

Civics Group	Index Number	Name (use BLOCK LETTERS)
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H1



**ST. ANDREW'S JUNIOR COLLEGE
2017 JC2 BT2**

H2 BIOLOGY

9744/1

Paper 1: Multiple Choice Mark Scheme

Tuesday

19th September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser (not supplied)
Soft pencil (type B or HB is recommended)

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name, civics group and index number on the multiple choice answer sheet in the spaces provided.

There are **30** questions in this paper. Answer all questions. For each question, there are four possible answers, A, B, C and D.

Choose the one you consider correct and record your choice in soft pencil on the separate multiple choice answer sheet.

INFORMATION TO CANDIDATES

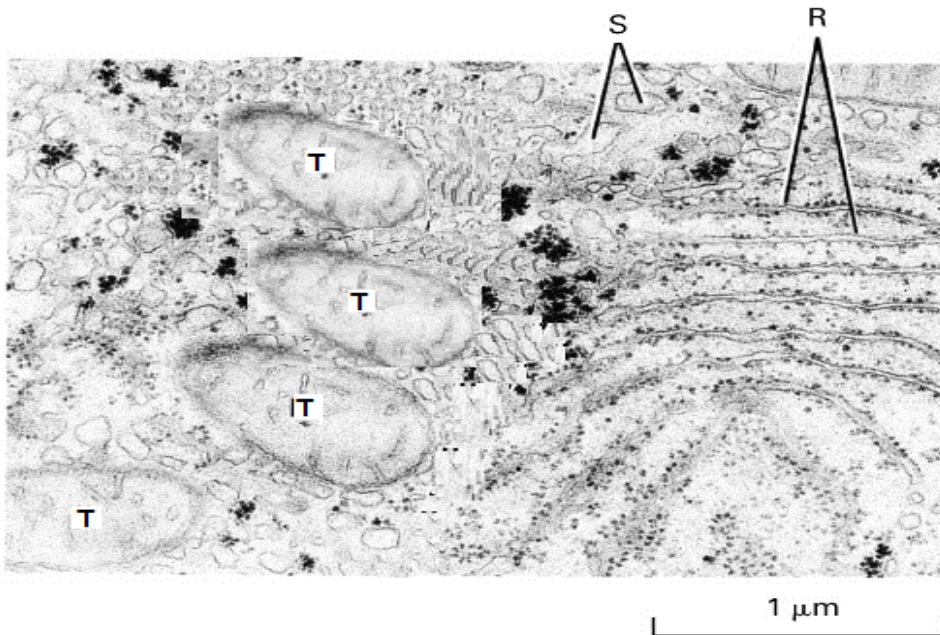
Each correct answer will score one mark. A mark will not be deducted for wrong answer. Any rough working should be done in this booklet.

At the end of the examination, submit both question paper and multiple choice answer sheet.

This document consists of **16** printed pages.

[Turn over

1 The figure below shows an electron micrograph of an eukaryotic cell.



Which of the following option correctly matches the structures **R**, **S** and **T** to their respective functions?

	R	S	T
A	Involved in proteins glycosylation	Site of lipid synthesis	To convert light energy to chemical energy
B	Site of protein synthesis	Site of detoxification reaction	Supplying cellular energy
C	Site of detoxification reaction	Involved in protein glycosylation	Remove worn out organelles
D	Site of protein synthesis	Contains proteins to be secreted	Storage of starch

2 Which comparative statement(s) concerning biological molecules is/are correct?

- 1 A collagen molecule is a fibrous protein that contains many amino acids with hydrophobic R-groups whereas a haemoglobin molecule is a globular protein with no amino acids with hydrophobic R-groups.
- 2 Sucrose hydrolysis results in glycosidic bond breakage and the production of equal proportions of fructose and α -glucose molecules, whereas cellulose hydrolysis results in only β -glucose molecules.
- 3 The glycosidic bonds of glycogen are formed between two α -glucose molecules, whereas in amylopectin, the bonds are formed between an α -glucose molecule and a β -glucose molecule.

- A** 2 only
B 3 only
C 1 and 2
D 1 and 3

- 3 Which two features contribute to the great tensile strength of cellulose?
- 1 glycosidic bonds linking the long chains of 1,4 α -glucose molecules
 - 2 the -OH groups of the glucose molecules project outwards and form H bonds with neighbouring chains
 - 3 the strength of the glycosidic bonds between the neighbouring chains of molecules
 - 4 the successive glucose molecules are orientated at 180° to each other
- A 1 and 3 only
 B 1 and 4 only
 C 2 and 3 only
 D 2 and 4 only
- 4 The statements below are about bonds found in biological molecules.
- 1 They are formed by condensation.
 - 2 Oxygen is part of the bond.
 - 3 ATP is hydrolysed to form the bonds.
 - 4 The bonds contain potential energy.

Which statements are correct for the bonds in the primary structure of proteins?

- A 1, 3 and 4 only
 B 3 and 4 only
 C 1 and 2 only
 D 1, 2, 3 and 4
- 5 The cell surface membrane structure is described as a 'fluid mosaic'.

Which statement describes the 'mosaic' part of the cell surface membrane?

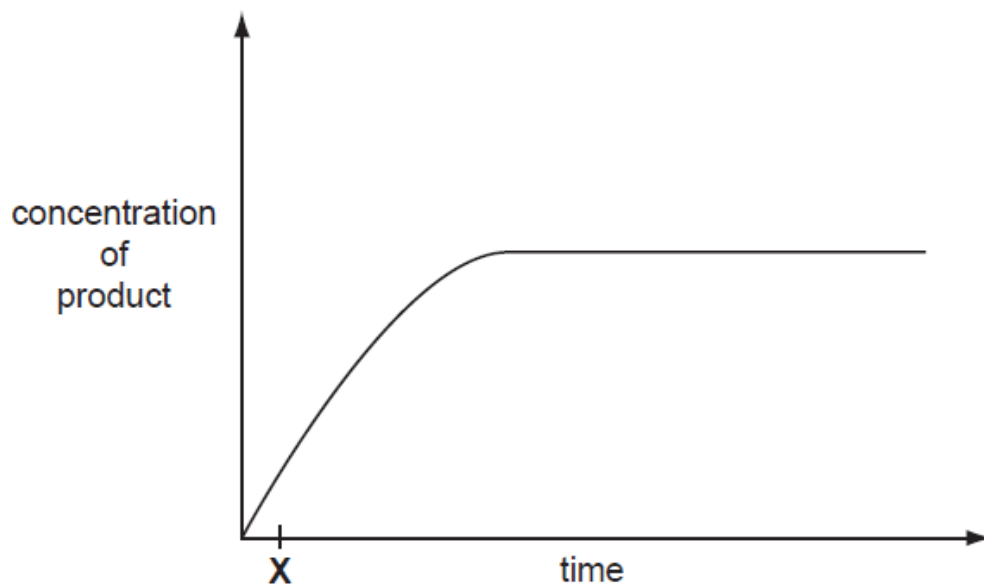
- A the different patterns that are obtained by the moving phospholipid molecules
 B the random distribution of cholesterol molecules within the phospholipid bilayer
 C the regular pattern produced by the phospholipid heads and membrane proteins
 D the scattering of the different proteins within the phospholipid bilayer
- 6 What supports the view that a membrane protein is involved in active transport?
- A It allows movement of molecules across a membrane if concentration differences exist.
 B It can only function if mitochondria are supplied with sufficient oxygen.
 C It has a tertiary structure with a binding site with a specific shape.
 D It is found in the cell surface membranes and the mitochondrial membranes.

7 What would be shown by a microscopic examination of a root tip squash?

- 1 cells with large nuclei at interphase
- 2 cells not dividing and nuclei undergoing mitosis
- 3 nuclei with paired homologous chromosomes visible
- 4 cell walls forming

- A** 1, 2 and 3
B 1, 2 and 4
C 1, 3 and 4
D 2, 3 and 4

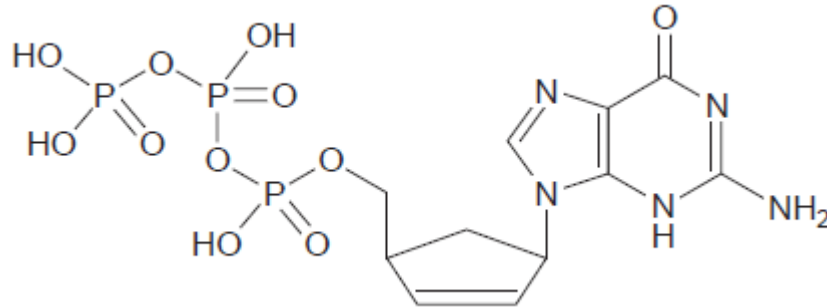
8 The graph shows the course of an enzyme-catalysed reaction at 30 °C.



What is true at time X?

- A** Most enzyme molecules will have free active sites.
B The number of available substrate molecules is high.
C The number of enzyme-substrate complexes is low.
D The rate remains the same if more enzyme is added.

- 9 The diagram shows the molecular structure of a chemical that can inhibit the activity of reverse transcriptase (which catalyses the reaction of synthesis of complementary deoxyribonucleic acid using ribonucleic acid as template). It is an analogue of a naturally occurring nucleic acid monomer.



Which option is correct?

	Analogue	Naturally occurring monomer
A	Acts as a competitive inhibitor	Is an activated DNA nucleotide
B	Acts as a non-competitive inhibitor	Is an activated RNA nucleotide
C	Acts as a competitive inhibitor	Is an activated RNA nucleotide
D	Acts as a non-competitive inhibitor	Is an activated DNA nucleotide

- 10 Which row is correct for adenine?

	has a single ring structure	is a purine	joins to its complementary base with 3 hydrogen bonds
A	✓	✓	✓
B	✓	✗	✗
C	✗	✓	✗
D	✗	✗	✓

key
 ✓ = correct
 ✗ = incorrect

- 11** Meselson and Stahl investigated DNA in bacteria. They grew bacteria in a medium with only heavy nitrogen, ^{15}N , until all of the bacterial DNA contained only heavy nitrogen.

These bacteria were then moved from the heavy nitrogen medium and cultured in a medium with only light nitrogen, ^{14}N .

Some bacteria were collected from each of the next three generations and their DNA was analysed.

Hybrid DNA contains both heavy and light nitrogen.

Which row shows the correct DNA of the first and third generations?

	DNA of first generation	DNA of third generation
A	all hybrid	half hybrid, half light
B	all hybrid	one quarter hybrid, three quarter light
C	half hybrid, half heavy	half hybrid, one quarter heavy, one quarter light
D	half hybrid, half light	one quarter hybrid, three quarter light

- 12** Scientists have made a nucleic acid (HNA) that has a sugar with the same number of carbon atoms as glucose instead of deoxyribose. Although genetic information can be stored by HNA, naturally occurring DNA polymerase cannot replicate HNA.

Which statements could explain why naturally occurring DNA polymerase cannot replicate HNA?

- 1 DNA polymerase cannot form bonds between the sugars of two HNA nucleotides.
- 2 DNA polymerase cannot form hydrogen bonds between two HNA nucleotides.
- 3 HNA nucleotides do not fit into the active site of DNA polymerase.
- 4 The shape of an HNA nucleotide is slightly larger than that of a DNA nucleotide.

- A** 1, 2, 3 and 4
B 1 and 4 only
C 2 and 3 only
D 3 and 4 only

13 Rifampicin is an antibiotic used to treat tuberculosis.

It works by inhibiting RNA polymerase in bacteria.

Which of these processes will be directly inhibited by this antibiotic?

- 1 ATP synthesis
- 2 transcription
- 3 translation

- A** 1 and 2
B 1 and 3
C 2 only
D 3 only

14 Transcription in eukaryotic cells results in the formation of pre-mRNA, which is made up of exons and introns.

Which of the following statements correctly describes what happens during the formation of mature mRNA from the pre-mRNA?

- A** The 5' of the intron is cut, and joined to the branch-point sequence, followed by the cutting of the 3' end to form the lariat loop.
B RNA splicing occurs, where all introns are recognised as they share highly similar sequences and are excised.
C RNA splicing occurs, where all the introns are excised and some of the exons joined together so that they can be transcribed.
D The addition of the 5' cap and the 3' poly-A tail occurs, followed by RNA splicing.

15 Electron micrographs may show large numbers of ribosomes forming chains along mRNA molecules.

What is the advantage of this arrangement, compared to when ribosomes appear singly on the mRNA?

- A** Different polypeptides can be produced simultaneously.
B Fewer tRNA molecules are required to translate the polypeptide.
C Large polypeptide chains can be produced.
D Polypeptides can be produced more rapidly.

- 16** In dogs, a gene on chromosome 27 is responsible for the curliness of the dog's hair. One form of this gene produces an enzyme with arginine at residues 151, but a mutant allele of the gene produces an enzyme which has cysteine at this point.

This latter form causes kinks in the keratin so that the coat is curlier. In heterozygotes, both alleles are co-dominant so an intermediate 'wavy' coat can be observed in the phenotype.

In this context, what is meant by gene mutation?

- A** change in the gene locus
- B** chromosome 27 inversion
- C** production of a new protein
- D** structural change in DNA

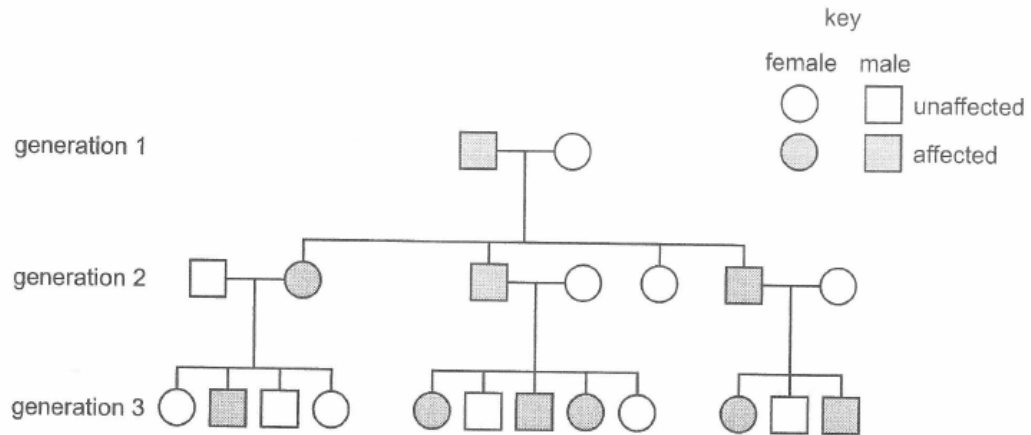
- 17** In mice, the allele for black hair colour (B) is dominant and brown hair colour (b) is recessive.

The agouti allele (A) causes banding on hairs so that the colour of the coat appears paler, black hair appears grey and brown hair appears beige. The recessive, non-agouti allele (a) gives a continuous pigment in the hairs so that the coat appears darker.

What would be the expected ratio of grey : beige : black : brown offspring if the parents had the genotypes Aabb and aaBb?

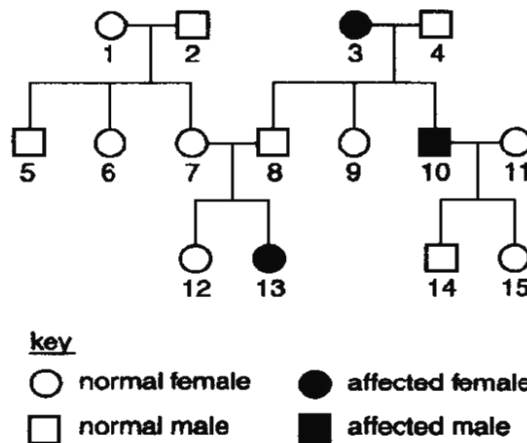
- A** 1 : 1 : 1 : 1
- B** 3 : 3 : 1 : 1
- C** 6 : 3 : 3 : 1
- D** 9 : 3 : 3 : 1

- 18 The pedigree shows the inheritance of a genetic condition in a family for three generations.



Which evidence indicates that this genetic condition is autosomal?

- A Affected females always have affected sons.
 B Affected males do not pass it on to their sons.
 C Affected parents always have affected offspring.
 D Males and females are equally affected.
- 19 The family tree shows the inheritance of a condition caused by the change in nucleotide sequence of gene R.



What is the probability that the first child is an affected girl when individual 7 mated with an affected male instead?

- A 0
 B 0.25
 C 0.50
 D 0.75

20 Stages of aerobic respiration are shown below.

- 1 Glycolysis
- 2 Citric acid cycle
- 3 Electron transfer chain

Which stage(s) involve(s) **both** phosphorylation of intermediates and generation of ATP?

- A** 1 only
B 3 only
C 1 and 2 only
D 1 and 3 only

21 The table below shows reactions occurring in a plant cell, and their respective locations.

	Reaction	Location in a cell
1	ribulose biphosphate + CO ₂ → glycerate-3-phosphate	Stroma
2	glucose + ATP → glucose-6-phosphate + ADP	Matrix
3	oxygen + 4H ⁺ + 4e ⁻ → 2 H ₂ O	Stroma
4	oxaloacetate + acetyl-CoA → citrate	Matrix

Which of the following is / are **incorrectly** matched?

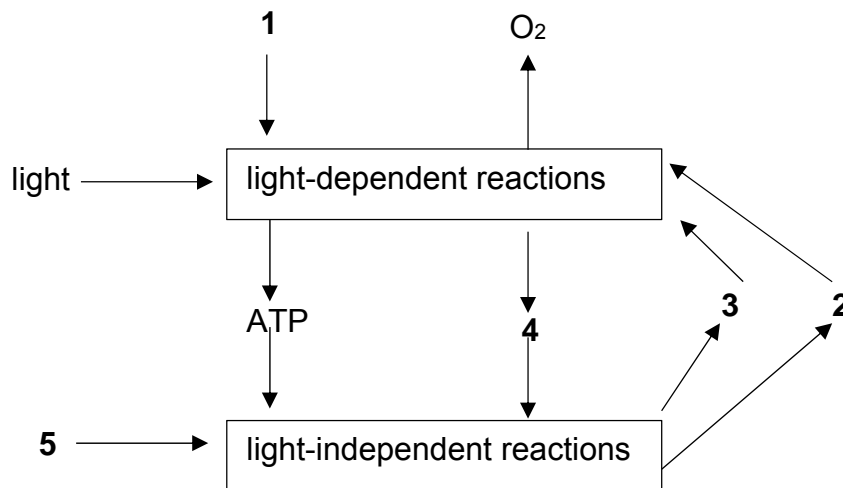
- A** 2 only
B 4 only
C 2 and 3 only
D 1, 2 and 3

22 Which statements help to explain the low yield of ATP from anaerobic respiration compared to aerobic respiration?

- 1 Energy in the chemical bonds of lactate can be obtained only after oxidation to pyruvate.
- 2 The electron transport chain is responsible for most of the transfer of chemical bond energy from glucose to ATP.
- 3 The decarboxylation of pyruvate in anaerobic respiration in yeast is not linked to ATP synthesis.
- 4 As a result of glycolysis, there is a net gain of only two molecules of ATP from each glucose molecule.

- A** 1, 2 and 3
B 1, 3 and 4
C 1 and 2 only
D 2 and 4

23 The diagram summarises the process of photosynthesis.



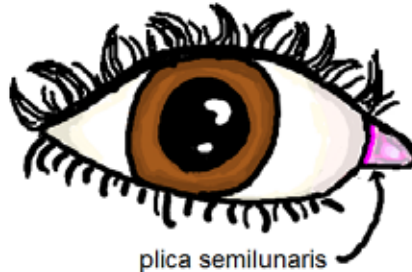
Which row identifies the reactants 1, 2, 3, 4 and 5?

	1	2	3	4	5
A	Carbon dioxide	ADP + phosphate	reduced NAD	NAD	water
B	Carbon dioxide	reduced NAD	ADP + phosphate	NADP	water
C	water	NAD	reduced NAD	ADP + phosphate	Carbon dioxide
D	water	NADP	ADP + phosphate	reduced NADP	Carbon dioxide

24 Which of the following is **not** the consequence of natural selection?

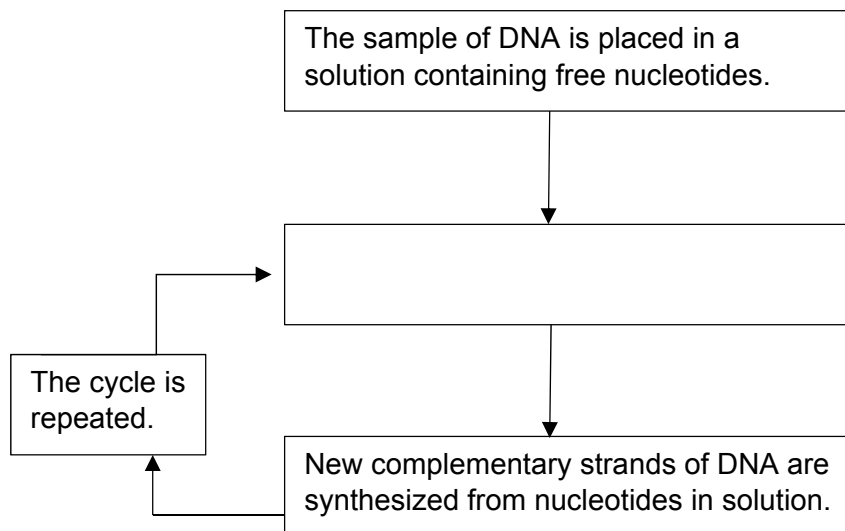
- A** The field mustard plant survived a summer drought in southern California because some individuals contained alleles that made them flower earlier. Plants with flowers wilt more easily than plants without flowers. Now, almost all the field mustard plants in California flower in spring.
- B** In areas with fewer predators of herbivorous insects, plants which produce higher concentrations of alkaloids (which are toxic to insects) dominated the landscape. Most of the herbivorous insects in these areas are found to be able to accumulate alkaloids in their bodies without affecting their metabolism.
- C** Endemic to New Zealand, the kakapo (a large flightless bird) had no natural predators before the humans arrived. They have evolved to have very few offspring throughout their entire lifespan. This phenomenon is also common for other island species which do not have natural predators in their respective habitats.
- D** Maple probably has the most variation in bark of any tree species. Japan experiences tornadoes which destroy large trees like the maple. Over the last few decades, it was observed that only the Japanese maple with dark-coloured bark remained.

- 25** The plica semilunaris is a small fold of tissue on the inside corner of the eye. It is the vestigial remnant of the nictitating membrane, an organ that is fully functional in some other species of mammals. For example, in diving animals like beavers and manatees, the nictitating membrane is transparent and moves across the eye to protect it while under water.



Which of the following statements **least** explains the presence and structure of plica semilunaris in humans?

- A** Early ancestors of humans were not divers.
 - B** Any presence of nictitating membrane in non-diving mammals posed a selective disadvantage for individuals who had it.
 - C** Mutations occurred to reduce the size of nictitating membrane in humans to its present-day vestigial structure as there was no use for it.
 - D** The genes involved in producing the plica semilunaris were inherited from a common ancestor shared by humans, beavers and manatees.
- 26** The polymerase chain reaction is summarised in the flowchart below.



Which statement completes the flow chart?

- A** Complementary strands of DNA are separated.
- B** Free nucleotides join on the end of DNA strands.
- C** Small sections of DNA are formed.
- D** Strands of DNA bind to RNA primers.

27 The statements are about restriction enzymes, which are naturally occurring molecules used in genetic engineering.

- 1 Restriction enzymes cut foreign DNA into smaller fragments.
- 2 Restriction enzymes are made by bacteria in response to bacteriophages.
- 3 Restriction enzymes cut DNA creating sticky ends.
- 4 Restriction enzymes cut at specific sequences of six nucleotides within the strands of a DNA molecule.

Which statements correctly describe the natural role of **all** restriction enzymes?

- A** 1, 2, 3 and 4
- B** 1 and 2 only
- C** 2, 3 and 4 only
- D** 3 and 4 only

28 Some of the features of different types of stem cells are listed.

- 1 They are able to develop into all cell types of the body to form a whole organism
- 2 They can develop into a wide range of different types of cell
- 3 They have active telomerase enzyme
- 4 They can only develop into a limited range of cell types

Which of the following will be shown by embryonic stem cells?

- A** 1 and 2
- B** 1 and 3
- C** 2 and 3
- D** 3 and 4

29 The following statements are about genetically modified crops.

- 1 All crops, including genetically modified crops, are unnatural as they have been produced by artificial methods.
- 2 Genetically modified crops are produced by adding single genes.
- 3 Genetically modified crops can cross-fertilise with non-modified crops.
- 4 Genetically modified crops can be adapted to their environment.
- 5 Genetically modified crops can be produced more quickly than selectively bred crops.

Which statements best support the view that genetically modified crops could help resolve world food shortages?

- A** 1 and 5
- B** 2 and 3
- C** 2 and 4
- D** 4 and 5

30 One type of genetically modified corn has

- a gene for the production of Bt toxin which protects the plant against a specific insect;
- a 'pat'-gene for tolerance to the herbicide 'Basta'. This gene is used to select plants with the Bt toxin gene;
- an 'amp'-gene which was introduced in the plant together with the Bt toxin gene. This gene gives resistance to the antibiotic ampicillin.

There is concern that the 'amp' gene may transfer to enterobacteria in the human intestine during nucleic acid digestion making treatment with ampicillin ineffective for diseases caused by enterobacteria.

Which statement explains why the transfer of this gene from the plant to bacteria in the human intestine is unlikely?

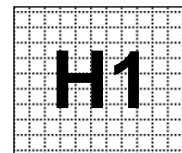
- A** An origin of replication and appropriate prokaryotic promoters are required for the 'amp' gene to be expressed.
- B** Bacteria cannot take up any DNA released during digestion of the plants by human nuclease enzyme, without the presence of a vector.
- C** 50% of the enterobacteria isolated from humans are 'amp' resistant.
- D** All plant DNA is digested and destroyed in the human intestine during digestion of plant cells by enzymes including human nuclease enzymes.

END OF PAPER

**SAJC H1 PRELIM 2017 PAPER 1
ANSWER SCHEME**

1	B	11	B	21	C
2	A	12	D	22	A
3	D	13	C	23	D
4	A	14	A	24	D
5	D	15	D	25	C
6	B	16	D	26	A
7	B	17	A	27	B
8	B	18	D	28	C
9	A	19	B	29	D
10	C	20	A	30	D

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

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 **11** 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.

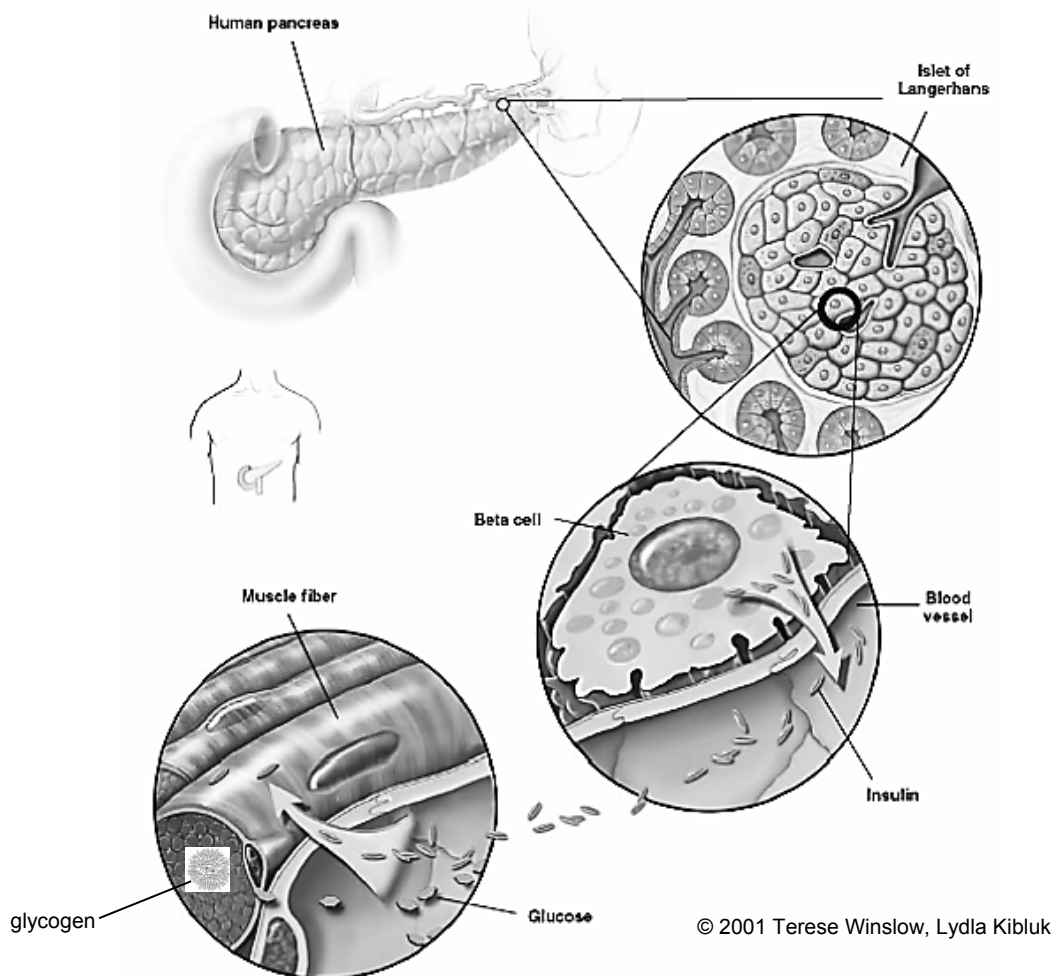


Fig. 1

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]

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

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.....[2]

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

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.....[3]

(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.

.....
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.....[2]

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

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.....[3]

(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.

.....
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.....
.....[2]

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.

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.....
.....[2]

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

.....
.....[1]

[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.

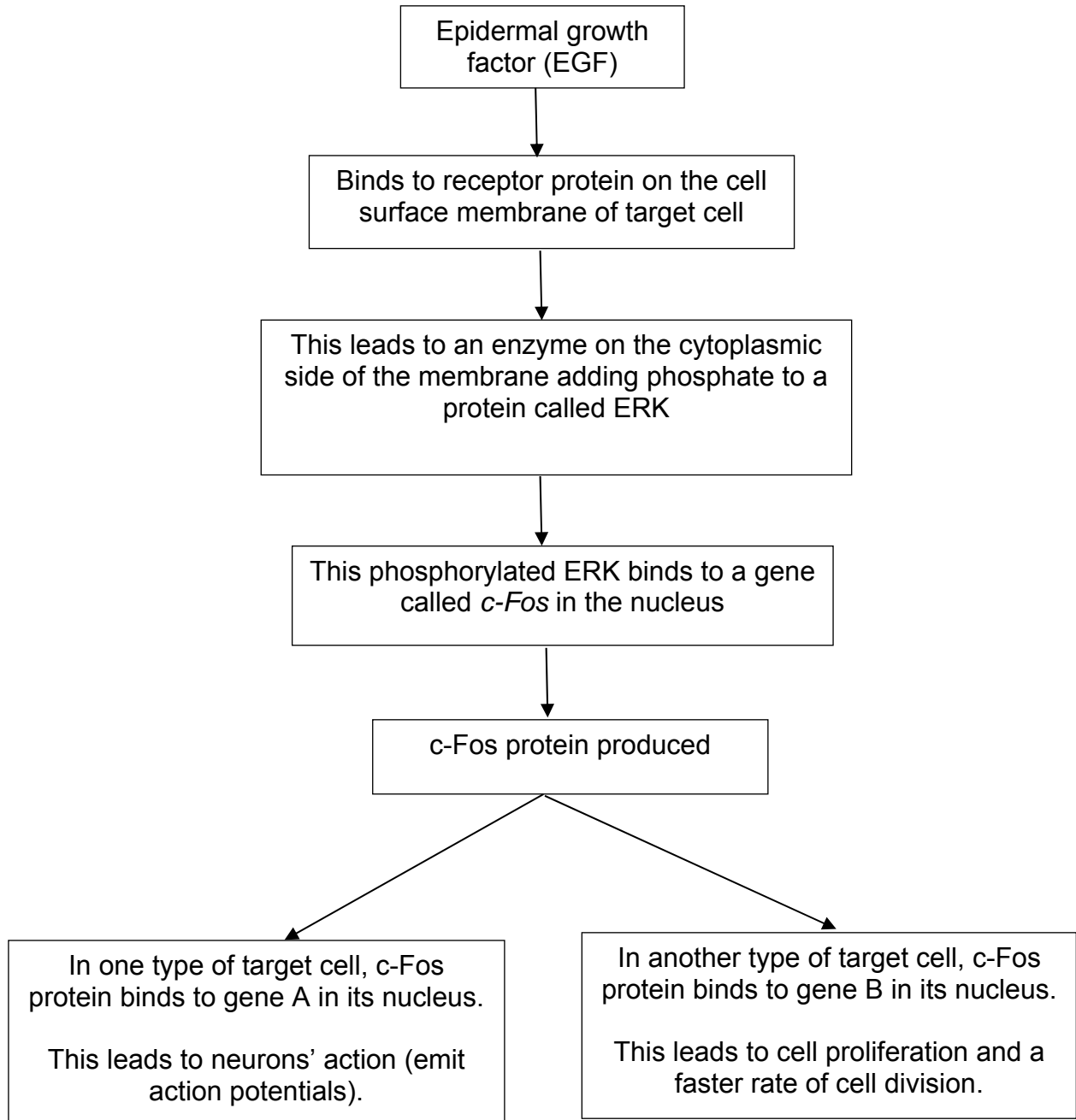


Fig. 2

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

.....
.....[1]

(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]

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

.....
.....[1]

(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]

(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.

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.....[1]

(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.

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.....[2]

(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.

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.....[4]

(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]

[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’.

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.....[1]

- (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.

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- (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.

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.....[2]

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

.....
.....[1]

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

.....
.....[1]

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

.....
.....
.....
.....[2]

[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]

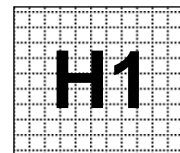
OR

- 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 -

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2017 Preliminary Examination**

H1 BIOLOGY

8875/2

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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.

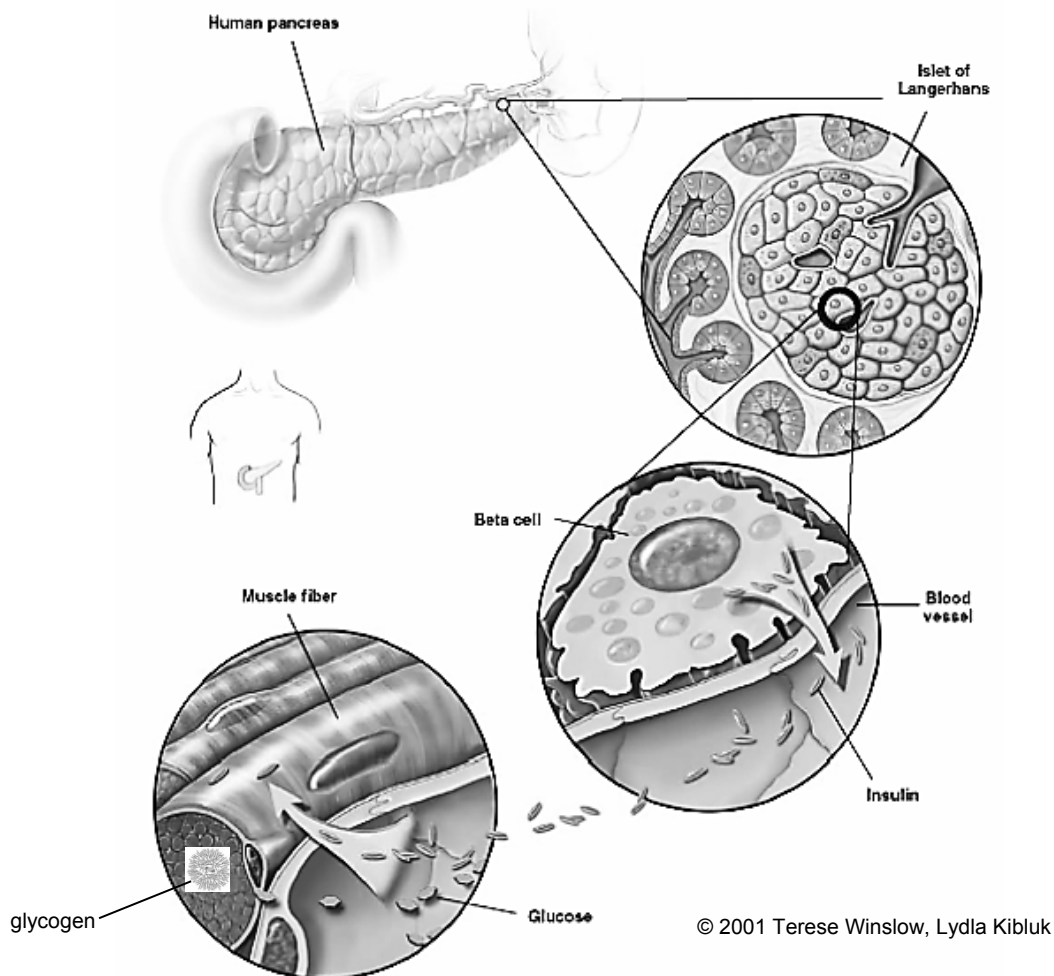


Fig. 1

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.

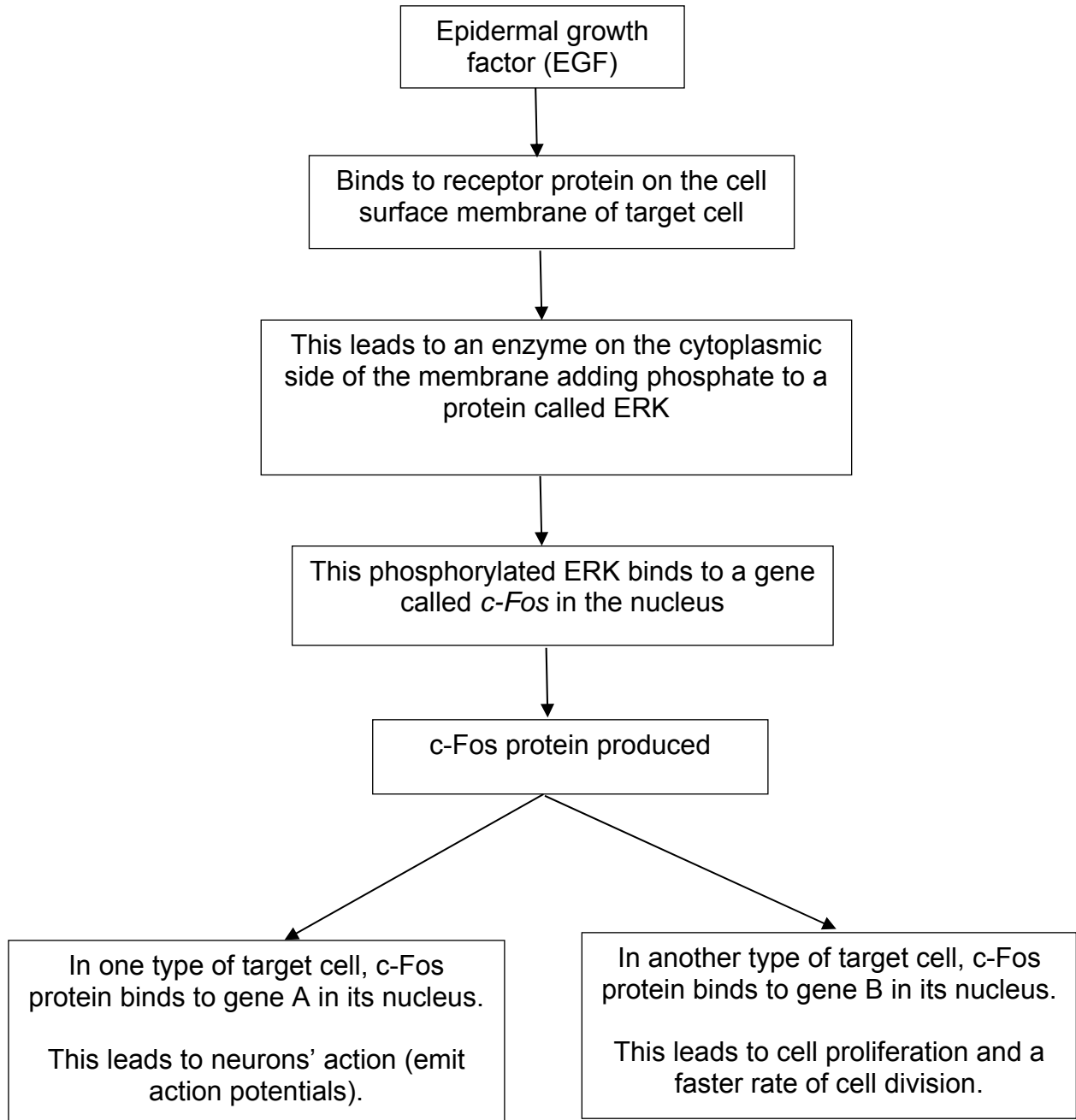


Fig. 2

(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 bisphosphate) combines with carbon dioxide ;
- 2 catalysed by **rubisco (ribulose bisphosphate 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