

Energy transfers in and between organisms – A2 Biology

1. No.1

0 1 . 1

A student used chromatography to separate the different photosynthetic pigments in a chlorophyll solution. She had the following materials.

Chromatography paper
A ruler and pencil
Suitable glassware
A solvent (solvent A)
2 cm³ of the chlorophyll solution

Describe how she could use these materials to separate the photosynthetic pigments by chromatography.

[4 marks]

Draw a line on the chromatography paper to mark origin. The line is drawn using ruler and pencil.
Then add chlorophyll solution to the origin. Add solvent below the origin. Remove chromatography paper immediately when the solvent reaches the top of chromatography paper.

0 1 . 2

Using solvent A, the student separated five pigments. She then repeated her method using a different solvent, B. Using solvent B, she separated six pigments.

Explain the difference between these results.

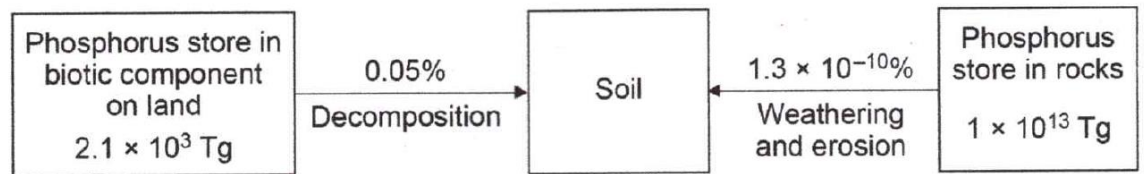
[2 marks]

Two pigments have same solubility in solvent A but different solubility in solvent B. One pigment is insoluble in A

2. No.3

0 3

Figure 1 shows part of a phosphorus cycle, including the mass of phosphorus in two stores.

Figure 1

One teragram (Tg) is 1×10^{12} grams.

The supply of phosphorus to the soil is shown as a percentage of the total phosphorus mass of each store.

0 3 . 1

Calculate in teragrams the difference in the supply of phosphorus to the soil from the two stores shown in **Figure 1**.

Show your working.

$$P \text{ supplied from biotic component to soil} = \frac{0.05}{100} = 0.0005$$

$$P \text{ supplied from biotic component} = 2.1 \times 10^3 \text{ Tg} \times 0.0005 = 1.05 \text{ Tg}$$

$$\text{phosphorus from rocks} = 1 \times 10^{13} \times 1.3 \times 10^{-10} = 1.3 \text{ Tg}$$

$$P \text{ Difference in supply} = 1.3 \text{ Tg} - 1.05 \text{ Tg} = 0.25 \text{ Tg}$$

Answer 0.25 Tg

Water shortage can inhibit crop production. Scientists investigated the effect of the mycorrhizal species *Glomus intraradices* on the growth of tomato plants under conditions of water shortage and no water shortage.

- The scientists planted tomato seeds into a large number of pots containing sterilised soil.
- They added a culture of *G. intraradices* to 50% of the pots and 50% were left untreated.
- After the seeds had developed into seedlings (young plants), the seedlings from the untreated and treated pots were planted into four separate large greenhouses (glasshouses).
- A very limited supply of water (water shortage) was provided to two of the greenhouses. A sufficient supply of water (no water shortage) was provided to the other two greenhouses.
- After 60 days, the scientists determined the mean mass of tomatoes (kg m^{-2}) from each greenhouse.

Greenhouse P – untreated seedlings with water shortage

Greenhouse Q – treated seedlings with water shortage

Greenhouse R – untreated seedlings with no water shortage

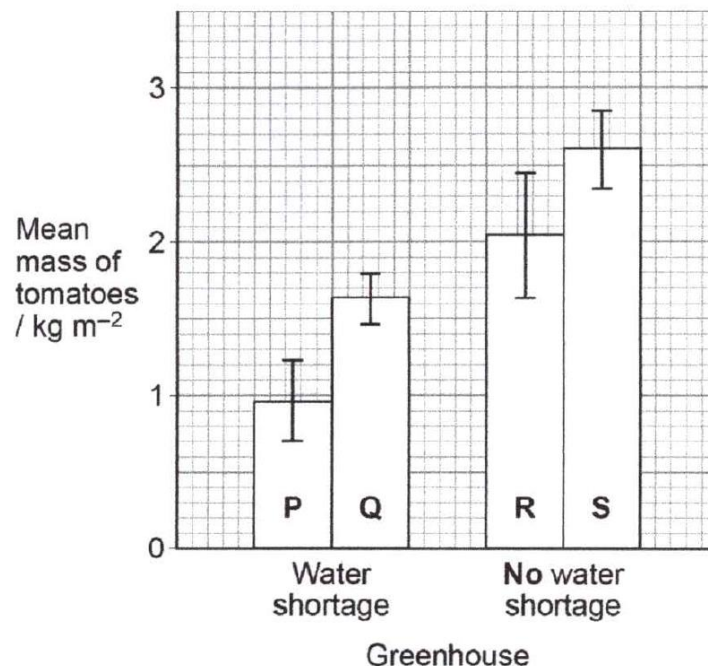
Greenhouse S – treated seedlings with no water shortage

Treated seedlings are plants grown with *G. intraradices*.

Figure 2 shows the scientists' results.

The error bars represent ± 2 standard deviations from the mean, which includes over 95% of the data.

Figure 2



03.2

Using all the information, evaluate the effectiveness of using mycorrhizae to increase crop production under conditions of water shortage and no water shortage.

[5 marks]

- There is no significant difference in production between R and S. There is ^{greater} production in the treated than untreated with water shortage. There is significantly greater production in Q than P.
- Generally, there is higher production in R and S compared to P & Q. S has the highest production among the four greenhouses (P, Q, R and S). It confirms that productivity is greatest in the conditions where there is no water shortage.
- There is significant decrease in production of the tomatoes treated with water shortage.
- There is a significant greater production in S than Q.
- The error bars for standard deviations overlap. This shows there is no significant difference because only *Elonius* was studied.
- Results may not be valid because investigations were done in the greenhouse and on sterile soil. Data generated in the open field would show a different trend.
- Small sample was used. This limits the credibility of data.

0 3 . 3 The tomato seeds were planted into sterilised soil.

Suggest **two** reasons why the soil was sterilised.

[2 marks]

- 1 To kill mycorrhizae
To remove spores.
- 2 To remove competitors

0 3 . 4 The soil used in this investigation had the recommended concentration of fertiliser.

Suggest **two** reasons why the soil contained the recommended concentration of fertiliser.

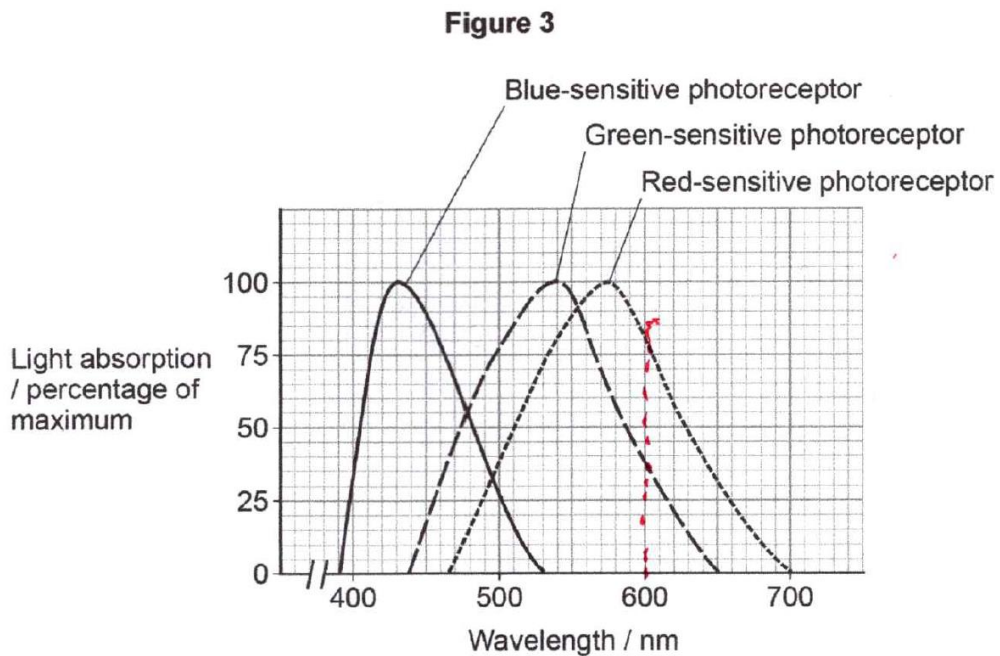
[2 marks]

- 1 To ensure mycorrhizae is the only variable.
Concentration of fertiliser would affect water potential of soil.
- 2 To ensure fertiliser is not a variable.

3. No.5

0 5 . 1

Figure 3 shows the wavelengths of light absorbed by three types of photoreceptor found in the human retina.



Use **Figure 3** and your knowledge of colour vision to explain how an orange colour is seen at 600 nm

[3 marks]

- Colour vision involves the cones. Each type of photoreceptor has a different pigment. Each cone has a different a different pigment.
- Each type of photoreceptor absorbs a different range of wavelengths. There is greater absorption by "red sensitive" than "green sensitive" cones. so, there is more impulses to brain from the "red sensitive than ^{than} "green sensitive" cones.

0 5 . 2

Which of the following statements is associated with high sensitivity to light in the retina?

Tick (✓) **one** box.

*many photoreceptors
give more sensitivity*

[1 mark]

A single photoreceptor connecting to one neurone and spatial summation

creates Low sensitivity (temporal)

☐

A single photoreceptor connecting to one neurone and temporal summation

Several photoreceptors connected to one (spatial) neurone produce high sensitivity

☐

Several photoreceptors connecting to one neurone and spatial summation

☒

Several photoreceptors connecting to one neurone and temporal summation

(spatial)

☐

0 5 3

Variation in flower colour is considered one of the factors involved in the evolution of the following two species of monkeyflower.

- *Erythranthe lewisii* (Great Purple Monkeyflower), which has pink flowers, is mostly found at higher altitudes (1600 to 3000 metres) and attracts bumblebees.
- *Erythranthe cardinalis* (Scarlet Monkeyflower), which has red flowers, is mostly found at lower altitudes (up to 2000 metres) and attracts hummingbirds.

Bumblebees and hummingbirds are important in the pollination of flowers. Pollination involves the transfer of male gametes to female gametes.

Explain the different processes that may have been involved in the evolution of these two species of monkeyflower. Use the information provided to justify your answer.

[5 marks]

Geographical isolation caused allopatric speciation. Separation due to altitude ensured the pollen was not exchanged between the two species. So, pollen from high altitude flower could not reach flower at low altitude. At each altitude, the flowers were subjected to selection pressure. Then they mutated to form variants that can survive the changes in environments.

Bearers of genes of advantage, reached maturity and reproduced to pass on the alleles of advantage. The alleles increased in frequency. This led to formation of new species.

There was reproductive isolation due to different pollinators at different altitudes. This ensured there was no gene flow between the two populations of flowers.

- So, different allele frequency in each population ensured different species can no longer interbreed to produce offspring.

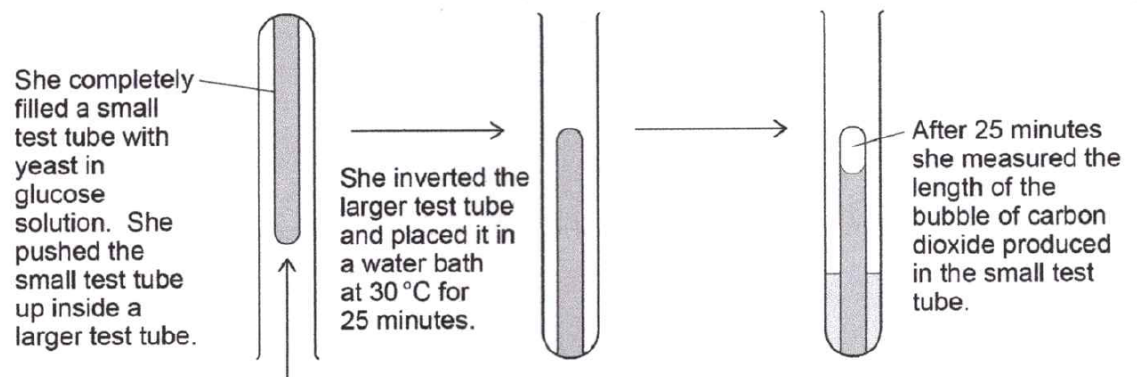
4. No.2

0 2

A student investigated the effect of different sugars on the rate of respiration in yeast. Yeast normally respires glucose.

Figure 2 shows the method she used for her first experiment.

Figure 2



0 2 . 1

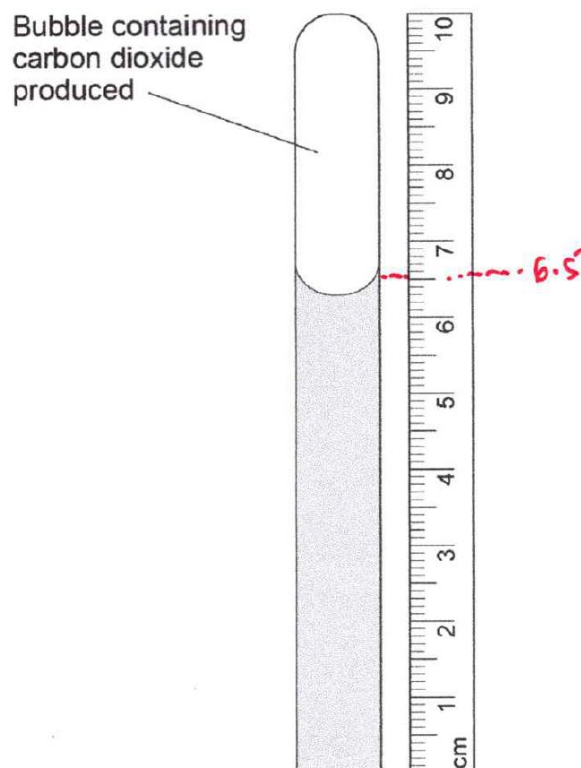
Other than those stated, suggest **two** variables the student needed to keep constant in her investigation.

[1 mark]

- 1 Mass of yeast
- 2 Volume of glucose

Figure 3 shows the result she obtained for yeast in glucose solution.

Figure 3



0 2 . 2

Use Figure 2 and Figure 3 to calculate the rate of carbon dioxide production in mm s^{-1} for yeast in glucose solution.

Give your answer in standard form and to 2 significant figures.

Show your working.

$$\frac{\text{CO}_2 \text{ produced}}{\text{time}} = \text{Rate of CO}_2 \text{ production}$$

[2 marks]

$$t = 25 \text{ min}$$

$$t = (25 \times 60) \text{ s}$$

$$\frac{37 \text{ mm}}{(25 \times 60)} = 0.02467$$

$$\approx \underline{\underline{2.5 \times 10^{-2}}}$$

Answer 2.5×10^{-2} mm s^{-1}

0 2 . 3

The student repeated the experiment using yeast in maltose solution. She found the rate of carbon dioxide production was slower than with yeast in glucose solution. Suggest why.

[2 marks]

Maltose is a disaccharide made of two glucose molecules joined by glycosidic bond. So, time is needed to hydrolyse maltose into glucose molecules. This makes rates of reaction slower.

0 2 . 4

A second student used a different method to investigate the effect of different sugars on the rate of respiration in yeast.

He set up a tube with yeast in glucose solution and added bromothymol blue. Bromothymol blue changes from blue to yellow when carbon dioxide is produced.

To determine the rate of respiration, he timed how long it took for the solution to change from blue to yellow.

Suggest:

- why the method the second student used would be less accurate than the method the first student used
- how the accuracy of the method the second student used could be improved.

[2 marks]

This method would be less accurate because

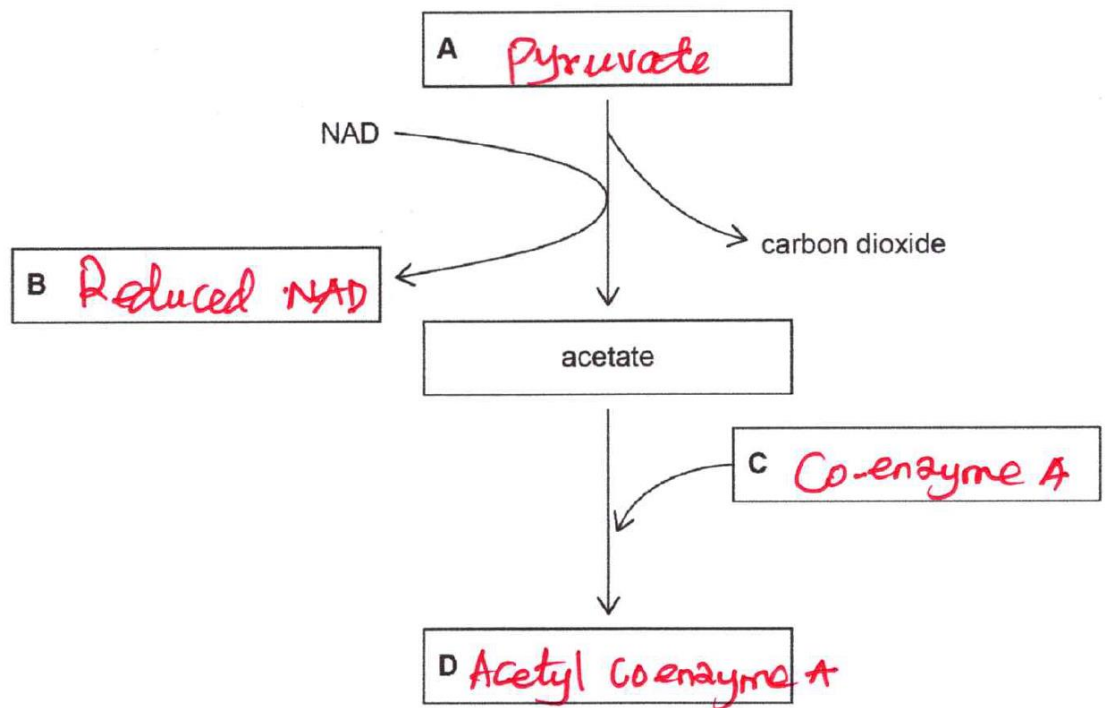
The colour is subjective.

The accuracy of this method could be improved by

Use a colorimeter to time how long it takes to reach a specific absorbance (end point).

0 2 . 5 Complete the boxes **A** to **D** in **Figure 4** to show the link reaction.

Figure 4



[2 marks]

5. No.3

0 3 . 1

Below are **four** statements about the structure of prokaryotic cells.

- ✓1. No prokaryotic cell has DNA that is associated with proteins. *+ true*
- ✓2. No prokaryotic cell has membrane-bound organelles. *- true*
- 3. All prokaryotic cells have one or more flagella. *- wrong*
- ✓4. All prokaryotic cells have smaller ribosomes than eukaryotic cells. *- true*

Which statements about the structure of prokaryotic cells are correct?

Tick (✓) **one** box.

[1 mark]

A statements 1, 2 and 3

☐*- 3 is false*

B statements 1, 2 and 4

☒*- true*

C statements 2, 3 and 4

☐*- 3 is false*

D statements 1, 2, 3 and 4

☐*- 3 false*

A student investigated the effect of **two** antibiotics on the growth of the bacterium *Micrococcus luteus*.

During the investigation, the student:

- transferred 9 cm^3 of a liquid culture of *M. luteus* into each of **three** bottles
- added the antibiotic chloramphenicol to the first bottle
- added the antibiotic novobiocin to the second bottle
- added no antibiotic to the third bottle.

After 24 hours, he diluted the contents of each bottle by 1 in 100 000 (10^{-5}). He then transferred 0.25 cm^3 samples from the first bottle onto each of 3 separate agar plates. He repeated this with 0.25 cm^3 samples from the second bottle and the third bottle, resulting in 9 agar plates in total.

He incubated the plates for 48 hours.

Table 1 shows the number of colonies of bacteria he counted on each plate after 48 hours' incubation.

9 x 0.144)

Table 1

Plate	Number of colonies of bacteria		
	with chloramphenicol	with novobiocin	with no antibiotic
1	2	238	276
2	4	263	258
3	6	261	324

- 03.2 Calculate the mean number of bacteria in the undiluted bottle of liquid culture containing novobiocin.

Give your answer in standard form. Show your working.

content of each bottle = 1 in 100,000 dilution [2 marks]
Mean colony count = $\left[\frac{238 + 263 + 261}{3} \right] \times 100,000 = 254,000$
in 0.25cm^3 and 9 bottles
Total bacteria in undiluted Bottle = $\frac{254 \times 100,000 \times 9}{0.25}$
 $= 9.144 \times 10^8$

Answer 9.144×10^8 bacteria

- 03.3 Starting with a single bacterium, calculate how many generations it would take to produce at least the number of bacteria you have calculated for your answer in Question 03.2

You can assume no bacteria die.

You could use the ln or log button on your calculator to calculate your answer.

$2^x = 9.14 \times 10^8$ [1 mark]
 $\ln 2^x = \ln 9.14 \times 10^8$
 $x = \frac{\ln(9.14 \times 10^8)}{\ln 2} = 30$

Answer 30 generations

03.4

M. luteus is **not** resistant to chloramphenicol.

Suggest **two** reasons why the bacteria were able to grow in the culture containing chloramphenicol.

[2 marks]

- 1 The concentration of chloramphenicol was too low to kill all the *M. luteus*.
Mutations took place.
- 2 There were too many bacteria for the antibiotic to kill.

6. No.5

0 5

Scientists investigated the effect that the release of heated water into a river from a power station had on the biodiversity of a local fish community over 29 years.

They measured the species richness and the number of fish of each species at the same site in October every year. The scientists used this information to calculate an index of diversity (d) of fish for each year.

Figure 7 and **Figure 8** show their results.

Figure 7

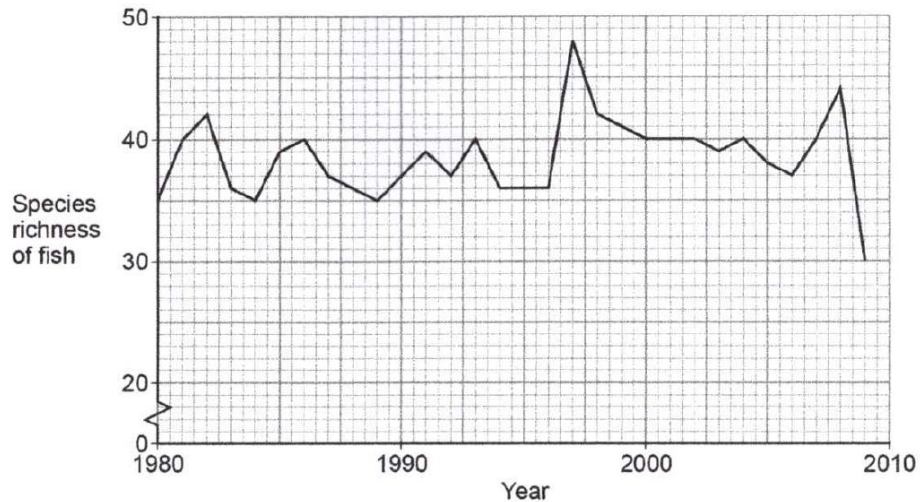
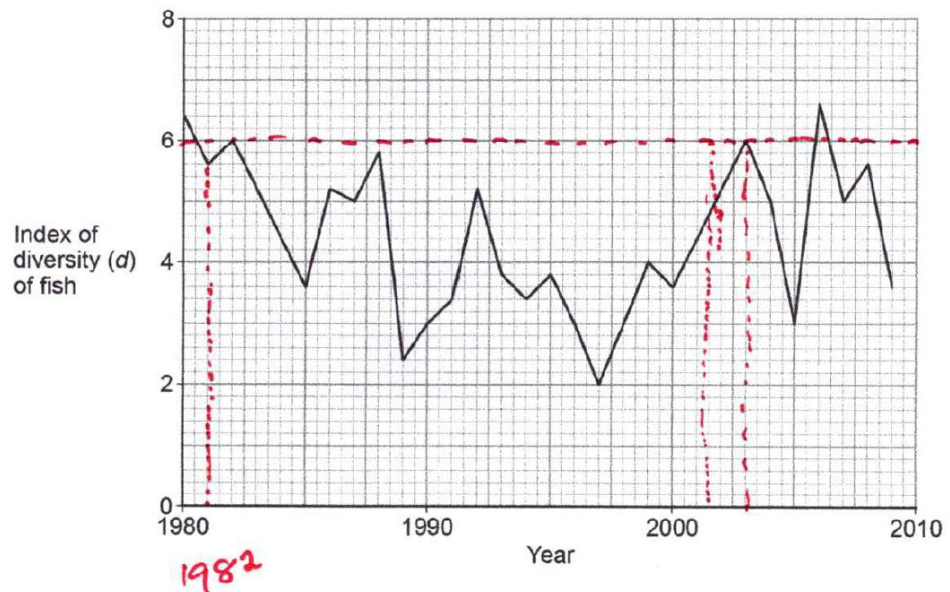


Figure 8



0 5 . 1

The scientists used the following formula to calculate the index of diversity (d) of fish.

$$d = \frac{N(N-1)}{\sum n(n-1)}$$

where N = total number of fish of all species
and n = total number of fish of each species

In some years, the values were $N = 624$ and $\sum n(n-1) = 64\,792$

Which years had these values?

Use **Figure 8** and the formula above to work out your answer.

[1 mark]

$$d = \frac{624(624-1)}{64\,792} = \frac{624 \times 623}{64\,792} = 6$$

from graph, $d=6$ is in 1982 and 2003

Answer 1982 and 2003

0 5 . 2

In 1997, the scientists recorded the highest species richness, but the lowest value of d over the 29 years.

Describe and explain how these results for 1997 were possible.

[2 marks]

There were many different species. However, there were a few species present in very large numbers.

0 5 . 3

A journalist studied **Figure 7** and **Figure 8** (on page 16) and concluded that releasing heated water from a power station has no effect on local fish communities.

Use all the information to suggest reasons why the journalist's conclusion might **not** be valid.

[4 marks]

The species richness values are lower after 29 years. However, data presented is only for one community. So, the data is not representative of all fish communities. The data measurements were taken only in October. The volume of heated water released each year is not given. Moreover, timing of heated water release each year is not known. All these reasons make the claim to be invalid.

7. No.7(7.2)

0 7

Write an essay on one of the topics below.

0 7 . 2

The importance of membranes in the functioning of cells.

[25 marks]

- Cell membranes separates cell's internal from the external one. This maintains cell structural integrity. This barrier prevents entry of toxic materials into the cell.
- Cell membranes are selectively permeable. So, they control of materials into and out of cell. The transport channel proteins regulates flow of ions into cell.
- Cell membranes contain receptors that bind with signalling molecules. This initiates chain reaction of events within the cell. This allows the cell to respond to changes in the external stimuli.
- Membranes are essential for passive transport, active transport and exocytosis. Passive transport allows the molecules to move down their concentration gradient.

- In active transport, ^{transport} proteins use ATP to move molecules against their concentration gradient. Endocytosis and exocytosis involve absorption and release of molecules across cell membrane. This shows that cell membranes support cellular transport.
- Among eukaryotes, internal membranes create compartments (organelles) for different processes. The mitochondria's membrane supports ATP production. Membranes of endoplasmic reticulum enable protein and lipid synthesis.
- Cell membranes provide structural support and maintain flexibility of the cell. It allows cell to change shape and divide.
- In prokaryotes, surface area to volume ratio is very high. So, materials such as oxygen diffuse across cell membrane into the cell.
- Absorption of end products of digestion occur across cell membranes of the micro-villi and epithelium lining cells inside the villi.
- To generate action potential, the cell membranes of the axon allows movement of Na^+ outside of axon. This causes a wave of depolarisation.
- During protein synthesis, the pores on the nuclear envelope allows for mRNA to leave nucleus and go to cytoplasm where ribosomes is located.

- Cell membrane regulates flow of glucose into and out of cell. This affects water potential inside the cell.
- At the synapse, arrival of action potential causes the vesicles to move and fuse with the ^{membrane of} pre-synaptic neuron. Then, the vesicles burst open to release neuro-transmitter across the synapse.