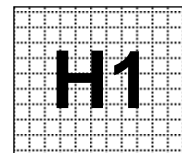


Civics Group	Index Number	Name (use BLOCK LETTERS)
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ST. ANDREW'S JUNIOR COLLEGE
2017 Preliminary Examination

H1 BIOLOGY

8875/2

Paper 2: Core (Mark Scheme)

Tuesday

12 September 2017

2 hours

Additional Materials: Answer Paper
Cover Sheet for Section B

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number 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 diagram, graph or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** the questions.

Section B

Compulsory question to be answered on writing paper provided.

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

For Examiner's Use	
Section A	
1	/16
2	/12
3	/12
Sub-total	/40
Section B	
4 or 5	/20
Total	/60

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

[Turn over

Section A

Answer **all** questions.

QUESTION 1

Hormones, insulin and glucagon, are proteins that regulate the concentration of blood glucose level. Type 2 diabetes is characterized both by insulin resistance, a condition in which various tissues in the body no longer respond properly to insulin action, and by subsequent progressive decline in beta (β)-cell function to the point that the cells can no longer produce enough additional insulin to overcome the insulin resistance. Researchers are actively exploring use of stem cells as a potential source of deriving new β -cells to treat type 2 diabetes.

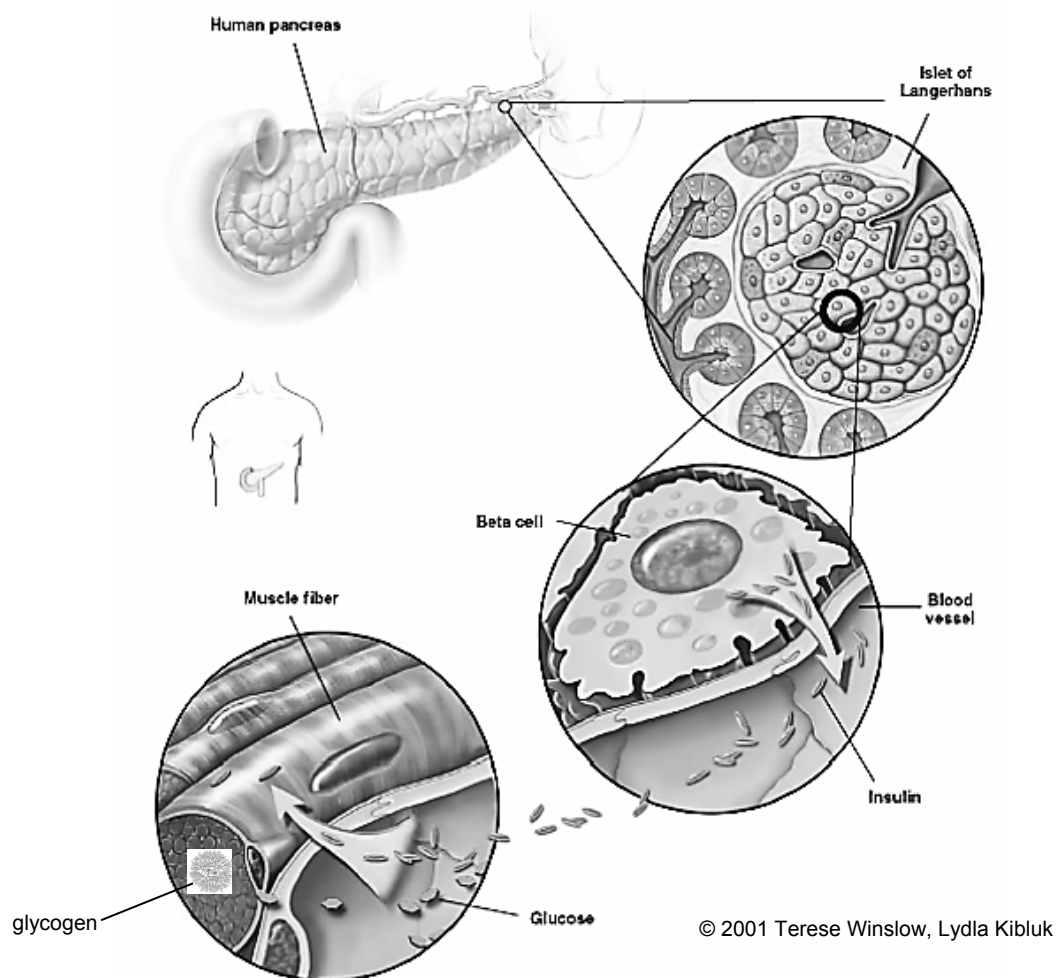


Fig. 1

The pancreas is located in the abdomen, adjacent to the duodenum (the first portion of the small intestine). A cross section of the pancreas shows the islet of Langerhans which is the functional unit of the endocrine pancreas. Encircled is the beta cell that synthesizes and secretes insulin. Beta cells are located adjacent to blood vessels and can easily respond to changes in blood glucose concentration by adjusting insulin production.

- (a) Cells that secrete proteins contain a lot of rough endoplasmic reticulum (rER) and a large Golgi body.

(i) Describe how the rER is involved in the production of insulin.

.....[1]

- 1 (RER has) **bound ribosomes** for protein synthesis

[REJECT: make amino acid]

[ACCEPT: amino acids joined together / polypeptide]

- 2 **Chemical** modification / post-translational modification of polypeptide

Note:

Point 2 is accepted in view that students have not learnt about the processing of insulin in detail. Chemical modification of insulin e.g cleavage of pro-insulin to insulin is done in the Golgi body

(ii) Describe how the Golgi body is involved in the secretion of insulin.

.....[2]

- 1 (Golgi body) further chemically modifies (insulin) ;

- 2 **packages** (insulin) into **secretory vesicles** which **move towards the cell surface membrane** (and fuse with it, to release insulin out of the cell) ;

- (b) Using type II diabetes as an example, explain how environment affects phenotype.

.....[3]

- 1 people with functional pancreas/with no type I diabetes have **functional genes which code for insulin release**;

(insulin is secreted when blood glucose level increases);

- 2 **overeating** of sugary foods for a long period of time causes repeated stimulation of the pancreas;

which responds by **secreting high levels of insulin**;

- 3 **repeated exposure** of target cells to large amounts of insulin **desensitizes** the cells' responsiveness to insulin;

- 4 result in the target cells **failing to take in glucose**; (blood glucose stays high) resulting in type II diabetes;

- (c) Insulin binds to receptors on the membrane of the muscle cells allow entry of glucose into the muscle cells leading to a lowering of blood glucose concentration. Suggest how a change in the amino acid sequence of the receptor found in the plasma membrane of the muscle cell could make the cell resistant to insulin.

.....[2]

[Max 1]

- 1 Different amino acid sequence lead to different interactions between R groups of amino acids,
- 2 leading to **different tertiary structure / three-dimensional** structure (of receptor) ;

[Compulsory]

- 3 (so insulin) does not fit / bind / is not complementary ;
[REJECT: any reference to 'active site', 'enzyme-substrate complex' or insulin not fitting/binding to an enzyme]

(d) Describe how phospholipids are arranged in a plasma membrane.

.....[3]

- 1 (phospholipid molecules arranged as a) bilayer ; [**ACCEPT** : double layer]
- 2 Polar phosphate head / charged phosphate group (of phospholipid molecules) faces outwards and interacts with aqueous medium of the external environment and the cytoplasm ;
- 3 Non-polar hydrocarbon chains of fatty acids in phospholipid molecules form the interior of the plasma membrane / cell membrane / cell surface membrane ;

(e) Phospholipids are a type of lipid. Lipids, in general, are made up of glycerol and fatty acids monomers covalently bonded together. Name the covalent bond and describe the breakage of this bond.

.....[2]

- 1 ester bond ; [Reject: ester]
- 2 Addition of 1 water molecule across each ester bond (via hydrolysis reaction) ;
- 3 Products of hydrolysis are the **hydroxyl group (-OH) in the glycerol molecule** and the **carboxyl group (-COOH) of a fatty acid** ;

Experiments have indicated that pancreatic stem cells (PSCs) can serve as sources of insulin secreting cells.

(f) State the source of PSCs and explain the PSCs' normal functions.

.....[2]

- 1 Pancreas ;
- 2 Give rise to pancreatic cells, to growth, **repair and maintenance** of pancreatic tissues.

(g) Suggest an advantage of using the patient's own PSCs to regenerate tissue or organs.

.....[1]

- 1 No immune response (to own tissue)
/ tissue will not be rejected

[Reject: "cells will not be rejected" as context is on tissue regeneration]

[Q1 Total: 16]

QUESTION 2

Epidermal growth factor (EGF) is released by cells, and is picked up either by the cell itself or by neighboring cells. It regulates the production of a number of proteins in target cells. Protein produced and its effect depends on the type of target cell.

Fig. 2 shows how EGF regulates 3 genes.

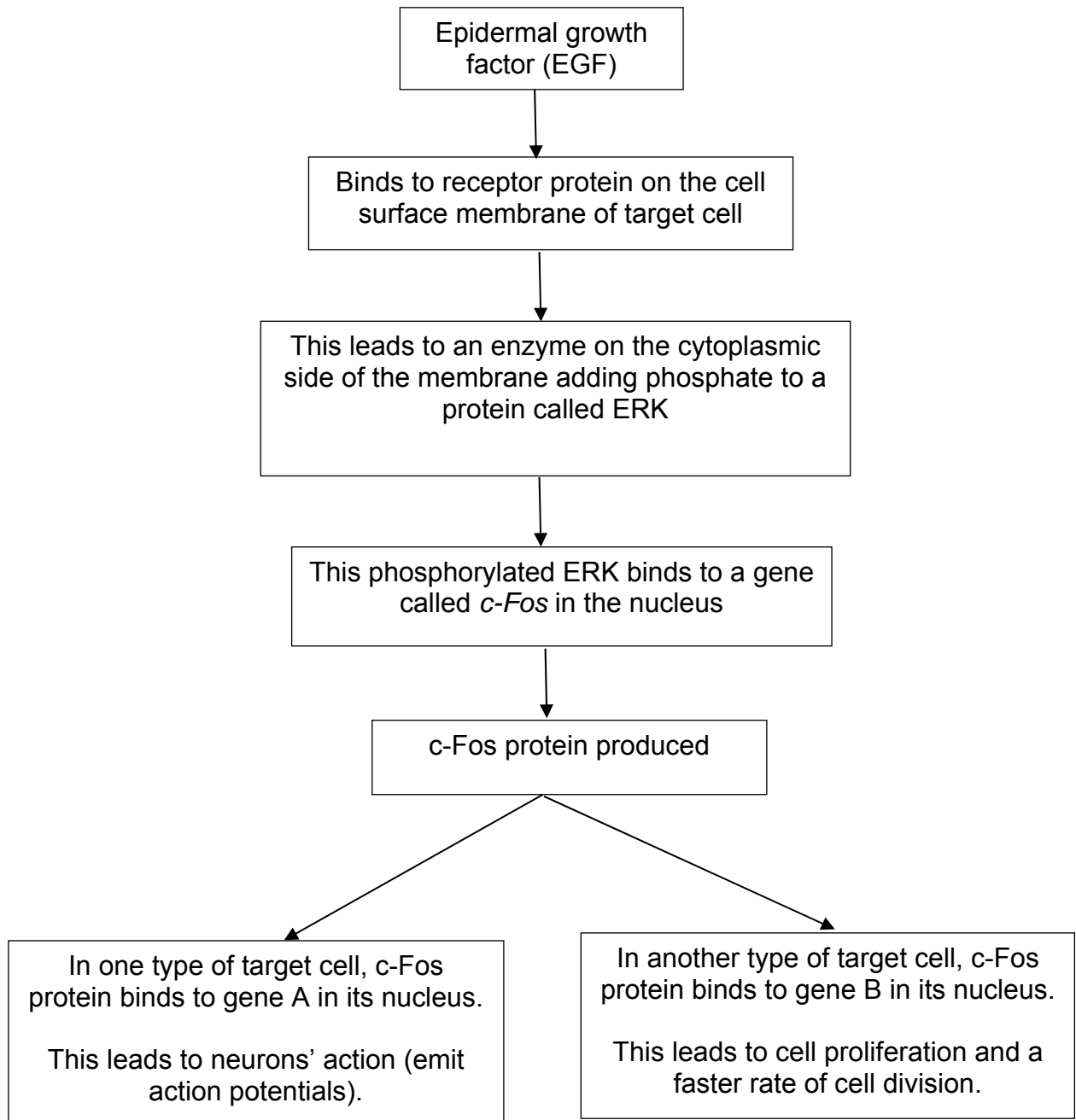


Fig. 2

(a) Name the **two** transcription factors in Fig. 2.

.....[1]

- 1 Phosphorylated ERK ; AND
c-Fos (protein)

(b) Dysregulation of checkpoints of cell division allows gene mutations, e.g. *c-Fos* gene, to occur spontaneously and accumulation of gene mutations can result in uncontrolled cell division and cancer.

(i) During which part of the cell cycle are gene mutations most likely to occur?

.....[1]

- 1 S phase of interphase ;

(ii) Suggest an explanation for your answer in (b)(i).

.....[1]

- 1 DNA replication via semi-conservative replication ;

(c) Gene B has been associated with a significant number of human cancers. Scientists used polymerase chain reaction (PCR) to make multiple copies of gene B extracted from a patient's cancer tissue sample.

The reaction mixture includes the sample of DNA to be copied plus the following ingredients:

- DNA primers
- buffer solution
- heat-stable DNA polymerase (Taq polymerase)
- deoxyribonucleoside triphosphates (deoxyATP, deoxyTTP, deoxyCTP and deoxyGTP)

(i) Suggest why a buffer needs to be present in the reaction mixture.

.....[1]

- 1 to control the pH
/ to stop the polymerase denaturing
/ to optimise pH for polymerase activity

(ii) The deoxyribonucleoside triphosphates that are added to the reaction mixture are the monomers used for making the new DNA strands.

Suggest **one further** reason for adding the deoxyribonucleoside triphosphates to the reaction mixture.

.....[1]

- 1 *Ideas that* it is a source of energy / AW ;
(hydrolysis of the dATP to dAMP and PP release energy which is used in the catalysis of phosphodiester bonds in the polynucleotide chain)

(iii) In the first stage of PCR, the mixture is heated to a temperature of around 90°C to denature the DNA. Suggest why high temperatures are needed to separate the two DNA strands.

-[2]
- 1 Idea of many hydrogen bonds between **complementary** strands together ;
 - 2 Hydrogen bonds break because of increased kinetic energy / vibrations ;

(iv) At the end of several cycles of PCR, many copies of the DNA sample in the reaction mixture will have been made. The DNA samples are then separated out to produce a DNA banding pattern.

State the technique used to separate out the DNA samples **and** describe how this technique works.

-[4]
- 1 Gel electrophoresis ;
 - 2 **Load** (10 µl of) sample into the **wells** in agarose **gel** ;
Gel electrophoresis conducted at 100V till tracking dye move to $\frac{3}{4}$ length of gel
 - 3 **DNA is negatively-charged** due to negatively-charged sugar-phosphate backbone **move towards the positively-charged electrode**
 - 4 through an agarose matrix which acts as a **molecular sieve** ;
 - 5 DNA fragments separated by size ; where shorter DNA fragments move faster [Reject: further] than longer ones;

(d) Methotrexate is a drug used in the treatment of cancer. It is a competitive inhibitor and affects the enzyme folate reductase.

Explain why this drug does not affect other enzymes.

-[1]
- 1 Methotrexate / drug is only similar shape to specific substrate / only fits this active site;

OR

Methotrexate / drug is a different shape to other substrates / will not fit other active sites;

[Q2 Total : 12]

QUESTION 3

- (a) An example of an aquatic salamander, the olm, *Proteus anguinus*, is shown in the photograph below. This species is an amphibian endemic to the caves of Slovenia and Croatia.

Olms have a number of special adaptations: external gills as adults, undeveloped eyes, lack of skin pigmentation and a slow metabolic rate.



Magnification $\times 0.1$

- (i) Explain what is meant by the phrase 'endemic to the caves of Slovenia and Croatia'.

.....[1]
 1 they are { found only in Slovenia and Croatia / not found in other countries / only found in these caves } ;

- (ii) Olms evolved from small populations of amphibians that lived in caves. These caves became blocked off from other caves by rock barriers.

Suggest how natural selection could have led to the evolution of the olm.

.....[5]

- 1 Genetic variation exists within the olm population (due to mutation)
- 2 Different selection pressures / different ecological niches available in different parts of the cave ; such as different types of food available;
- 3 description of a beneficial characteristic
 / e.g. undeveloped eyes as the cave is dark allows olm to develop its other senses to ensure its survival ; etc
- 4 Individuals with a selective advantage in the cave **survived** till reproductive age **and reproduce**; and
- 5 pass on their advantageous/beneficial alleles to their offspring;

- 6 Over many generations, allele frequencies change and olms with external gills as adults, undeveloped eyes, lack of skin pigmentation and a slow metabolic rate, became the predominant phenotype.

- (b) A transgenic animal is one that carries a foreign gene that has been deliberately inserted into its genome. The foreign gene is constructed using recombinant DNA methodology. In addition to the gene itself, the DNA usually includes other sequences to enable it to be expressed correctly by the cells of the host.

Atlantic salmon (foreground) which normally grows in Spring and Summer was genetically modified to produce the Aquadvantage® salmon (background).



Fig.3.1

Credits : <http://foreverconscious.com/wp-content/uploads/2014/04/gmo-salmon-compare.png>

- (i) Explain why the genetically engineered Aquadvantage® salmon (GM salmon) is considered a transgenic animal.

.....[2]

- 1 Active growth hormone gene from Pacific Chinook salmon ;
- 2 Combined with regulatory sequences / promoter of the ocean pout ;
- 3 Inserted into genome of fertilized Atlantic salmon eggs ;

- (ii) Describe the **effect** of the genetic modifications carried out on the GM salmon.

.....[1]

- 1 GM salmon produces higher levels of fish growth hormone ;
Accelerated growth rate of fish ;
/ Reaches its desired market length in a shorter period of time ;
[REJECT] GM salmon grows to larger size

- (iii) Explain the significance of the transgenic GM salmon in solving the demand for food in the world.

.....[1]

- 1 Increased yield ; grow to its full length in a shorter period of time
/ More fish can be harvested in a year ;
/ Allows salmon to grow all year around (instead of only during Spring and Summer).

(iv) State one ethical and one environmental implications of GM salmon.

.....[2]

Disruption of ecological balance [Environmental]

- 1 Ecological balance is disrupted
Accidental release of transgenic organisms into the environment might upset the balance of the ecosystem.
- 2 Fast-growing salmon may outcompete the wild salmon population and affect the food chain.
- 3 Larger transgenic salmon may be preferably selected as mates over smaller wild types.
- 4 Danger that the active growth hormone gene is transferred to other fish.

AND

Animal rights issue [Ethical]

- 1 Animal rights – GM animals may suffer unnecessarily;
 - Eg. Increased use of the growth hormone may have harmful effects on fish health .

[Q3 Total : 12]

Section B

Answer one question.

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.

- 4** **(a)** Explain what is meant by primary, secondary, tertiary and quaternary structure of haemoglobin. [10]
- (b)** Haemoglobin is a globular protein. Using a named example of fibrous protein, give **three** differences between fibrous and globular proteins. [3]
- (c)** Explain how the allele for haemophilia may be passed from a man to his grandchildren.

You may use genetic diagrams to support your answer. [7]

[Q4 Total: 20]

OR

- 5** **(a)** Describe the structure of a chloroplast. [6]
- (b)** Describe how, in photosynthesis, light energy is converted into chemical energy, in the form of ATP. [8]
- (c)** Outline the steps of the Calvin cycle. [6]

[Q5 Total: 20]

- **END OF PAPER** -

QUESTION 4(a)

Explain what is meant by primary, secondary, tertiary and quaternary structure of haemoglobin. [10]

Primary structure (max 2)

- 1 Refers to the type, number and sequence of amino acids in a linear polypeptide chain ;
- 2 making up each haemoglobin polypeptide (individual α and β subunits)
- 3 ref (each α -chain is) 141 amino acids long and (each β -chain is) 146 amino acids long
- 4 Peptide bond involved in joining all amino acid monomers together

Secondary structure (max 2)

- 5 Refers to the folding of the polypeptide into regular structures
- 6 α -helices / coiling of polypeptide chain into a regular helical conformation.
- 7 hydrogen bonds formed between the $-\text{CO}$ group of peptide bond on one amino acid and the $-\text{NH}$ group on peptide bond of another amino acid

Tertiary structure (max 3)

- 8 the folding of the polypeptide chain into its unique 3-dimensional shape; ref. globular shape of haemoglobin
- 9 Amino acids far away in primary structure are brought close together (by R group interaction);
- 10 Non-polar/hydrophobic (side chains of) amino acids are buried in the interior; Polar and charged/hydrophilic (side chains of) amino acids are on the surface;
- 11 Bonds involved include hydrophobic interactions, hydrogen bonds and ionic bonds between R groups of amino acids within each polypeptide chain

Quaternary structure (max 3)

- 12 Refers to the arrangement of the polypeptide subunits within a protein that is made up of more than one polypeptide chain / spatial arrangement of more than one polypeptide chain
- 13 Association of prosthetic haem group per subunit to form a conjugated polypeptide ;
- 14 ref. to the association of 2α and 2β subunits to form functional haemoglobin molecule
- 15 Bonds involved include hydrophobic interactions, hydrogen bonds and ionic bonds between R groups of amino acids in the four subunits

Teachers' comments:

It is important to state the definitions of each level of folding and tailor your points to the haemoglobin case study. Note that disulfide bonds are not present in haemoglobin.

QUESTION 4(b)

Haemoglobin is a globular protein. Using a named example of fibrous protein, give three differences between fibrous and globular proteins. [3]

	Fibrous	Globular
1	Collagen – structural protein	Haemoglobin - transport protein
2	insoluble / large	Soluble / small
3	Primary, (mainly) secondary, and quaternary structure, no tertiary structure	Primary, secondary, tertiary and quaternary structure
4	Repeated amino acid sequences / ref. gly-X-proline or gly-X-hydroxyproline motif	Little repetition

QUESTION 4(c)

Explain how the allele for haemophilia may be passed from a man to his grandchildren. You may use genetic diagrams to support your answer. [7]

- 1 (haemophilia) allele on X chromosome / X-linked inheritance ;
- 2 allele recessive ;
- 3 man, / homogametic / has one X chromosome
- 4 one Y chromosome (which does not have blood clotting allele) ;
[ACCEPT symbol: X^H and X^h explained]
- 5 Only daughter(s) get his X chromosome ;
[ACCEPT symbol: $X^H X^h$; mother is normal and not a carrier]
- 6 Grandson(s) has 50% chance of carrying (haemophilia) allele ;
[ACCEPT symbol: $X^H Y$ **and** $X^h Y$]
- 7 Granddaughter(s) has 50% chance of carrying (haemophilia) allele ;
[ACCEPT symbol: $X^H X^H$ **and** $X^H X^h$ or $X^h X^h$]

QUESTION 5(a)**Describe the structure of a chloroplast.****[6]**

- 1 double membrane ;
- 2 stroma ;
- 3 contains enzymes ; named enzyme, e.g. rubisco (Calvin cycle);
- 4 also sugars / lipids / starch ;
- 5 70S ribosomes ;
- 6 Circular DNA ;
- 7 Internal membrane system consisting of stacks of thylakoids called grana interconnected via intergranal lamella ;
- 8 (grana) membranes hold, photosynthetic pigments / ATP synthase / ETC (electron transport chain) ;
- 9 Size : 3 – 10 μm

QUESTION 5(b)

Describe how, in photosynthesis, light energy is converted into chemical energy, in the form of ATP. [8]

- 1 Light energy absorbed by chlorophyll / pigments in photosystems ;
- 2 energy transferred from light harvesting complexes til it reaches special chlorophyll a in reaction centre ;
- 3 electron, excited and captured by primary electron acceptor ;
- 4 electron passes along, chain of electron carriers / ETC ; of decreasing energy level ;
- 5 energy released used to pump protons ;
from stroma into thylakoid space ;
- 6 thylakoid membrane impermeable to protons ;
- 7 proton gradient formed ;
- 8 protons move down gradient through ATP synthase ;
- 9 ATP produced from ADP and Pi ;

QUESTION 5(c)

Outline the steps of the Calvin cycle.

[6]

- 1 RuBP (Ribulose biphosphate) combines with carbon dioxide ;
- 2 catalysed by **rubisco (ribulose biphosphate carboxylase)** ;
- 3 forms unstable 6C compounds which produced two molecules of phosphoglycerate (PGA) ;
- 4 PGA conveted to phosphoglyceraldehyde (PGAL) ;
- 5 using reduced NADP and ATP (from light dependent stage / photophosphorylation) ;
- 6 some PGAL used to regenerate RuBP ;
- 7 using ATP ;
- 8 (one) PGAL (exit Calvin cycle) to form hexose / carbohydrates