



# Cambridge International AS & A Level

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## MARINE SCIENCE

9693/43

Paper 4 A Level Data-handling and Investigative Skills

May/June 2026

1 hour 45 minutes

You must answer on the question paper.

No additional materials are needed.

### INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

### INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages. Any blank pages are indicated.

Answer **all** questions.

- 1 Figure 1.1 shows an electron micrograph of some organelles in an algal cell.

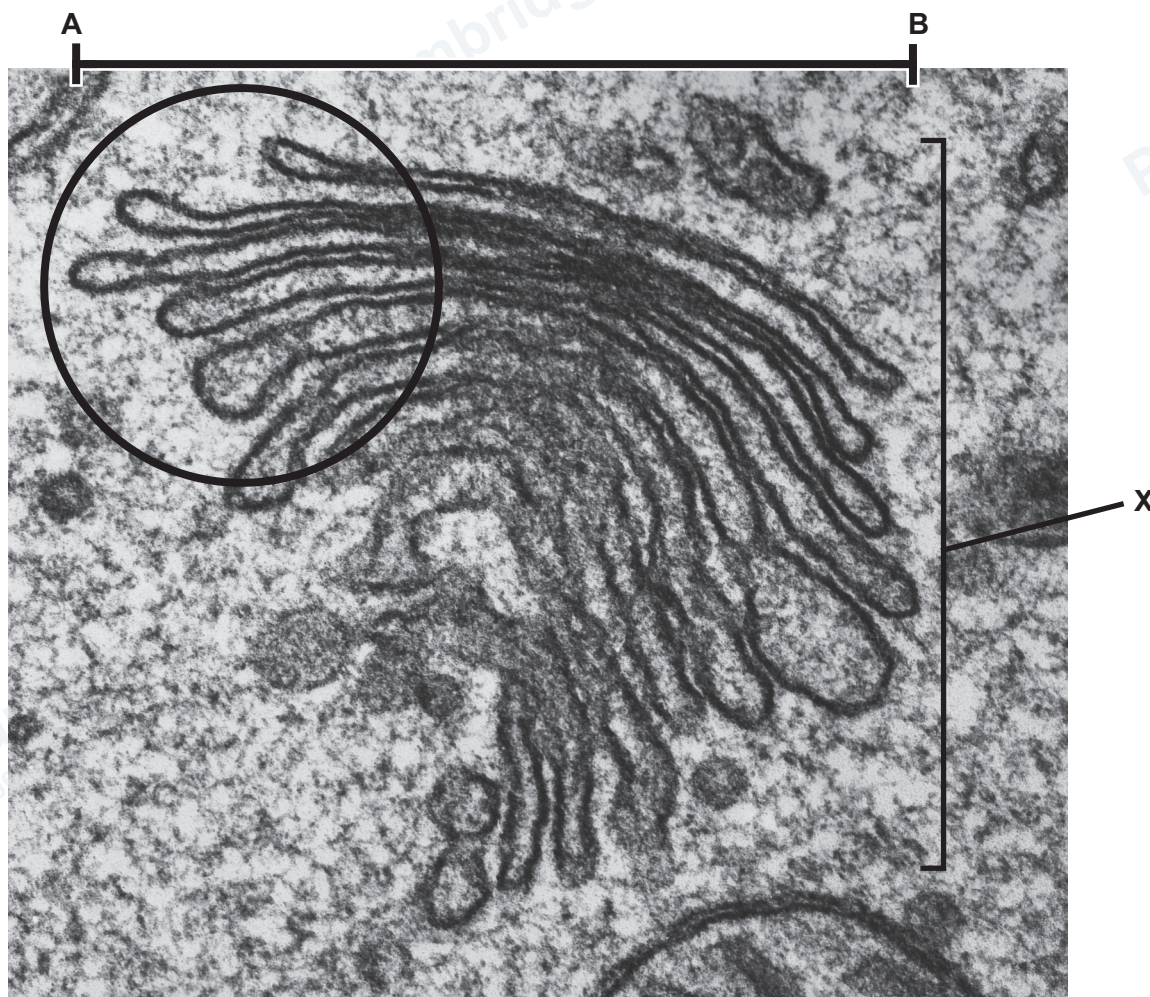


**Figure 1.1**

- (a) (i) Make a large drawing of the area inside the circle in Figure 1.1.

[4]

- (ii) Give the name **and** function of the organelle labelled **X** in Figure 1.1.

name .....

function .....

[2]

- (iii) The magnification of the electron micrograph in Figure 1.1 is  $\times 11\,000$ .

Calculate the actual width of organelle **X** in micrometres, between **A** and **B**.

.....  $\mu\text{m}$  [3]

- (b) Some algae contain substances called flavonoids, which help them to withstand changes in salinity.

Scientists investigated the effect of spraying algal extracts containing flavonoids on water loss from lettuce plants. The lettuce plants were watered with different concentrations of sodium chloride solution.

This is the method the scientists used.

- Lettuce plants were grown in three groups of containers in a laboratory.
- The containers were watered with pure water,  $50 \text{ mmol dm}^{-3}$  sodium chloride solution or  $100 \text{ mmol dm}^{-3}$  sodium chloride solution.
- After four weeks, the mean percentage water content of the lettuce plants was determined.
- A liquid algal extract was made by blending algae with water.
- The experiment was repeated but with different lettuce plants which were also sprayed every day with the algal extract.

The results are shown in Table 1.1.

Table 1.1

| lettuce plants                 | mean percentage water content of lettuce plants |                                                                 |                                                                  |
|--------------------------------|-------------------------------------------------|-----------------------------------------------------------------|------------------------------------------------------------------|
|                                | watered with pure water                         | watered with $50 \text{ mmol dm}^{-3}$ sodium chloride solution | watered with $100 \text{ mmol dm}^{-3}$ sodium chloride solution |
| not sprayed with algal extract | 75                                              | 60                                                              | 50                                                               |
| sprayed with algal extract     | 85                                              | 80                                                              | 75                                                               |

- (i) Give **one** variable that the scientists need to standardise in the experiment.

..... [1]

- (ii) Explain why the increasing concentration of sodium chloride affects the water content of the lettuce plants.

.....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

(iii) Algae that live in estuaries can change the quantities of flavonoids that they produce.

Explain the benefits of this to these algae.

Use the information in Table 1.1 to support your answer.

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..... [2]

[Total: 15]

2 Plastic pollution is a major threat to marine ecosystems.

Plastics can be classified as macroplastics and microplastics. Macroplastics have a diameter greater than 5 mm, while microplastics are smaller than this.

(a) Describe the negative impacts of microplastics on marine food webs.

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..... [3]

(b) The age of a piece of plastic can be estimated by measuring how much chemical breakdown has occurred.

Scientists collected macroplastics and microplastics from the same area of oceanic water. They measured the total mass and age of each type of plastic in this area of ocean.

Figure 2.1 shows the results.

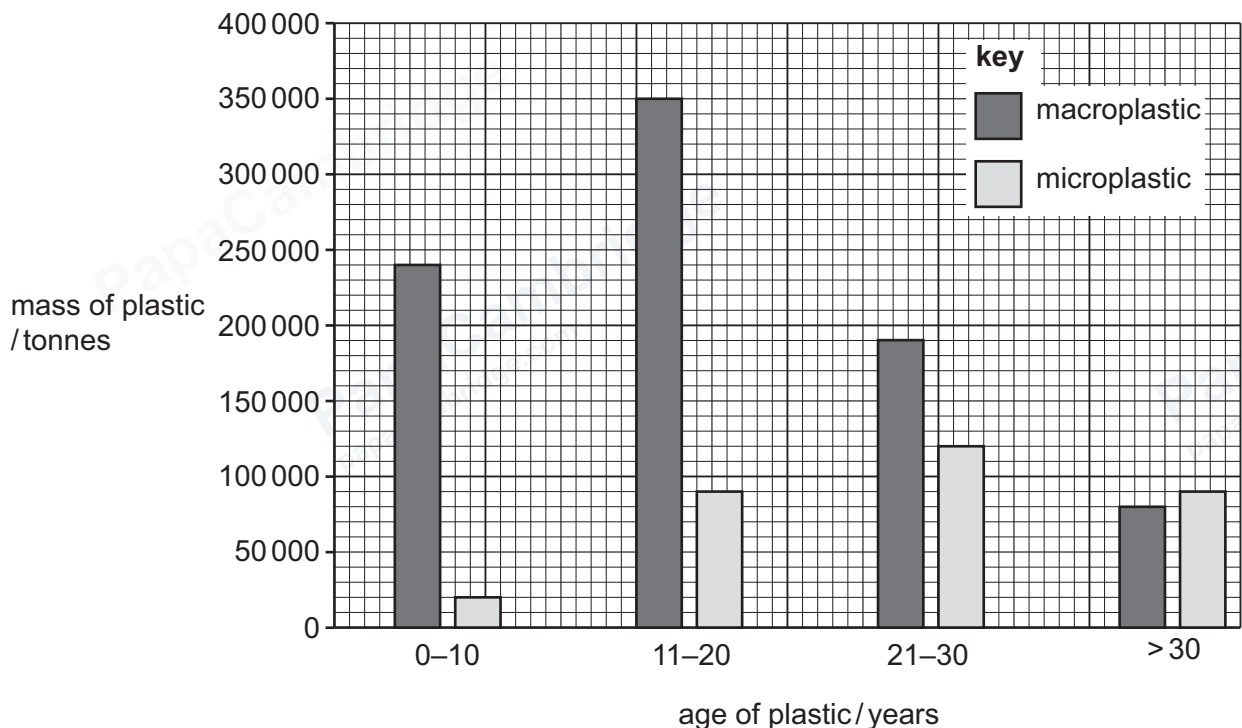


Figure 2.1



- (i) Use Figure 2.1 to calculate the percentage of the total mass of plastic aged between 0 and 10 years that is composed of microplastic.

..... % [2]

- (ii) Compare the results for macroplastics and microplastics shown in Figure 2.1.

.....  
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..... [2]

- (iii) Suggest explanations for the change in mass of macroplastics and microplastics shown in Figure 2.1.

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..... [4]





(c) Suggest **two** ways that a school can minimise the amount of plastic waste generated by students.

1 .....

.....

2 .....

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[2]

[Total: 13]

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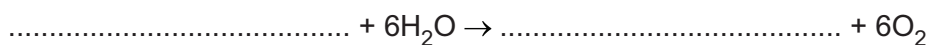
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- 3 The depth of water and light intensity both affect the rate of photosynthesis of marine producer organisms.

(a) (i) Complete the balanced equation for photosynthesis.



[1]

(ii) Outline the light-dependent stage of photosynthesis.

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..... [3]

- (b) A scientist investigated the effects of light intensity and depth of water on the rate of photosynthesis of three types of alga: a green alga, a red alga and a brown alga.

The different depths of water were simulated by using light with combinations of colours that can penetrate to each depth.

The algae were placed in sea water and exposed to different combinations of colours of light that corresponded to different depths of water. The experiment was repeated using different intensities of light.

- (i) The rate of photosynthesis was determined by measuring the rate of oxygen production.

The brown alga produced 35 mm<sup>3</sup> of oxygen during a 30-minute period, when it was at a simulated depth of 50 m and with a light intensity of 1 arbitrary unit.

Calculate the rate of photosynthesis.

Give your answer to **three** significant figures.

State the unit.

..... [3]

- (ii) Figure 3.1 shows the type of alga that had the fastest rate of photosynthesis at each simulated depth and light intensity.

**key**

- × green alga  
● brown alga  
△ red alga

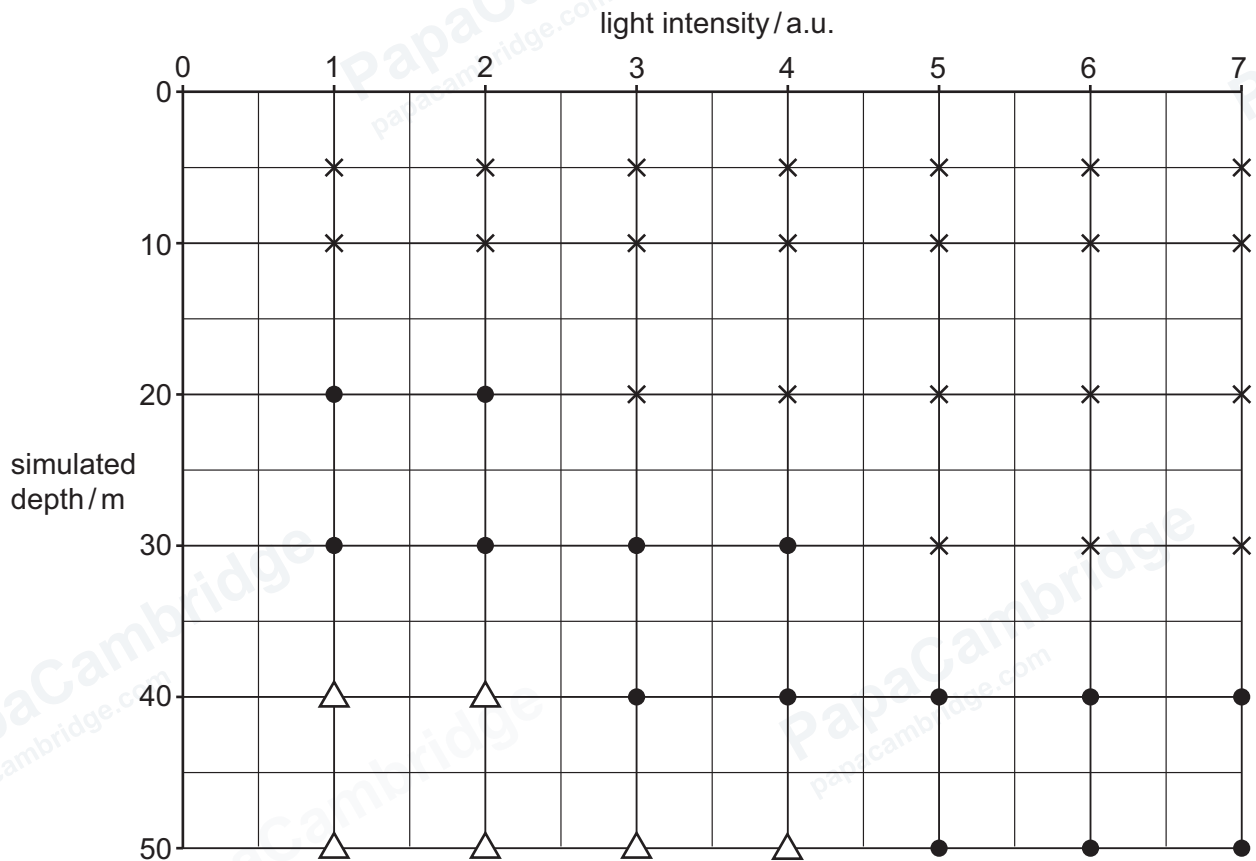


**Figure 3.1**

Table 3.1 shows some of the pigments present in each species of alga.

**Table 3.1**

| species    | presence of pigment |             |             |
|------------|---------------------|-------------|-------------|
|            | chlorophyll a       | fucoxanthin | phycobilins |
| green alga | present             | not present | not present |
| brown alga | present             | present     | not present |
| red alga   | present             | not present | present     |



### Table 3.2

| pigment              | colours of light absorbed |
|----------------------|---------------------------|
| chlorophyll <i>a</i> | red, blue                 |
| fucoxanthin          | blue, green               |
| phycobilins          | blue, green, yellow       |

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[5]

[Total: 12]

- 4 Illegal fishing activities can be prevented by monitoring fishing areas and confiscating boats.

(a) State **one** method of monitoring fishing.

.....  
 ..... [1]

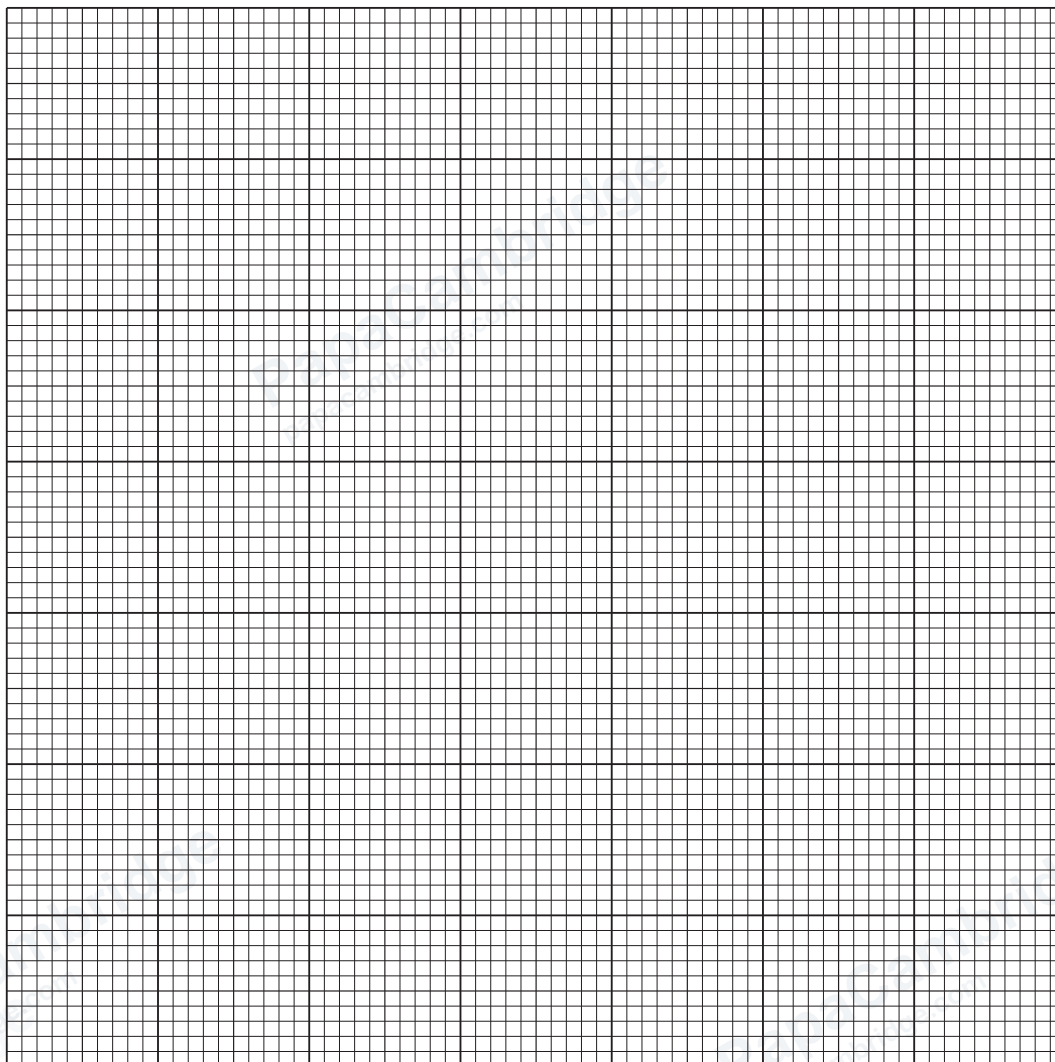
- (b) To make fish populations more sustainable, monitoring of fishing was increased in an area of Indonesia from 2014.

Table 4.1 shows the number of boats confiscated due to illegal fishing and the estimated fish population in this area of Indonesia between 2012 and 2018.

**Table 4.1**

| year | number of boats confiscated | estimated fish population<br>/ million tonnes |
|------|-----------------------------|-----------------------------------------------|
| 2012 | 23                          | 6                                             |
| 2013 | 18                          | 5                                             |
| 2014 | 46                          | 7                                             |
| 2015 | 75                          | 6                                             |
| 2016 | 95                          | 10                                            |
| 2017 | 125                         | 14                                            |
| 2018 | 95                          | 16                                            |

(i) Draw a graph to display the information in Table 4.1.



[6]

(ii) Discuss the success of the increased monitoring of fishing on the sustainability of the fish populations shown in Table 4.1.

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[3]

- (c) The confiscation of illegal fishing boats may have impacted the income of local people involved in the fishing industry.

Scientists investigated whether there was a correlation between the number of boats confiscated and the mean income of people involved in the fishing industry.

Table 4.2 shows a Spearman's rank table for the number of boats confiscated and the mean monthly income of people involved in the fishing industry.

**Table 4.2**

| year | number of boats confiscated | rank number of boats confiscated | mean monthly income of people/US\$ | rank mean monthly income of people/US\$ | $D$  | $D^2$          |
|------|-----------------------------|----------------------------------|------------------------------------|-----------------------------------------|------|----------------|
| 2012 | 23                          | 2                                | 450                                | 2.5                                     | -0.5 | 0.25           |
| 2013 | 18                          | 1                                | 350                                | 1                                       | 0    | 0              |
| 2014 | 46                          | 3                                | 450                                | 2.5                                     | 0.5  | 0.25           |
| 2015 | 75                          | 4                                | 480                                | 4                                       | 0    | 0              |
| 2016 | 95                          |                                  | 650                                | 5                                       |      |                |
| 2017 | 125                         | 7                                | 750                                | 7                                       | 0    | 0              |
| 2018 | 95                          |                                  | 740                                | 6                                       |      |                |
|      |                             |                                  |                                    |                                         |      | $\Sigma D^2 =$ |

- (i) Complete Table 4.2. [2]
- (ii) Use the formula to calculate the Spearman's rank correlation coefficient for the data in Table 4.2.

$$r_s = 1 - \left( \frac{6 \times \Sigma D^2}{n^3 - n} \right)$$

$r_s$  = Spearman's rank correlation coefficient

$\Sigma$  = sum of (total)

$D$  = difference in rank between each pair of measurements

$n$  = number of pairs of items in the sample

..... [1]

- (iii) Table 4.3 is a critical values table for the Spearman's rank correlation coefficient.

Table 4.3

| number of pairs | critical value ( $P < 0.05$ ) |
|-----------------|-------------------------------|
| 5               | 1.000                         |
| 6               | 0.886                         |
| 7               | 0.786                         |
| 8               | 0.738                         |
| 9               | 0.700                         |
| 10              | 0.648                         |

The scientists made this null hypothesis:

There is no correlation between the number of boats confiscated and the mean monthly income of people involved in the fishing industry.

Evaluate the scientists' null hypothesis. Use your calculated value from **4(c)(ii)** and Table 4.3 to support your answer.

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..... [3]

- (iv) Outline possible long-term sociological impacts of increased monitoring of fishing on the local people involved in the fishing industry.

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..... [2]



- (v) The scientists also tested the validity of the data by calculating the standard deviations for the mean monthly income of the local people involved in the fishing industry.

In 2012, the mean monthly income was USD 450 +/- USD 170 (1 s.d.).

In 2018, the mean monthly income was USD 740 +/- USD 240 (1 s.d.).

Explain what the standard deviations show about the difference in mean monthly income between 2012 and 2018.

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..... [2]

[Total: 20]



- 5 Figure 5.1 shows a photograph of a species of marine mollusc called a cowrie, *Mauritia mauritiana*.

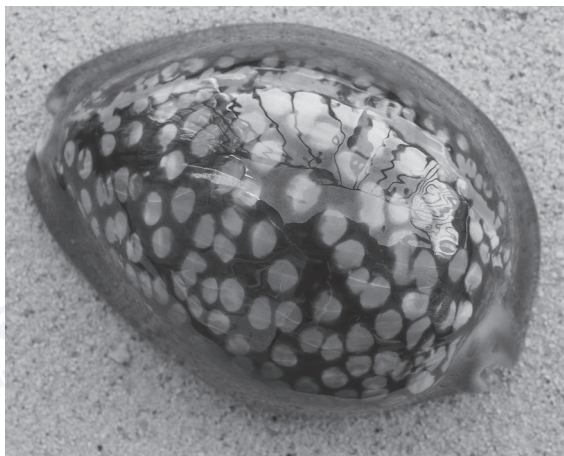


Figure 5.1

- (a) Explain why increased atmospheric carbon dioxide gas may have negative impacts on hard-shelled molluscs such as cowries.

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..... [4]



- (b) A student noticed that cowrie shells on an area of shore near to a sewage pipeline appeared smaller than cowrie shells from other areas of the shore.

When tested, the sewage contained high concentrations of copper ions.

Plan an ethical, laboratory-based investigation that you could do to investigate the effect of the concentration of copper ions on the growth of cowries.

You are provided with a stock solution of 10% copper sulfate solution as a source of copper ions.

Copper ions are potentially toxic to humans and are an environmental risk.

Your plan should:

- include a clear statement of the hypothesis
- identify the independent, dependent and standardised variables
- include full details of the method so that another person can follow it
- describe how you would analyse your results
- be safe and ethical.

[illegible]



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..... [11]

[Total: 15]





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