EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examinations 2023
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	2	2	-		

REGISTRATION NUMBER		

H2 Biology 9744/02

Paper 2 Structured Questions

14 September 2023

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.

Candidates are to answer:
All questions on the Question Paper.

Write your answers in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue, or correction fluid/tape.

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

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

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Total	

This document consists of **28** printed pages.

Answer **all** questions.

1 Fig. 1.1 shows an electron micrograph of a eukaryotic cell.

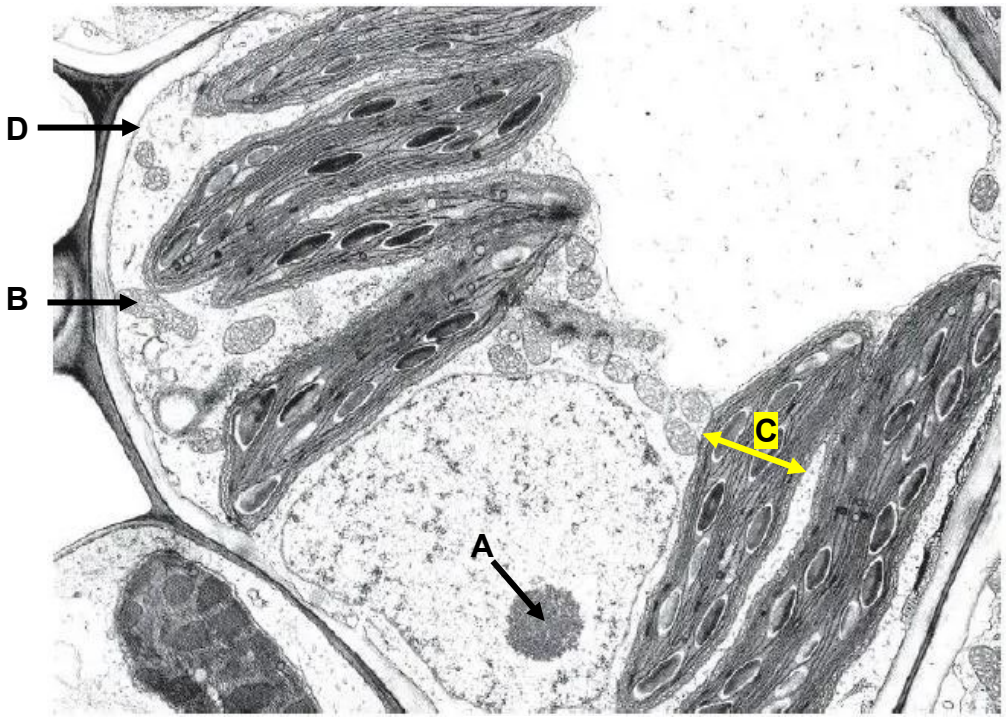

Fig. 1.1

(a) **(i)** Fill in the table to identify structures **A** and **D** and describe their functions.

structure	identity	function
A		
D		

[2]

(ii) Using the width of structure **C** as indicated by the arrow in Fig. 1.1, calculate the magnification of the electron micrograph. Show your working clearly.

[2]

(b) Fig. 1.2 is an electron micrograph of three cells of the same species of bacterium, *Erwinia carotovora*.

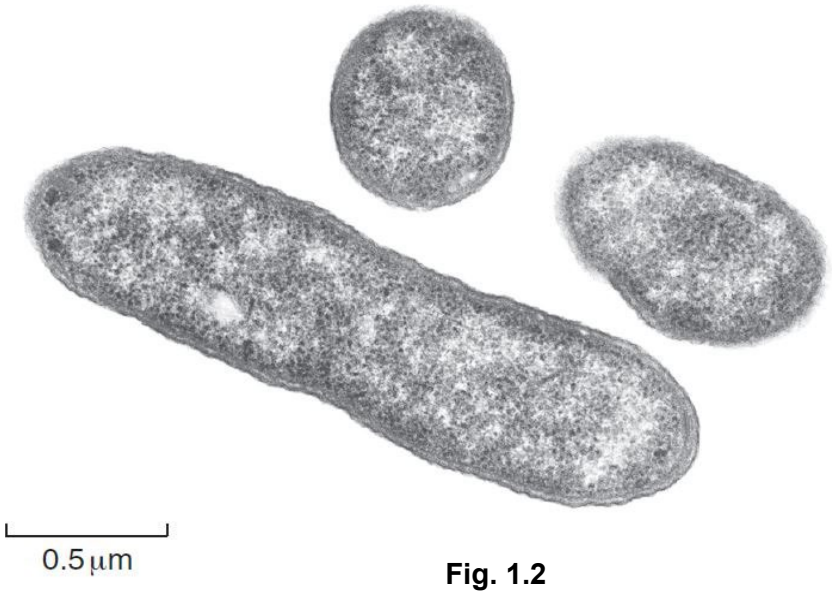

Fig. 1.2

(i) Name two structures found in animal cells which are **not** present in the cells shown in Fig. 1.2.

……

……

……

……[2]

(ii) *E. carotovora* is a rod-shaped bacterium.

Explain why two of the bacterial cells in Fig. 1.2 do **not** appear rod-shaped.

……

……[1]

(iii) Scientists think that the origins of structures **B** and **C** of Fig. 1.1 were very different from that of eukaryotic cells. The evidence for this is that they both have features in common with bacterial cells like *E. carotovora.*

Compare the structural features of **B** and/or **C** with *E. carovotora*;

……

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……[3]

[Total: 10]

2 Fig. 2.1 is a representation of a starch molecule. Starch is a polysaccharide made up of amylose and amylopectin.

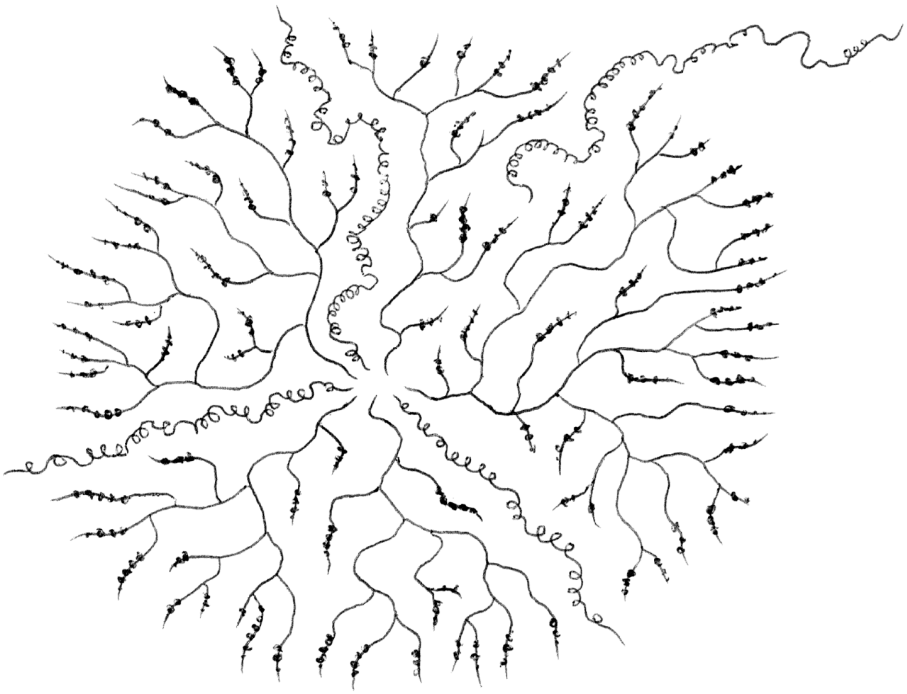

Fig. 2.1

(a) (i) Using arrows, label clearly on Fig. 2.1, amylose and amylopectin. [1]

(ii) Explain how **one** structural feature of amylopectin is related to its function in living organisms.

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……[3]

(b) Cellulose is another polysaccharide.

Fig. 2.2 shows three monomers from a molecule of cellulose.

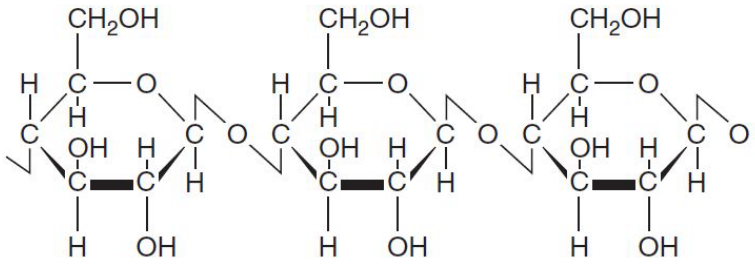

Fig. 2.2

(i) State the name of the monomer that makes up cellulose.

……[1]

(ii) Cellulose has high tensile strength which makes it suitable for the cell walls of plants.

Explain how cellulose has such a high tensile strength making it suitable for the cell walls of plants.

……

……

……

……

……

……[3]

(c) Glycogen has a similar structure to amylopectin. Glycogen is stored in the liver, kidney, and muscles of mammals.

State two ways in which the structure of glycogen differs from the structure of cellulose.

……

……

……

……[2]

[Total: 10]

3 Neutrase® is an enzyme that is used to hydrolyse proteins in solution. When the enzyme is mixed with a 2% protein solution, the reaction mixture changes from white to colourless.

A student carried out an experiment to find the effect of copper sulfate and potassium sulfate on the activity of Neutrase®. The student made four reaction mixtures in test-tubes **A** to **D**. The contents of each test-tube are shown in Table 3.1.

Table 3.1

test-tube	volume added / cm^3				
	2% protein	0.05 mol dm^{-3} copper sulfate	0.01 mol dm^{-3} copper sulfate	0.01 mol dm^{-3} potassium sulfate	water
A	0.1	0.1	0.0	0.0	0.0
B	0.1	0.0	0.1	0.0	0.0
C	0.1	0.0	0.0	0.1	0.0
D	0.1	0.0	0.0	0.0	0.1

0.5 cm^3 of a 1% Neutrase® solution was then added to test-tube **A** and immediately placed into a colorimeter. The colorimeter was used to measure the intensity of light that is absorbed by the solution (absorbance) over 100 seconds. The procedure was repeated with the other reaction mixtures, **B**, **C** and **D**.

The results are shown in Fig. 3.1.

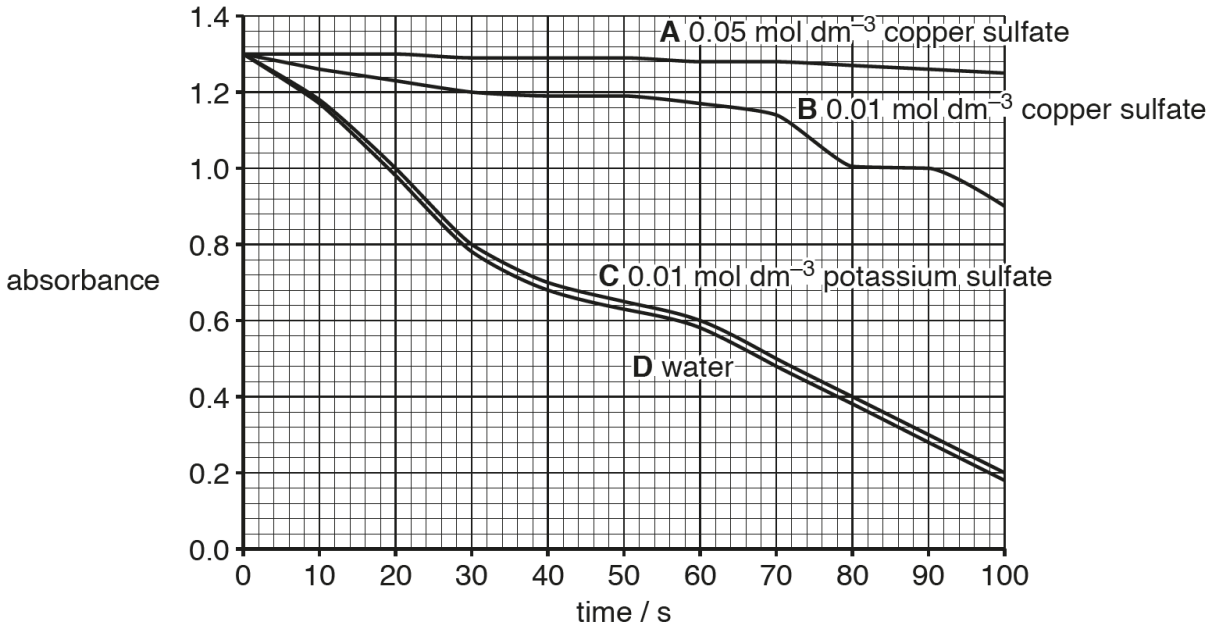

Fig. 3.1

(a) **(i)** Suggest **and** explain why measuring the absorbance of the reaction mixture over 100 seconds is a suitable method for determining the activity of Neutrase®.

.....

.....

.....

.....

.....[2]

(ii) With reference to Fig. 3.1, describe the effects of 0.01 mol dm^{-3} copper sulfate solution and 0.01 mol dm^{-3} potassium sulfate solution on the activity of Neutrase®.

copper sulfate .....

.....

.....

.....

potassium sulfate .....

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.....

.....[4]

(b) Copper and sulfate ions are not similar in conformation to proteins used in the experiment.

Explain the effect of copper sulfate solution on the activity of Neutrase®.

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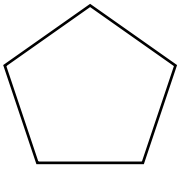
…….....[3]

[Total: 9]

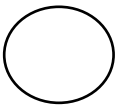
4 Genetic information is encoded in DNA. DNA is made up of monomers called nucleotides.

A DNA nucleotide consists of three types of molecules joined together.

(a) These shapes represent the components of DNA:



deoxyribose sugar



phosphate group

nitrogenous base

(i) Using the above shapes, draw a diagram to show a dinucleotide. [2]

(ii) A gene was isolated from the DNA of bacterial cells and the base composition of the template strand was analysed.

- 40% of the bases were thymine
- 20% of the bases were guanine
- 10% of the bases were cytosine

Fill in the table below to show the percentage of nucleotides required in these bacterial cells to produce a transcript of this strand of the gene.

percentage of nucleotides needed with a particular base				
adenine	cytosine	guanine	thymine	uracil

[1]

(b) The DNA molecules are further organised into structures called chromosomes.

Describe the packing of DNA in eukaryotic chromosomes.

……

……

……

……

……

……[3]

(c) Many diseases arise due to gene mutations and/or chromosomal aberrations.

(i) Distinguish between gene mutations and chromosomal aberrations.

……..

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……..

……..[2]

Fig. 4.1 shows an error occurring during meiosis II.

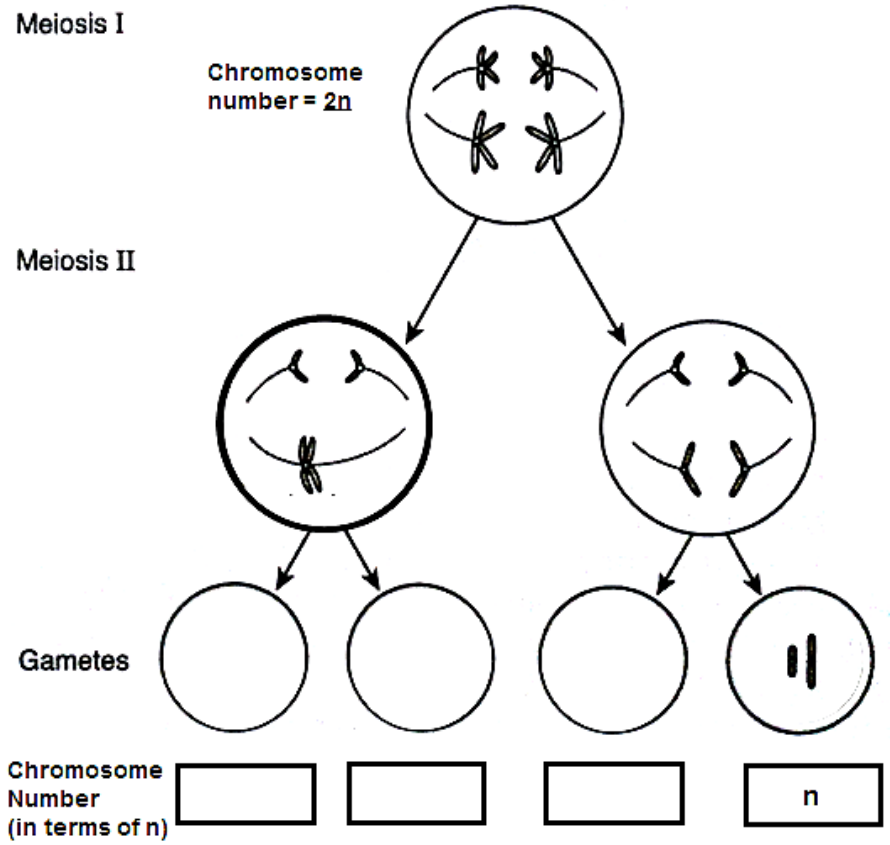

Fig. 4.1

(ii) Complete Fig. 4.1 with the correct chromosome structures and chromosome number (in terms of n) in the gametes. [1]

(iii) Describe the error shown in Fig. 4.1.

……..

……..[1]

[Total: 10]

5 The summer squash plant, *Cucurbita pepo*, produces edible fruits that vary in shape. Fruit shape in squashes is controlled by two genes, **A/a** and **B/b**, that are located on different chromosomes.

Fig. 5.1 shows the fruits of three different varieties of squash plants.

Patty pan
(disc-shaped)

Di Nizza
(spherical)

Alfresco
(long)

Fig. 5.1

(a) (i) Table 5.1 shows the possible genotypes of the Patty pan and Alfresco varieties.

Complete Table 5.1 to show the possible genotypes of the Di Nizza variety.

Table 5.1

variety	**possible genotypes**			
Patty pan (disc-shaped)	**AABB**	**AaBB**	**AABb**	**AaBb**
Di Nizza (spherical)	.....	.....	.....	.....
Alfresco (long)	**aabb**			

[1]

(ii) A gardener used pollen from a male flower of Alfresco to pollinate a female flower of Di Nizza. The gardener grew the seeds produced from this cross and found that half the offspring produced spherical fruits and half produced long fruits.

Draw **one** genetic diagram to explain this result.

[4]

(b) Explain how **one** event in meiosis can result in genetic variation.

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.....

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.....

…….....[3]

(c) Sex determination in humans depends on the *SRY* gene on the Y chromosome. The product of the *SRY* gene switches on the genes that enable an embryo to start to develop male characteristics.

To transcribe the *SRY* gene, the H3K9 histone must be demethylated by the enzyme coded by the *Jmjd1a* gene.

Define epistasis and state the relationship between the *SRY* gene and the *Jmjd1a* gene.

.....

.....

.....

…….....[2]

[Total: 10]

6 Mutant Ras proteins have been associated with many types of human cancer. Ras proteins function downstream from cell surface receptors, such as the epidermal growth factor receptor (EGFR).

Fig. 6.1 shows the activation of Ras following binding of the epidermal growth factor (EGF) at its receptor. GRB2 and Sos are cytosolic proteins associated with this signalling pathway.

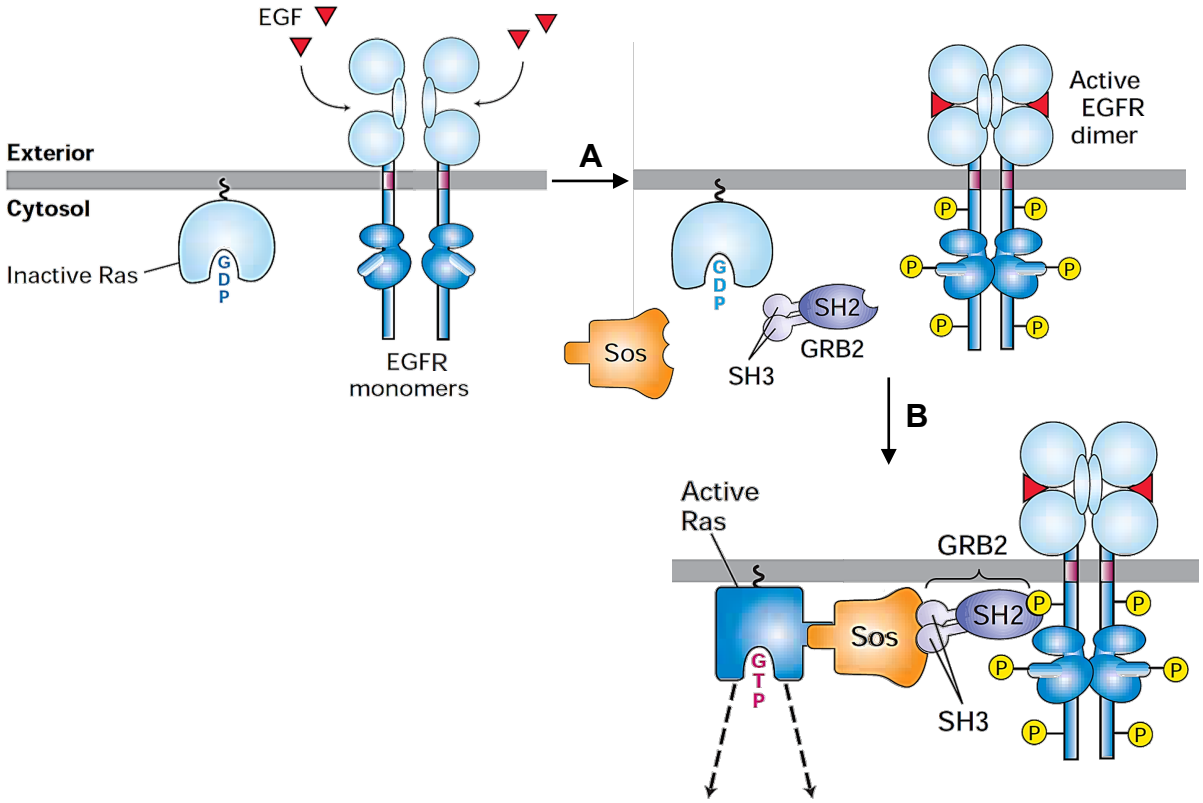

Fig. 6.1

(a) Describe the downstream events that occur after EGF binds to its receptor, as indicated by **A** and **B** in Fig. 6.1.

A .....

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.....

.....

B .....

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.....[5]

Active Ras protein can bind and activates other downstream relay proteins within the cell, such as Raf. Raf is a protein kinase that can trigger a sequence of events, as shown in Fig. 6.2.

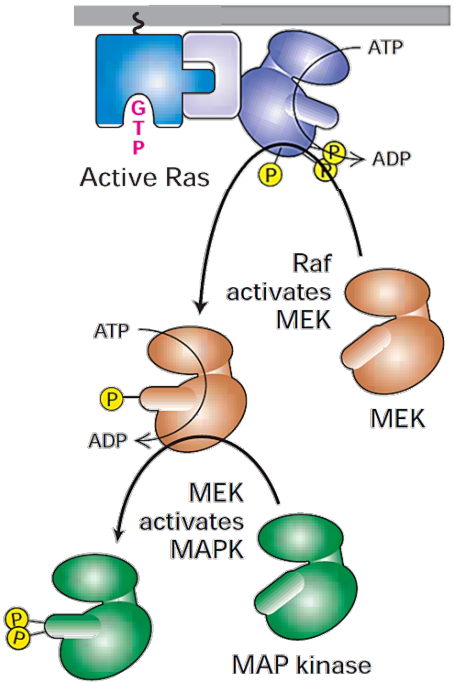

Fig. 6.2

(b) Describe the sequence of events triggered by Raf and explain its importance in signal transduction.

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.....

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.....[3]

(c) In a separate signalling pathway, activated EGFR can also result in the activation of PLC-γ. PLC-γ is an enzyme that cleaves a modified phospholipid molecule called PIP_2 into IP_3 and DAG. Both IP_3 and DAG function as second messengers.

Describe the role of second messengers.

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…….....[2]

[Total: 10]

7 In experiments it was found that, in an intact mitochondrion:

- there is a membrane potential across the inner mitochondrial membrane whereby there is an unequal distribution of charges across the membrane
- the membrane potential arises because the mitochondrial matrix has a negative charge and the intermembrane space has a positive charge
- the transport of ATP, ADP and inorganic phosphate (P_i) is driven by the membrane potential across the inner membrane

Fig. 7.1 shows the location of some inner mitochondrial membrane carrier proteins.

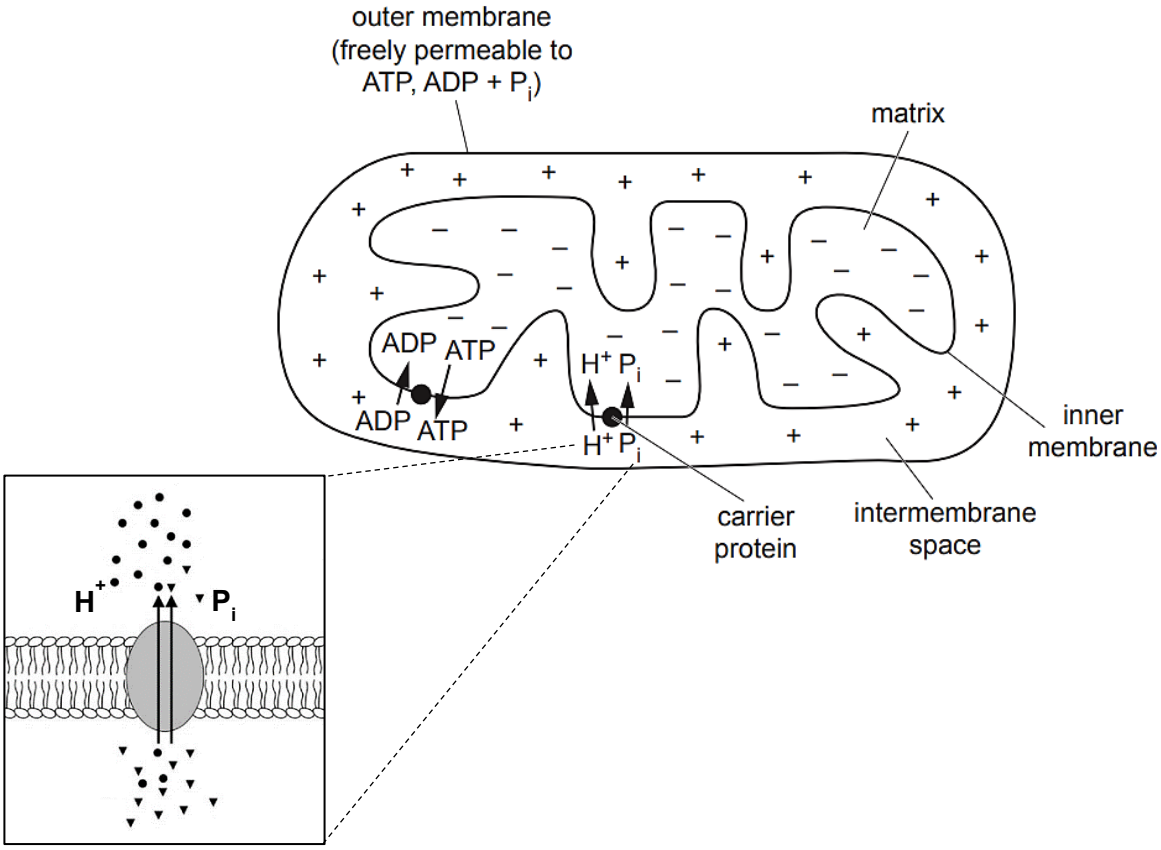

Fig. 7.1

(a) **(i)** Reduced NAD and reduced FAD transfer hydrogen atoms to carriers located in the inner mitochondrial membrane.

Explain how hydrogen atoms from reduced NAD and reduced FAD lead to a membrane potential forming across the inner mitochondrial membrane during oxidative phosphorylation.

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……

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……

……[4]

(ii) Suggest and explain how P_i is transported across the inner membrane of the mitochondrion into the matrix.

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……[2]

The production of reduced electron carriers from the first three stages of aerobic respiration are shown in Fig. 7.2.

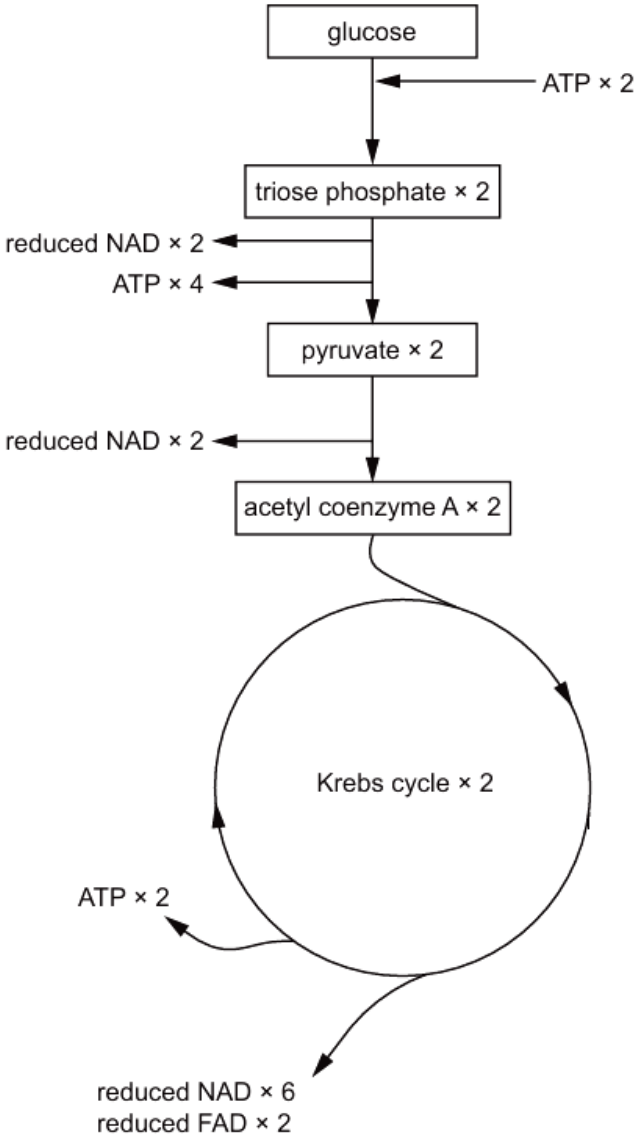

Fig. 7.2

At one time it was thought that the oxidative phosphorylation of:

- one molecule of reduced NAD results in the synthesis of 3 ATP molecules
- one molecule of reduced FAD results in the synthesis of 2 ATP molecules.

Using Fig. 7.2, a theoretical value for the net number of ATP molecules that are synthesised for each molecule of glucose can be calculated.

Modern research has shown that the actual net number of ATP molecules synthesised for each glucose molecule respired is much lower than this theoretical value.

(b) **(i)** Using Fig. 7.2, calculate the theoretical value for the net number of ATP molecules that are synthesised for each molecule of glucose respired in all phosphorylation reactions.

Show your working.

answer = ... [2]

(ii) Suggest one reason why the actual net number of ATP molecules synthesised is less than the theoretical number.

……

……..….[1]

Photosynthesis is another important energy transfer process.

(c) Explain why temperature can be a limiting factor of photosynthesis.

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.....

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.....

.....

.....[3]

[Total: 12]

8 Genome-wide association studies find links between single nucleotide polymorphisms (SNPs) and phenotypic features such as human diseases. SNPs are points on the DNA that vary in the population because of single base substitutions.

Fig. 8.1 summarises results for three diseases – rheumatoid arthritis, type 1 diabetes and type 2 diabetes. The 22 human autosomes and the X chromosome (chromosome 23) are shown.

Chromosome locations with SNPs that are associated with a disease at a statistically significant level (greater than 5 arbitrary units) are shown in black.

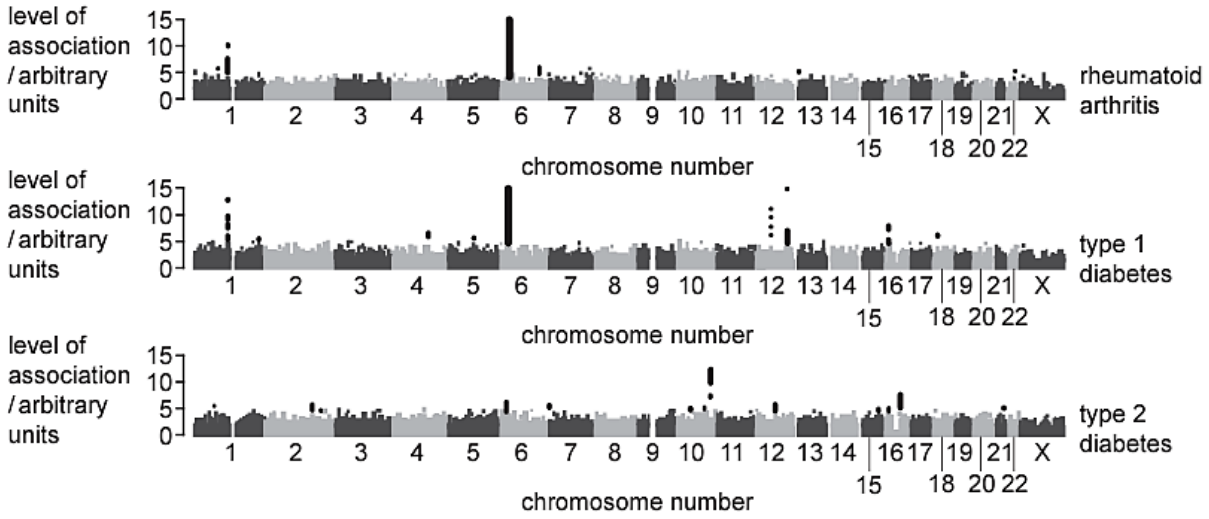

Fig. 8.1

(a) **(i)** Identify the chromosomes that contain SNPs that have a high level of association with **both** rheumatoid arthritis and Type 1 diabetes.

……[1]

(ii) Genetic diseases are caused at the level of the gene and the chromosome.

With reference to Fig. 8.1, compare the genetic basis of the three diseases.

……

……

……

……[2]

One of the SNPs associated with rheumatoid arthritis results in the introduction of an additional restriction site for *Sma*I, as shown in Fig. 8.2. The restriction sites for *Sma*I are indicated by the arrows.

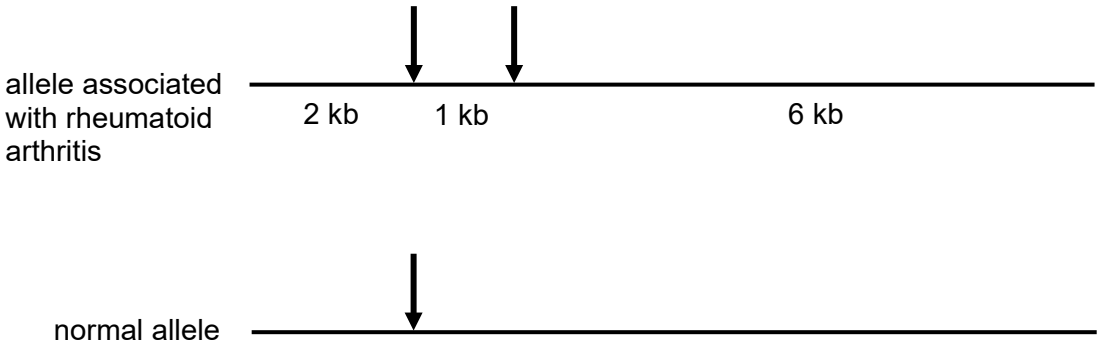

Fig. 8.2

(b) (i) Various probes can be used in Southern blotting for disease detection.

Design a probe such that a different band pattern will be produced for the various genotypes. Draw this probe on Fig. 8.2 to show where will it bind on the allele associated with rheumatoid arthritis. Label this probe clearly as **(b)(i)**. [1]

(ii) The allele associated with rheumatoid arthritis is a dominant allele.

Using the probe you have designed for **(b)(i)**, draw the band pattern that will result for all genotypes in the population in Fig. 8.3. [4]

Fig. 8.3

(iii) Not all probes will be useful in producing a distinct band pattern between those who have rheumatoid arthritis allele and those who do not.

On Fig. 8.2, draw to show where such a probe will anneal to the allele associated with rheumatoid arthritis. Label this probe clearly as **(b)(iii)**. [1]

[Total: 9]

9 The main cause of tuberculosis (TB) in humans is the bacterium, *Mycobacterium tuberculosis*. Generally, a healthy person who inhales droplets containing these bacteria has effective defence mechanisms in their respiratory airways to prevent infection.

One example of a defence mechanism against such pathogens in the respiratory airways involves the action of resident phagocytes.

(a) State the specific type of phagocyte that acts as the primary defence against *M. tuberculosis*.

…….....[1]

(b) Describe the mode of action of this phagocyte in killing bacteria cells.

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.....

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.....

…….....[3]

(c) It is sometimes possible for *M. tuberculosis* to survive within these phagocytes without being destroyed.

Suggest **one** way in which *M. tuberculosis* may survive within these phagocytes.

.....

…….....[1]

Fig. 9.1 shows the reported number of new cases of tuberculosis (TB) in the USA and the number of new cases per 100000 of the population of the USA between 1993 and 2018.

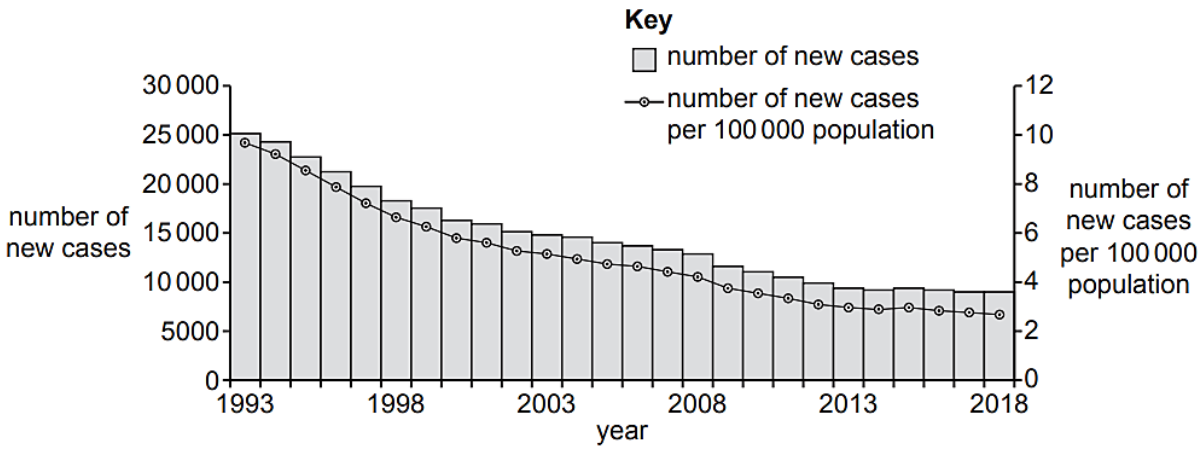

Fig. 9.1

(d) **(i)** Calculate the percentage decrease in the number of new cases of TB in the USA between 1993 and 2012. Show all your working.

answer .....% [2]

(ii) Suggest an advantage of calculating the number of new cases per 100000 each year in the prevention and control of TB across the world.

……..

……..…..[1]

(e) TB is endemic (always present) in many populations across the world and many countries have high numbers of cases.

Suggest **two** reasons why it is difficult to reduce the number of cases of TB across the world.

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…….....[2]

The genes in bacteria are commonly arranged into operons.

Fig. 9.2 shows the structure and control of the *trp* operon.

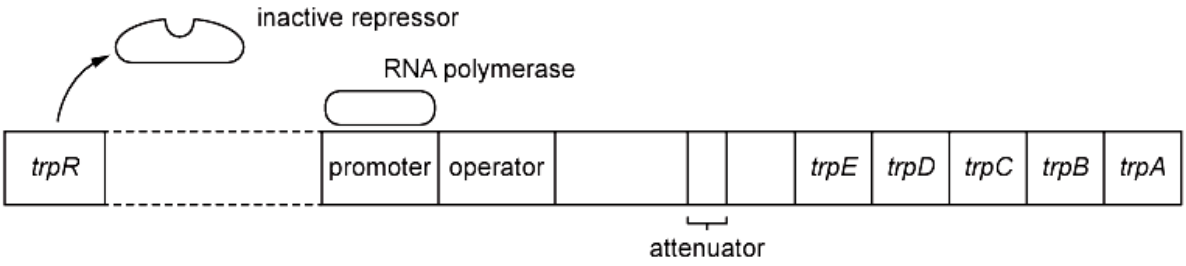

Fig. 9.2

(f) Describe the differences in structure **and** control between the *lac* operon and the *trp* operon.

.....

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…….....[3]

(g) Explain why structural genes in operons are transcribed together.

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…….....[2]

[Total: 15]

10 The global demand for meat is growing. Over the past 50 years, meat production has more than tripled. However, the production of meat has large environmental impacts.

Fig. 10.1 shows the mass of meat eaten from 1980 to 2010.

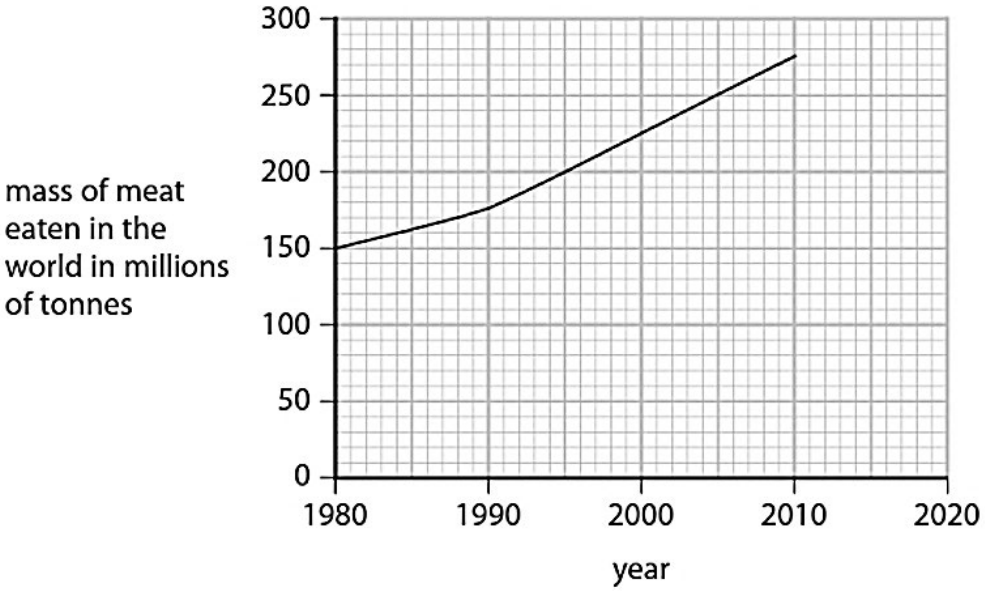

Fig. 10.1

(a) With reference to Fig. 10.1, calculate the rate of increase of the meat eaten in the world from 2000 to 2010.

..... millions of tonnes per year [1]

(b) Ruminant animals such as cows, buffaloes and sheep produce large amounts of methane when they digest food, adding to greenhouse gases in the environment.

Explain how increased meat production contributes to an increase in another greenhouse gas such as carbon dioxide in the environment.

.....

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.....

.....[2]

(c) Explain how a large increase in the mass of meat eaten will impact global food supply in the future.

.....

.....

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.....[2]

[Total: 5]