NAME: _____ CLASS: _____ INDEX: _____

CATHOLIC JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
Higher 2

BIOLOGY
Paper 3 Long Structured and Free-Response Questions

9744/03
13 September 2023
2 Hours

Candidates answer on the Question Paper.

Additional Material: Writing Booklet.

READ THESE INSTRUCTIONS FIRST

Write your **name (as per NRIC)**, **class**, and **index number** on all the work you hand in.

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

[PILOT FRIXION ERASABLE PENS ARE NOT ALLOWED]

You may use a soft pencil for any diagrams, graphs, or rough working.

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

Section A
Answer **all** questions in the spaces provided on the Question Paper.

Section B
Answer any **one** question in this section.
Write your answers in the writing booklet provided.

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 Examiner's Use	
Section A	/50
1	
2	
3	
Section B	/25
4 or 5	
Total	/75

Section A

Answer **all** the questions in this section.

1 Endosymbiont is a cell which lives inside another cell with mutual benefit.

The organelle in Fig. 1.1 is believed to have evolved from the early prokaryote that was engulfed by phagocytosis.

The engulfed prokaryotic cell remained undigested as it contributed new functionality to the engulfing cell. Over generations, the engulfed prokaryotic cell lost some of its independent utility and became a supplemental organelle.

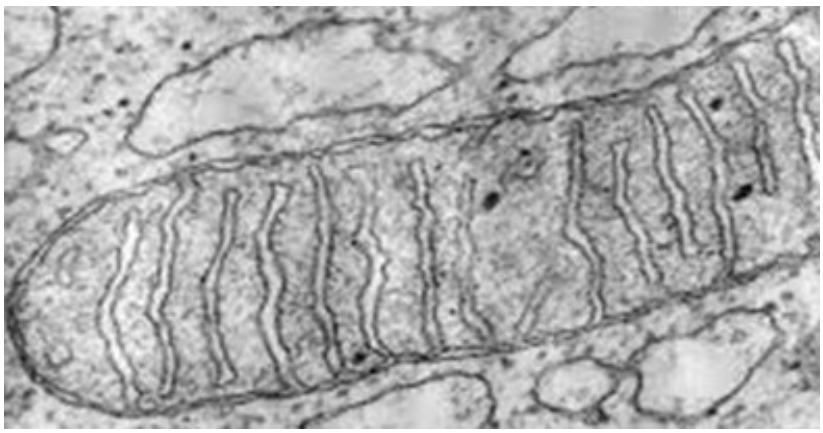

Fig 1.1

(a) Explain how the organelle shown above supports the endosymbiotic theory.

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(b) Explain how the organelle is adapted to its function.

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Scientists use the DNA of the organelle shown in Fig. 1.1 for phylogenetic analysis.

Analysis of DNA has been used extensively to study the evolutionary relationships across many species.

(c) Explain the advantages of using the DNA of the organelle shown in Fig. 1.1 for phylogenetic analysis as compared to using nuclear DNA.

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The DNA of the organelle shown in Fig. 1.1 is more susceptible to oxidation than nuclear DNA, possibly because of its proximity to the electron transport chain in its inner membrane. As a result, the rate of mutation becomes much higher.

(d) Suggest why the DNA of the organelle shown in Fig. 1.1 has a high mutation rate.

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…… [1]

Part of the sequence of the template DNA strand from 2 gene loci that code for different transport proteins in the organelle in Fig. 1.1 were shown in Fig. 1.2 below.

In addition, Fig. 1.2 shows the corresponding sequences containing the mutation, mutation **A** and mutation **B** respectively.

Wild-type sequence at gene locus 1	3' – CTT AGA CTT ACT – 5'
Sequence containing mutation **A**	3' – CTT AGT ACT TAC – 5'
Wild-type sequence at gene locus 2	3' – CTC CTA AAA CCT – 5'
Sequence containing mutation **B**	3' – CTC CCA AAA CCT – 5'

Fig. 1.2

(e) With reference to Fig. 1.2, state which mutation results in a frameshift.

…… [1]

Fig. 1.3 below shows the triplet codes that code for the different amino acids.

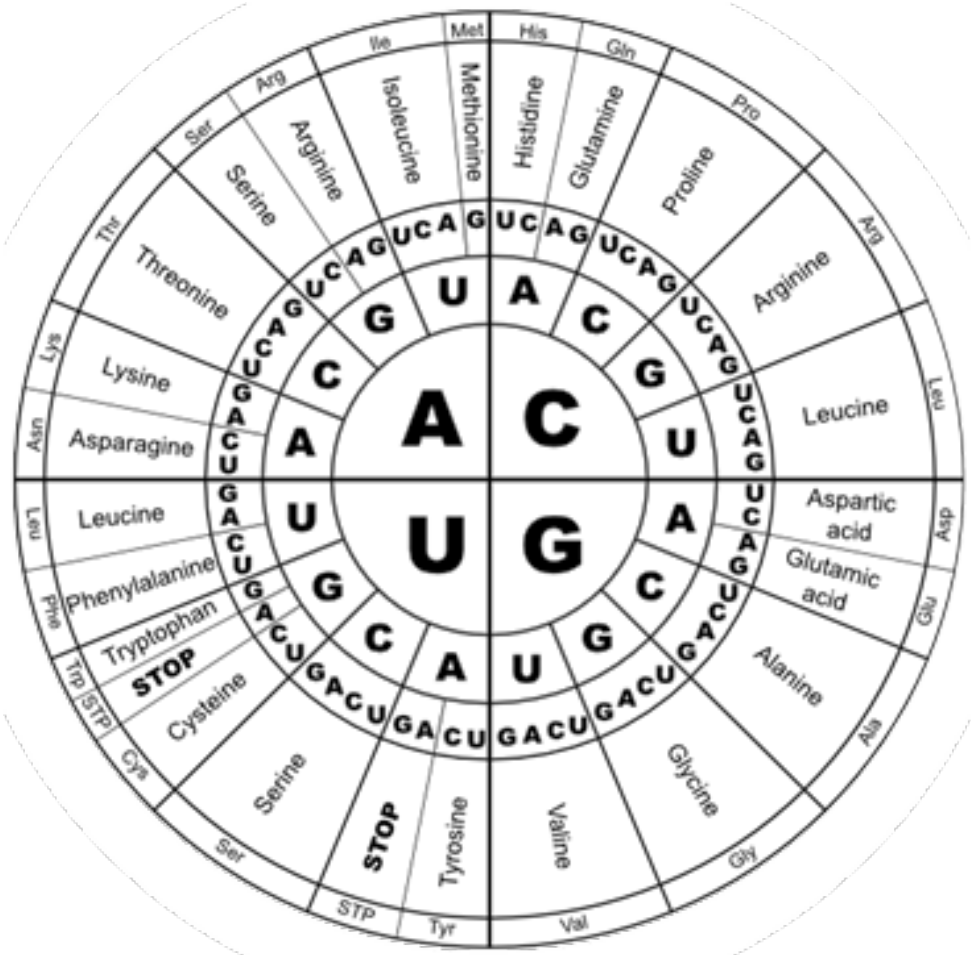

Fig. 1.3

It was found that mutation **A** produced a fully functional transport protein, while mutation **B** led to the production of a non-functional transport protein.

(f) With reference to Fig. 1.2 and Fig. 1.3,

(i) suggest how mutation **A** could still lead to the production of a fully functional transport protein. Explain your answer.

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(ii) suggest how mutation **B** led to the production of a non-functional transport protein. Explain your answer.

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Different respiratory substrates are available to muscles to maintain the ATP levels required for muscle contraction. These include glucose and fatty acids from the blood as well as glycogen in the muscle.

Table 1.1 shows the percentage contribution of each of these respiratory substrates to muscle respiration in an athlete, during a 40 km long-distance run. Results are shown at four different times from the start of the run.

Table 1.1

Time / Minutes	Percentage Contribution to Muscle Respiration		
	Glucose from blood	Fatty acids from blood	Glycogen in muscle
60	67	17	26
120	46	22	32
180	16	30	54
240	10	62	28

(g) With reference to Table 1.1., explain the change in percentage contribution of the different respiratory substrates to muscle respiration.

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(h) Suggest why fatty acids can also be utiilised for cellular respiration.

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…… [1]

An in-vitro study showed that a complete oxidation of 1 molecule of glucose produces 2880 units of energy.

It was found that the hydrolysis of 1 molecule of ATP generates 31 units of energy.

(i) Based on the information above and your background knowledge,

(i) calculate the percentage efficiency of energy production of anaerobic respiration in the cell as compared to the complete oxidation of glucose in-vitro. Show your working clearly. [2]

(ii) calculate the percentage efficiency of energy production of aerobic respiration in the cell as compared to the complete oxidation of glucose in-vitro. Show your working clearly. [2]

(iii) Suggest why the amount of energy generated by the aerobic respiration in the cell is different from the complete oxidation of 1 molecule of glucose in-vitro.

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Photosynthesis and respiration are cellular processes that are commonly compared.

(j) Contrast between Krebs cycle and Calvin cycle.

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[Total: 30]

2 Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis*. This pathogen primarily infects the lungs, leading to pulmonary TB.

Fig. 2.1 below briefly illustrates the life cycle of *M. tuberculosis* in infected individuals.

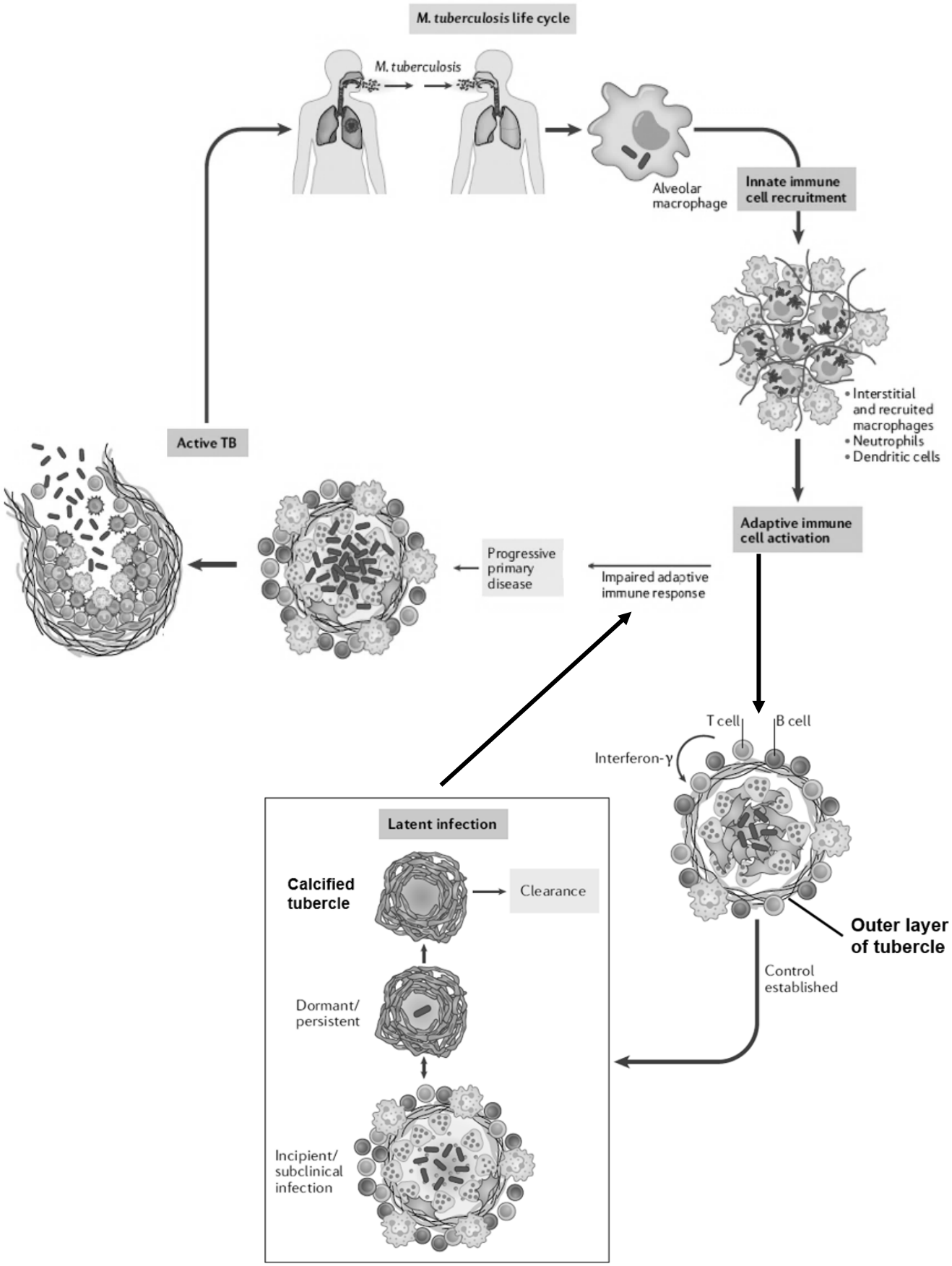

Fig. 2.1

With reference to Fig. 2.1 and your background knowledge,

(a) describe how *M. tuberculosis* could be transmitted from person to person.

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…… [2]

(b) explain how a tubercle is formed upon entry of *M. tuberculosis* into the lung.

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(c) explain why individuals suffering Acquired Immunodeficiency Syndrome (AIDS) are more likely to develop active pulmonary TB.

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The treatment of active TB involves daily treatment with a combination of at least two antibiotics for about 6 months.

(d) Suggest why a combination of antibiotics is used for the treatment of active TB.

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…… [1]

Isoniazid and rifampin are two antibiotics commonly used to treat active TB.
Isoniazid inhibits synthesis of cell wall while rifampin inhibits RNA synthesis during transcription.

(e) Suggest why isoniazid and rifampin are lethal to *M. tuberculosis* but not mammalian cells.

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…… [2]

[Total: 13]

3 **(a)** Explain what you understand by ‘coral bleaching’.

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…… [2]

Rising seawater temperatures are contributing to coral bleaching, with mass coral bleaching events projected to increase in both frequency and severity.

Fig. 3.1 shows the impact of thermal bleaching stress on stored protein and carbohydrate reserves and reproductive output of two categories of corals five months after the bleaching event – corals that were resistant to bleaching events and corals that were bleached but later recovered.

For both types of corals, zooxanthellae was able to recolonise them and both types of corals also looked visually healthy.

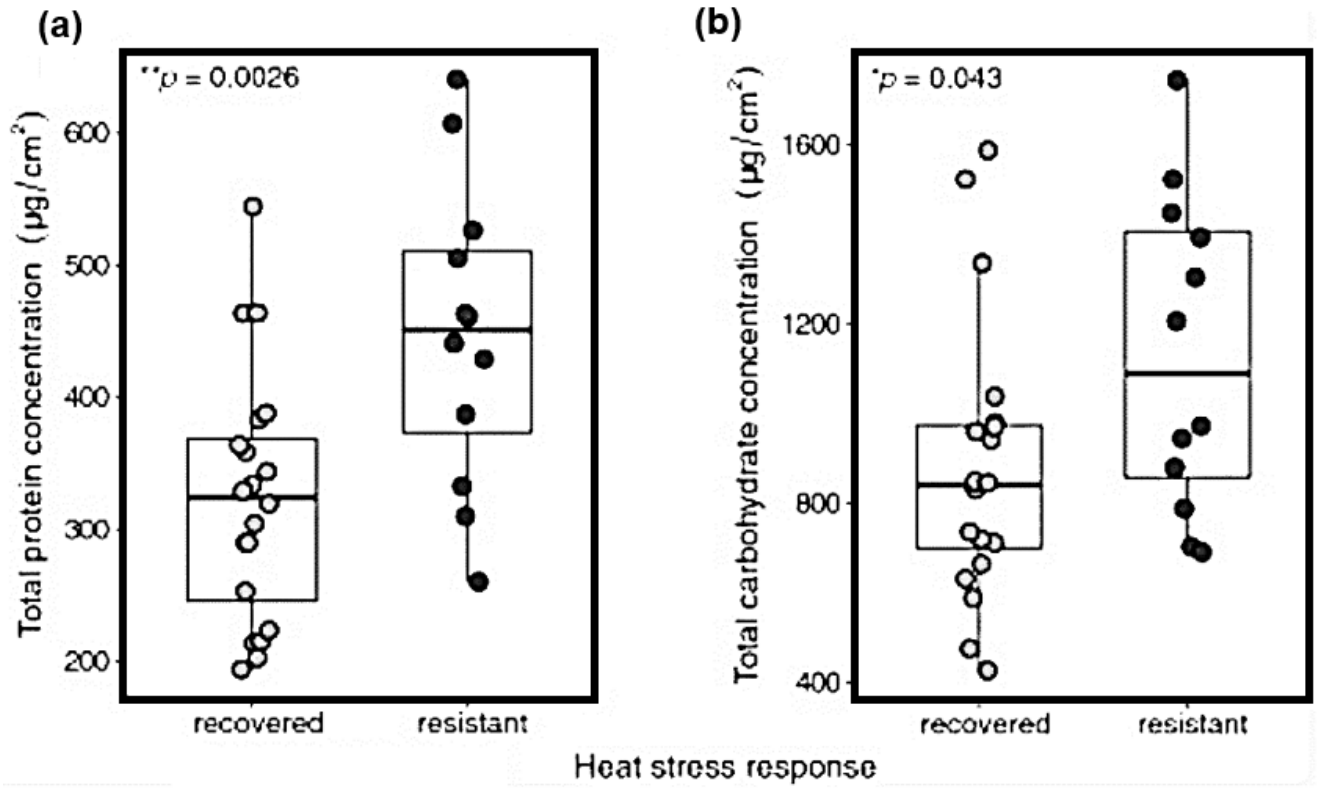

Fig. 3.1: Energetic condition of recovered and resistant coral colonies five months after mass bleaching event. **(a)** Total protein content normalised to host tissue surface area. **(b)** Total carbohydrate content normalised to host tissue surface area. The data point represents a single colony.

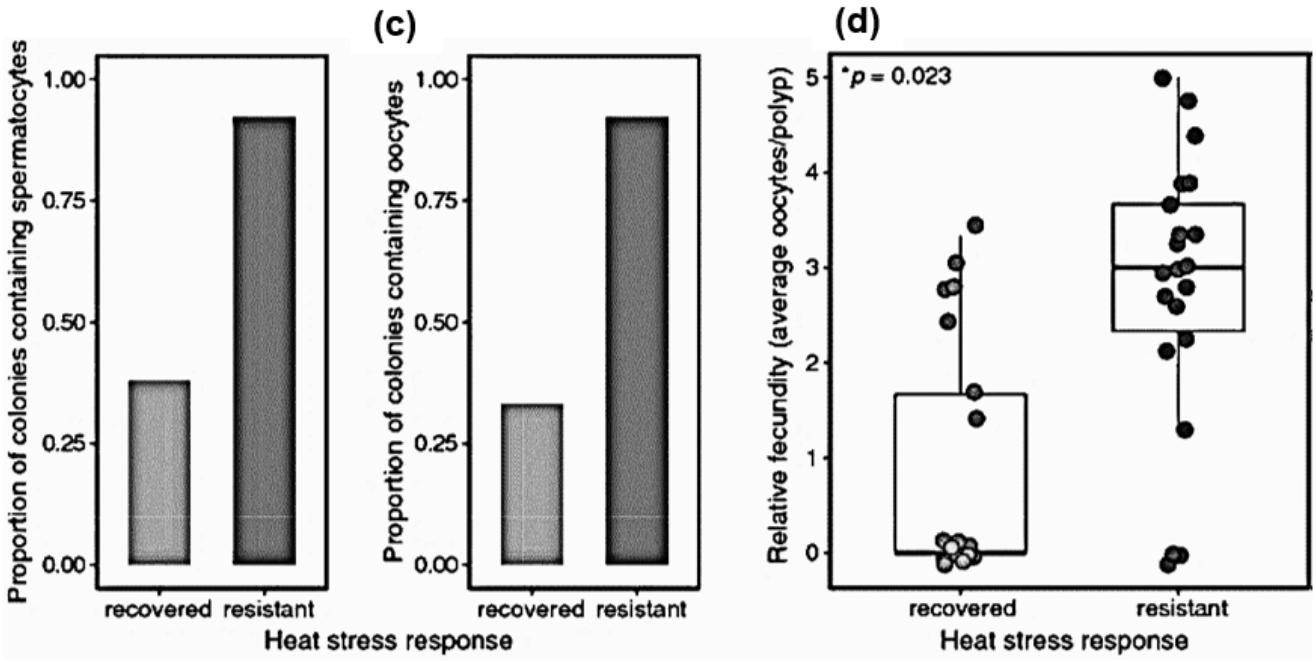

Fig. 3.1: (c) Proportion of recovered and resistant colonies containing male gametes (spermatocytes) & female gametes (oocytes). **(d)** Relative fecundity (fertility) in recovered and resistant colonies. Each data point represents one colony.

(b) Suggest which type of corals would demonstrate greater potential and better ability in reef recovery after disturbance. Justify your choice with evidence from Fig. 3.1.

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Methods of coral reef restoration are evolving rapidly with investment in research and development. A number of emerging interventions are currently being tested experimentally across various scales, from individual corals (e.g., genetics, reproduction, physiology), to coral populations, reef communities, and reef ecosystems.

These include manual removal of macroalgae and coral predators (such as crown-of-thorns starfish), the direct transplantation of coral colonies or coral fragments or coral larvae at designated restoration sites and rubble stabilization (where the loose coral rubble beds of dead and broken down coral skeletons and rock fragments have been secured to serve as natural substrates for young corals to survive and grow to form stable new reefs). Artificial structures have also been deployed to mimic natural processes and integrated into reef landscapes to serve as substrates for coral recruitment, coral planting and for fish aggregation.

To improve coral reef resilience, scientists are now looking at the possibility of isolating genes of zooxanthellae found in corals that are more resistant to thermal stress and transferring them to the more heat-susceptible zooxanthellae and introducing these genetically modified zooxanthellae to corals before planting the corals back into reefs.

(c) Discuss the possible implications of using such an intervention for reef restoration.

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…… [2]

[Total: 7]

Section B

Answer **One** question in this section.

Write your answers on the writing booklet provided.

Your answer should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answer must be in continuous prose, where appropriate.

Your answer must be set out in sections **(a)** and **(b)**, as indicated in the question.

4 **(a)** Using **two** named examples, discuss the significance of operon in bacterial growth. [13]

(b) The presence of the F factor in bacteria is the most important factor that contributes to the development of antibiotic resistance in bacteria. Do you agree? Justify. [12]

[Total: 25]

5 **(a)** Explain the importance of mitosis and describe how this process is important in the production of lymphocytes and adaptive immune response. [13]

(b) Discuss what genetic variation is and how variation, including harmful recessive alleles, may be preserved in a natural population. [12]

[Total: 25]

END OF PAPER

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