

Civics Group	Index Number	Name (use BLOCK LETTERS)
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H2



**ST. ANDREW'S JUNIOR COLLEGE
2025 JC2 PRELIMINARY EXAMINATIONS**

H2 BIOLOGY

9744/2

Paper 2

Wednesday

3rd September 2025

2 hours

Materials: Question Paper Set A and Set B

READ THESE INSTRUCTIONS FIRST

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

Write in dark blue or black pen on both sides of the paper.

You may use a soft pencil for any diagram, graph or rough working.

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

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

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

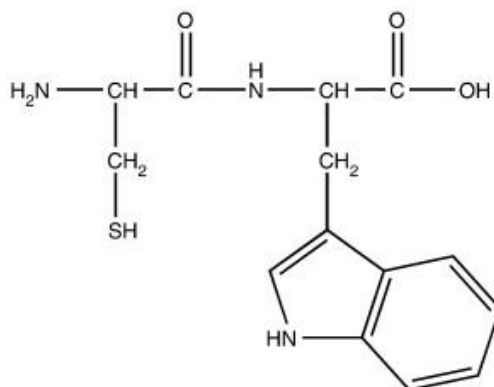
For Examiners' Use	
1	/10
2	/12
3	/10
4	/10
5	/10
6	/6
7	/9
8	/10
9	/8
10	/10
11	/5
Total	/100

This document consists of 16 printed pages and **0** blank page.

[Turn over

QUESTION 1

- (a) Fig. 1.1 shows the structure of the dipeptide consisting of cysteine and tryptophan. Complete the diagram to show the hydrolysis of the dipeptide.

**Fig.1.1**

Picture credits : <https://linkinghub.elsevier.com/retrieve/pii/S0039602810003869>



[2]

In bacteria like *Escherichia coli*, tryptophan is incorporated into polypeptides during protein synthesis. The availability of tryptophan within the cell is tightly regulated by the *trp* operon which is known as a repressible operon.

Fig. 1.2 summarises the structure and control of the *trp* operon.

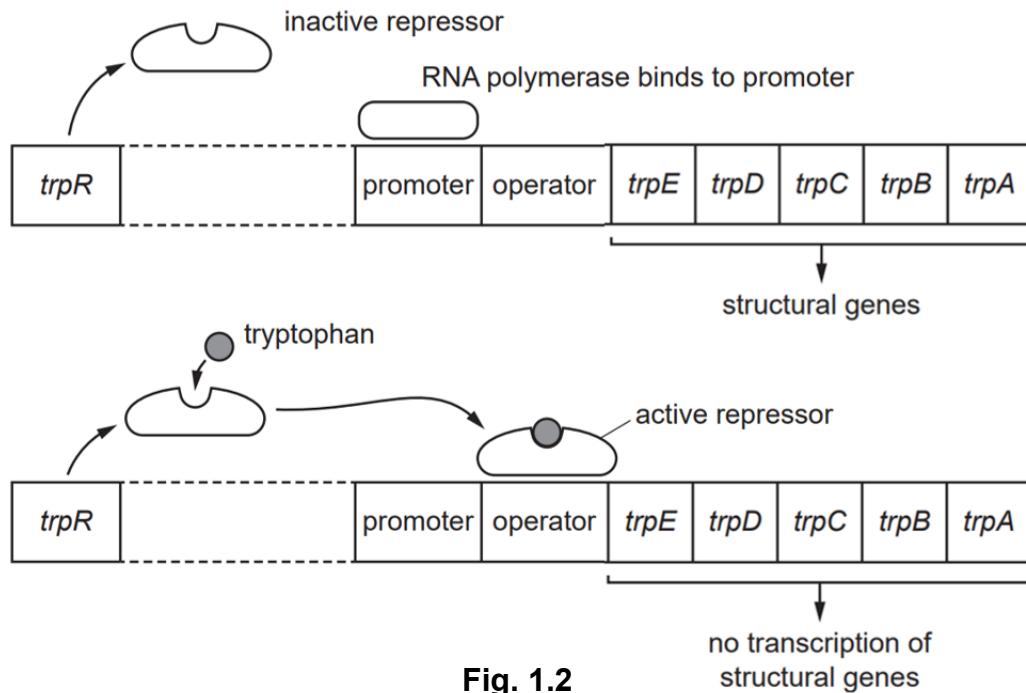


Fig. 1.2
Picture modified from 9700/W22/42

(b) Suggest and explain the advantage of having repressible operons in prokaryotes.

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[2]

A number of mutations have been found in the *trp* operon. One of these mutations results in a mutant operator (O^c)

(c) Predict and explain the likely effect of the O^c mutation on the synthesis of tryptophan in *E. coli*.

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[3]

(d) Describe **three** differences in the structure and organisation of prokaryotic and eukaryotic genomes.

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[Total: 10]

QUESTION 2

(a) In chickens, feather color is either white, black or speckled.

The alleles for black feathers and white feathers are denoted by “ C^B ” and “ C^W ” respectively.

A cross between a white chicken and a black chicken gave rise to a speckled chicken.

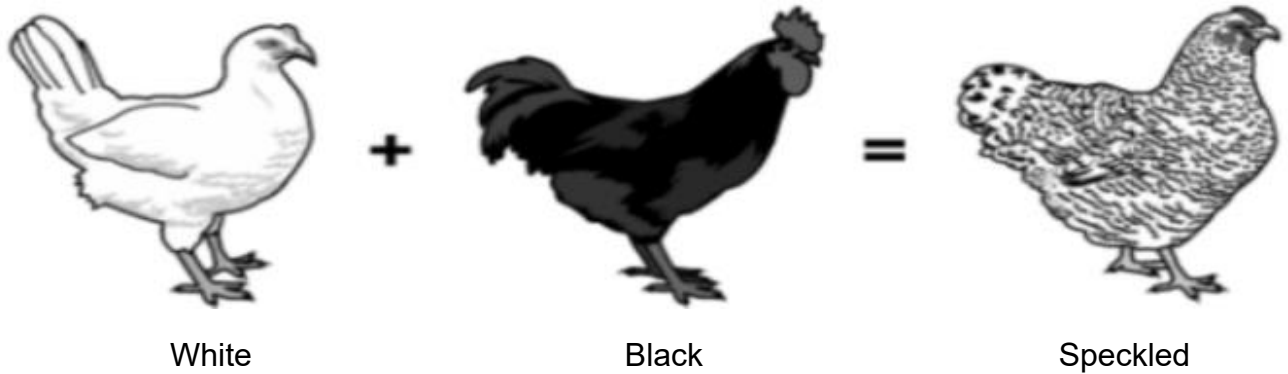


Fig. 2.1

(i) Using the information provided, explain the appearance of the speckled chicken.

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(ii) Using the symbols provided, draw a genetic diagram to show the results of a sibling mating between two speckled chickens.

(b) *Drosophila melanogaster*, commonly known as the fruit fly, has been a cornerstone of genetic research for over a century. The practical benefits of using *Drosophila* are numerous and contribute significantly to its widespread adoption in laboratories.

(i) Suggest why fruit flies are good experimental organisms for carrying out crosses in genetic research.

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[1]

The *purple* gene is known for its impact on eye color in *Drosophila*. The recessive allele results in a characteristic "purple eye" phenotype, a clear deviation from the normal, wild-type red eyes typically observed in fruit flies

The vestigial gene controls wing development in *Drosophila*. The recessive allele leads to a distinctive "short, 'vestigial' wings" phenotype. Flies exhibiting this mutation are unable to fly, representing a significant morphological and functional alteration from the normal, long wings of wild-type flies.

Pure breeding flies with red eyes and long wings were crossed with pure breeding flies with purple eyes and vestigial wings. All the F1 flies show red eyes and long wings.

These F1 flies undergo a **test cross** and the following results were obtained in this F2 generation.

Phenotype of F2 flies	Observed number
red eyes and long wings	305
red eyes and vestigial wings	41
purple eyes and long wings	39
purple eyes and vestigial wings	315
Total	700

(ii) A chi-squared (χ^2) test was carried out. **Fill in the blanks in the table** below to reflect the expected ratio and expected numbers for each class of phenotype. Calculate the χ^2 value.

$$\chi^2 = \sum \frac{(O - E)^2}{E} \quad \nu = c - 1$$

where Σ = 'sum of...'

O = observed 'value'

ν = degrees of freedom

E = expected 'value'

c = number of classes

A chi-squared table.

degrees of freedom	probability, p				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

<i>Classes</i>	<i>Observed number (O)</i>	<i>Expected ratio</i>	<i>Expected number (E) 2d.p.</i>
red eyes and long wings	305		
red eyes and vestigial wings	41		
purple eyes and long wings	39		
purple eyes and vestigial wings	315		
Total	700		

[1]

Calculated $\chi^2 = \dots\dots\dots$ [1]

- (iii) Using the **probability that the difference between observed and expected results is due to chance** for the calculated χ^2 , state the conclusions that can be drawn.

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- (iv) Explain the conclusion derived from (iii).

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[Total: 12]

QUESTION 3

Translation is a fundamental biological process involving several key macromolecules. One such macromolecule is ribosomal RNA (rRNA) which is a structural component of ribosomal subunits.

- (a) Use an arrow on Fig. 3.1 to indicate the location where ribosomal RNA (rRNA) and proteins are assembled to form ribosomal subunits. Identify the organelle.

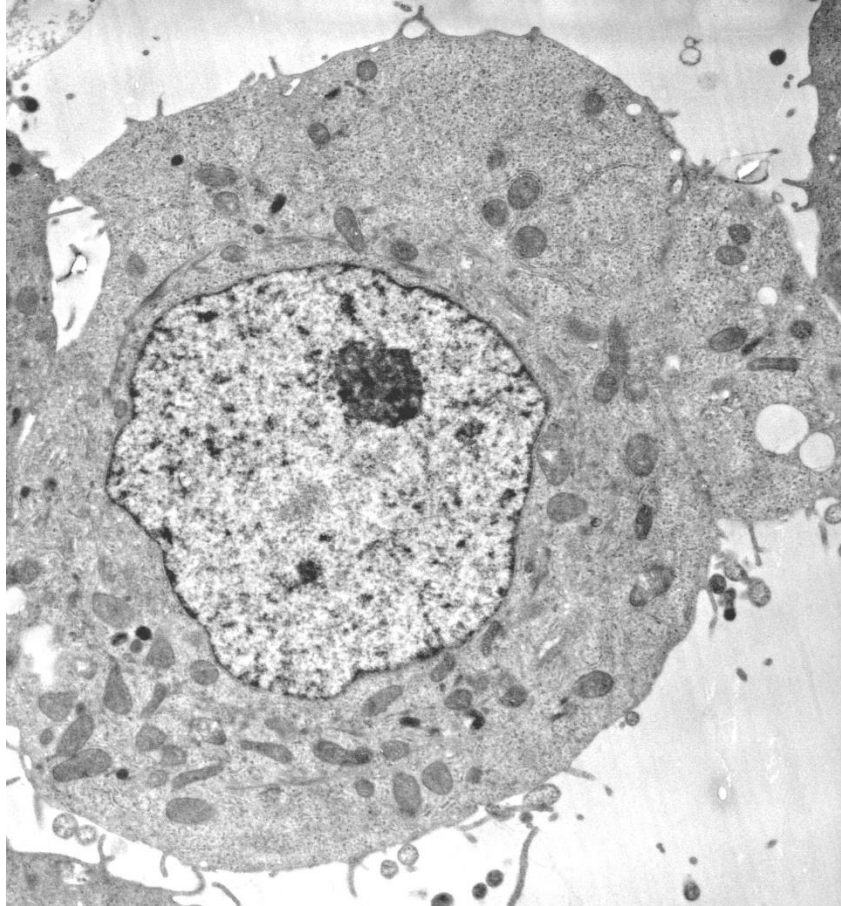


Fig. 3.1

Picture modified from <https://commons.wikimedia.org/wiki/>

[1]

Fig. 3.2 shows the two eukaryotic ribosomal subunits formed.

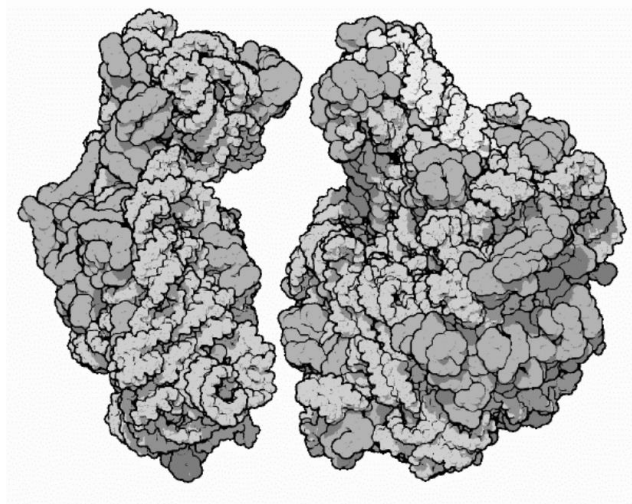


Fig. 3.2

(b) Explain the functions of the two ribosomal subunits in translation.

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(c) Outline the key events that occur during the initiation of translation in a eukaryotic cell.

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- (d) With reference to the reproductive cycle of the influenza virus and named cellular structures or molecules in its host, explain why the influenza virus is described as an obligate parasite.

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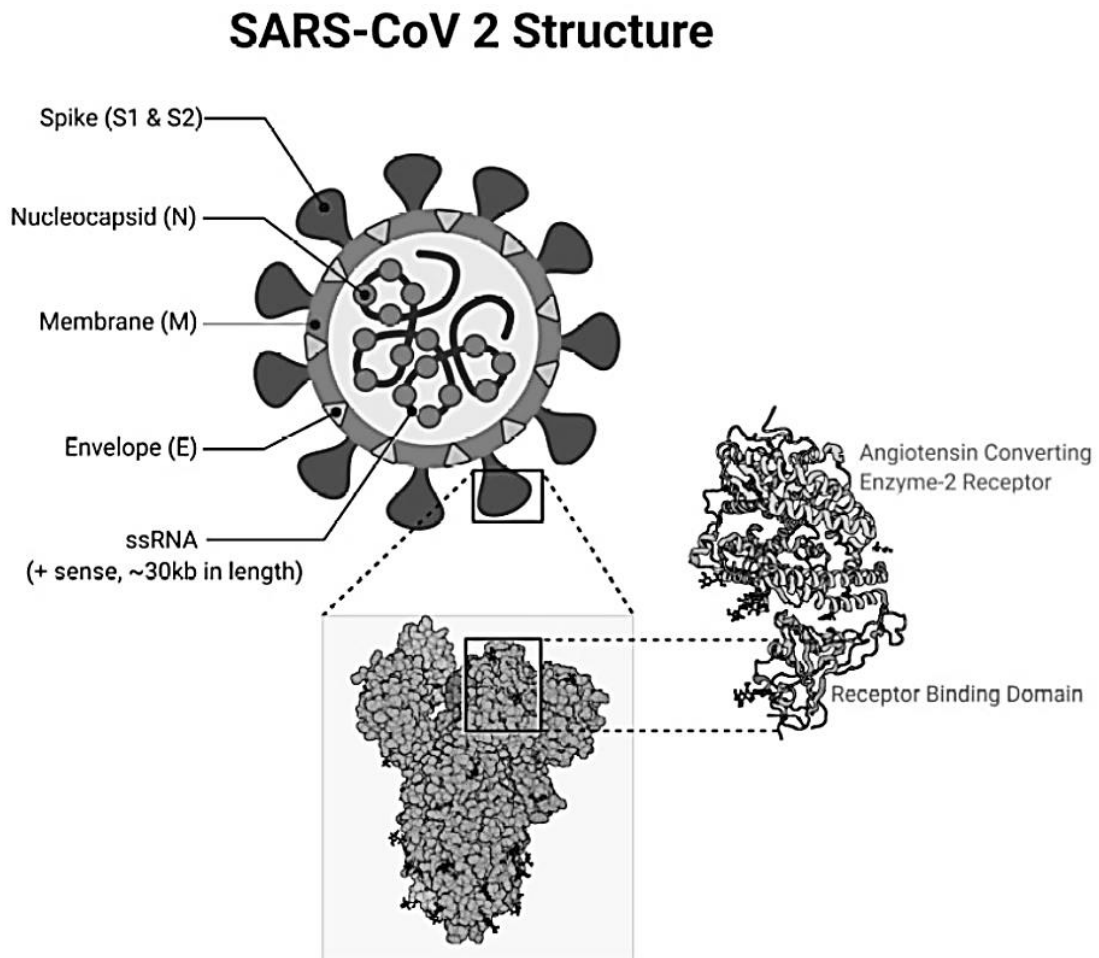
.....[3]

[Total: 10]

QUESTION 4

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infects human host cells of multiple organ systems, resulting in the disease COVID-19.

Fig. 4.1 shows the structure of the SARS-CoV-2, and its interaction with angiotensin-converting enzyme 2 (ACE2) receptor found on host cells.



SARS- CoV 2 Structure Contributed by Rohan Bir Singh, MD; Made with Biorender.com

Fig. 4.1

- (ii) Both influenza virus and SARS-CoV-2 replicate their own genome. The influenza virus carries its own viral RNA polymerase in its virions but not SARS-CoV-2. Suggest why.

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- (iii) Contrast the mode of exit from host cells, between influenza virus and SARS-CoV-2.

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- (iv) Explain how viral protease inhibitors work in the treatment of SARS-CoV-2 infection

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- (b) The SARS-CoV-2 infections may induce the formation of syncytia, which are multinucleated cells, similar to those formed in HIV infections.

- (i) Describe how HIV infections lead to syncytia formation.

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- (ii) State how T cells of the adaptive immune system may react towards syncytia to result in its direct destruction.

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[Total: 10]

QUESTION 5

Fig. 5.1 shows a process occurring between a bacterium (*Escherichia coli*) and a phagocyte.

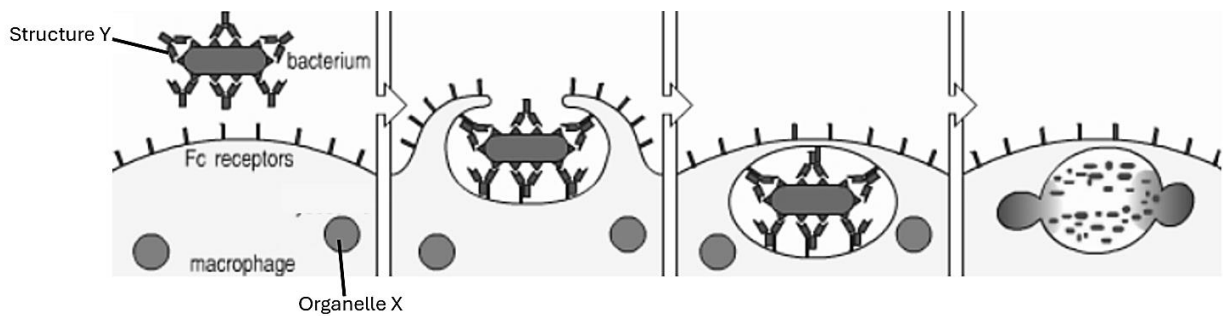


Fig. 5.1

(a) Identify organelle X and explain how its structure facilitates the process in Fig. 5.1.

Organelle X :

[1]

How structure of X facilitate process:

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[2]

(b) Explain how the structure of Y facilitates the process in Fig. 5.1.

How structure of Y facilitate process:

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[2]

- (c) Fig. 5.2 shows a process occurring in *Escherichia coli* which facilitates gene transfer between bacteria cells. Beneficial genes such as genes that code for bacterial capsule found outside the cell wall.

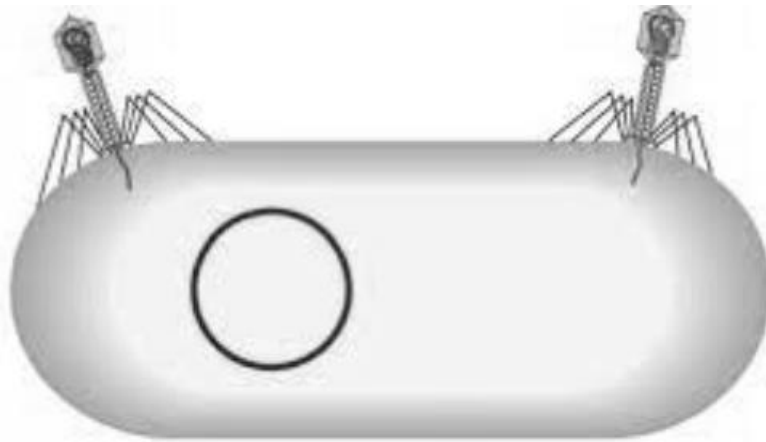


Fig. 5.2

With reference to the reproductive cycle of bacteriophages, describe this process of gene transfer and how it benefits the recipient bacteria.

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- (d) Bacteriophages can also serve as antibacterial agents.

Comment on the potential effectiveness of bacteriophages and **antibodies** of the immune system in bacterial infections.

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[Total: 10]

QUESTION 6

Fig. 6.1 shows a pedigree tree tracing the inheritance of a genetic disorder in a family.

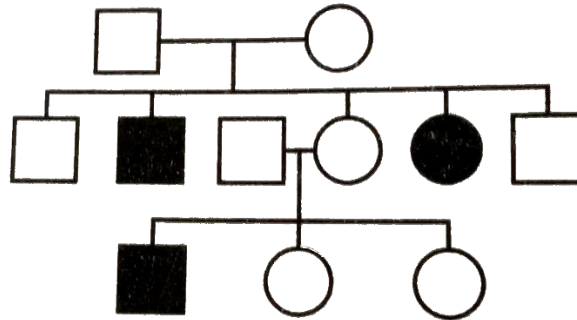


Fig. 6.1

(a) With reference to Fig. 6.1, state the mode of inheritance of this genetic disorder.

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Fig. 6.2 shows the two alleles of a gene involved in the same genetic disorder.

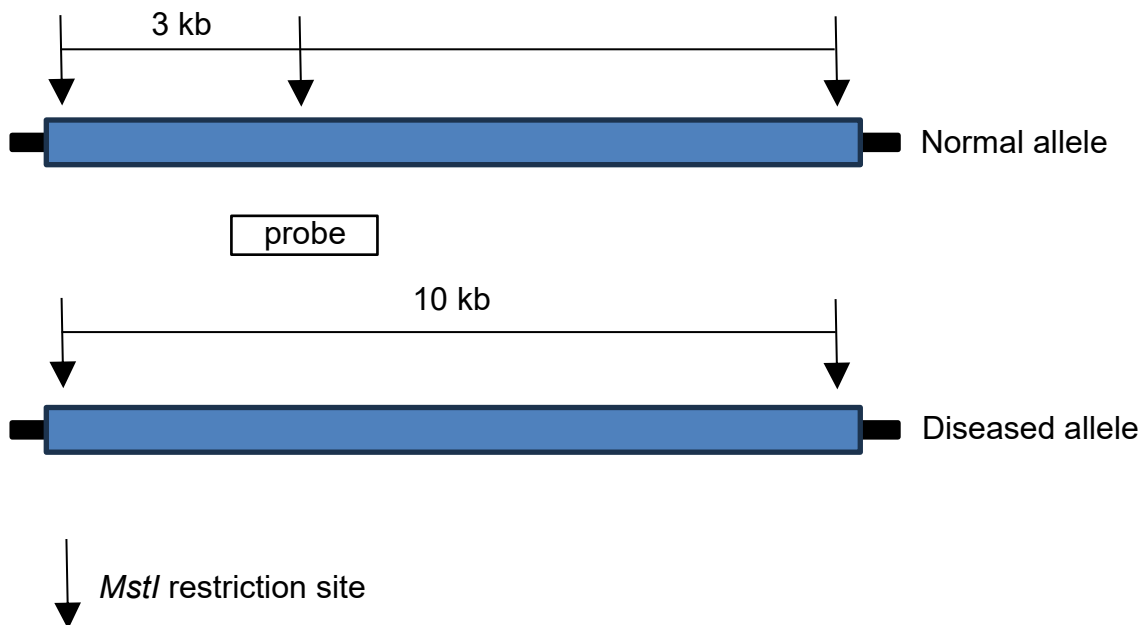
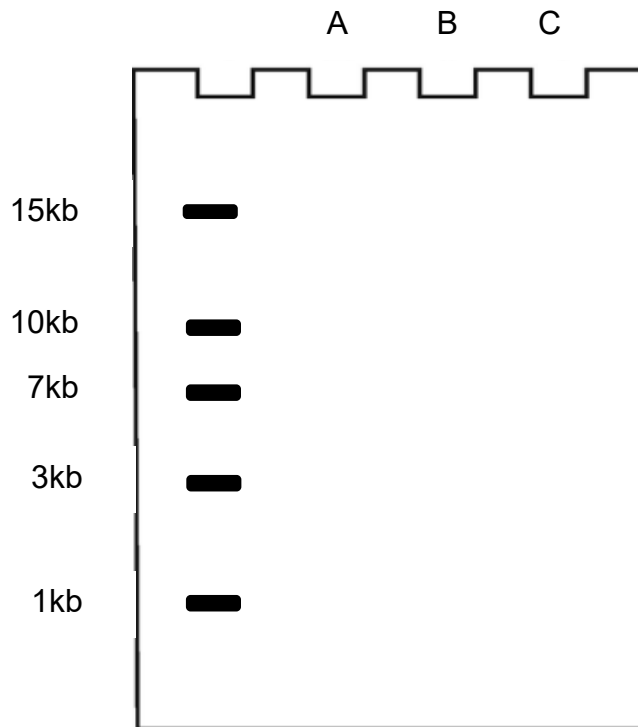


Fig. 6.2

A family was screened for this genetic condition. Genomic DNA from cheek cells were isolated and treated with restriction enzyme *MstI* which cut DNA at specific sites indicated (↓).

The gel was loaded with a DNA molecular weight ladder and samples from one healthy individual (A), one carrier (B), and one affected individual (C).

(b) Draw the expected banding pattern on the **autoradiogram** for individuals A – C.



[3]

(c) Explain how harmful recessive alleles may be preserved in a natural population.

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[Total: 6]

- (c) Inhibitors can block electron flow at specific points in the electron transport chain, preventing further electron transfer downstream of the block. By observing which carriers become reduced and which become oxidized when an inhibitor is introduced, we can deduce their positions relative to the block.

An investigation to study the effect of three inhibitors A, B and C, on the electron transport chain in the mitochondria was carried out. In each of the three experiments, a different inhibitor was added. Table 7.2. shows the state of the electron carriers, W to Z, after the addition of inhibitor.

Table 7.2

Inhibitor added	Electron carrier			
	W	X	Y	Z
A	oxidised	reduced	reduced	oxidised
B	oxidised	oxidised	reduced	oxidised
C	reduced	reduced	reduced	oxidised

- (i) Give the order of the electron carriers in this electron transport chain.

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[1]

- (ii) Explain your answer.

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[Total: 9]

QUESTION 8

Retinoblastoma is a malignant childhood tumour of the eye, originating from neuronal cells of the developing retina and typically diagnosed by clinical symptoms in children under 3 years of age. At the cellular level, retinoblastoma develops when both alleles of the *RB1* gene on chromosome 13 are mutated.

If an early mutation of one *RB1* allele occurs and subsequently, non-disjunction occurs in the same cell lineage, a subset of cells will be mutated (mosaicism) while others remain normal. Such individuals with the mutated cells have an increased risk for the development of retinoblastoma.

- (a) State if the *RB1* gene is a tumour suppressor gene or an oncogene. Explain your answer.

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- (b) Explain how non-disjunction during mitosis can contribute to the development of retinoblastoma in a patient with a mutation in one *RB1* allele.

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The *RB1* gene encodes a protein that is involved in cell cycle progression through the recruitment of histone deacetylase, which controls the expression of genes required for S phase entry.

(c) Explain the effect of non-functional RB proteins on S phase entry.

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In recent studies, scientists have identified “kill switches” among small ribonucleic acids called microRNAs (miRNAs), as well as in larger protein-coding RNAs, all of which are encoded by the genome of eukaryotic cells. These microRNAs function by binding to specific messenger RNA (mRNA) targets in cancer cells, resulting in the degradation of the mRNA or inhibition of its translation into protein. This regulatory mechanism make them promising candidates for cancer treatment over traditional chemotherapy.

(d) Explain the advantages of using microRNA-based therapies compared to traditional chemotherapy for the treatment of cancer.

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[Total: 10]

QUESTION 9

In 2017, researchers have successfully cloned 2 macaque monkeys (*Macaca fascicularis*) for the first time, by using the somatic cell nuclear transfer (SCNT) method.

Fetal fibroblasts derived from an aborted monkey fetus were used for nuclear transfer into oocytes obtained from female monkeys of the same species. Artificial activation of oocytes is carried out before being transferred to healthy surrogates for implantation in the womb. Pregnancy was subsequently confirmed in surrogates and yielded 2 live births. This is shown in Fig. 9.1 below.

Such cloning via SCNT allows the production of genetically uniform monkeys as animal models for basic research in primate biology, for studying human disease mechanisms and therapeutic treatments.

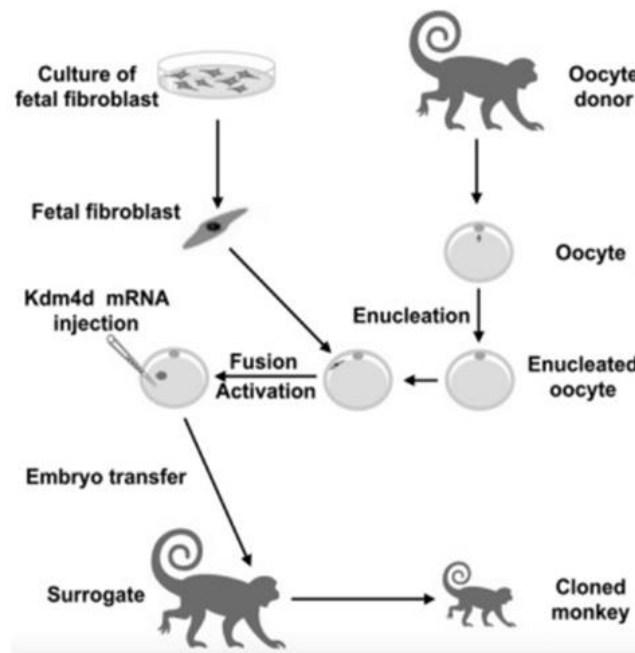


Fig. 9.1

- (a) SCNT involves removing the nucleus of an unfertilized egg cell, replacing it with the nucleus of a somatic cell (fetal fibroblast). Explain why this step is necessary.

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- (b) Upon artificial activation of the oocytes, they can either be directly transferred to a surrogate female to produce a cloned animal or such oocytes are allowed to form blastocysts *in-vitro* and embryonic stem cells can be extracted for therapeutic treatments.

What is the potency level and function of such cells used for therapeutic treatments?

Potency level:

Function:

[3]

Scientists have an alternative method of generating embryonic stem cells, which is to genetically reprogramme adult cells to an embryonic stem cell-like state by introducing transcription factors into adult cells such as skin cells. Such induced pluripotent stem cells (iPSCs) are generally preferred over SCNT as they overcome moral questions about the status of the embryo and its potential destruction.

- (c) Suggest one **other reason** why the use of iPSCs evades the ethical concerns over SCNT derived embryonic stem cells.

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[1]

- (d) Suggest two applications of how embryonic stem cells can be used in regenerative medicine and disease research.

Application 1

Application 2

[2]

[Total: 8]

QUESTION 10

Fig. 10.1 shows the Kakapo, New Zealand's unique, critically endangered herbivorous parrot. It is the world's only flightless parrot with green plumage, strong legs and large feet. Formerly widespread, Kakapo are now found exclusively on predator-free offshore islands, consisting of dense forest undergrowth and trees.



Fig. 10.1

- (a)** Explain how natural selection resulted in the evolution of kakapos with strong legs and large feet.

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- (b)** Suggest a reason why kakapos have lost the ability to fly.

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(c) Table 10.1 shows the taxonomic classification information of the kakapos.

Fill in the table to depict accurately, the taxonomic ranks.

Taxonomic rank	Information
Kingdom	Animalia
	Chordata
Class	Aves
	Psittaciformes
Family	Strigopidae
Genus	
Species	<i>Strigops habroptilus</i>

[1]

(d) Describe the principles which scientists use to classify organisms into taxonomic groups.

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(e) There is another parrot native to New Zealand. Similar to the kakapos, this parrot also has green plumage, and also has strong legs.

Discuss why the information provided is insufficient to conclude that this parrot and the kakapos are the same species.

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[Total: 10]

QUESTION 11

In the Gulf of Maine, Atlantic cod was once so abundant that Cape Cod was named in its honour. Fig. 11.1 shows data of how spawning stock biomass have plummeted drastically, leaving barely enough stocks to sustain a healthy population.

Yet despite increasingly strict quotas on commercial fishing, fish populations have not rebounded as expected. A recent study suggests that rapidly-warming waters in the Gulf is holding back the recovery.

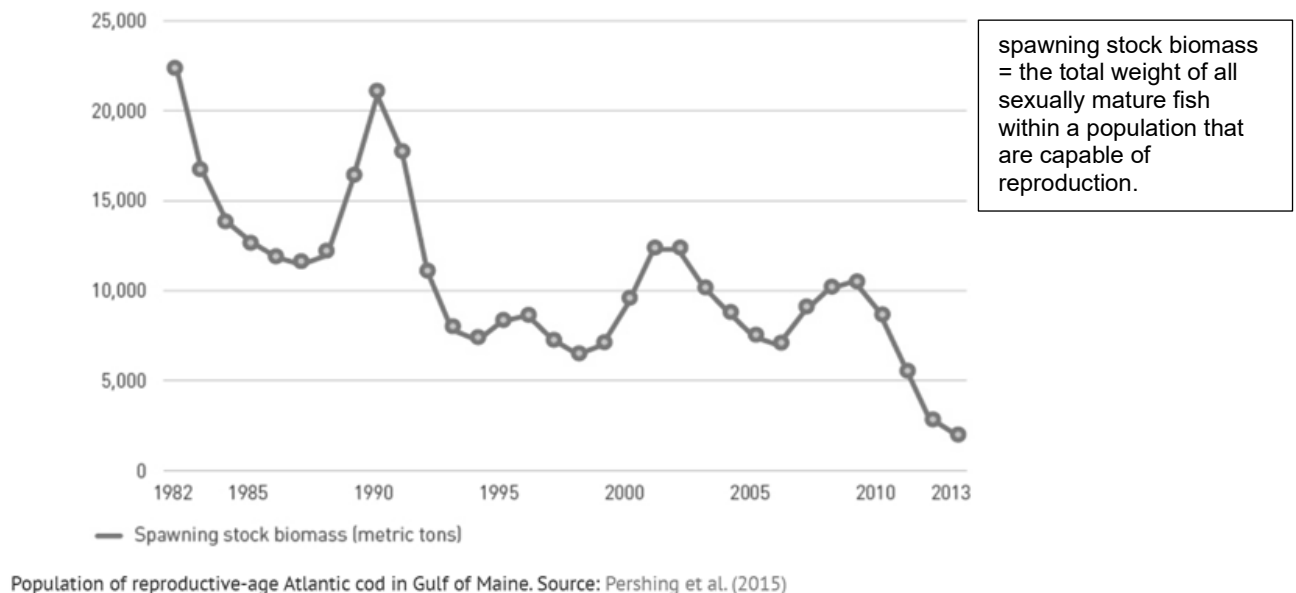


Fig. 11.1

(a) With reference to Fig. 11.1, calculate the percentage decline in spawning stock mass of cod from 1982 to 2013. Show your working and give your answer in **whole number**.

percentage decline = [2]

Global warming is significantly impacting fish migration patterns as rising ocean temperatures force fish to move towards cooler waters, often shifting their ranges northward or into deeper, colder areas.

Another extensive study was done on 2,572 fish populations belonging to 146 species in the Atlantic and Pacific Oceans. They found that the faster the fish migrates toward the poles, the faster their abundance declines. According to data collected, a poleward shift of 17km per year may result in a decline of 50% in the abundance of populations.

(b) Suggest and explain 2 factors that are contributing to these declines as fish populations are forced to migrate?

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[Total: 5]

End of paper