EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examinations 2024
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	2	3	-		

REGISTRATION NUMBER		

H2 Biology

9744/02

Paper 2 Structured Questions

11 September 2024

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	
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8	
9	
10	
11	
Total	

This document consists of **29** printed pages and **3** blank pages.

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Answer **all** questions.

1 The unicellular fungus *Kluyveromyces lactis* is found in dairy products. It is a safe microorganism to culture for the extraction of the enzyme lactase.

Lactase catalyses the breakdown of lactose, a sugar found in milk.

The reaction catalysed by lactase is summarised in Fig. 1.1.

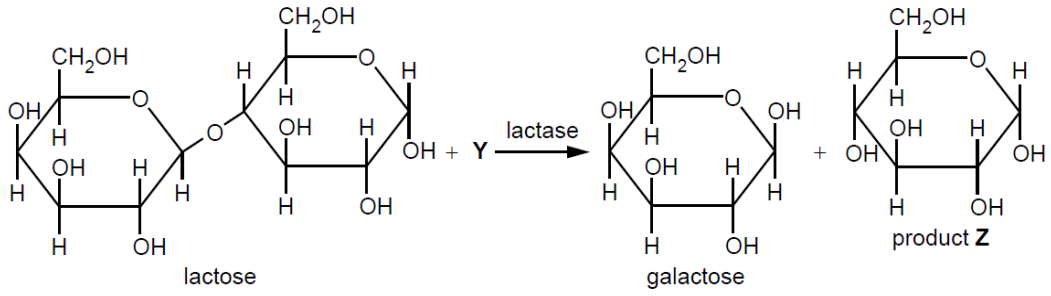

Fig. 1.1

(a) Describe the reaction that is catalysed by lactase. Use Fig. 1.1 to help you. In your answer, identify **Y** and product **Z**.

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[3]

(b) On a commercial scale, immobilised lactase can be used to produce lactose-free milk.

One of the products of the reaction shown in Fig. 1.1 acts as an inhibitor of lactase. This is an example of product inhibition.

(i) Suggest why product inhibition is advantageous in *K. lactis* when lactase is acting as an intracellular enzyme but can be a disadvantage when extracted lactase is used free in solution to produce lactose-free milk.

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[2]

(ii) Suggest how using immobilised lactase for the production of lactose-free milk helps to reduce the problem of product inhibition.

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……..…… [1]

(c) When developing an enzyme-catalysed reaction for use in industry, the progress of the reaction is studied to determine the optimal conditions for product formation.

Explain how substrate concentration can affect the rate of an enzyme-catalysed reaction.

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[4]

[Total: 10]

2 Lysosomes are cell structures that contain acid hydrolases which are enzymes that work best in acidic environments.

Fig. 2.1 shows some processes that occur in neutrophils.

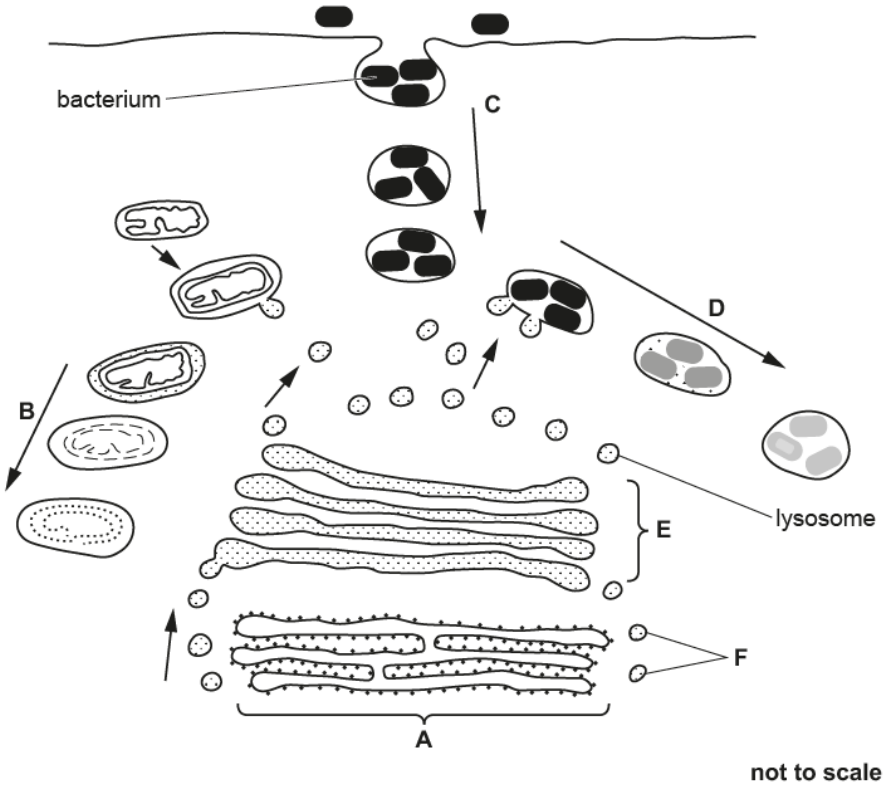

Fig. 2.1

(a) Name the cell structures labelled **A** and **E**.

A ……

E …… [1]

(b) State the function of **F**.

……

…… [1]

(c) Describe the role of cell surface membrane during process **C**.

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…….. [3]

(d) With reference to the processes occurring at **B** and at **D** in Fig. 2.1, outline the roles of acid hydrolases in lysosomes.

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(e) Carrier proteins in the membranes of lysosomes maintain a lower pH than the surrounding cytoplasm by moving hydrogen ions.

Suggest how the carrier proteins maintain the lower pH within the lysosomes.

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…….. [1]

[Total: 10]

3 The early development of an animal involves divisions of the zygote and daughter cells by mitosis to form an embryo consisting of genetically identical cells.

Fig. 3.1 shows several cells at different stages of the cell cycle in an embryo of whitefish, *Coregonus artedi*.

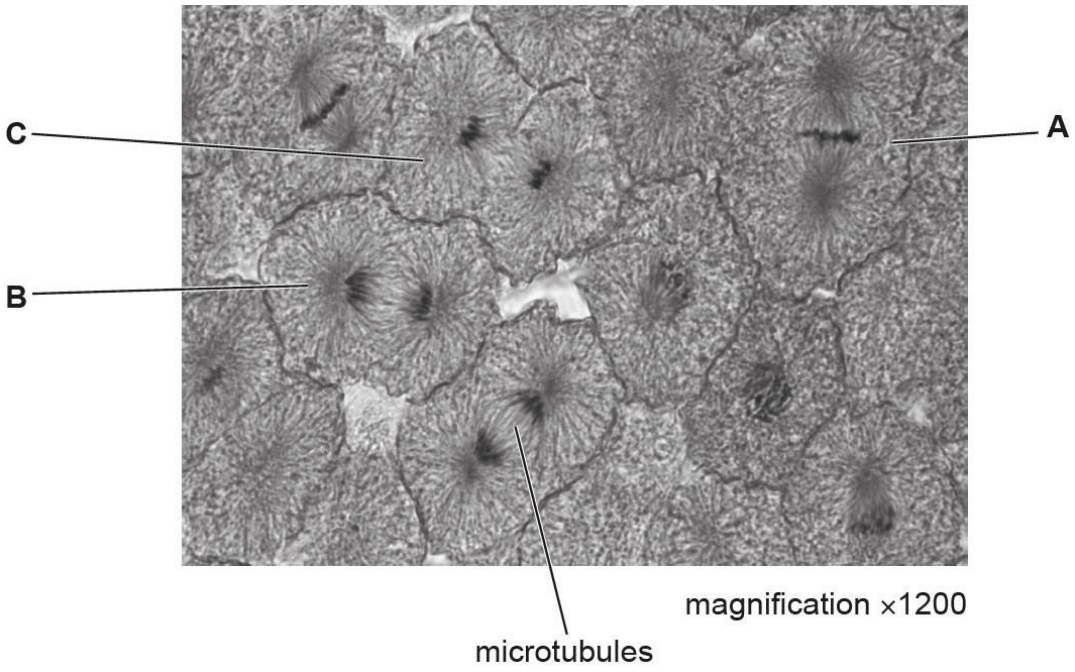

Fig. 3.1

(a) **(i)** Name the stage of mitosis in cell A and in cell C, shown in Fig. 3.1.

A ..... [1]

C ..... [1]

(ii) Describe the role of microtubules in cell B.

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[2]

(b) Uncontrolled mitosis can cause cancer in humans.
Paclitaxel is a drug used in the treatment of some forms of cancer.

Researchers investigated the effect of Paclitaxel on the mitotic cell cycle of cancer cells.

- The cancer cells were grown for two days and then divided into groups.
- Each group was treated with a different concentration of Paclitaxel.

After 28 hours (one cell cycle):

- the percentage of cells in stages of mitosis was calculated
- the ratio of the number of cells in anaphase to the number of cells in metaphase was determined.

The results of the investigation are shown in Fig. 3.2.

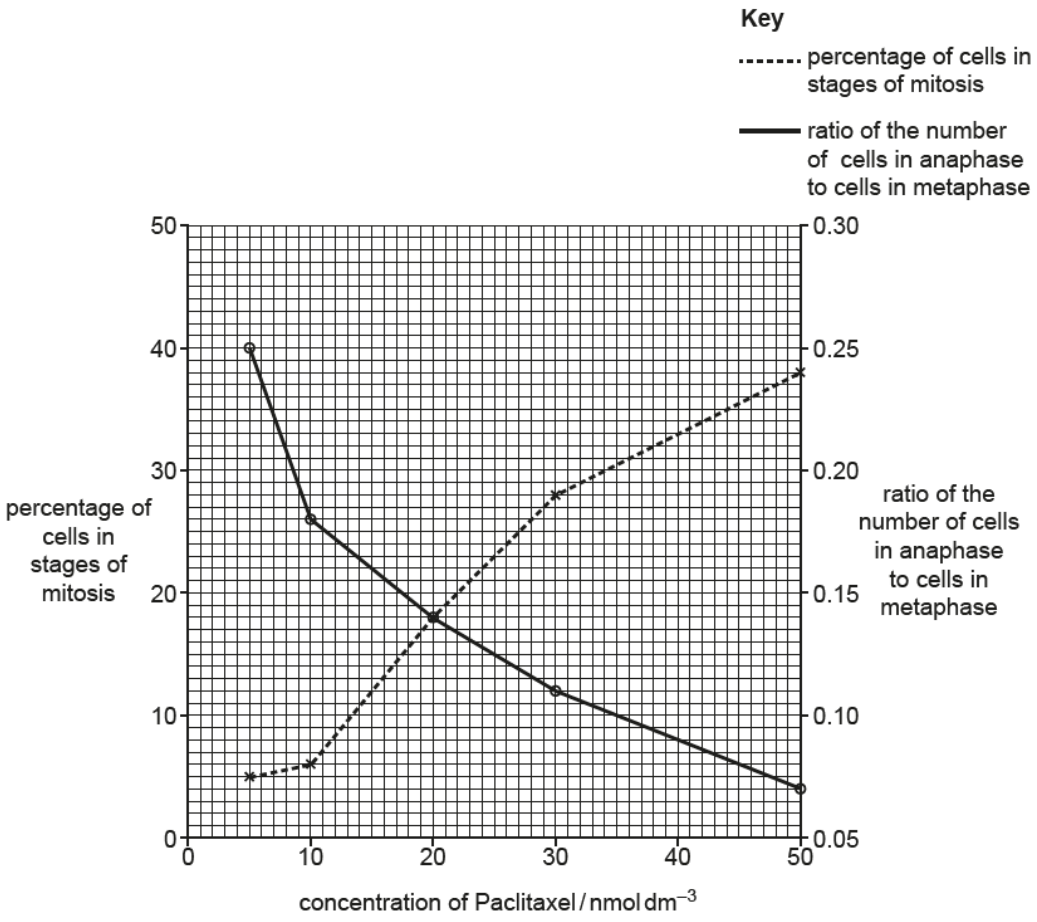

Fig. 3.2

With reference to Fig. 3.2, describe the results and suggest an explanation for the effect of Paclitaxel on the mitotic cell cycle.

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(c) Fig 3.3 depicts a model of cancer development from a single abnormal cell.

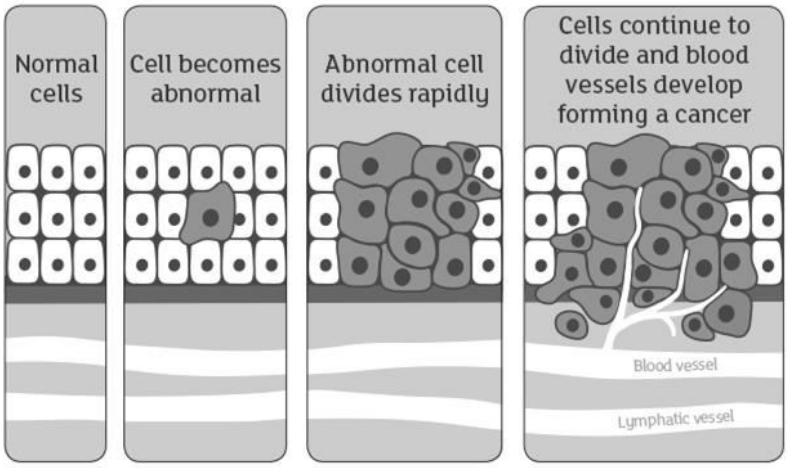

Fig 3.3

Explain what may have led to the development of this abnormal cell from a normal cell before it divides rapidly.

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…….. [2]

[Total: 10]

4 In typical cells, nucleic acids are synthesised from eight different nucleotides.

Fig. 4.1 represents the three different components of a nucleotide.

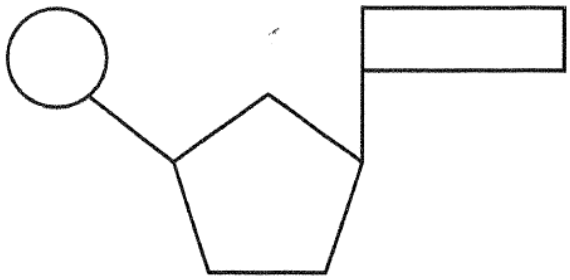

Fig. 4.1

(a) Describe how differences in these components result in the eight different nucleotides from which nucleic acids are synthesised.

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…….. [2]

Fig. 4.2 shows the sequence of bases in a section of a single-stranded RNA virus. The bases code for the first few amino acids of a polypeptide chain.

5' UACAUGGAUUACCCCGUUGUACAU 3'
Fig. 4.2

Each codon codes for a specific amino acid as shown in Table 4.1.

Table 4.1

UUU	phe	UCU	ser	UAU	tyr	UGU	cys
UUC	phe	UCC	ser	UAC	tyr	UGC	cys
UUA	leu	UCA	ser	UAA	STOP	UGA	STOP
UUG	leu	UCG	ser	UAG	STOP	UGG	trp
CUU	leu	CCU	pro	CAU	his	CGU	arg
CUC	leu	CCC	pro	CAC	his	CGC	arg
CUA	leu	CCA	pro	CAA	gln	CGA	arg
CUG	leu	CCG	pro	CAG	gln	CGG	arg
AUU	ile	ACU	thr	AAU	asn	AGU	ser
AUC	ile	ACC	thr	AAC	asn	AGC	ser
AUA	ile	ACA	thr	AAA	lys	AGA	arg
AUG	met	ACG	thr	AAG	lys	AGG	arg
GUU	val	GCU	ala	GAU	asp	GGU	gly
GUC	val	GCC	ala	GAC	asp	GGC	gly
GUA	val	GCA	ala	GAA	glu	GGA	gly
GUG	val	GCG	ala	GAG	glu	GGG	gly

(b) Using information from Fig. 4.2 and Table 4.1,

(i) State the third amino acid coded by the section shown in Fig. 4.2 if the virus was a positive-sense RNA virus.

…… [1]

(ii) State the fourth amino acid coded by the section shown in Fig. 4.2 if the virus was a negative-sense RNA virus.

…… [1]

A series of mutations has occurred, causing all the cytosine of the single-stranded RNA virus in Fig. 4.2 to be replaced with guanine.

Assuming that the average mass of each amino acid is 100 Da,

(iii) Estimate the mass of the entire polypeptide translated from the mutated virus if the virus was a positive-sense RNA virus.

…… [1]

(c) Some non-coding DNA can only be found in eukaryotic chromosome but not in prokaryotic

chromosome.

Suggest possible roles for non-coding DNA that are not involved in regulation of gene expression in eukaryotic chromosome.

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……. [2]

(d) In a typical human cell, the percentage of each type of RNA is:

mRNA 3%
tRNA 15%
rRNA 80%
others 2%

Suggest explanations for the different percentages of mRNA, tRNA and rRNA.

mRNA

……...

……. [1]

tRNA

……...

……. [1]

rRNA

……...

……. [1]

[Total: 10]

5 Fig. 5.1 shows a human immunodeficiency virus (HIV) particle about to attach to the cell surface membrane of a T-helper cell at a receptor protein called CD4. A second protein (coreceptor) called CCR5 is also necessary for the virus particle to enter and then infect the T-helper cell.

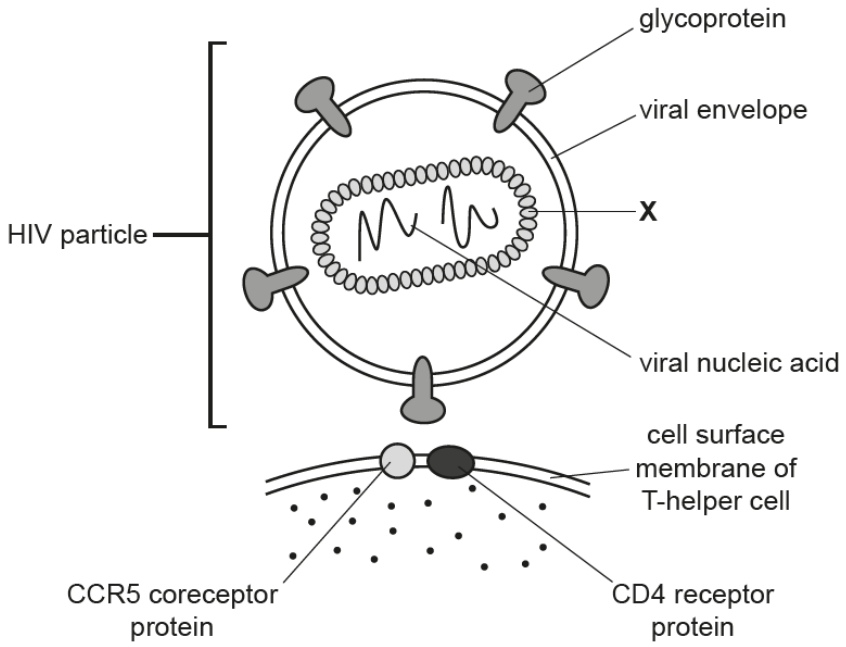

Fig. 5.1

(a) Identify structure labelled **X**.

…….... [1]

Fig. 5.2 shows the 4 stages of how a HIV particle enters the T-helper cell.

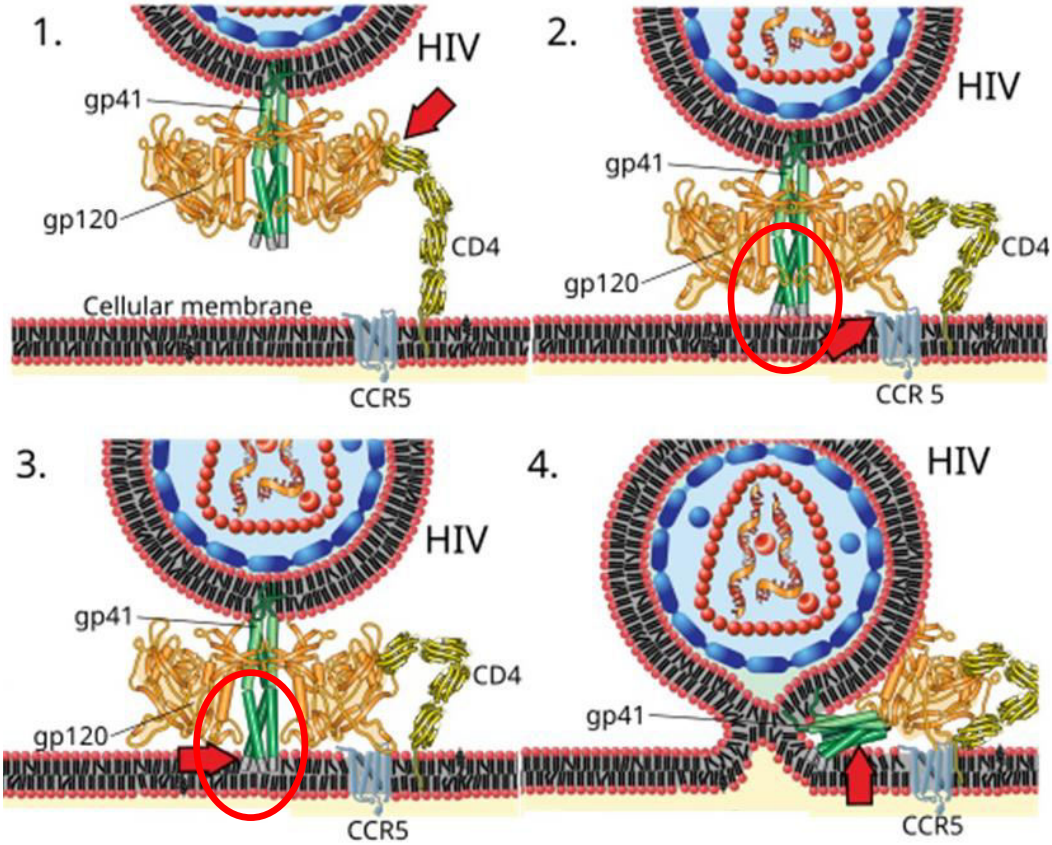

Fig. 5.2

(b) Studies have shown that some individuals did not become infected with HIV even though they were repeatedly exposed to the virus. Later discoveries indicated that these individuals had a mutation in the gene for the CCR5 coreceptor protein.

With reference to Fig. 5.2, explain how mutation of the gene for the CCR5 coreceptor protein provided protection against HIV infection.

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…… [3]

(c) Acquired Immunodeficiency Syndrome (AIDS) refers to a series of symptoms and illnesses caused by HIV. There can be a latent period of up to ten years between infection

and the onset of symptoms.

State **two** enzymes found in HIV and describe how they contributed to the occurrence of latency.

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…….. [5]

(d) Name a bacteriophage that also undergoes latency in its reproductive cycle.

…….. [1]

[Total: 10]

6 The fruit fly, *Drosophila melanogaster*, has autosomal genes for body colour and wing shape.

Gene **B/b** is involved in the production of body colour:

- **B** = dominant allele for brown body colour
- **b** = recessive allele for black body colour

Gene **D/d** is involved in wing shape:

- **D** = dominant allele for straight wing
- **d** = recessive allele for curved wing

A dihybrid test cross was carried out between flies heterozygous for body colour and for wing
shape and flies homozygous recessive for body colour and for wing shape.

(a) Table 6.1 shows the number of offspring of each phenotype obtained in the test cross.

Table 6.1

Phenotype	Observed number	Expected number
Brown body colour, straight wings	2843	
Brown body colour, curved wings	855	
Black body colour, straight wings	842	
Black body colour, curved wings	2768	

Use Table 6.1 to calculate the expected number of each phenotype. Write your answers in the table. [1]

(b) A chi-squared (χ^2) test was carried out to compare the observed results with the results that would be expected from a dihybrid cross involving genes on different autosomes.

The value of χ^2 = 2097.836.

Table 6.2 shows the critical values for the χ^2 distribution.

Table 6.2

Degrees of freedom	p value		
	0.05	**0.01**	**0.001**
1	3.841	6.635	10.828
2	5.991	9.210	13.816
3	7.815	11.345	16.266
4	9.488	13.277	18.467

Explain how the value of χ^2 and Table 6.2 can be used to assess the significance of the difference between the observed results and the expected numbers in Table 6.1.

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…….. [3]

(c) State the type of inheritance observed in Table 6.1.

…….. [1]

(d) Draw a genetic cross to explain the observed results in Table 6.1.

[5]

[Total: 10]

7 Extended periods of stress can cause the buildup of adenosine molecules in brain tissue.

Adenosine is a ligand that binds to a G protein-coupled receptor on brain cells. The subsequent downstream signalling response of adenosine is illustrated in Fig 7.1 below.

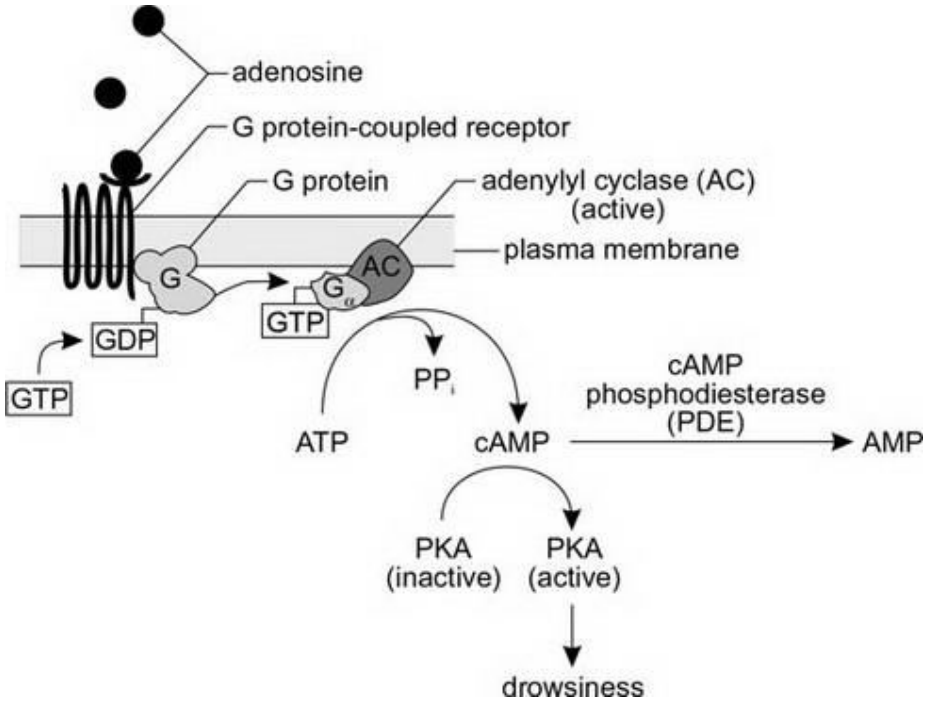

Fig. 7.1

(a) Describe how the structure of G protein relates to its function.

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…… [2]

(b) A single adenosine molecule can induce a large cellular response. With reference to Fig. 7.1, explain why this is possible.

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…… [2]

The cellular response to cAMP varies widely in different types of cells. In brain cells and

other cells of the central nervous system, cAMP activates a Protein Kinase A (PKA), which slows brain activity and causes drowsiness.

Normally, cAMP concentrations in the cell are kept low by the enzyme cAMP phosphodiesterase (PDE), converting cAMP to regular AMP (not cyclic). But high levels of cAMP can be attained during periods of mental fatigue or other kinds of stress.

Caffeine is an adenosine signaling antagonist, blocking the effect of adenosine. Fig. 7.2 shows the structures of adenosine and caffeine.

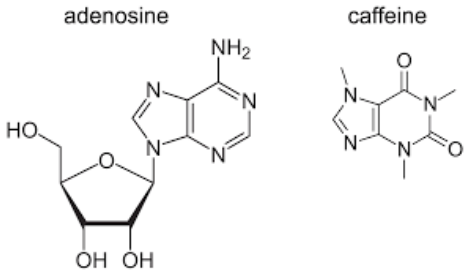

Fig. 7.2

(c) With reference to Fig. 7.1 and Fig. 7.2, explain the effect of excessive consumption of caffeinated drinks on an individual.

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…….. [4]

(d) Mutations can occur in adenylyl cyclase (AC) which results in a constitutively active adenylyl cyclase enzyme. With reference to Fig. 7.1, explain why individuals suffering from such mutations are not allowed to operate heavy machinery.

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…….. [2]

[Total:10]

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8 Fig. 8.1 shows a transmission electron micrograph of part of a chloroplast.

Fig 8.1

(a) Identify structures **C** and **D**.

C ..... [1]

D ..... [1]

(b) Explain why membrane **C** has many different coloured pigments to function efficiently.

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..... [3]

(c) Fig. 8.2 is a diagram of a section through a mitochondrion.

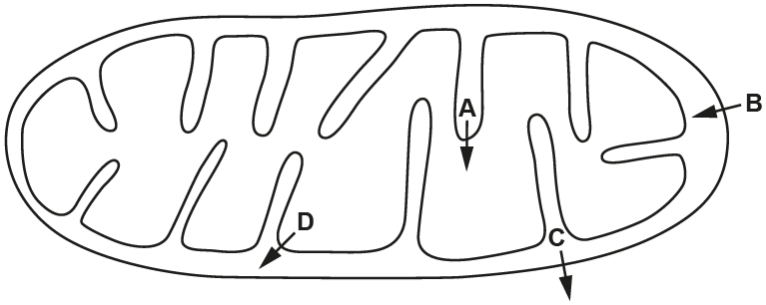

Fig 8.2

The four arrows, **A**, **B**, **C** and **D**, show the movement of molecules and ions.

Use the letters to identify **all** the arrows (one or more) that show:

(i) active transport of protons ……. [1]

(ii) diffusion of carbon dioxide ……. [1]

(d) Cyclical processes such as the Calvin cycle and Kreb cycle occur in during photosynthesis and respiration respectively.

Distinguish between these two cyclical processes.

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[Total: 10]

9 The sea blush, *Plectritis congesta*, is a flowering plant that grows on the west coast of North America.

Individual sea blush plants produce fruit that is either winged or wingless. Investigations have shown that this characteristic is controlled by a single gene with two alleles:

- a dominant winged fruit allele
- a recessive wingless fruit allele.

Fig. 9.1 shows the difference in structure between winged fruit and wingless fruit phenotypes.

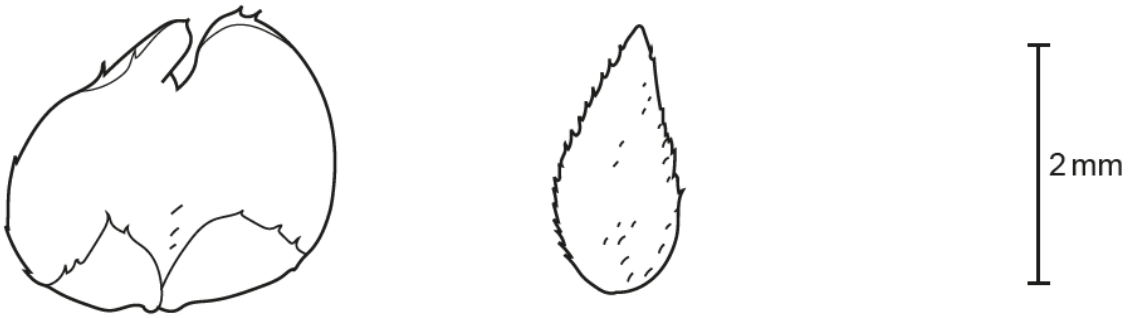

Fig 9.1

(a) A large sample of sea blush fruits was collected and their fruit-wing characteristic was recorded.

Name the type of variation that is shown for the fruit-wing characteristic of the sea blush.

…… [1]

(b) Early taxonomists classified sea blush plants with winged fruits as a different species to sea blush plants with wingless fruits.

Since this time, evidence from observations and experiments has confirmed that the plants belong to the same species.

Suggest **three** examples of the evidence obtained that helped to confirm that these sea blush plants belong to the same species.

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…….. [3]

The west coast of North America also used to have an extensive lake system.

Approximately 20 000 years ago, the lakes started to dry up and they now consist of isolated small pools. Four different species of the desert pupfish have been found living in these pools. Evidence indicates that over 20 000 years ago, there was only one species of pupfish living in the lake system.

Fig. 9.2 shows a desert pupfish.

Fig 9.2

(c) Explain how the change from an extensive lake system to just a few pools could have resulted in the evolution of four species of desert pupfish.

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(d) Due to the different soil composition of the various pools, the nutrient content of the pools may differ. Table 9.1 shows the length of pupfish in two different lake pools A and B.

Table 9.1

No.	Lake pool A	Lake pool B
1	22.9	13.7
2	19.8	18.2
3	24.4	17.5
4	27.9	15.1
5	23.1	21.6
6	25.7	19.2
7	28.2	21.6
8	25.6	24.8
9	28.7	25.2
10	31.5	27.8
11	26.2	25.2
12	37.0	34.0
	Mean = 26.75	Mean = 21.99

A research scientist was interested in finding out if the nutrient content of the lake pools influenced the length of pupfish and decided to carry out a t-test analysis.

Given that the t-test value is 2.26, examine the data in Table 9.1 and use the information given in Table 9.2 on the next page to decide whether the nutrient content of the different pools affected the length of pupfish.

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…….. [2]

Table 9.2

Degrees of freedom	Significance level					
	20% (0.20)	10% (0.10)	5% (0.05)	2% (0.02)	1% (0.01)	0.1% (0.001)
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.598
3	1.638	2.353	3.182	4.541	5.841	12.941
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.859
6	1.440	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.405
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073
16	1.337	1.746	2.120	2.583	2.921	4.015
17	1.333	1.740	2.110	2.567	2.898	3.965
18	1.330	1.734	2.101	2.552	2.878	3.922
19	1.328	1.729	2.093	2.539	2.861	3.883
20	1.325	1.725	2.086	2.528	2.845	3.850
21	1.323	1.721	2.080	2.518	2.831	3.819
22	1.321	1.717	2.074	2.508	2.819	3.792
23	1.319	1.714	2.069	2.500	2.807	3.767
24	1.318	1.711	2.064	2.492	2.797	3.745
25	1.316	1.708	2.060	2.485	2.787	3.725
26	1.315	1.706	2.056	2.479	2.779	3.707
27	1.314	1.703	2.052	2.473	2.771	3.690
28	1.313	1.701	2.048	2.467	2.763	3.674
29	1.311	1.699	2.043	2.462	2.756	3.659
30	1.310	1.697	2.042	2.457	2.750	3.646
40	1.303	1.684	2.021	2.423	2.704	3.551
60	1.296	1.671	2.000	2.390	2.660	3.460
120	1.289	1.658	1.980	2.158	2.617	3.373
∞	1.282	1.645	1.960	2.326	2.576	3.291

[Total: 10]

10 Measurements of the surface temperature of land and oceans can be taken from locations around the world. The mean global surface temperature for land and ocean combined can be calculated for a fixed time period.

Scientists calculated:

- the mean global temperature for the twentieth century
- the mean global temperature for each decade (ten years) from 1880 to 2020.

The mean temperature for each decade was compared to the mean for the twentieth century.
For each decade, the difference in temperature was calculated.

The calculated differences are shown in Fig. 10.1.

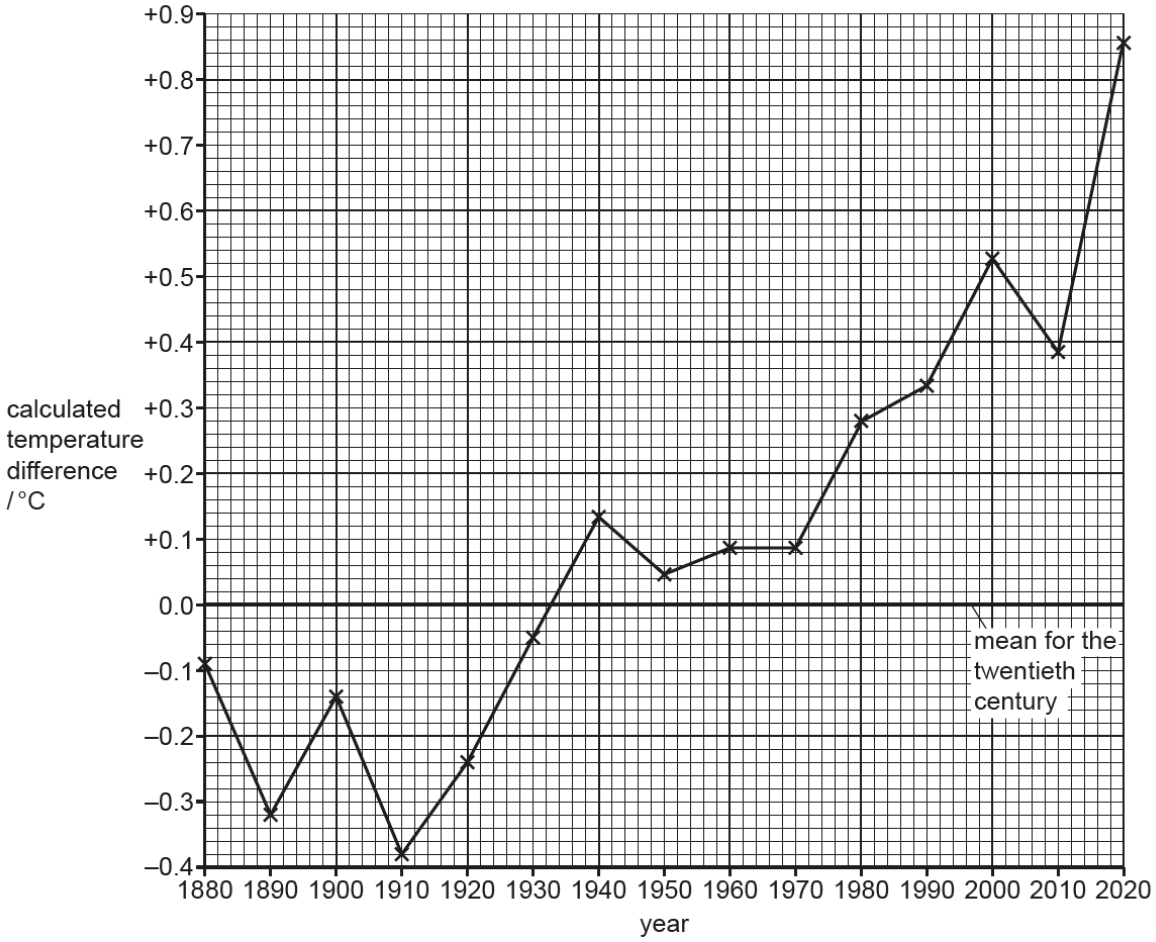

Fig. 10.1

(a) Calculate the rate of increase in temperature per **decade** between 1980 and 2020.

Show your working.

Write your answer to **two** decimal places.

…… °C per decade [2]

(b) The moose, *Alces alces*, is a large member of the deer family. It lives in temperate forests in North America and northern Europe, where snow is present for large parts of the year. The moose feeds on a plant in the lake called watermilfoil, *Myriophyllum aquaticum*.

Fig. 10.2 shows an adult male moose feeding in a lake.

Fig. 10.2

Moose populations have decreased in North America since 1980.

Suggest **and** explain reasons for the decrease in moose populations.

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..... [3]

[Total: 5]

11 Cells of the immune system respond to the presence of non-self antigens.

(a) State what is meant by a non-self antigen.

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..... [1]

(b) Four different types of cells of the immune system are shown in Table 11.1.

Complete Table 11.1:

- use a tick (✓) if the description applies to the named cell of the immune system
- use a cross (✗) if the description does **not** apply.

Table 11.1

description of cell	cell of immune system		
	B-lymphocyte	**plasma cell**	**T-helper cell**
able to undergo differentiation to become effector cells			
main role is to secrete cytokine during an immune response			
present during a **primary** immune response to a virus			

[3]

(c) Some vaccination programmes have been more successful than others.

Suggest **one** factor that contribute to the success of a vaccination programme.

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..... [1]

[Total: 5]

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