

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE
NAME

ANSWERS

CLASS

BIOLOGY

8875/02

Paper 2 Structured Questions

14 September 2017

Additional Materials: Answer Paper

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

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	40
1	11
2	10
3	12
4	7
Section B	20
Total	60

This document consists of **5 printed pages and 1 blank page.**

[Turn over

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

1 **Table 1.1** shows some features of four biological molecules that are all polymers.

(a) Complete Table 1.1 by using a tick (✓) to indicate the features that apply to each polymer.

Table 1.1

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				
contains glycosidic bonds				
polymer is branched				
contains nitrogen				
can be found in both animal and plant cells				

[4]

feature	amylopectin	cellulose	RNA	polypeptide
synthesised from amino acid monomers				✓
contains glycosidic bonds	✓	✓		
polymer is branched	✓			
contains nitrogen			✓	✓
can be found in both animal and plant cells	;	;	✓ ;	✓ ;

- (b) Fig. 1.1 is a simple diagram of a phospholipid molecule.

Explain how the structure of a phospholipid molecule makes it suitable for its function in cell membranes. You may label and annotate **Fig. 1.1** as part of your answer.



Fig. 1.1

Structure: Hydrophilic / polar, phosphate, head / group and hydrophobic / non polar, hydrocarbon / fatty acid, tails / chains; **R** *if labelled correctly but incorrectly described in the text*

Structure: Phosphate heads faces aqueous medium and fatty acid tails faces each other / inwards / interior of the cell membrane, forming the phospholipid bilayer ;

Function: resulting in partially / selectively permeability **R** *semi-permeable* / ability to act as a barrier to, hydrophilic substances / water soluble substances / polar substances / ions / AW ;

Structure + function: Presence of unsaturated hydrocarbon tails in phospholipid results in kinks, preventing the close packing of phospholipids, thus regulating fluidity of membrane;

Max 3m

[3]

- (c) State two components of a cell surface membrane other than phospholipid molecules and describe their function.

*max two components, one mark each
one mark for function to match the stated component*

Glycolipid / glycoprotein; **R** *oligosaccharide*
Receptors for cell signalling / cell-cell recognition / cell-cell adhesion;

Cholesterol;
Regulate membrane fluidity / in low temperatures increases fluidity / in high temperatures decreases fluidity / provides mechanical stability to membranes ;

Protein; **Ignore** *any qualification of component e.g. channel / carrier / transport*
Receptor for cell signalling / enzyme / channel protein / provides hydrophilic pore / channel / carrier protein / provides specific binding site for facilitated diffusion / active transport / transport of hydrophilic / polar / charged molecules ;

*max two components, one mark each
one mark for function to match the stated component*

[4]

[Total: 11]

- 2 Fig. 2.1 below shows a diagram of a cell. The parts of a diagram are not drawn to scale.

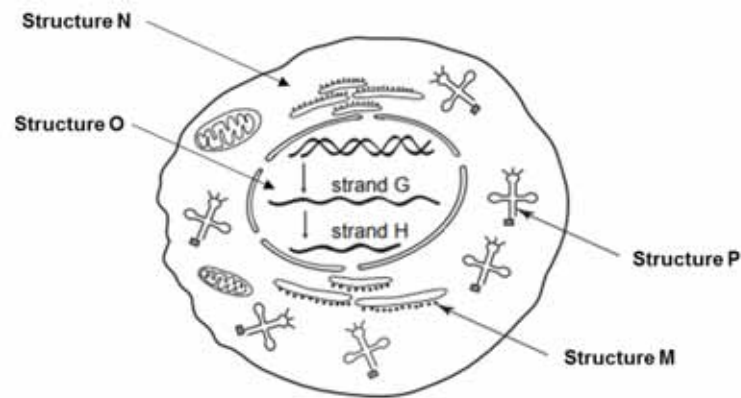


Fig. 2.1

- (a) (i) In which structure would RNA polymerase be found?

Structure O which is the nucleus ;

[1]

- (ii) Explain the mode of action of RNA polymerase.

Catalyses the formation of phosphodiester bond between incoming ribonucleotide and 3'OH end of the growing RNA strand ;

RNA polymerase has an active site that is complementary to the ribonucleotides in terms of shape, size, charge and orientation ;

Binding of incoming ribonucleotides to active site leads to formation of enzyme-substrate complex, which is a transition state;

Lowers the activation energy as it provides an alternative pathway for the reaction ;

[4]

- (b) Strand H is shorter than strand G. Describe the process that results in this shortening, using **appropriate names for both strands**.

Strand G is pre-messenger ribonucleic acid while strand H is mature ribonucleic acid, after post-transcriptional modification;

Strand H is shortened due to RNA splicing as introns are removed;

[2]

(c) Name strand H and structures P and M. Explain how each contributes to protein synthesis.

Strand H: mature ribonucleic acid. It contains genetic information from the DNA in nucleus to the ribosomes in cytoplasm and acts as a template for protein synthesis ;

Structure P: transfer ribonucleic acid (tRNA). It carries the correct amino acid to the ribosomes during translation ;

Structure M: Ribosome. Contains peptidyl transferase that catalyses the formation of peptide bonds between adjacent amino acids ;

[3]
[Total: 10]

3 (a) Sometimes a gene has more than two alleles, termed *multiple alleles*.

The ABO blood group system in humans is controlled by a gene with three alleles, I^A , I^B and I^o . Alleles I^A and I^B are codominant and I^o is recessive to both.

The blood group **AB** is the result of codominance.

Explain what is meant by *codominance* in this context.

I^A allele codes for A antigen and I^B allele codes for B antigen;

Individual with genotype $I^A I^B$ will have both A and B antigens and therefore, AB blood group;

Phenotype of heterozygote different from either homozygote whereby $I^A I^A$ gives A blood group and $I^B I^B$ gives B blood group;

Ref. more than 2 phenotypes possible;

[3]

- (b) In humans, a gene that codes for the production of a protein, called factor VIII, is located on the X chromosome. The dominant allele for this gene produces factor VIII, but the recessive allele does not produce factor VIII.

A person who is unable to make factor VIII has haemophilia in which the blood fails to clot properly.

Explain why a man with haemophilia cannot pass haemophilia to his son but may pass haemophilia to his grandson.

son receives Y chromosome from father / did not inherit X chromosome containing haemophilia allele from father ;

father will pass haemophilia allele to daughter(s) ;

daughter may pass allele to, her son / his grandson ;

[3]

- (c) A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black (C^B) and splashed-white (C^W). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

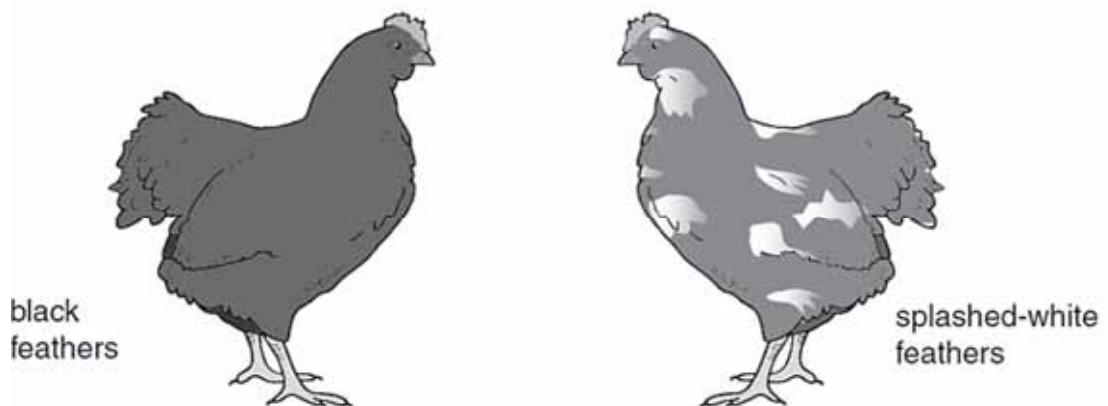


Fig. 3.1

Another gene may cause stripes on feathers (barred feathers). This gene is carried on the X chromosome. The allele for barred feathers (X^A) is dominant to the allele for nonbarred feathers (X^a).

In chickens, the male is homogametic and has two X chromosomes while the female is heterogametic and has one X chromosome and one Y chromosome.

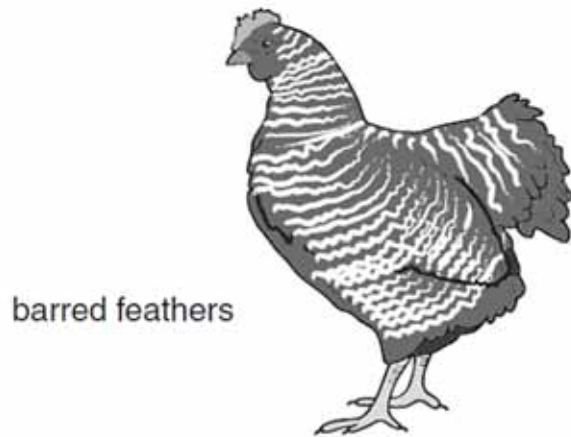


Fig. 3.2

- (i) A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

Using the symbols given above draw a genetic diagram to show this cross.

(c) (i) (male) $C^B C^B X^a X^a$; x (female) $C^W C^W X^A Y$;
 (gametes) $C^B X^a$ $C^W X^A$ or $C^W Y$;
 $C^B C^W X^A X^a$; $C^B C^W X^a Y$;
 (male, blue, barred) (female, blue, non-barred)

*accept other symbols but only with key
 if male XY and female XX then mark gametes and offspring genotypes to max 2
 if other symbols used but no key then mark to max 2*

- 1 mark for parental genotype;
 1 mark for gametes;
 1 mark for offspring genotype and matching;

[3]

- (ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

with non-barred female (X^aY);

if all offspring barred, must be X^AX^A / homozygous ;

if some offspring non-barred, must be X^AX^A / heterozygous ;

[3]

[Total: 12]

4 Genetic information in humans can be obtained by DNA profiling.

In DNA profiling, the polymerase chain reaction is used by a scientist to amplify a particular sequence of DNA.

- (a) Briefly describe the steps of polymerase chain reaction.

Denaturation of double-stranded DNA to single-stranded DNA at 95°C by breaking hydrogen bonds;

Annealing of primers via complementary base pairing between primers and flanking sequence of the target DNA when temp is lowered to 50-60°C;

During elongation stage, temp increased to about 72°C where Taq polymerase catalyse the addition of deoxyribonucleotides to the 3'OH end of primers ;

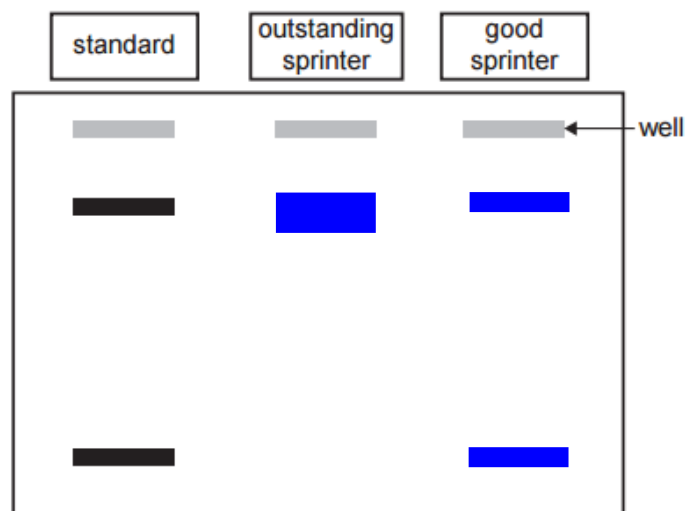
The sequential process of denaturation-annealing-elongation is repeated many times. This is called a chain reaction as the products of the previous reaction are used as reactants in the next cycle.

[4]

Scientists investigating the performance of athletes found that one gene contributing to the performance of sprinters is the ACTN3 gene. There are two alleles of the gene, the 577R allele and the 577X allele. The 577X allele codes for a very short protein fragment in muscle fibres due to a stop codon mutation. The table below summarises the athletic potential for the three possible genotypes for the ACTN3 gene.

ACTN3 genotype	Athletic potential
577R / 577R	outstanding sprinter
577R / 577X	good sprinter or long-distance runner
577X / 577X	very good long-distance runner

- (b) A scientist tested sprinters to see if they possessed the 577R allele. Samples were obtained from athletes' muscle fibres. A standard containing proteins of the same lengths as the proteins coded for by both alleles 577X and 577R was used as a comparison. The standard and the samples were exposed to gel electrophoresis. In gel electrophoresis, protein molecules separate according to size and charge in the same way as DNA molecules. The result for the standard is shown below.



- (i) On the diagram of the gel above, draw the bands expected for an outstanding sprinter and for a good sprinter. [1]
- (ii) Explain why you have placed the bands in these positions.

Outstanding sprinter only has one band as only one allele is present, thicker band due to the presence of two copies of the same allele / homozygous;

Good sprinter has two bands due to two different alleles / heterozygous;

[2]

[Total: 7]

Section B

Answer EITHER 4 or 5.

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) Explain how ATP is produced in living organisms. [8]

1. Source of energy for synthesis of ATP: Photophosphorylation in chloroplast comes from light while oxidative phosphorylation in mitochondria comes from oxidation of glucose;
2. Electron transport chain are found in thylakoid membrane in chloroplasts and inner membrane in mitochondria;
3. Electrons are passed along the electron transport chain from one electron carrier to the next, each with an energy level lower than the one preceding it;
4. Energy is used to pump protons from matrix of the mitochondrion into the intermembrane space + from stroma of chloroplast into thylakoid space;
5. This produces a high concentration of H^+ due to impermeable nature of membranes to protons, generating a steep electrochemical proton gradient;
6. Stalked particles containing ATP synthases ® **ATPase** are embedded on inner mitochondria membrane / thylakoid membrane;
7. Protons diffuse through them, synthesizing ATP by the phosphorylation of ADP with inorganic phosphate (P_i);
8. Substrate-level phosphorylation in glycolysis: synthesis of ATP using phosphate groups from glycolytic intermediates;
9. Substrate-level phosphorylation in Krebs cycle: synthesis of ATP using phosphate group from GTP;

(b) Describe the structure of chloroplast and distinguish it from the mitochondria. [7]

Structure of chloroplast:

1. Organelle bounded by a double membrane;
2. Contains 70S ribosomes and circular DNA;
3. Contains series of electron carriers forming the electron transport chain and stalked particles containing ATP synthase embedded on the thylakoid membrane;
4. Thylakoid membrane extensively folded;
5. Cylindrical in shape / rod-shaped;

Structural differences:

6. Chloroplast contains photosynthetic pigments such as chlorophyll/carotenoids but mitochondria do not;
7. Chloroplast contains starch grains while mitochondria contain glycogen granules;
8. Orientation of the stalked particles in chloroplast is such that the ATP synthase faces the stroma while that in mitochondria faces the mitochondrial matrix;

9. Inner membrane of chloroplast is thylakoid while that of mitochondria is cristae / inner mitochondrial membrane;
10. Mitochondrial matrix in mitochondria vs stroma in chloroplast;

(c) Describe, with examples, how the environment may affect the phenotype [5]

- 1 Genetically identical zygote can be different due to wide range of environment effects;
- 2 The expression of genotype may be influenced by environment factors like nutrients, light, or temperature;
- 3 E.g. Fur colour in Himalayan rabbits is affected by a temperature-sensitive enzyme involved in pigment synthesis;
- 4 Low temperature can results in active enzyme that result in black pigment formation. Thus, Himalayan rabbit are black extreme parts of the body;
- 5 E.g. Phenotypes of honey bee (drones, queen or workers) are determined by the diet of larvae during development;
- 6 Royal jelly diet will give rise a queen bee;
- 7 Spontaneous somatic mutation may occur due to exposure to harmful radiation or carcinogens and cause different phenotypes;

[Total:20]

Or

6 (a) Explain how variation could arise in a sexually-reproducing population. [8]

1. Meiosis is an important step for sexual reproduction as haploid gametes are produced;
2. Meiosis results in genetic variation as the reduction division allows the combining of genetic materials from two parents / individuals;
3. Due to crossing over of non-sister chromatids of homologous chromosomes, at the chiasmata, during prophase I;
4. Thus allowing corresponding sections to be exchanged, separating linked genes / creating new combination of alleles in each chromatid;
5. Due to independent assortment of chromosomes during metaphase I, whereby the orientation of homologous pair of chromosomes along the metaphase plate is independent of other bivalents;
6. This is followed by independent segregation during anaphase I, resulting in numerous possible chromosomal combinations in a gamete, i.e. $2n$, where n = number of homologous pairs of chromosomes;
7. In addition, during fertilization, random fusion of gametes occurs, resulting in numerous combinations of a zygote;

Maximum 2 marks on mutation;;

8. (Spontaneous) gene mutation: change in DNA sequence of a gene / change in one or a few nucleotides, giving rise to new alleles;
9. Chromosomal aberrations: change in structure of chromosomes due to translocation / deletion / duplication of chromosomal fragment + elaboration;
10. Chromosomal aberration: change in number of chromosome i.e aneuploidy / polyploidy – extra / lack of one chromosome or sets of chromosomes + elaboration;

(b) Describe how natural selection may bring about the evolution of the Galapagos finches.

1. Selection pressure: limited / different food source which led to the variety of beaks in different species of Galapagos finches
2. Idea of adaptive radiation: development of a variety of species from a single ancestral form (idea of descent with modification)
3. Variation in terms of beak size and shape exist between individuals within the Galapagos finches population
4. Individual finches who are better adapted to obtaining the food source will survive till maturity and produce fertile, viable offspring compared to the others
5. Ref to passing down of beneficial alleles to the offspring, accumulate genetic differences over long periods of time, leading to evolution of the finches

[5]

(c) Describe the unique features of stem cells and with reference to named examples, distinguish between pluripotent and multipotent stem cells.

Unique features of stem cells:

1. Stem cells are unspecialised cells ;
2. During a single division, they can divide into one genetically identical daughter cell and another more specialised daughter cell which can undergo further differentiation ;
3. They are capable of dividing and renewing themselves for long periods ;
4. They can give rise to specialised cell types according to internal / external signals ;

Differences:

- 5 Pluripotent stem cells such as embryonic stem cells can differentiate into almost any cell type to form any organ or any cell type ;
- 6 While multipotent stem cells such as blood / haematopoietic stem cells can differentiate into a limited range of cell type, usually of a closely-related family of cells;
- 7 Embryonic stem cells can give rise to the three primary germ layers: ectoderm, endoderm and mesoderm (which subsequently give rise to the multiple specialised cell types that form the heart, lungs, skin and other tissue) while blood / haematopoietic stem cells can differentiate into red blood cells, white blood cells, platelets etc. (for cell replacement / tissue repair) ;
- 8 Pluripotent stem cells like ESCs are not totipotent but are multipotent ;
- 9 Pluripotent stem cells like ESCs are obtained from the blastocyst in an embryo while multipotent stem cells like blood / haematopoietic stem cells are adult stem cells that can be found in organs / tissues such as the brain, bone marrow, skeletal muscle, skin or liver;

[7]

[Total:20]