

| Name | Subject Class | Class | Candidate Number |
|------|------------------|-------|---------------------|
| | 2BIX01 | | |



ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

BIOLOGY

HIGHER 1

8875/02
17 AUGUST 2017
2 hours

Paper 2

Additional Material: Writing Paper

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on this answer booklet.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.

Section A

Answer **all** questions.

Section B

Answer any **one** question.

At the end of the examination, circle the number of the Section B question you have answered in the grid opposite.
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 | |
| Section B | |
| 4 or 5 | |
| Total | 60 |

1 Fig. 1.1 shows part of a cell.

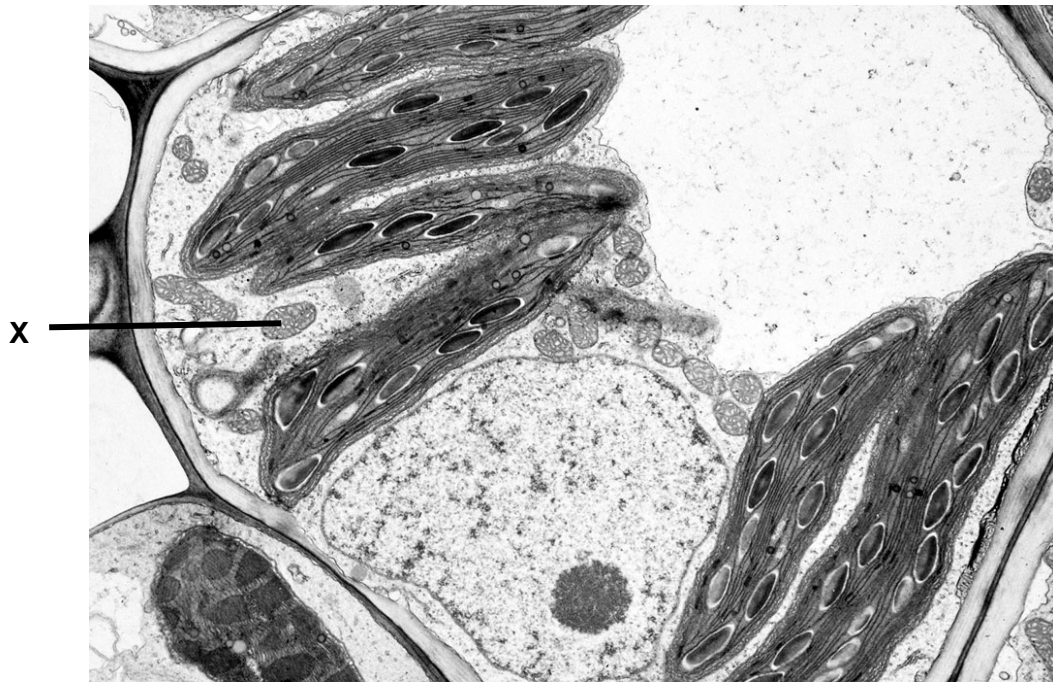


Fig. 1.1

(a) (i) Outline the role of the organelle labelled X.

1. Link pathway where pyruvate undergoes oxidative decarboxylation to produces CO_2 and reduced NAD;
2. Krebs cycle where acetyl co-A undergoes oxidative decarboxylation to produces CO_2 and reduced NAD;
3. Oxidative phosphorylation to produce ATP via chemiosmosis;

[2]

(ii) Identify two molecules with different modes of transport across the double membrane of X and explain their modes of transport.

1. CO_2 / oxygen by simple diffusion down the concentration gradient;
2. As CO_2 is a small molecule that can pass through the phospholipid bilayer;
3. Pyruvate / ADP /ATP by facilitated diffusion;
4. As pyruvate has negatively charged oxygen that cannot pass through the hydrophobic core of the membrane;
5. As ADP/ATP has negatively charged phosphate group that cannot pass through the hydrophobic core of the membrane;
6. Both pyruvate and ADP/ATP are large molecules;

[4]

(b) (i) Explain the significance of glycolysis in aerobic respiration.

1. Substrate level phosphorylation where 2 net ATP is produced
2. Via the oxidation of glucose into 2 molecules of pyruvate.
3. Pyruvate is a substrate for the Link pathway; (which is able to enter the mitochondria) for oxidative decarboxylation mitochondria matrix via the link pathway followed by the Krebs cycle; [4]
4. Reduced NAD produced carries H to the cristae for the synthesis of more ATP via oxidative phosphorylation;

An experiment was carried out to investigate the effect of temperature on respiration in isolated mitochondria extracted from a worm. Respiratory substrate was provided and oxygen consumption was monitored at 15°C, 25°C and 35°C. Fig. 1.2 shows the temperature coefficients, Q_{10} , when temperature is increased from 15°C to 25°C and from 25°C to 35°C. Q_{10} measures the ratio of the rate of respiration when the temperature increases by 10°C.

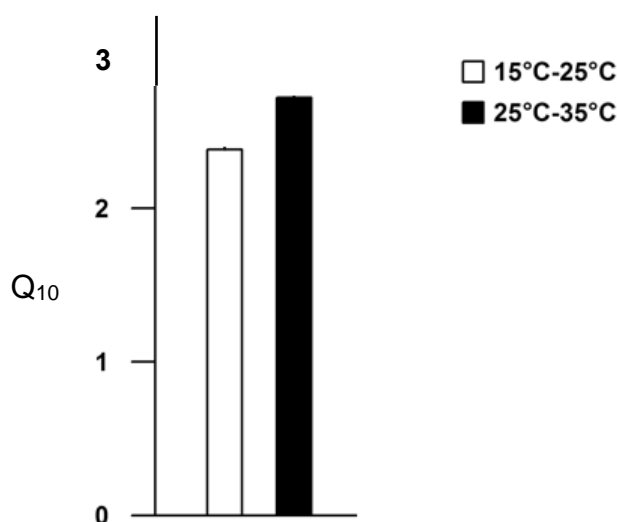


Fig. 1.2

(ii) Describe and explain the effect of temperature on the Q_{10} of mitochondria respiration.

1. There is a higher Q_{10} from increasing the temperature from 25 °C – 35°C than from increasing from 15 °C – 25°C.
2. The Q_{10} for 15°C – 25°C is at 2.4 while that of 25°C – 35°C is 2.7.
3. Suggest that the enzyme is more efficient at 35°C;
4. Increase in temperature increases the kinetic energy of the enzyme and substrate, causing an increase in effective collision and formation of ES complex, increasing the rate of reaction;

[3]

[Total: 13 m]

- 2 Fig. 2.1 shows plant cells undergoing mitosis. Each of the cells **A**, **B**, **C** and **D** is in a different stage of mitosis.

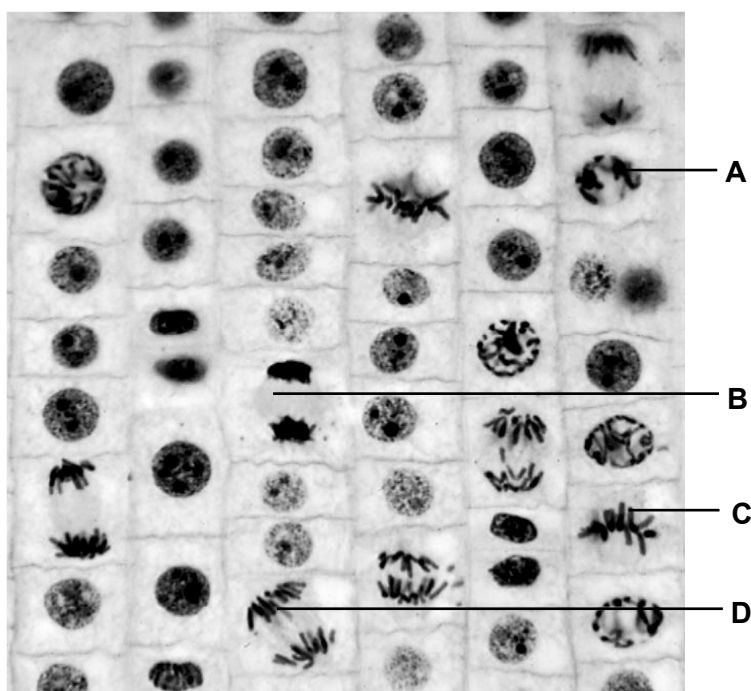


Fig. 2.1

- (a) (i) Using the letters provided, write the correct order of the stages in mitosis.

A, C, D and B;

[1]

- (ii) Describe the stage of mitosis in cell B.

1. Telophase;

2. Chromosomes having reached the opposite poles start to decondense;

3. Spindle fibers disintegrate and nucleolus re-appears around the chromatin;

4. Nuclear membrane reforms around chromatin;

[3]

Fig. 2.2 shows the change in DNA content of a plant cell during one cell cycle

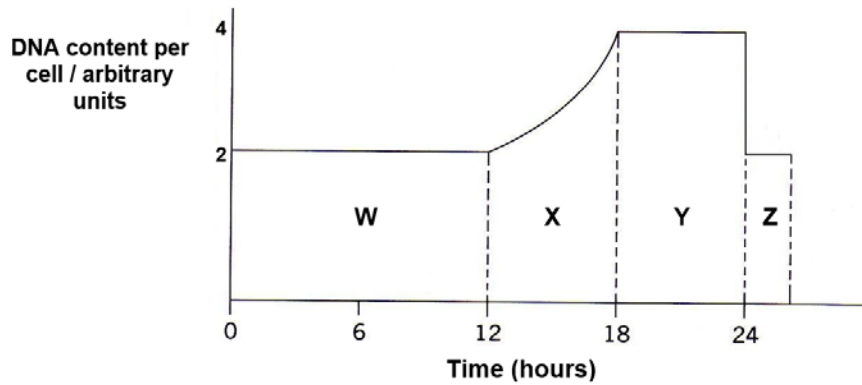


Fig. 2.2

- (b) (i) With reference to Fig. 2.2, identify which period (W to Z) of the cell cycle the radioactivity of the nuclei would first increase if radioactive thymine was added to the cell culture at 0 hours. Explain your answer.

1. Period X;

2. Doubling of DNA amount from 2 to 4 a.u. due to semi-conservative replication of DNA during S phase of Interphase;

3. Thymine incorporated into the new daughter strands/DNA formed; [3]

- (b) (ii) Explain why it is necessary for the cell cycle to be tightly regulated at various checkpoints that control the rate of cell division.

Dysregulation of cell division would result in uncontrolled cell division/cancer;

[1]

Horses were found to have three different coat colours – chestnut (brown), white and roan (patches of brown and white). The hair found on horses may be curly or smooth. These two traits are determined by two genes found on separate chromosomes, and each gene has two allelic forms.

When a true breeding chestnut horse with smooth hair was mated with a white horse with curly hair, all the progeny foals have roan coats with smooth hair.

- (c) Using appropriate symbols, construct a genetic diagram to show the expected genotypes and phenotypes of the F_2 progeny when two horses in the F_1 generation are crossed.

Appropriate symbols given:

1m

Let C^B denotes the allele coding for chestnut/brown coat colour
 C^W denotes the allele coding for white coat colour
 H denotes the dominant allele coding for smooth hair
 h denotes the recessive allele coding for curly hair

F_1 phenotype: Roan coat with smooth hair

F_1 genotype: $C^B C^W Hh$ x $C^B C^W Hh$

1m

F_1 gametes

$(C^B H)$ $(C^B h)$ $(C^W H)$ $(C^W h)$ $(C^B H)$ $(C^B h)$ $(C^W H)$ $(C^W h)$

1m

Punnett Square:

| | $(C^B H)$ | $(C^B h)$ | $(C^W H)$ | $(C^W h)$ |
|-----------|---|---|---|---|
| $(C^B H)$ | $C^B C^B HH$ Brown coat with smooth hair | $C^B C^B Hh$ Brown coat with smooth hair | $C^B C^W HH$ Roan coat with smooth hair | $C^B C^W Hh$ Roan coat with smooth hair |
| $(C^B h)$ | $C^B C^B Hh$ Brown coat with smooth hair | $C^B C^B hh$ Brown coat with curly hair | $C^B C^W Hh$ Roan coat with smooth hair | $C^B C^W hh$ Roan coat with curly hair |
| $(C^W H)$ | $C^B C^W HH$ Roan coat with smooth hair | $C^B C^W Hh$ Roan coat with smooth hair | $C^W C^W HH$ White coat with smooth hair | $C^W C^W Hh$ White coat with smooth hair |
| $(C^W h)$ | $C^B C^W Hh$ Roan coat with smooth hair | $C^B C^W hh$ Roan coat with curly hair | $C^W C^W Hh$ White coat with smooth hair | $C^W C^W hh$ White coat with curly hair |

All genotypes and phenotypes correct in punnett square – 1m

F_2 phenotypic ratio - 3 brown coat with smooth hair : 1 brown coat with curly chair :
 6 roan coat with smooth hair : 2 roan coat with curly hair :
 3 white coat with smooth hair : 1 white coat with curly hair

1m

[5]

[Total: 13 m]

- 3 Arthropods are a vast group of animals that have been on earth for about 500 million years. Fig. 3.1 shows the dorsal (top) and ventral (bottom) views of the horseshoe crab (genus *Limulus*) and some characteristics representative of all arthropods. Fig. 3.2 shows a fossil and an artist's impression of the *Sanctacaris*, which is one of the earliest arthropods and proposed by some scientists to be the ancestor of the horseshoe crab.

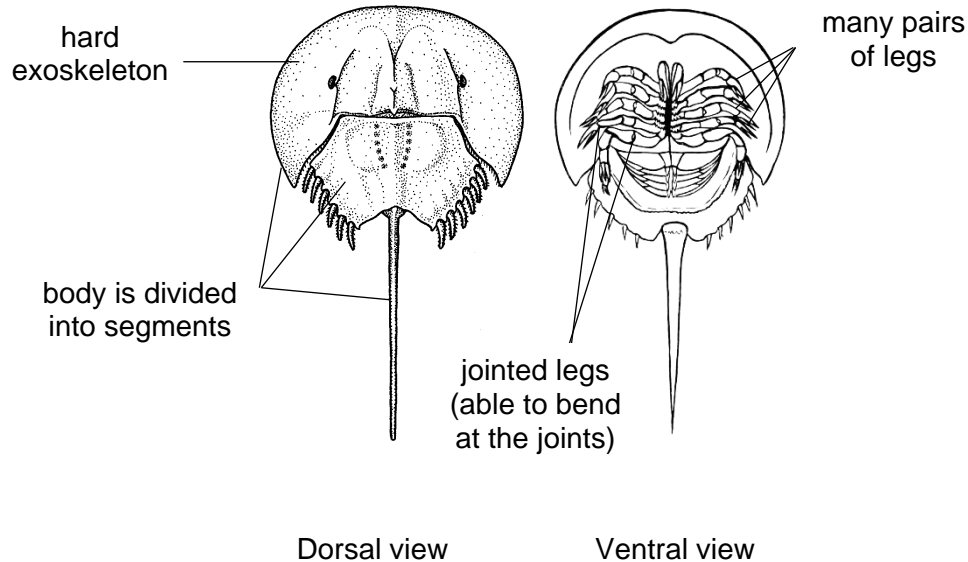


Fig. 3.1

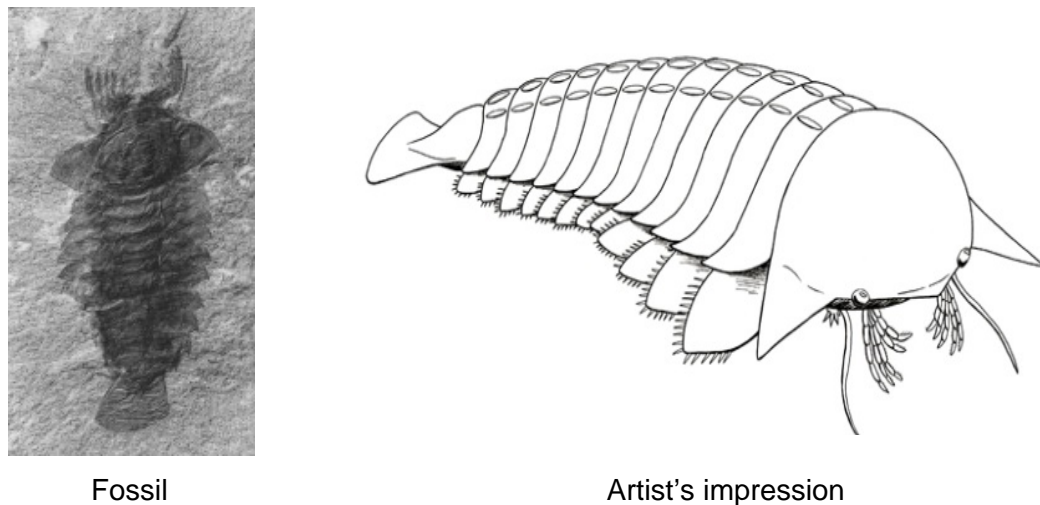


Fig. 3.2

- (a) (i) With reference to Figs. 3.1 and 3.2, explain why anatomy can be used to establish evolutionary relationships between fossils and their living descendants.

1. Certain anatomical/physical structures of ancestors and descendants will be similar as descendants inherited a common set of genes from ancestors;
2. Over time, natural selection/ divergent evolution/ descent with modification may result in slight differences in these structures as they serve different functions in the descendants;
3. From the *Sanctacaris* fossil, it appears to have features of the horseshoe

crab – segmented body (although it has more segments – support point 2), jointed legs, many pairs of legs, hard exoskeleton (and hence it can be fossilised);

4. Ref to comparative anatomy to elucidate level of relation;

[3]

- (ii) Based on its flap-like appendages, Sanctacaris was believed to be an aquatic arthropod. The horseshoe crab, however, utilises land habitats for certain parts of its life cycle - the eggs are laid on the coast and juveniles are found on the sandy tidal flats. Adults are found deeper in the ocean until they return to the beach to lay their eggs.

Using the theory of natural selection, suggest how horseshoe crabs evolved from Sanctacaris.

1. Valid selection pressure, e.g. increasing area of land mass, lack/loss of suitable food for Sanctacaris juveniles in the ocean, predation of Sanctacaris eggs in ocean;
2. As genetic variation existed in the population of Sanctacaris, there is also phenotypic variation;
3. Individuals with traits which enable them to go on land will have a selective advantage → they are more likely to survive, reproduce and pass on the alleles for these traits to their offspring;
4. Over a long time, the population on land will have traits that make them more adapted for land, e.g. ventral, longer legs, which are different from Sanctacaris population in the ocean;

5. The Sanctacaris population in the ocean eventually died out;

[4]

- (b) (i) Explain why molecular homology is preferred over anatomical homology in elucidating relationships between organisms.

| Molecular evidence | Morphological evidence |
|--|---|
| 1. Unambiguous and objective | Subjective |
| 2. Quantifiable | Traits may be qualitative and cannot be quantified |
| 3. Open to statistical analysis | Statistical software cannot be used to quantify differences |
| 4. Silent mutation taken into consideration when quantifying differences | Silent mutation not expressed in phenotype |
| 5. Able to distinguish between convergent and divergent evolution | Similarities may be due to convergent evolution |

@1m, max 2

- (ii) Suggest why molecular homology was not used in establishing the relationship between the horseshoe crab and the Sanctacaris.

Sanctacaris fossil did not contain any DNA/proteins;

[1]

- (c) Genetic variation is essential for evolution. Explain how DNA mutations give rise to phenotypic variation.

1. **Mutations refer to rare occurrences which change in the DNA nucleotide sequence, i.e. deletion, addition, substitution;**
2. **DNA codes for RNA during transcription and mRNA codes for polypeptides during translation;**
3. **Change in amino acid sequence may result in a change in 3D conformation of the protein and hence a change in function;**
4. **Function of the protein can change the phenotype of the organism e.g. structure, behaviour, which makes it different from the rest of the population;**

[4]

[Total: 14 m]

Section BAnswer **EITHER 4 OR 5.**

Write your answers in the lined pages 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

4 (a) Compare the structure of collagen and DNA.

[6]

Differences:

1. **Monomers consisting of deoxynucleotides vs amino acids;**
2. **4 types of nucleotides vs 20 types of amino acids;**
3. **Bonds between monomers are phosphodiester bonds vs peptide bonds**
4. **Double stranded vs three polypeptide chains / α chains wound around to form tropocollagen;**
5. **Two strands wound to form a double helix vs tropocollagen associate to form collagen (fibrils and fibers);**
6. **No cross-links present vs cross-linked (between tropocollagen molecules);**
7. **No regular sequence in DNA versus Gly-X-Y sequence repeated in collagen.**

Similarity

1. **Bonding in between chains are H bonds for both DNA and collagen;**
2. **DNA and tropocollagen are both helical (Not: DNA and collagen are both helical.)**

Differences max 5, @1m

(b) With reference to the fluid mosaic model, describe the roles of phospholipids and proteins in a cell surface membrane. [8]

1. **Each phospholipid consists of one glycerol molecule condensed with two fatty acid chains and one phosphate group;**
2. **Amphipathic nature of phospholipid results in the formation of a bilayer;**
3. **Where the hydrophilic phosphate heads make contact with the aqueous environment;**
4. **And hydrophobic fatty acid tails face the interior to form a hydrophobic core;**
5. **Phospholipid molecules are held together by weak hydrophobic interactions (and not covalent bonds) which allows the membrane to be fluid;**
6. **This allows for the embedment of proteins in the cell surface membrane;**
7. **Hydrophobic core and proteins These allow the membrane to be selectively permeable;**
8. **Small hydrophobic / non-polar substances are able to pass through in the lipid bilayer;**
9. **Ions, hydrophilic/polar molecules and large molecules are unable to pass through;**
10. **Membrane fluidity allows for exocytosis and endocytosis / formation of vesicles;**
Min. 3 m for phospholipids
11. **Presence of (transmembrane) channel proteins/carrier proteins (with hydrophilic channel/core) embedded in a scattered / random manner;**
12. **regulate movement of polar/hydrophilic substances into and out of cell;**
13. **To carry out facilitated diffusion and active transport;**
14. **Short carbohydrate groups can also attach to the proteins or phospholipids to form glycoproteins or glycolipids;**

15. Helps in cell-cell recognition which enables the cells to distinguish between cell types;
 16. Helps in cell-cell adhesion so that cells bind to form tissues;
 17. Glycoproteins function as receptors for chemical signals;
 18. Proteins can perform enzymatic activity;
 19. Aid in attachment to cytoskeleton;
- Min. 3 m for proteins*

(c) Discuss the ethical concerns that have arisen from the human genome project. [6]

1. The issue of who owns (and controls) genetic information – whether the individual has complete control over who has access to his genetic information, or is access controlled by the company/researcher who carries out the genome sequencing, or even controlled the government;
2. The issue of how insurers/employers/courts/schools/adoption agencies/military may request for and use DNA testing/have access to personal genetic information to discriminate people based on their genomes;
3. It is unclear how personal genetic information affects an individual and society's perceptions of that individual / how genomic information affect members of minority communities;
4. There is an issue of whether healthcare personnel are properly counseling parents about the risks and limitations of genetic technology (eg. with regards to the reliability of the genetic test, or whether the detected condition can be treated, and to help patients anticipate and deal with options to deal with the disease, if present, and whether relatives should be informed of the condition so that they can decide whether to test for the condition as well);
5. The reliability and usefulness of foetal genetic testing has not been verified in many cases;
6. To-be parents may have to make difficult decisions of whether to terminate pregnancy due to presence of genetic disorder (especially one for which there is currently no cure or treatment for);
7. The issue of whether testing should be performed when no treatment is available/treatment is extremely expensive and the patient cannot afford it, as diagnosing such a condition could lead to more anxiety and frustration;
8. The issue of whether parents have the right to have their children tested for adult-onset diseases, as there is potential for conflict between a parent's choice and a child's welfare (eg. a parent refuses to consent to a test that is clearly in their child's best interest, or a parent who decides to pursue a genetic "enhancement" that involves significant risks for a child, or that may limit a child's life prospects);
9. There is also the related issue of who has the right to determine whether newborns or others who are incapable of valid consent (eg. mentally incapacitated) should undergo genetic screening;
10. The genetic tests may only indicate a probability and not a certainty of a particular polymorphism/allele being associated with a disease or condition. (There is difficulty in interpreting a positive result because some people who carry a disease-associated mutation never develop the disease.) Hence the genetic tests may not be reliable;

[Total: 20 m]

OR

5 (a) Explain the roles of membranes in transcription and translation. [6]

1. Compartmentalisation increases efficiency of reactions;
2. Physically separate chemical reactions, which allows localisation of specific molecules in specific compartments/allows suitable environment to be created;
3. Transcription: RNA Polymerase works optimally in nucleus/nucleoplasm or any valid e.g.;
4. Translation: Enzymes catalysing chemical modifications in RER/Golgi body found in the lumen of cisternae or any valid e.g.;
5. Allow high concentration of enzymes and molecules to accumulate;
6. Transcription: RNA Polymerase accumulates in nucleus or any valid e.g.;
7. Translation: polypeptide chain enters RER lumen via pores in membrane or any valid e.g.;
8. Separate reactions in time/sequence;
9. Transcription: mRNA is synthesised in the nucleus before it leaves the nucleus via the nuclear pore to be used as a template for translation in the cytoplasm or any valid e.g.;
10. Translation: Enzymes found in RER catalyse reactions preceding those found in Golgi body or any valid e.g.;
11. Increase surface area for attachment of membrane proteins;
12. Translation: Ref to RER/Golgi body and relevant proteins/enzymes or any valid e.g.;

@1m, max 6

The same example cannot be marked twice for different roles. There must be at least one role matched to a specific example (transcription or translation) before full marks can be awarded.

(b) Describe the role of enzymes in the cloning of human Insulin gene from mRNA using *E. coli*. [8]

Formation of ds cDNA with sticky ends:

1. Insulin mRNA (isolated from beta cells of islets of Langerhans in pancreas) is reversed transcribed by reverse transcriptase;
2. to form a single stranded complementary DNA (cDNA);
3. RNase is used to remove the mRNA template strand from the DNA/RNA hybrid;
4. DNA polymerase then used to synthesize the complementary strand to cDNA strand to obtain a double stranded cDNA molecule;
5. DNA linkers with a (appropriate) restriction site are added to the blunt ends of the ds cDNA by terminal transferase;
6. Use of restriction enzyme to produce sticky ends on ds cDNA;

Formation of recombinant plasmid:

7. Plasmids with 2 selectable markers (e.g. ampicillin resistance gene and lacZ gene), one of which (lacZ) has the restriction site (of the restriction enzyme to be used) and will be inactivated by insertion of insulin cDNA/ OWTTE;
8. Cut by same restriction enzyme used to cleave ds cDNA;
9. to produce complementary sticky ends that will anneal with ds cDNA via complementary base pairing with formation of H bonds;

10. DNA ligase added to the mixture of dsDNA and cut plasmids;
11. to form recombinant plasmids via the formation of phosphodiester bonds;
12. Transformation of competent *E. coli* via heat shock treatment before selection of transformed *E. coli* with recombinant plasmid;
13. Via selection of white bacteria colonies with the ability to grow on ampicillin- and X-gal-containing media (if lacZ gene indicated) / identifying transformed *E. coli* colonies containing human insulin gene by nucleic acid hybridisation;

(c) Explain the normal functions and features of two named stem cells in a living organism. [6]

1. Named stem cell (in syllabus): embryonic stem cells and blood/haematopoietic stem cells; R! adult/somatic stem cells
2. They are unspecialised/undifferentiated;
3. Capable of dividing and renewing themselves for long periods via mitotic cell division (i.e. self-renewing), while still maintaining the undifferentiated state;
4. Can differentiate into specialised cell types under presence of appropriate chemical signals;
5. Embryonic stem cells are multipotent;
6. As they are able to differentiate into almost any cell type to form any organ or type of cell but not those of the extra-embryonic membranes;
7. They can differentiate into any of the three germ layers: endoderm, mesoderm and ectoderm;
8. While haematopoietic stem cells are pluripotent;
9. As they are able to differentiate into all the blood cell types (but not other types of cells);
10. Hence allowing replacement of blood cells lost through normal wear and tear, injury or disease;

@1m

[Total: 20 m]