



VICTORIA JUNIOR COLLEGE
BIOLOGY DEPARTMENT
JC2 PRELIMINARY EXAMINATIONS 2015
Higher 1

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CANDIDATE NAME

ANSWERS

CLASS

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INDEX NUMBER

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BIOLOGY

8875/02

Paper 2 Core Paper

14 September 2015

Additional Materials: Answer Paper

2 hours

READ THESE INSTRUCTIONS FIRST

Write your CT GP/ INDEX no. and name on all the work you hand in.
Write in dark blue or blue pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions

Section B

Answer any **one** question.

Write your answers on separate answer paper provided.

At the end of the examinations,

1. hand in section A and the 2 questions you attempted from section B separately;
2. fasten all your work securely;
3. enter the number of the section B questions you have answered in the grid opposite.

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

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

This paper consists of **18** printed pages.

Section A

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

- 1 **Figure 1.1** shows ribosomes attached to the endoplasmic reticulum, in the process of synthesising lytic enzymes for the lysosomes in a eukaryotic cell.

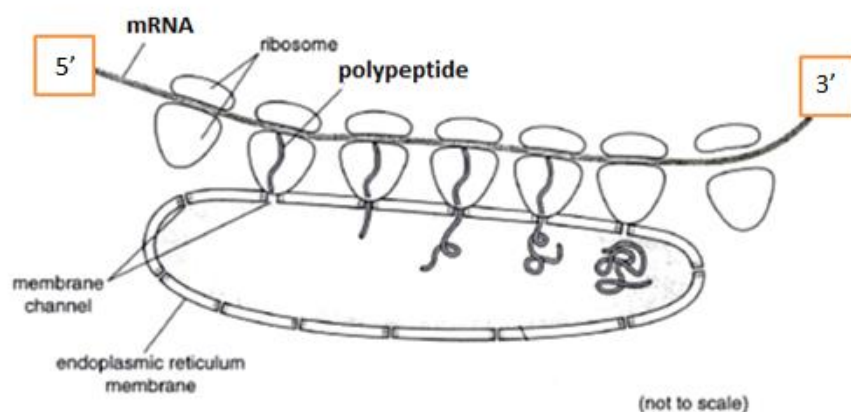


Figure 1.1

Source: GCE A Level N2009/P2

- (a) Label in the boxes provided above, the 5' and 3' end of the mRNA. [1]

Comments:

Many students got this wrong, presumably because they remember that the synthesis of the new polynucleotide (be it DNA or RNA) always occur in a 5' to 3' direction with respect to the growing chain. In this case, students have missed out that the new chain is not a polynucleotide and hence does not have a 5' and 3' direction.

Steps on working this out.

In translation involving one ribosome, the mRNA is read from the 5' to 3' direction. As it proceeds along this direction, the length of the polypeptide that is synthesised should get longer. The next ribosome that is attached to the same mRNA starts later (than the first one), so the polypeptide that is attached to it should be shorter than the first ribosome. So looking at Figure 1.1, the ribosome with the longest polypeptide is on the right. This means that the 3' end of the mRNA is on the right.

- (b) Describe two structural differences between the ribosome and the endoplasmic reticulum. [2]

Ribosome	Endoplasmic reticulum
Non-membrane bound organelle	Made up of a single membrane
Consists of rRNA and proteins	Made up of phospholipids and proteins
Consists of 2 subunits : large SS and small SS	No separation into subunits. Instead it consists of a system of interconnected membranes.

- (c) Suggest two possible functions of the protein that made up the membrane channel. [2]

(Any 2, 1m each)

- allowing large molecules across the membrane;;

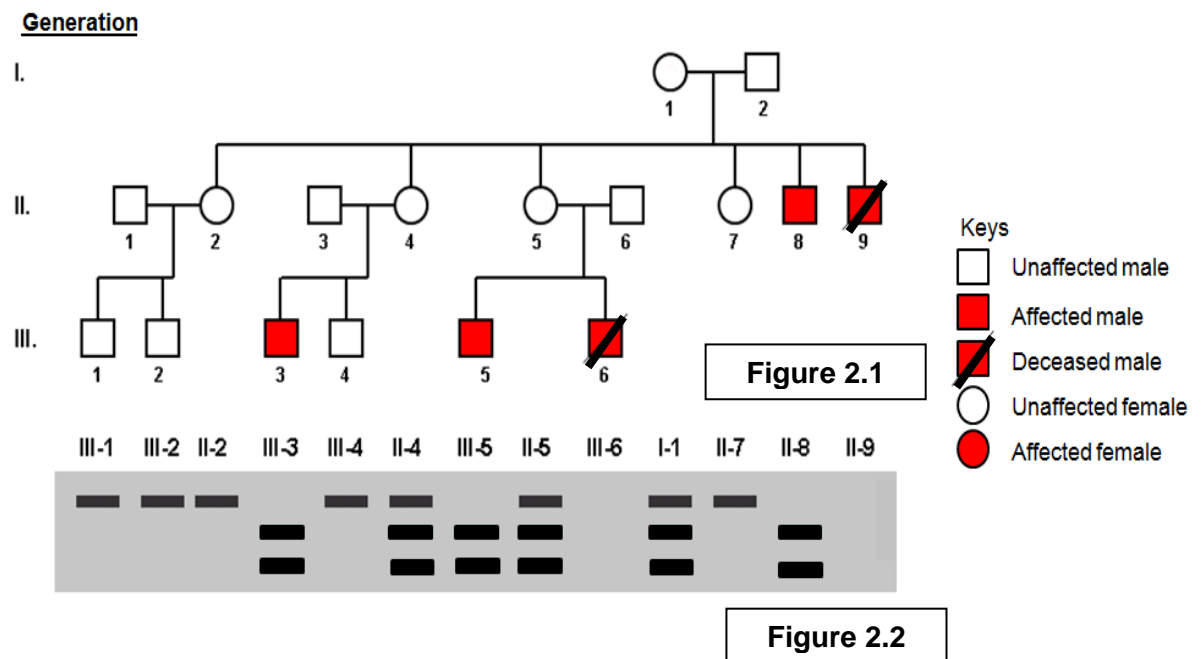
- the channel protein functioning as a receptor to bind the signal protein;;
 - to hold the ribosome;;
- (d) Explain how the ribosomes above increase the efficiency of protein synthesis in the cell. [2]
(2 *m max*)
- by forming polysome/polyribosomes;
 - allowing the (same) mRNA to be translated by many ribosomes at the same time;;
 - increase the number of polypeptides formed **per unit time**;;

An mRNA coding for the same polypeptide was isolated from the **nucleus** of the same cell. It is found to be longer in length compared to the mRNA shown in **Figure 1.1**.

- (e) Explain the significance of this difference to the cell. [2]
- mRNA in Fig 1.1 is shorter as it has undergone splicing/ post transcriptional modification where some introns are removed and exons joined together/ different exons joined together;;
 - allows one gene to code for a variety of different polypeptides;;
- (f) Outline how a lysosome is formed after the enzymes have been synthesised in the endoplasmic reticulum.[2]
- Enzymes are packaged and move to the GA via transition vesicles;;
 - In GA, further modification (or eg. of modification) of the enzymes may occur;
 - Followed by budding off the GA/packaging to form lysosomes;

- 2 Haemophilia A is a blood clotting disorder caused by a mutation in the gene that codes for an essential blood-clotting protein, anti-haemophilic factor (AHF). The disorder is characterized by episodes of internal and external bleeding in affected individual.

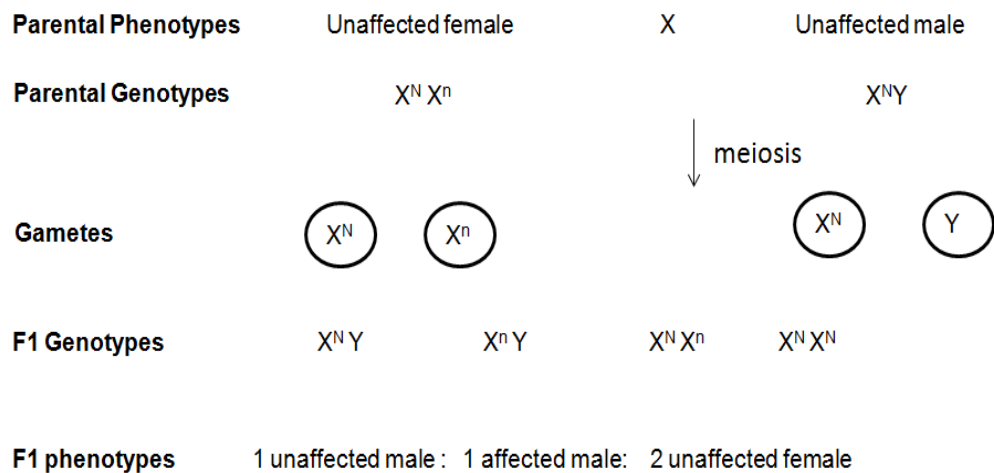
Figure 2.1 shows a pedigree of a family with history of haemophilia A. The AHF gene was first isolated from each individual using Polymerase Chain Reaction (PCR). The PCR products were then digested using restriction enzymes and the resulting fragments separated by gel electrophoresis. **Figure 2.2** shows the results of the gel electrophoresis for some of the individuals.



(a) Using evidence from the **Figure 2.1**, state two pieces of evidence to show that the inheritance of haemophilia A is sex-linked, recessive. [2]

- More males affected than females;;
- Phenotypically normal parents can produce an affected child/Traits show skipping of generation;;

(b) Explain, using a genetic diagram, how a cross between two phenotypically normal individuals, II-3 and II-4, can result in an affected child, III-3. [3]



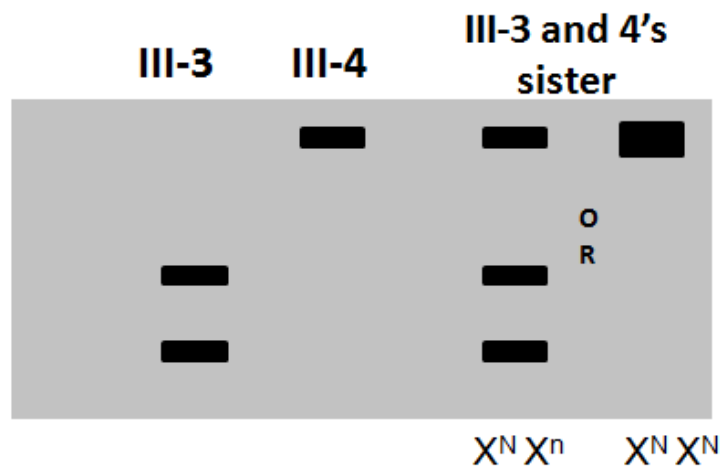
Keys:
 N is the allele for normal AHF
 n is the allele for mutated AHF
 N is dominant over n
 X and Y are sex chromosomes

- correct parental genotypes with keys;;
- correct gametes and genotype of F1 generation;;
- correct corresponding phenotype and ratio;;

(c) With reference to Figure 2.2, suggest what could have happened to the AHF gene to cause the difference in the gel pattern between individuals III-1 and III-3. [4]

- Affected individual III-3 has a **mutation that results in the gain of a restriction site**;;
- Hence the **DNA is digested/hydrolysed to form 2 smaller restriction fragments**;;
- III-1 is **homozygous** for the normal allele; hence **only 1 band**;
- **Smaller fragments move through the gel at a faster** rate than larger ones, hence the **two fragments are further away from the well** (or idea of);;

(d) If couple II-3 and II-4 has a daughter, what will be a possible gel electrophoresis result for her? Draw the band(s) in the box provided below and state her corresponding genotype. [2]



3 (a)

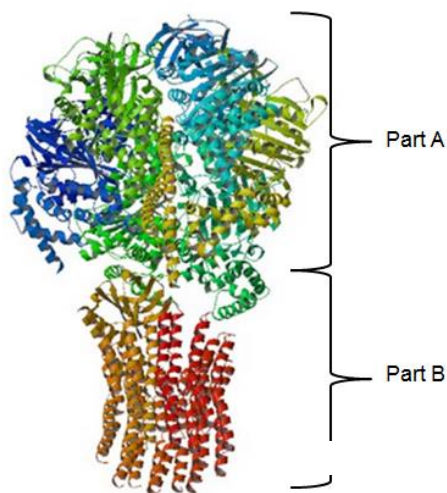


Figure 3 ATP synthase

Source: www.rcsb.org

[synthase-chemiosmotic-coupling](#)

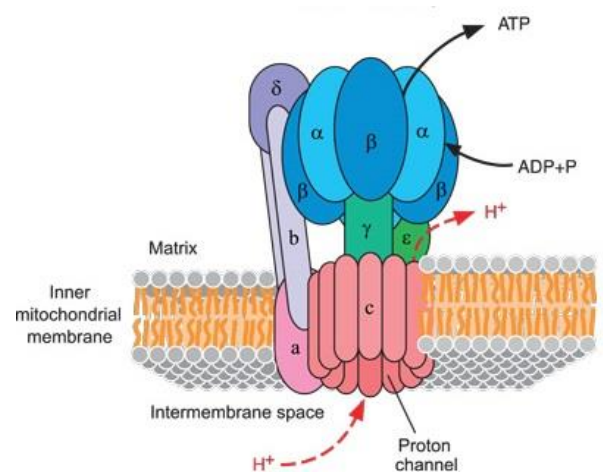


Figure 2.2

Source: <https://www.premedhq.com/atp->

With reference to the figure, relate the structure of A and B to their specific functions [4]

- (i) Part A [2]
 - has **enzymatic activity**;
 - as the **globular shape**/ specific 3D conformation;
 - allows for **formation of active site**/ specificity of enzyme;
 - to **catalyse the formation of ATP** from ADP and Pi;

Accept: stability in the cytoplasm as hydrophobic R groups are not exposed;
- (ii) Part B [2]
 - **Embedding protein** into membrane;

- Made up of **α -helices**;
- **Hydrophobic R groups are exposed**;
- Can **interact with the hydrophobic hydrocarbon tails** of the phospholipids;

(b) Describe the importance of ATP synthase in ATP production. [2]

- Protons are **charged**;
- ATP synthase provides a **channel**;
- for the **diffusion of protons**/ movement of protons down a concentration gradient;
- from the **intermembrane space into the matrix**;
- So that the **energy released** as protons flow down the gradient is **harnessed** (to form ATP);

(c) Brown adipose tissue or brown fat is one of two types of fat found in mammals. It is especially abundant in newborns and in hibernating mammals. The mitochondria present in these tissues have a higher than normal concentration of a protein known as thermogenin present on the inner membrane. This protein uncouples electron transport from oxidative phosphorylation.

Based on the information above, suggest the function of brown fats in newborns and hibernating animals. Explain your answer. [2]

- Uncoupling would mean there is no ATP synthesis;
- Energy loss as heat;
- To keep body temperature constant or idea of;

[Total: 10]

- 4** **Figure 4.1** illustrates two major classes of stem cells as well as somatic cells that can be found within a living multicellular organism.

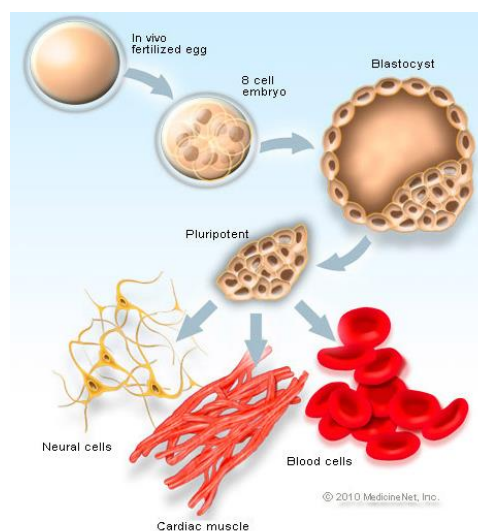


Figure 4.1

[<http://www.medicinenet.com/script/main/art.asp?articlekey=14526>]

With reference to **Figure 4.1**,

(i) differentiate between stem cells and somatic cells. [2]

- Stem cells are **unspecialised** whereas somatic cells are **specialised** cells/ have **specialised structures** to perform **specific functions**;; OR
- Stem cells are **capable of giving rise to differentiated cells** whereas somatic cells are already **differentiated**;;
- cells from **inner cell mass/ fertilised egg/ 8-cell embryo** are able to give rise to **specialised cells like neural cells, cardiac muscles and blood cells**;;

OR

- Stem cells can **self-renew**/ divide whereas somatic cells have **left the cell cycle**/ not dividing;;
- **Fertilized egg can divide to form 8-cell embryo/ 8-cell embryo to blastocyst**. Whereas **neural cells/blood cells/cardiac cells** cannot **divide further**;;

(ii) identify the two classes of stem cells and account for their separate classification. [2]

- Fertilised egg/ 8-cell embryo are **zygotic** stem cells; and inner cell mass of the blastocyst are **embryonic** stem cells;
- Their classification are based on their potency level;
- zygotic stem cells are **totipotent**/ can give rise to **all types of cells** to form the **whole organism**;
- whereas embryonic stem cells are **pluripotent**/ can give rise to **almost all types of cells but NOT the whole organism**;

(b) Adult stem cells in the mature organism occur in small numbers throughout the body. Explain their biological significance despite occurring in small numbers. [3]

- Found within **differentiated** tissue, where they can be activated to undergo **asymmetric division**;;
- Gives rise to two daughter cells, **one daughter cell remains a stem cell to provide a continuous pool/ supply of (unspecialised) stem cells** (throughout life time of organism), while **the other daughter cells will differentiate into specialised cells of that tissue**;;
- To **maintain the cellular composition of the tissue and to replace dead, damaged or worn out cells** resulting from disease, injury or natural aging process;;

- (c) Cordlife is a commercial enterprise that charges its customers to cord blood banking. It is touted as the “unique opportunity for parents to help safeguard the health of their child by storing the newborn’s cord blood stem cells at birth.”

Explain the basis of the claim that cord blood can safeguard the health of a child when cord blood stem cells are stored from birth. Suggest if the claim is valid. [3]

- Cord blood is a **source of blood/ hematopoietic stem cells**;
- Which is **multipotent** adult stem cells which can give **rise to all types of blood cells**;
- Can be **induced** years later to **differentiate** into various blood cells;
- **if the child develops a disease involving blood cells that requires cell replacement** (or mention of blood related diseases);
- It will have a **lower risk of invoking a immune response** as it is not foreign;
- Validity of claim – only if the stem cells are healthy; if the stem cells contain genetic mutations, cord blood cannot safeguard the health of the child;

Section B

Answer EITHER 5 or 6.

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.

Either

5 (a) Describe the process of Polymerase Chain Reaction (PCR). [6]

When there may be/ starting with only very small amounts/ minute quantities of the original DNA to work with, PCR can be used to help amplify/ produce many copies of the DNA;;

In PCR, the reaction occurs when a DNA sample and a DNA polymerase, nucleotides, primers and other reagents (e.g. ATP) are added to a sample tube;

Denaturation Step:

- Denature DNA sample at 95°C to break the hydrogen bonds holding the double stranded DNA together to form single-stranded DNA;;

- Each strand will act as a template for the synthesis of its complementary strand;;

Annealing Step:

- Lower temperature to 54 - 68°C for DNA primers (added *in excess*) in PCR mixture to anneal to DNA template;;
- Two types of DNA primers, the forward and reverse primers, are used which bind by complementary base pairing to sequences flanking opposite ends of the target DNA sequence to be amplified;;

Elongation/Extension Step:

- Raise temperature to 72°C which is the optimum working temperature of the heat-stable *Taq* polymerase;;
- During the period of time where the temperature is 72°C, *Taq* polymerase catalyzes the synthesis of the new complementary strand by the addition of free deoxyribonucleotides to the 3' end of the primer;;
- The primers provide the free 3'OH for the DNA polymerase to add new dNTPs (deoxyribonucleoside triphosphates) to elongate the newly synthesized strand. Sufficient time is given for the elongation of the new DNA strands which are complementary to the template DNA molecules;;

Repeat of 3 step cycle

- The PCR cycle (*denaturation, annealing, and elongation*) is repeated for another 25 - 30 cycles in the automated thermocycler/ thermal cycler/PCR machine to obtain over 1 billion copies of the double-stranded target DNA sequence;;
- There are three steps in each PCR cycle, and each PCR cycle doubles the amount of target DNA; (This is an exponential reaction so more than one billion copies of the original or "target" DNA are generated in 30 PCR cycles)

(b) How does PCR differ from DNA replication? [6]

PCR	DNA replication
Occurs outside the cell (<i>in vitro</i>)	Occurs within a cell (<i>in vivo</i>)
DNA primers being used	RNA primers
Specific DNA sequences is being synthesized/ copied (size range 0.1 to 5 kb)	Entire genome is being copied
High temp (95°C) is being used to denature (break hydrogen bonds)	Helicase breaks the hydrogen bonds so that DNA unwinds into

and separate the DNA into single strands	single strands
Variation in temperature required in 1 cycle	Temperature is fairly constant throughout the entire process
No Okazaki fragments formed	Okazaki fragments formed in lagging strand
Origin of replication not required; replication starts where primers bind	Replication starts at origin of replication
Does not require DNA ligase, primase	Requires DNA ligase, primase
Taq polymerase – no proof reading ability	DNA polymerase – has proof reading ability

Max 6 point-to-point differences

- (c) Explain the significance of genetic engineering in improving the quality and yield of crop plants and animals and also in solving the demand for food in the world (e.g. Bt corn, golden rice and GM salmon). [8]

Define genetic engineering - the application of recombinant DNA technology to introduce genetic material/ foreign genes in order to alter the hereditary traits/ genetic makeup of a cell, organism, or population;

Genetically Modified Organism: Refers to an organism that has acquired one or more genes by artificial means. The genes may or may not be from the same species. OR

Transgenic organism: to describe organisms that had been genetically engineered to express a foreign gene from another species.

Improved yield e.g. Bt corn

- In the case of Bt corn, the gene of interest is derived from the soil bacterium, *Bacillus thuringiensis*, ► produces a protein called the Bt delta endotoxin that kills *Lepidoptera* larvae, in particular, European corn borer. Growers use Bt corn as an alternative to spraying insecticides for control of European and corn borer;;
- This gene codes for crystal proteins (Cry proteins) which acts as insect stomach poisons that must be eaten to kill the insect. Once eaten, the insect's own digestive enzymes activate the toxic form of the protein. The Cry proteins bind to specific receptors on the intestinal lining and rupture the cells. Within hours, the gut wall breaks down and normal gut bacteria invade the body cavity where they multiply and cause sepsis and subsequent death of the organism within 2 or 3 days.

- Bt maize has revolutionized pest control and many farmers have benefited financially;;
- As this toxin is lethal to the pest but harmless to other animals, this Bt corn allows farmers to control pest infestations in order to reduce crop losses.

Improved quality e.g. golden rice

- Vitamin A deficiency is the leading cause of preventable blindness in children and increases the risk of disease and death from severe infections eg diarrhea, respiratory infection, and childhood diseases, such as measles.
- Rice grain, which serves as a food staple for much of the world do not contain vitamin A naturally.
- It was discovered that **geranyl geranyl diphosphate (GGPP)** found in rice seed can be a precursor to carotenoid production. **Beta-carotene** and other carotenes (the red, yellow, and orange pigments found in carrots and other vegetables) are natural **precursors** (inactive form) **of vitamin A**.
- Thus it is possible to genetically engineer a new breed of rice variety, **golden rice** which can **express the enzymes** necessary for the **conversion of GGPP to beta-carotene**.
- To engineer **golden rice**, genes coding for **phytoene synthase** (isolated from plant) and **phytoene desaturase** (isolated from bacteria) must be introduced into the rice plant cells. These enzyme-coding genes catalyze the biosynthesis of beta-carotene from precursor GGPP in the endosperm (edible part of the grain)
- A bacterium, ***Agrobacterium tumefaciens***, containing a **Ti plasmid**, was used to introduce all the **enzyme-coding genes** necessary for the complete biochemical pathway for beta-carotene production. OR another way of introducing DNA into plant cells is through DNA coated particles that are literally shot through the cell wall using a modified gun. This is commonly referred to as the use of a 'gene gun'.

Improved yield and quality e.g. GM salmon

- Recombinant DNA composed of an antifreeze promoter from an ocean pout and a growth hormone gene from a Pacific Chinook salmon is synthesized. Fusing of a strong gene promoter such as the ocean pout antifreeze promoter leads to enhancement in the expression of the gene construct.
- The recombinant DNA is then introduced into fertilized eggs of Atlantic salmon. Subsequent selection and breeding led to development of the genetically modified salmon.
- Due to the year-round production of growth hormone (due to the antifreeze promoter), this allows for continuous feeding and growth of the GM salmon. The GM salmon is able to grow quicker in size while feeding more efficiently (less feed is consumed to reach a larger size).

[Total: 20]

6 (a) Compare the molecular structure of a triglyceride and a phospholipid, relating these structures to their functions in living organisms. [8]

Similarities [2M max]

- Both triglyceride and phospholipids are formed from **glycerol combined with fatty acids** via ester linkages.;;
- Each hydroxyl group (-OH) in the glycerol reacts with the carboxyl group (-COOH) of a fatty acid. In the reaction, **one molecule of water is removed and an ester bond (-COO-)** is formed between the glycerol and fatty acid. This is a *condensation reaction*.;;

Differences [6M max]

	triglyceride	phospholipid
Structure	Formed from three fatty acid molecules combined with one glycerol molecule via ester bonds ;	Formed from two fatty acid molecules combined with one glycerol molecule via ester bonds but the third hydroxyl group of glycerol forms a phosphoester bond with phosphate group ;
Function	Storage form of energy; Source of metabolic water;	Good thermal insulator; Protective layer for delicate internal organs (e.g. kidney); Provides buoyancy to aquatic mammals;
Structure	No linkage to additional molecules ; Hydrophobic in nature;	Additional small molecules , usually charged or polar, can be linked to the phosphate group to form a variety of phospholipids;. Phospholipids are amphipathic . They have both a hydrophobic and hydrophilic region.;
Function	Large and uncharged and hence insoluble in water → can be stored in large amounts without affecting the water potential of cells and can be prevented from diffusing out of cells;;	Helps in cell adhesion and cell recognition ;; Allows for separation of the cell content from the aqueous external cell environment and compartmentalisation (formation of organelles) within the cell where specialized biochemical reactions occur.;; Provides fluidity to the membrane which is important for cell sealing and healing.;; As a barrier to most water-soluble molecules and ions (due to the hydrophobic core of the bilayer). However, It allows fat-soluble substances and small molecules (e.g. carbon dioxide, oxygen) to

		move across easily;;
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(b) Explain how anatomical, embryological and molecular homology supports Darwin's theory of natural selection [7]

- Anatomy, embryological and molecular homology provide evidences supporting evolution as a remodeling process in which characteristics present in an ancestral organism are altered by natural selection in its descendants over time; (Darwin's theory of descent with modification)
- As they face different environmental conditions;

Anatomical homology (max 2m)

- An example of an anatomical homology is that of the number and arrangement of bones in the forelimbs of mammals/ **pentadactyl limb of mammals**;
- The **forelimbs of all mammals**, including humans, cats, whales and bats, show the **same arrangement of bones from the shoulder to the tips of the digits**, even though these appendages have very different functions: lifting, walking, swimming and flying;
- similarity is due to their **descent from a common ancestor with the same basic plan** that has been **modified** to allow the **forelimb to adapt to a certain method of locomotion in a particular environment**;
- OR
- Vestigial structures which are reduced or non-functional but shows **homology to functioning structures in other species**;
- such as appendix is human, pelvis and leg bones of snakes;
- Reflect descent with modification from a shared ancestry;
- when structure loses function as the selection pressure that selects for it is no longer present;

Embryological homology (max 2m)

- The embryological **development** of all **vertebrates share remarkable similarities**;
- Although anatomical homologies are **no longer visible in adult organisms**/ ultimately **differentiate into different structures in different organisms**;
- All share the **presence** of a **post anal tail / pharyngeal pouches / 2-chambered heart** [mention at least 2 traits];;
- **pharyngeal pouches** in mammalian embryos are the **equivalent to gill arches** and slits in fish embryos at early developmental stages;
- become parts of the ears and throat in humans and other mammals and gills in fishes ;
- **2-chambered heart** is retained in fish but develops into 3-chambered heart in amphibians and 4-chambered hear in mammals;
- Similarities **during early embryonic development** can be explained if they **descended from a common ancestor** / early stages of development in different species to reveal anatomical structural **similarities to a common fish-like ancestor**;

Molecular homology (max 2m)

- All forms of life use the **same genetic language** of DNA and RNA and the **genetic code is universal**. ;
- Likely that all **species descended from common ancestors** that used the **same code**;
- **Closely related species have more similar DNA/RNA/amino acid sequences** in the homologous genes / proteins;
- Differences are a result of **accumulated DNA mutations as descendants evolve independently** ;
- Similarity in sequences is not only seen in **coding regions but also non-coding** ;

(c) **Discuss the ethical and social implications of genetically modified salmon. [5]**

Social Implication

- If released into the wild, GM salmon may upset the **ecological balance** of the native species resulting in decrease in biodiversity;
- GM salmon may be more aggressive / **prey on smaller fish of the same species**;
- Interbreeding with wild salmon may **transfer the gene for growth hormone to the wild population**;
- **Affect the fitness of the next generations** under the selective pressure of the natural environment;
- GM salmon may **transfer diseases to wild population**;

Ethical Implication

- **Concern whether genetic manipulation** of animals for the benefit / exploitation of mankind is **acceptable**;
- May **have harmful effects on health of GM salmon**;
- Like **abnormalities** in the head and jaw due to overgrowth of cartilage;
- Some religious groups do not agree that scientists have the **right to tamper with nature by mixing genes among species**;
- Religious groups with **strong dietary restrictions** may not be informed about genetic content of food;
- GM salmon has growth hormone genes from human or bovine which may be **against the dietary restrictions of some religious groups**;
- **Patenting a genetically modified animal** may be considered unethical as it reduces them to the level of objects;