

CANDIDATE NAME			СТ	GROUP	16S7_	
CENTRE NUMBER			BER			

BIOLOGY

9744/01 21 September 2017 Paper 1 Multiple Choice Questions Additional Materials: Optical Mark Sheet 1 hour

INSTRUCTIONS TO CANDIDATES

- 1. Write your **name** and **CT group** in the spaces provided at the top of this cover page.
- 2. Fill in your particulars on the Optical Mark Sheet. Write your NRIC number and shade accordingly.
- 3. There are thirty 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 Optical Mark Sheet.

4. At the end of the paper, you are to submit **only** the Optical Mark Sheet.

INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

The used of an approved scientific calculator is expected, where appropriate.

1 The diagram shows a single-celled organism with structures **P** to **S** labelled.



Which statement(s) correctly describes the structures P to S?

- 1 Structure **P** is double membranous with infoldings called cisternae and functions in metabolism of glucose.
- 2 Structure **Q** is double membranous with flattened sacs called cristae and functions to modify and package products of the endoplasmic reticulum.
- 3 Structure **R** is composed of phospholipids, proteins and carbohydrates and functions to prevent cell lysis.
- 4 Structure **S** is composed of microtubules and provides cell motility.
- **A** 3 only **B** 4 only **C** 1 and 4 **D** 2 and 3
- 2 Viruses are a major class of microorganisms, but they are not cells.

Which statement about viruses supports the view that viruses are not cells?

- 1 Viruses are very small in size.
- 2 Viruses are only able to replicate in a host cell.
- 3 Viruses have no metabolic activities of their own.
- 4 Viruses have protein capsids.
- 5 Viruses contain only a single form of nucleic acid.
- 6 Viruses can evolve by genetic recombination.
- **A** 1, 2 and 3 **B** 1, 5 and 6 **C** 2, 3 and 5 **D** 3, 4 and 6

3 The graphs show the rate of uptake of sugars by a culture of animal cells under different conditions.



Which statements correctly describe the uptake of sugars by the animal cells?

- 1 3-carbon sugar passes through the phospholipid bilayer down a concentration gradient.
- 2 3-carbon sugar passes through channel proteins against a concentration gradient.
- 3 6-carbon sugar passes through carrier proteins against a concentration gradient.
- 4 6-carbon sugar passes through the phospholipid bilayer down a concentration gradient.

Α	1 and 3	В	2 and 3	С	2 and 4	D	1 and 4
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4 α - and β -amylase enzymes can break the α -1,4-glycosidic bonds of polysaccharides, but not the α -1,6-glycosidic bonds.

 α -amylase acts randomly within polysaccharides and can produce glucose, maltose, trisaccharides and short, branched chains.

β-amylase acts at the ends of polysaccharides to remove successive maltose molecules.

Which statement about polysaccharide digestion is correct?

- A Both α -amylase and β -amylase are required for the complete digestion of starch to produce only glucose molecules.
- **B** Digestion of amylose by α -amylase will produce only branched molecules.
- **C** Digestion of amylose using β -amylase will yield a higher proportion of disaccharides than digestion using α -amylase.
- **D** Disaccharides can be produced from the digestion of cellulose using β -amylase, but not using α -amylase.

5 Phosphatidylcholines are phospholipids that have choline as part of the polar head section.

A high proportion of phospholipids in erythrocyte (red blood cell) membranes are phosphatidylcholines.

The table shows the results of an analysis to determine the four most abundant component fatty acids of human erythrocyte phosphatidylcholines.

fatty acid	molecular formula		
palmitic acid	C ₁₆ H ₃₂ O ₂ CH ₃ (CH ₂) ₁₄ COOH		
linoleic acid	$C_{18}H_{32}O_2$ $CH_3(CH_2)_4(CH=CHCH_2)_2(CH_2)_6COOH$		
oleic acid	$C_{18}H_{34}O_2$	CH ₃ (CH ₂) ₇ CH=CH(CH ₂) ₇ COOH	
steric acid	$C_{18}H_{36}O_2$	CH ₃ (CH ₂) ₁₆ COOH	

The diagram shows a phosphatidylcholine. The site of action of four different phospholipases, A_1 , A_2 , C and D, are indicated.



In phosphatidylcholines,

- saturated fatty acids are more commonly found in position R₁ than unsaturated fatty acids, and
- unsaturated fatty acids are more commonly found in position R₂ than saturated fatty acids.

Which statement about enzyme action on isolated erythrocyte phosphatidylcholines is correct?

- A The action of phospholipase A₁ is likely to yield a higher proportion of oleic acid than stearic acid.
- **B** The action of phospholipase A₂ is likely to yield a higher proportion of linoleic acid than palmitic acid.
- **C** The products of the combined action of phospholipases A₁, A₂ and D will be free fatty acids, glycerol and choline.
- **D** The action of phospholipases A₁, A₂ and C will cause an increase in the pH of the reaction medium.

6 Isocitrate dehydrogenase catalyses the following reaction in the Krebs cycle:

isocitrate + NAD⁺ $\rightarrow \alpha$ -ketoglutarate + CO₂ + NADH

The curves in the graph are obtained when the initial rate of reaction is plotted against isocitrate concentration in the presence of various levels of ADP and excess NAD⁺.



Which statement about this system is correct?

- A ADP competes with isocitrate for the active site of isocitrate dehydrogenase.
- **B** ADP binds to an allosteric site of isocitrate dehydrogenase and prevents binding of isocitrate to the active site.
- **C** ADP binds to isocitrate and makes it easier for isocitrate to bind to the active site.
- **D** ADP binds to an allosteric site of isocitrate dehydrogenase and makes it easier for isocitrate to bind to the active site.
- 7 Which is a correct statement about obtaining human embryonic stem cells for research?
 - A Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.
 - **B** The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.
 - **C** The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.
 - **D** The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

8 In the classic paper that demonstrated the semi-conservative replication of DNA, scientists Meselson and Stahl began by showing that DNA itself will form a band when subjected to density gradient centrifugation.

Escherichia coli grown in ¹⁵N DNA were switched to ¹⁴N and then harvested at eight different time points. The DNA was centrifuged resulting in the banding pattern shown.



Which statements correctly explain the results?

- 1 At 20 min, the entire DNA of *E. coli* exists as hybrid with 100% ¹⁵N DNA.
- 2 At 20 min, DNA of *E. coli* is 50% hybrid with 50% ¹⁵N DNA.
- 3 At 38 min, there are two bands consisting of 50% hybrid DNA and 50% light DNA.
- 4 At 60 min, there is 25% hybrid DNA and 75% light DNA.
- **A** 1 and 2 **B** 3 and 4 **C** 2, 3 and 4 **D** 1, 2, 3 and 4

9 The diagram shows the rRNA gene undergoing transcription in the nucleolus of a cell with regions **X** and **Y** labelled.



Which row is correct?

	presence of nucleosomes	direction of transcription	presence of ribosomes
Α	\checkmark	X to Y	×
в	\checkmark	Y to X	\checkmark
с	×	X to Y	×
D	×	Y to X	\checkmark

10 The morphology of chromosomes changes with the stages of cell cycle as shown in the diagram.



Which statements explain the changes in morphology of the chromosomes?

- 1 DNA replicates during S phase to produce an identical copy of itself in which the sister chromatids are joined together by two centromeres.
- 2 At G₂ phase, the centromere comprises many tandemly repeated DNA sequences that exist as heterochromatin.
- 3 Chromosomes at M phase is highly coiled and folded around histone-like scaffold proteins.
- 4 From anaphase to next G₁ phase, chromosomes have only one DNA molecule which coils around the histone core.

A 2 and 4 B 3 and 4 C 1, 2 and 3 D 1,	I, 2, 3 and 4
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11 The diagram shows the time course of events in a T4 phage infection.



Which statements correctly describe the events taking place in stages W to Z?

- 1 During Stage **W**, T4 phage tail fibres bind to specific molecules on the bacterial cell and the viral DNA penetrates into the cell via contraction of the tail sheath.
- 2 During Stage X, T4 phage replicates its own RNA genome.
- 3 From 13 minutes to 20 minutes, structural proteins including the head, tail, base plate and tail fibre proteins for Stage **Y** are synthesized.
- 4 From 13 minutes to 20 minutes, mRNA coding for enzymes required to liberate the mature phage particles in Stage **Z** are synthesized.
- **A** 1 and 3 **B** 2 and 3 **C** 1, 2 and 4 **D** 2, 3 and 4
- **12** *Escherichia coli* cells are first grown in a medium containing glucose and all twenty amino acids. Subsequently, these cells are transferred to another medium for one hour, in which the only source of sugar is lactose and the only source of nitrogen is ammonium ions.

Compared with the cells grown in the first medium, which statements about the cells grown in the second medium are correct?

- 1 The *lac* repressor binds to the *lac* operator.
- 2 Catabolite-activator protein (CAP) binds to the CAP binding site.
- 3 The *trp* repressor binds to the *trp* operator.
- 4 RNA polymerase binds to the *trp* promoter.
- **A** 1 and 3 only **B** 2 and 4 only **C** 1, 2 and 3 **D** 2, 3 and 4

13 To analyse the control elements of the human insulin gene, a researcher deleted different regions of the DNA upstream of its transcription start site *in vitro*. Each of the upstream regions was separately fused with the coding region of the *green fluorescent protein* (*GFP*) gene, forming different fusion gene constructs. These constructs were then separately introduced into human pancreatic cells. The following results were obtained.

	fusion ger	ne construct		transcription start site	expression of <i>GFP</i> gene / %
Α	В	С	D	F	100
А		, C	D	⊢	200
А	B		, D	⊢	20
	В	C	/	►	95

Which region, A, B, C or D, binds a repressor protein?

14 The following is the DNA sequence on the template strand of a gene, from the 3' to 5' direction. The gene has 37 codons in total, and the table shows the first 7 codons.

codon	1	2	3	4	5	6	7
DNA	CAC	GTG	GAC	TGA	GGA	СТС	СТС

Three different gene mutations can occur and are described as follows:

- 1 insertion of two adenines in between codon 2 and 3
- 2 deletion of the thymine in codon 4
- 3 substitution of thymine for adenine in codon 6

Which row correctly identifies the possible effects of these gene mutations?

	frameshift mutation	frameshift mutation premature ending of a polypeptide	
Α	1, 3	2 only	1, 2
в	2 only	2, 3	1, 2, 3
с	2, 3	1, 3	2, 3
D	1, 2	1 only	1, 2, 3

15 Mutations in either *BRCA1* or *BRCA2* genes are responsible for the majority of hereditary breast cancer in humans.

The proteins produced by the two genes migrate to the nucleus where they interact with other proteins, such as those produced by the tumour suppressor gene, *p53* and the DNA repair gene, *RAD51*.

		gene	
	BRCA1 or BRCA2	p53	RAD51
A	encoding normal protein	encoding normal protein	encoding abnormal protein or no protein
в	encoding normal protein	encoding abnormal protein or no protein	encoding normal protein
с	encoding abnormal protein or no protein	encoding abnormal protein or no protein	encoding normal protein
D	encoding abnormal protein or no protein	encoding abnormal protein or no protein	encoding abnormal protein or no protein

Which combination of gene activity is most likely to result in breast cancer?

16 The diagram shows a series of electronmicrographs depicting the different stages in meiosis, in the order in which they occur.



Which statements are incorrect?

- 1 The 11 bivalents line up along the equatorial plate in the stage shown in image 8.
- 2 During the stage shown in image 9, sister chromatids separate.
- 3 Cells after the stage shown in image 10 are haploid.
- 4 During the stage shown in image 11, DNA is replicated.
- 5 Homologous chromosomes pair up in the stage shown in image 12.
- A 1 and 3
- **B** 2 and 5
- **C** 1, 2 and 4
- **D** 2, 4 and 5

17 The table shows the results of a series of crosses in a species of small mammal.

coat colour phenotype					
male parent	female parent	offspring			
dark grey	light grey	dark grey, light grey, albino			
light grey	albino	light grey, white with black patches			
dark grey	white with black patches	dark grey, light grey			
light grey	dark grey	dark grey, light grey, white with black patches			

What explains the inheritance of the range of phenotypes shown by these crosses?

- A one gene with a pair of codominant alleles
- B one gene with multiple alleles
- **C** one sex-linked gene with a dominant and recessive allele
- D two genes, each with a dominant and recessive allele

Use the following information to answer **Questions 18** and **19**.

18 In a family, a genetic disorder occurs in some individuals as shown in the pedigree.



Individual III-2 marries a phenotypically normal male.

What is the probability that their first child will be affected with the genetic disorder?

- **A** 1/4
- **B** 1/8
- **C** 1/12
- **D** 1/16

19 Consider the identical twins, individuals III-3 and III-4. Neither individual has the genetic disorder. A study of many other traits expressed by these two individuals when they were aged 20 was carried out.

What would the likely findings of such a study reveal?

- A All the traits are the same as the twins are genetically identical.
- **B** Some of the traits are the same as the twins are genetically identical while some other traits are also different due to the influence of the environment.
- **C** Some of the traits are the same when the twins have the same alleles while some other traits are also different when the twins have different alleles.
- **D** All the traits are different due to the influence of the environment.
- **20** Duroc Jersey pigs are typically red, but a sandy variation is also seen. When two different varieties of true-breeding sandy pigs were crossed to each other, they produced F₁ offspring that were red. When these F₁ offspring were crossed to each other, they produced red, sandy and white pigs in a 9:6:1 phenotypic ratio.

	red	sandy	white
Α	AABB	AAbb	aaBB
В	AaBb	AaBB	aabb
С	Aabb	aaBB	aabb
D	AaBB	Aabb	aabb

Which row correctly shows the possible genotypes for each phenotype?

- 100 90 action spectrum 80 70 chlorophyll b 60 percentage rate of light 50 photoabsorption chlorophyll a synthesis 40 30 -20 -10 0 0 400 450 500 550 600 650 700 wavelength of light / nm
- **21** The diagram shows the action spectrum and absorption spectra of chlorophylls a and chlorophyll b.

Which statements are correct?

- 1 Both chlorophyll a and b have little absorption in the range of wavelength which corresponds to green light.
- 2 Both chlorophyll a and b have higher absorption spectra peaks at the range of wavelength which corresponds to blue light as compared to that which corresponds to red light.
- 3 There is absence of an exact match between absorption and action spectra in the middle region due to presence of carotenoids and accessory pigments.
- 4 The action peaks correspond to the absorption peaks, where the rate of photosynthesis is the highest at the range of wavelength which corresponds to red light.
- **A** 1 and 3
- **B** 2 and 4
- **C** 1, 2 and 3
- **D** 2, 3 and 4

22 The diagram shows part of a chloroplast and part of a mitochondrion.



Which row correctly shows the mode and direction of proton movement and the location of ATP synthesis in these two organelles?

		proton moveme	location of ATP synthesis			
	modo	dire	ction		TF Synulesis	
	mode	chloroplast mitochondrion		chloroplast	mitochondrion	
Δ	active transport	ve stroma to matrix port thylakoid mem membrane		stroma	matrix	
A	facilitated diffusion	thylakoid membrane to stroma	inner membrane to matrix	Stoma	maux	
	active	thylakoid space	intermembrane			
В	transport	to stroma	space to matrix		intermembrane space	
	facilitated diffusion	stroma to thylakoid space	matrix to intermembrane space	thylakoid space		
С	active transport	stroma to thylakoid space	matrix to intermembrane space	stroma	matrix	
	facilitated diffusion	thylakoid space to stroma	intermembrane space to matrix			
	active	stroma to	intermembrane			
	transport	thylakoid space	space to matrix		intormombrano	
D	facilitated diffusion	thylakoid space to stroma	matrix to intermembrane space	stroma	space	

23 Ethylene gas is a plant hormone that regulates plant growth, development and response to environmental stress. It is produced from leaves, roots, stems, flowers and especially ripened fruits.

Plants have various ethylene receptors, which are located in the endoplasmic reticulum (ER) and are all structurally related. The diagram shows the ethylene signalling pathway. Ethylene receptors are dimeric, transmembrane proteins, with a copper-containing ethylene-binding domain and a domain that interacts with a cytoplasmic protein called CTR1.



Which statements provide the most direct evidence that the ethylene gas signalling mechanism functions to mediate gene expression?

- 1 In the absence of ethylene, active CTR1 stimulates the ubiquitination and degradation in proteasomes of EIN3.
- 2 In the absence of ethylene, the active ethylene receptors halts transcription of ethylene-responsive genes through degradation of EIN3.
- 3 In the presence of ethylene, its binding inactivates the receptor, altering their conformation so that they no longer activate CTR1.
- 4 In the presence of ethylene, the EIN3 protein does not undergo selective degradation and can now activate the transcription of the large number of ethylene-responsive genes.

Α	1 and 2	В	2 and 3	С	2 and 4	D	3 and 4
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24 Tiburon is an isolated island off the coast of Mexico. Desert bighorn sheep became extinct on this island hundreds of years ago. In 1975, 20 desert bighorn sheep were taken from a population in the American state of Arizona as shown in the figure and were re-introduced to Tiburon Island. By 1999, the population of desert bighorn sheep on Tiburon Island had risen to 650.



Which statement about the 1999 population of desert bighorn sheep on Tiburon Island is correct?

- A The gene pool of this population will be identical to the gene pool of the Arizona populations.
- **B** This population is more homogenous with less genetic variation than the Arizona populations as it is an example of the founder effect.
- **C** This population will have become a new species because the mutation rate on Tiburon Island will be much higher than in Arizona.
- **D** Having been through a population bottleneck, the current population will now show increased genetic variation compared to the Arizona populations.

25 DNA-DNA hybridization has been used to study the evolutionary placement of red and giant pandas. A perfect match between two hybrid strands will yield the highest melting temperature (T_m) due to optimal hydrogen bonding between the bases while mismatches will lower the T_m leading to less than ideal hybridization.

The table shows the melting temperature of hybrid pairs of DNA (°C).

	Red panda	Raccoon	Giant panda	Spectacled bear
Red panda	80	68	52	44
Raccoon	-	82	53	42
Giant panda	-	-	83	75
Spectacled bear	-	-	-	81

Based on the results in the table, which phylogenetic tree would provide the most reasonable inference to the evolutionary relationships among these species?



26 A study was carried out over a 12-year period on the rate of evolutionary change in the anole lizard populations found in a group of Caribbean islands.

It determined the average colouration pattern in a certain population changed from predominantly brown with green flecks to predominantly green with brown flecks.

This occurred during a prolonged pattern of above average annual rainfall between 1971 and 1983. During that time, there was an increase in the broad-leaved green plants.

Which effects might the introduction of a predator that hunts anoles using motion, rather than colour, to detect its prey have on the anole lizard population?

- **A** A new mutation would emerge that introduced a grey colour to the anole population.
- **B** The numbers of brown versus green anoles in the population would shift to a less balanced ratio over time.
- **C** The number of green anoles in the population would increase further.
- **D** The anole population would become highly endangered.
- 27 Read the following statement.

"At first, all giraffes had short necks because they all ate leaves close to the ground, but when all those leaves were gone, some giraffes started being born with long necks."

Which statement would be most helpful in correcting this misconception?

- A Phenotypic variations occur through spontaneous mutations and are subsequently selected for or against.
- **B** The phenotype for neck length changed in giraffes so that the species did not go extinct.
- **C** Short-necked giraffes developed long necks in response to increased competition for food.
- **D** When the environment changed, the struggle to exist created new mutations in the gene pool and natural selection acted on them.

28 The diagram shows the process of phagocytosis of a pathogen by a neutrophil.



Which row is correct?

	Р	Q	R	S	body's line of defence
A	antibiotic	extensions of cell wall	lysozyme	lysosome	innate immunity
В	antibiotic	extensions of cell membrane	phagosome	antigen- presenting cell	cell-mediated immune response
с	antigen	extensions of cell wall	antigen- presenting cell	lysozyme	humoral immune response
D	antigen	extensions of cell membrane	lysosome	phagosome	innate immunity

29 Malaria is caused by the protozoan parasite, *Plasmodium falciparum*. Female *Anopheles* mosquitoes pick up *P. falciparum* in a blood meal taken from an infectious person. *P. falciparum* then go through several developmental stages before they migrate to the mosquito salivary glands. Once in the salivary glands, the parasites can be transmitted to a susceptible human host when the mosquito takes another blood meal. The time spent developing in the mosquito is determined by temperature.

Both *Anopheles* and *P. falciparum* are sensitive to temperature. Because *Anopheles* mosquitoes are ectotherms, each stage in their life cycle (i.e. egg, larva, pupa and adult) is dependent on temperature, examples of which are illustrated in the following graphs.



Investigations into the effect of global warming on malaria transmission often focused on the blood meal-egg laying stage in adult females.

	reason for the use	limitation of the use
Α	Temperature-dependencies are not the same across the different developmental stages of the <i>Anopheles</i> mosquitoes.	Increased temperature increased larval mortality and decreased developmental speed.
В	<i>P. falciparum</i> is transmitted by adult females.	Optimum temperature for <i>P. falciparum</i> growth does not necessarily correspond to the vector's optimum temperature.
С	<i>P. falciparum</i> is transmitted by adult females.	Temperature-dependencies are not the same across the different developmental stages of the <i>Anopheles</i> mosquitoes.
D	Optimum temperature for <i>P. falciparum</i> growth does not necessarily correspond to the vector's optimum.	Increased temperature increased larval mortality and decreased developmental speed.

Which row shows the reason for and limitation of the use of female Anopheles mosquitoes?

30 Many studies in recent years have investigated the effects of climate change on biodiversity.

Which statements about the impact on climate change on the level of biodiversity are correct?

- 1 At the population level, climate change is able to decrease genetic diversity due to mutation and directional selection.
- 2 At the community level, climate change has led to phenological shifts in flowering plants and insect pollinators, causing mismatches between plant and pollinator populations that lead to the extinctions of both the plant and the pollinator.
- 3 At the biome level, large portions of Amazonian rainforest in tropical South America could be replaced by tropical savannahs.
- **A** 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

--END OF PAPER---

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