	Anglo-Chinese Junior Colleg JC2 Biology Preliminary Examination Higher 2	e	A Methodist Institution (Founded 1886)
CANDIDATE NAME		FORM CLASS	
TUTORIAL CLASS		INDEX NUMBER	

BIOLOGY

Paper 2 Structured Questions

Candidates answer on the Question Paper. No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Name, Class and Index number in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

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

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.

The number of marks is given in brackets [] at the end of each question or part question.

For Examiners'					
us	se only				
1	/	8			
2	/	11			
3	/	10			
4	/	8			
5	/	11			
6	/	10			
7	/	10			
8	/	12			
9	/	10			
10	/	5			
11	/	5			
Total	/	100			

9744/02

2 hours

23 August 2023

Answer all questions.

- 1 The cell surface membranes of different cells have a similar basic structure, but the proportions of the various molecules present vary between membranes and even between the inner and outer layers of a membrane.
 - Fig. 1.1 shows the structure of a typical cell surface membrane.



Fig. 1.1

- (a) With reference to Fig. 1.1,
 - (i) identify molecules **A** and **B** and describe their respective functions.

Α	
Function	
В	
Function	
	[4]

Examiner (ii) State one way in which the outer layer of the membrane is different from the inner layer. (iii) Describe the significance of the difference stated in your answer for (a)(ii).[1]

3

For

Use

Fig. 1.2 shows an organelle which contains an extensive network of internal membranes.





(b) With reference to Fig. 1.1, suggest if molecule B will be found in the internal membranes found within the organelle shown in Fig. 1.2. Explain your answer.

......[2] [Total: 8]

One mechanism for bacterial resistance to antibiotics is through the action of efflux pumps, which are proteins found on the bacterial cell surface membrane. Table 2.1 shows the intracellular concentrations of an antibiotic in two strains of bacteria, after exposure to the antibiotic for 24 hours.

Table 2.1

strain of bacteria	intracellular concentration of antibiotic / mg L^{-1}
antibiotic-resistant	0.008
antibiotic-susceptible	0.125

(a) Explain why antibiotics do not harm the human cells when used to treat humans.

(b) Describe how the efflux pumps are held in position within the membrane.

(c) With reference to Table 2.1, explain how the presence of efflux pumps allow bacteria to be resistant to the antibiotic.

(d) Some strains of this bacteria show resistance to the antibiotic while other strains are susceptible, even though they both belong to the same species.

Suggest explanations for this observation.

[Total: 11]

3 Fig. 3.1 shows models of a haemoglobin molecule and part of a keratin molecule.





(a) Outline the main structural differences between these two proteins, visible in Fig. 3.1.

[3]

(b) Describe the role of bonds in haemoglobin in increasing the efficiency of the loading and unloading of oxygen.

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Unlike haemoglobin which circulates in the blood, myoglobin is the oxygen-binding protein located primarily in muscles. Myoglobin serves as a local oxygen reservoir that can temporarily provide oxygen when blood oxygen delivery is insufficient. This happens during periods of intense muscular activity when the concentration of oxygen drops below 20 mm Hg.

Fig. 3.2 shows the model of a myoglobin molecule.



Fig. 3.2

Fig. 3.3 shows the relationship between the concentration of oxygen and the percentage saturation of the two oxygen-binding proteins, haemoglobin and myoglobin.



Fig. 3.3

		9	For Examiner
(c)	(i)	Identify the curves corresponding to haemoglobin and myoglobin.	Use
		C	
		D[1]	
	(ii)	With reference to Fig. 3.2 and Fig. 3.3, explain your answer to (c)(i).	
		[4]	
		[Total: 10]	



(c) Protein T, not shown in Fig. 4.1, is normally involved in the initiation of translation.

The unfolded protein response (UPR) is a cellular stress response that is triggered by an accumulation of unfolded or misfolded proteins after a high rate of translation. During the UPR, a kinase known as PERK is activated and acts on protein T.

Suggest how the activation of PERK prevents the accumulation of unfolded or misfolded proteins.

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 	• • • • • • • •	 	 	 		 	 	 		•
 		 	 	 		 	 	 	[2	<u>']</u>

[Total: 8]

5 SARS-CoV-2 is the virus responsible for the COVID-19 pandemic. It is a positive-sense single-stranded RNA enveloped virus which uses its viral spike glycoproteins to infect human cells bearing ACE2 receptors.

Fig. 5.1 shows the viral reproductive cycle within an infected cell.





(a) Compare the reproductive cycle of SARS-CoV-2 shown in Fig. 5.1 with that of the influenza virus.

[4]

(b) Many different strains of SARS-CoV-2 have been detected since the start of the pandemic, a feature that is shared with the influenza virus.

Explain how new strains of the influenza virus may arise.

[3]

The polymerase chain reaction (PCR) test has been considered the most accurate test for diagnosing an infection by SARS-CoV-2.

To conduct the PCR test, viral RNA is first extracted from the patient's biological sample, then reverse transcribed to form complementary DNA (cDNA). The cDNA is then amplified through PCR, and the presence of significant quantities of amplified DNA indicates a positive test result.

(c) Explain the basis for the high accuracy of the PCR test.

Another method used for diagnosis is the antigen rapid test (ART), which can be done without the need for analysis in a laboratory and can yield results within minutes.

Scientists evaluated the effectiveness of ART in diagnosing COVID-19 in 500 patients, where the presence of SARS-CoV-2 in the patients were then confirmed by PCR testing. The results are shown in Table 5.1.

|--|

	result by PCR				
Tesult by ART	positive	negative			
positive	111	3			
negative	9	377			

The sensitivity of a diagnostic test is defined as its ability to detect a disease when a patient is confirmed to be infected.

The specificity of a diagnostic test is its ability to correctly indicate the absence of disease when a patient is confirmed as not infected.

Both measures of sensitivity and specificity are calculated as percentages.

(d) Calculate the sensitivity and specificity of the ART method, showing your workings in the space provided.

[2]

[Total: 11]

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6 Gene expression can be controlled at the transcriptional level. An investigation was carried out to find out the effect of an enhancer sequence on the transcription of a gene.

Fig. 6.1 summarises the results of the investigation, with five different experiments, (a) to (e):

(a) shows the gene without an enhancer, while (b) to (e) shows the gene under the influence of the enhancer at different arrangements.





(a)	Describe the function of the enhancer.
	[3]
(h)	Evolution have the enhancer is able to perform its function in the new location shown in
(u)	Fig 6 1(c)
	[2]
(a)	With reference to Fig. 6.1(d) and 6.1(e) describe the relationship between the estivity of the
(C)	enhancer and its arrangements
	[2]

Specificity protein 1, Sp1, was found to stimulate transcription of a gene. It was discovered that Sp1 binds specifically to GC box sequences found within the gene. In order to study Sp1 further, the method shown in Fig. 6.2 was used to obtain and purify Sp1.



[3]

(d)

7 A recombinant frequency of 1% indicates a distance of 1 centimorgan (cM) between two genes on a chromosome. Recombinant frequency can be calculated using the equation:

Recombinant frequency = <u>Number of recombinant offspring</u> x 100% Number of total offspring

In tomato plants, the two genes controlling the height of plant and the type of leaf are on the same homologous pair of chromosomes. They are located 12 cM apart on chromosome 1. The allele D, for a tall plant, is dominant to the allele d, for a dwarf plant. The allele M, for normal leaves, is dominant to the allele m, for mottled leaves.

Pure-breeding tall tomato plants with mottled leaves are crossed with pure-breeding dwarf plants with normal leaves. All the F1 tomato plants are tall with normal leaves. The F1 tomato plants then undergo a test cross, which gives 250 offspring. There are equal numbers between the two parental phenotypes and equal numbers between the recombinant phenotypes.

(a) State the genotype of both plants from the parental generation.

.....[2]

(b) Draw a genetic diagram of the test cross to show the observed results, clearly indicating the numbers of individuals in each different phenotypic class in the offspring.

[5]

Table 7.1 shows the height of 50 tomato plants measured in metres, to the nearest cm.

1.52	2.05	2.39	2.14	1.84	1.65	1.91	2.34	1.04	2.95
1.72	2.28	2.32	2.00	2.11	1.66	1.74	1.97	2.21	1.43
2.08	1.76	2.68	1.91	2.07	1.85	2.19	2.14	1.99	1.57
2.06	2.45	1.82	1.11	2.68	1.86	2.19	1.56	2.78	1.23
2.83	2.01	2.44	2.04	2.63	1.90	2.21	1.37	2.57	2.54

Table 7.1

(c) State and explain the type of genetic variation shown in the height of tomato plants.

[3]

[Total: 10]

[1]

8 Fig. 8.1 is an electron micrograph of a mitochondrion.



Fig. 8.1

(a) (i) On Fig. 8.1, clearly label and name the precise location where the Krebs cycle occurs.

(ii) Explain the importance of structure **Q** to the function of the mitochondrion.

(b) The metabolic activity of mammalian cells can be measured by the uptake of glucose into the cells.

With reference to named stages in aerobic respiration, explain why the uptake of glucose can be used to measure the metabolic activity of mammalian cells.

 	 	 [4]

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In an investigation, the effects of environmental temperature on oxygen and carbon dioxide levels in the air around a cockroach were studied. Fig. 8.2 shows the experimental set-up consisting of a closed animal chamber, a heat lamp and three digital probes linked to a computer.





The set-up was allowed to equilibrate for 10 minutes. After 10 minutes, ice packs were wrapped around the sides of the animal chamber to decrease the temperature of the chamber. Measurements were collected using the digital probes for a further 20 minutes. The experiment was conducted once every day for the next six days with the same cockroach.

For Examiner Use

Fig. 8.3 shows the graphs plotted from the mean results of the seven experiments.



Fig. 8.3

(c)	(i)	With reference to Fig. 8.3, comment on the results of this investigation.
		[3]
	(ii)	Identify one variable which should be kept constant and explain how it could affect the validity of the results if it is not controlled.
		[2]
		[Total: 12]

9 A species of zooplankton, *Daphnia dentifera*, feeds on phytoplankton. An increase in nitrogen compounds dissolved in the lakes will cause the phytoplankton populations to increase.

The yeast *Metschnikowia bicuspidata* is a parasite of *D. dentifera*. Biologists monitored the infections of *D. dentifera* population in a lake in Indiana, USA.

Fig. 9.1 shows the relationship between nitrogen levels dissolved in the water and the number of individuals infected in the *D. dentifera* population.





(a) (i) Explain the relationship between total nitrogen level and number of infected individuals in the *D. dentifera* population.

[3]

(ii) Biologists predicted that there would be fewer infected individuals in the *D. dentifera* population over many generations. Describe the evolutionary process that supports this prediction.

[4]

D. dentifera is a member of the crustacean group. Table 9.1 shows part of the amino acid sequence of ATP synthase from four different species of crustaceans.

species	amino acid sequence			
P. monodon	KSFKEILAGK	YDDLPEAAFY	MQGSIEDVVA	KAEQLAAQAS
M. japonicus	KSFKEILAGK	YDDLPEAAFY	MQGSIEDVVE	KAEQLAAQAS
L. vannamei	RSFKEILAGK	YDDLPEAPFY	MQGSIEDVIE	KAEQLAAQPS
P. leniusculus	ASFKEILAGK	YDHLPKLPST	CRGDIQDVLE	KAEQLATQGS

Table 9.1

(b) Explain what the data indicate about the relationships between *P. monodon* and the other three crustaceans.

 •••••
 •••••
[3]

[Total: 10]

10 Colostrum is a form of milk. Colostrum is produced by mammals to feed their newborn babies for a few days after birth.

Table 10.1 shows two classes of antibodies in human and in bovine colostrum.

Table 10.1

class of antibody	antibody concentration/ mg cm ⁻³			
Class of antibody	human colostrum	bovine colostrum		
IgA	17.4	3.9		
lgG	0.4	47.6		

(a) With reference to Table 10.1, compare the antibody composition of human colostrum with that of bovine colostrum.

(b) Vaccines are able to stimulate the production of antibodies in human.

Outline the benefits and risks of vaccination.

[3]

[Total: 5]

11 Pollen grains present in peat bogs and lake sediment may provide evidence of climate change.

In an investigation, the age of the sediment in a lake was determined. The lake sediment was also analysed for the abundance of pollen grains belong to four types of plant.



The results are shown in Fig. 11.1.



(a) With reference to Fig. 11.1, describe the changes in abundance of pollen grains from ash trees over the last 14 000 years.

(b) Ash trees grow in wet, poorly-drained soils. Grass grows in drier conditions.

With reference to Fig. 11.1, deduce the changes in climate at this lake over the last 14 000 years.

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(c) Explain how information in the graph suggests that other types of plants besides those shown in Fig. 11.1 were present around this lake.

.....[1]

[Total: 5]