells.

5 Regeneration
Some animals are able to regenerate whole parts of the body, such as legs in crustaceans and arms in starfish.

Max 3

1. Cell cycle can be out on hold at specific checkpoints. Allows cycle to be assayed for accuracy and can be halted if there are errors for repair or trigger apoptosis to occur.

2. Three main checkpoints (G1, G2 and M) act as control points where stop and go-ahead signals can **regulate the cell cycle. /**whereby there are sensitive mechanisms to detect internal state of the cell. Example nutritional state , DNA damage, cell size, DNA replication , chromosome attachment

3. A tumour suppressor gene called p53 gene produces a stop signal and plays key role in monitoring the integrity of DNA, producing proteins that halt cell cycle by regulating cyclin and cyclin dependent kinases interaction.

4. Mutation of the gene can cause dysregulation of the cyclin and cyclin dependent kinases interaction that interrupt the fine control of the checkpoints can lead to uncontrolled cell division.

5. This is because there is no detection of the presence of unreplicated or damaged DNA and hence lead to unrestrained proliferation of cells that could have DNA damage→ cancer cells. Hence, need for fine control of replication of DNA and cells for genetic stability and normal growth.

6. Ensured that replication occurs only when required in situations of growth , cell replacement so as to avoid wastage of resources and energy to replicate when not necessary .
And other AVP

Max 4

(b) Describe the calvin cycle. [6]

Phase 1 (CO_2 fixation) /carboxylation

1. **Carbon dioxide acceptor is** ribulose bisphosphate **(RuBP), a five-carbon sugar.**
2. **This is process is known as** carboxylation **/ Carboxylation is catalysed by the enzyme** RuBP carboxylase (RUBISCO)**.**

3. **The intermediate six-carbon product is** unstable**/This intermediate six-carbon product will be broken down to two molecules of** glycerate 3-phosphate **(GP) / 3-phosphoglycerate, a three-carbon organic acid.**

Phase 2 (Reduction)

4. **Glycerate-3-phosphate is** phosphorylated **by** ATP **to form** 1, 3-bisphosphoglycerate**.**
5. 1, 3-bisphosphoglycerate is reduced by NADPH to form glyceraldehyde 3-phosphate (G3P) / triose phosphate (TP).

Phase 3 (Regeneration of CO_2 acceptor RuBP)

6. Glyceraldehyde 3-phosphate **(G3P) / triose phosphate has to be used to regenerate the RuBP.**
7. ATPs **are used to form glucose. Therefore, more ATPs are used in total compared to NADPH in Calvin cycle.**
8. **To form a** glucose molecule **(6-carbon),** two G3P **(3-carbon) are combined together.**

(c) Discuss the ethical and social implications of the Genetically modified animals. [8]

Max of four from ethical issues and 4 from social

Social implications of genetically modified plants / animals pertain to their impact on human health and the environment.

Threat to safety of the environment:

1. **Spread of resistance from genetically modified crops to weeds via unintended gene transfer**. Pollen grains from GM plants e.g. herbicide-resistant GM oilseed rape; can be carried in the wind or via insect pollinators and cross-breed with wild type relatives and weeds.

   The transference of such genes (in this case, herbicide resistance gene) may result in superweeds that are resistant to herbicides. These "superweeds" are more invasive; often overrunning agricultural areas rapidly and can also outcompete natural plant species.

   Strategies to minimise such risk include greater isolation distances during the initial field testing, planting a border of unrelated plants with which the transgenic plants would not hybridise through the spread of transgenic pollen.

2. **Establishment of GM crops as weeds**. Seeds or pollen grains from GM crops that have been modified to withstand unfavourable environmental conditions, e.g. herbicide resistant, disease resistant, may be carried to other places. These crops grow quickly and may establish themselves as weeds in the new location. E.g. GM oilseed rape contains genes for resistance to the herbicide Basta.

3. **Reduced effectiveness of pesticides.** There is concern that insects may become resistant to GM crops that can produce their own pesticides. E.g. Bt corn produces its own Bt toxin.

   The continued exposure of pests to Bt plants will inevitably lead to selection for resistance and that the large-scale introduction of Bt crops endangers the durability of Bt as an insecticide, both in crops and sprays.

4. **Upsetting the ecological balance**. When GMOs are introduced into the ecosystem, these organisms can affect the food chains in undesirable ways.

   For e.g. GM salmon can grow rapidly to a larger size than native salmon and are more aggressive. If these GM salmon escape into the oceans, they may upset the natural balance of wild salmon populations, resulting in a decrease in biodiversity.

5. **Monoculturing** of GM plants. More and more countries are opening up to GM crops, this can lead to the problem of monoculturing in which the plants are so genetically identical that a single type of pest can bring down fields rapidly and drastically.

Ethical issues

1. **Is it ethical to manipulate the genome of plants and animals?** The gene inserted into the organism may not be of any use to the organism in its survival but rather, is for human use. Do living organisms have 'rights'?

2. Genetic engineering also compromises **species integrity** by moving genes from one source to another source that is not possible by normal hybridisation processes.

3. **Who has the rights to patent a GM plant and animal?** Some people argue that patenting plants and animals is itself unethical as this would reduce the organism to the level of objects. If patenting is not allowed, how can a company protect the results of their laborious research programmes?

4. **Is it acceptable to engineer an organism to be used as food for human consumption?** One of the aims of genetic engineering is to increase the growth rate and yield of animals such as pigs, cattle and poultry. Increased use of growth hormone has harmful effects on the health of animals. For e.g. the use of bovine somatotrophin in dairy cattle allowed them to produce more milk. However, this modification could increase their risk of mastitis (inflammation of the mammary glands).

   There appears to be little concern about whether the animals are biologically capable of withstanding the additional stress of increased production of milk, meat and other products.

5. **Religious reasons or dietary restrictions**. Muslims are concerned about the presence of genes from pigs in their food products. Plants that have been genetically altered with animal genes might not be accepted by vegetarians.
   One example will be long life tomatoes that have been modified by the addition of a salmon gene by Top Tomatoes Ltd in Australia.

6. **Inadequate risk assessment**. No one can anticipate all the possible consequences and potential risks when GMOs are introduced into the environment. Is it morally right for companies to start marketing their products for human use without knowing for sure all the potential health risks that their products may bring?

7. **Medical experiments may cause suffering in animals**. Do results of such experiments, which could lead to prevention of diseases, warrant the use of animals in this way? For e.g., the oncomouse is a transgenic mouse into which a gene that causes cancer (oncogene) has been introduced. The mice develop tumours more frequently than normal and are used in cancer research. A balance has to be struck between the well-bring of animals and humans.

8. **Transparency - Consumers in many countries are not aware that the products that they are buying might be genetically modified**.

Rules to transparent sharing of information and communication of associated risks (if any) ensure protection of consumer rights.

Uninformed consumers are not aware of any potential health risks associated with the modified food which they are consuming. One way to overcome this is by labelling the GM food so that the consumers can make informed decisions in their choice of food. However, labelling is not mandatory in some countries, thus is unjust to consumers who oppose GMOs.

9. Is GMOs likely to make a marked difference to Third World countries, or is the use of this technology going to result in an over-reliance on rich, developed countries?

Some biotechnology companies are pushing for **Terminator Technology**, which is designed to genetically switch off a plant's ability to germinate a second time. As a result, such **GM seeds cannot be saved at the end of one crop cycle for sowing in the following cycle**.

Opponents of this technology believe that this is a strategy by companies to force the farmer to buy a fresh supply of seeds each year; many of whom are in the developing countries and do not have the financial ability to do so. Supporters of this technology however, argued that the control of seed germination prevent farmers from pirating their technology (biopiracy).

[Total: 20]