

- 1 In mammals, digested food is absorbed by active transport and diffusion. In an investigation into the absorption of sugars a short piece of intestine was turned inside out, so that the absorptive surface was on the outside. The ends of the intestine were tied to form a bag containing oxygenated buffer solution.

The apparatus used is shown in Fig. 2.1.

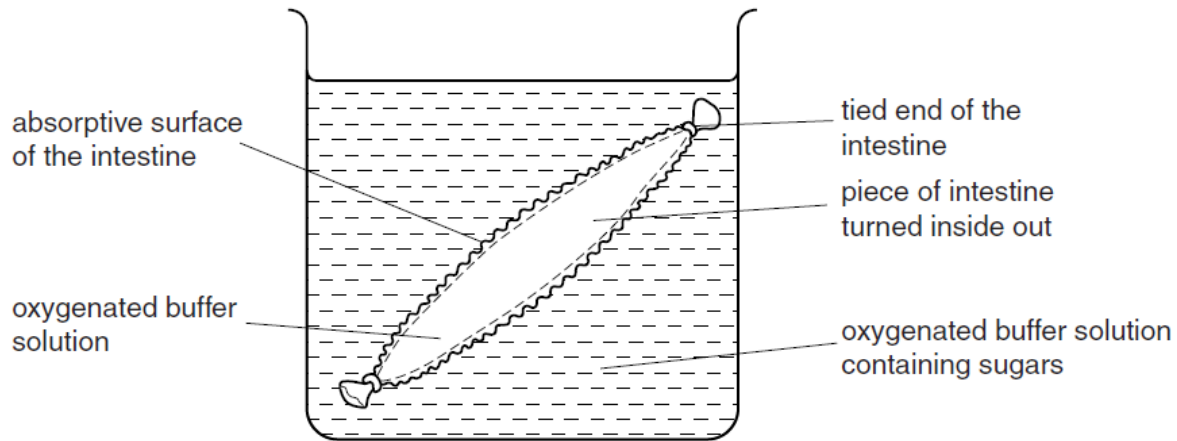


Fig. 2.1

- (a) (i) Outline a method that could have been used to oxygenate the buffer solution.

.....

 [2]

- (ii) Identify **one** important variable, other than those shown in Fig. 2.1, that should be standardised in this investigation.

..... [1]

- (b) Substances which are absorbed by the intestine collect in the centre of the bag. Samples from the contents of the bag can be removed for analysis.

The absorption of glucose was investigated using untreated pieces of intestine and pieces of intestine that had been treated with a respiratory inhibitor. The investigation was then repeated using fructose.

Table 2.1 shows the results of this investigation.

Table 2.1

sugar	relative rate of absorption by the intestine	
	without respiratory inhibitor	with respiratory inhibitor
glucose	95	30
fructose	30	31

- (i) Outline a procedure by which the rate of absorption of glucose could be determined.

[3]

- (ii) Suggest how the relative rate of absorption of the sugars is calculated.

.....[2]

- (c) State the conclusions that can be drawn about the absorption of sugars from this investigation.

[3]

[Total: 11]

- 2 The effect of temperature on the permeability of cell membranes was investigated using discs of a plant tissue. When discs of this plant tissue were placed in water, chloride ions were released from the cell vacuoles.

Discs of this plant tissue were placed in tubes of deionised water in water baths at different temperatures for 30 minutes as shown in Fig. 2.1.

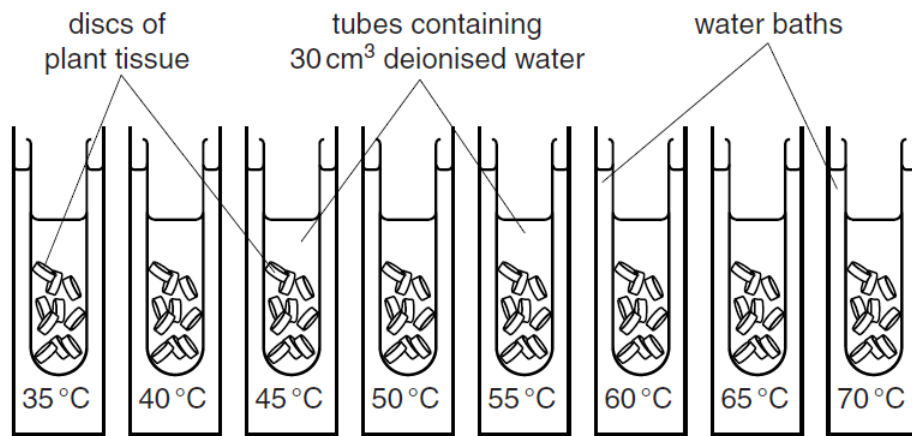


Fig. 2.1

The concentration of chloride ions in the water around the plant tissue was measured using an ion-sensitive electrode.

- (a) (i) State how three different variables have been standardised in this investigation.

1.
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2.
.....
3.
.....[3]

- (ii) Suggest how the reliability of the results could be improved.

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

3

- a | Explain what is meant by the term *biodiversity*.

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..... [2]

- b | Discuss the benefits of maintaining the biodiversity of a marine ecosystem, such as that in the coastal waters of Canada.

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..... [3]

- 4 (a) Describe how ATP is synthesised by oxidative phosphorylation. [8]

- (b) Using examples, outline the need for energy in living organisms. [7]

[Total: 15]

- 5 (a) Describe the structure of a kidney, including its associated blood vessels. [6]

- (b) Describe the mechanisms involved in reabsorption in the proximal convoluted tubule **and** describe how the epithelial cells of the proximal convoluted tubule are adapted to carry out this process. [9]

[Total: 15]

- 6 (a) Explain the role of ATP in active transport of ions **and** in named anabolic reactions. [7]
- (b) Outline the process of anaerobic respiration in both mammal and yeast cells. [8]

[Total: 15]

- 7 (a) Outline, with reference to blood glucose concentration, the principles of homeostasis in mammals. [6]
- (b) Describe the roles of the endocrine and nervous systems in control and coordination in mammals. [9]

- 8 A student investigated the effect of different growth media on the germination and growth of pollen.

The growth media tested are shown in Table 1.1.

Table 1.1

component	concentration of components in each growth medium		
	medium A	medium B	medium C
sucrose solution / %	10	10	10
boric acid / mg dm^{-3}	0	100	100
calcium nitrate / mg dm^{-3}	0	300	300
magnesium sulfate / mg dm^{-3}	0	0	200
potassium nitrate / mg dm^{-3}	0	0	100

Fig. 1.1 shows the apparatus used by the student in this investigation.

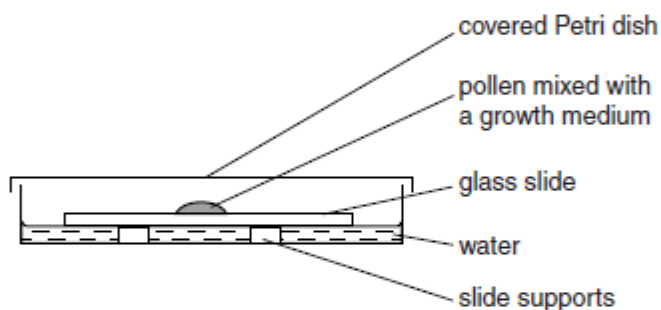


Fig. 1.1

The student carried out the following procedure when investigating each growth medium, A, B and C:

- pollen from a mature anther of a flower was removed with a paint brush
- the pollen was mixed with two drops of the growth medium on a slide
- the slide was placed in the Petri dish as shown in Fig. 1.1
- the apparatus was kept at room temperature
- every 10 minutes the slide was removed and the pollen observed using a light microscope
- the percentage of the pollen germinated was estimated
- the lengths of the 10 longest pollen tubes in a field of view were measured
- the mean pollen tube length was calculated.

The results of the three investigations are shown in Table 1.2.

Table 1.2

	mean length of ten longest pollen tubes / μm						
time / min	10	20	30	40	50	60	70
medium A	23.9	48.5	72.4	97.6	128.2	156.0	180.0
medium B	27.6	58.4	89.9	121.7	154.8	186.8	219.2
medium C	38.2	76.1	112.6	150.6	188.5	226.5	264.7
	percentage germination						
medium A	5	18	26	38	51	55	57
medium B	8	12	22	31	46	52	61
medium C	3	8	18	28	36	48	56

- (a) Identify the independent variable and the two dependent variables.

independent

dependent

.....[2]

- (b) (i) Describe how the student could have measured the length of the pollen tubes using a microscope.

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.....

.....[3]

- (ii) Suggest why the percentage germination was calculated.

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.....[1]

- (c) The student carried out t -tests on the results to compare the lengths of the pollen tubes when grown in different media.

To carry out a t -test the number in the sample must be counted. It is also necessary to carry out two calculations from the data.

- (i) State the **two** calculations that must be carried out in order to complete a t -test.

.....
 [1]

- (ii) State why the student decided to use 18 degrees of freedom in each of the t -test calculations.

.....
 [1]

The student carried out a number of t -tests to find out if, after 70 minutes, the difference in mean pollen tube length is significant:

1. between medium A and medium B $t = 2.50$
2. between medium A and medium C $t = 3.56$
3. between medium B and medium C $t = 1.94$

Table 1.3 shows the critical values for the t -test.

Table 1.3

degrees of freedom	10	12	14	16	18	20	22	24	26	28	30	40	50	60
probability 0.05	2.23	2.18	2.14	2.12	2.10	2.09	2.07	2.06	2.06	2.05	2.04	2.02	2.01	2.00
probability 0.01	3.17	3.06	2.98	2.92	2.88	2.85	2.82	2.80	2.78	2.76	2.75	2.70	2.68	2.66

- (iii) State what conclusions can be drawn about the significance of the differences in mean lengths from the three values of t given above.

.....

 [3]

(d) From the results in Table 1.2 and the *t*-tests the student concluded that:

- calcium has no effect on the germination of pollen grains but increases the growth rate of pollen tubes
- sucrose is needed for pollen tube germination but has no effect on the growth rate of the pollen tube.

(i) With reference to Table 1.2 state the evidence that supports these conclusions and the evidence that does **not** support these conclusions.

evidence that supports these conclusions

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evidence that does not support these conclusions

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.....[4]

(ii) Outline a further investigation that the student might carry out to provide more support for the conclusions about the role of sucrose in the germination of pollen and in the growth of pollen tubes.

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.....[2]

(iii) Predict the results of this investigation if the student's conclusion about the effects of sucrose is correct.

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.....[2]

[Total: 19]

- 9 1 Hybridisation is used by plant breeders to develop new varieties of crop and garden plants. A student investigated the ability of one species of grass, species **A**, to hybridise with two other species of grass, **B** and **C** by studying the chromosomes of the hybrids.

The diploid number of chromosomes for each species was:

- species **A** 12
- species **B** 20
- species **C** 14

The main steps in the procedure used by the student are described below.

1. The undeveloped anthers of species **A** were removed from 40 immature flowers.
2. Each of the flowers (still attached to the plant) was placed inside a separate plastic bag.
3. When the flowers of species **A** were mature, pollen from species **B** was transferred onto the stigmas of 20 flowers of species **A**.
4. Step 3 was repeated, transferring pollen from species **C** to the stigmas of the other 20 flowers of species **A**.
5. Each of the flowers of species **A** was then replaced inside its plastic bag.
6. All the fruits formed by species **A** were collected and the embryo plants were removed.
7. The number of chromosomes in the cells of the embryo plants was counted.

- (a) (i) Identify the independent and dependent variables in this investigation.

independent variable

dependent variable [2]

- (ii) State the variable being controlled by the use of plastic bags.

.....

..... [1]

- (b) (i) Suggest a method by which the student could have obtained and transferred the pollen from species **B** to species **A**.

.....

..... [1]

- (ii) Identify **one** potential safety issue with the experimental method you have described.

State a suitable precaution.

.....

..... [1]

- (c) The fruits of the grass species used by the student are similar in structure to maize fruits.

In steps 6 and 7 the student collected the fruits formed by species **A** in order to count the chromosomes in the cells of the embryos.

Suggest a procedure by which the student could:

- obtain cells of the embryo plant in which chromosomes would be present
- make the chromosomes visible so that they could be counted.

Outline the main stages of this procedure.

[5]

- (d) Table 1.1 shows the results that the student obtained from the investigation.

Table 1.1

number of chromosomes in the embryo plants	
hybrid of species A and species B	hybrid of species A and species C
16	26

Explain the results of the student's investigation as shown in Table 1.1.

[3]

(e) In a second investigation, the student repeated the procedure to hybridise the grasses.

- The fruits were collected and 50 of each hybrid were planted.
- The number of fruits that germinated was counted.
- Pollen was collected from the flowers of the hybrid grass plants that grew from the fruits.
- The chromosomes were counted in a random sample of 30 pollen grains from each hybrid.

Table 1.2 shows the results of this investigation.

Table 1.2

number of fruits that germinated									
hybrids from the crosses between A and B					hybrids from the crosses between A and C				
35					46				
number of chromosomes in the pollen grains									
6	6	8	7	10	13	13	13	13	13
16	8	16	9	0	13	13	13	13	13
8	8	16	6	6	13	13	13	13	13
6	10	8	16	9	13	13	13	13	13
13	12	16	8	6	13	13	13	13	13
8	8	16	6	10	13	13	13	13	13

- (i) The student also counted the number of chromosomes in the female gametes of each hybrid.

Predict the number of chromosomes you would expect the student to find in the female gametes of each hybrid.

hybrid from the cross **A × B**

hybrid from the cross **A × C** [1]

The student concluded that hybrids from the cross of **A × C** could be bred successfully but hybrids from the cross of **A × B** could not be bred successfully.

- (ii) State the evidence in Table 1.2 that supports this conclusion.

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.....

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..... [2]

- (f) The student carried out a further investigation to find out if the difference in the germination of the two hybrid grasses was significant. The student counted the number of fruits that germinated from eleven samples of 50 fruits of each hybrid.

The student collated all the data in order to calculate the mean, mode and median of the fruit germination of both hybrids.

Table 1.3 shows the data.

Table 1.3

sample number	number of fruits germinated	
	hybrid A \times B	hybrid A \times C
1	30	41
2	31	42
3	32	44
4	32	45
5	34	45
6	34	46
7	34	47
8	35	48
9	36	48
10	38	49
11	37	48
mean	34	
mode	34	
median	34	

The student recorded the calculations for the hybrid from the cross of A \times B in Table 1.3.

- (i) Complete Table 1.3 by writing in the values of the mean, mode and median for the hybrid from the cross of A \times C. [2]

- (ii) State a reason why the student used the *t*-test to find out if the difference in germination of the two hybrids was significant.

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 [1]

- (iii) State a null hypothesis for this test.

.....
 [1]

- (iv) State why the student used 20 degrees of freedom for this test.

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 [1]

[Total: 21]

- 10 (a) Explain how meiosis and fertilisation may result in genetic variation in offspring. [7]
(b) Explain, using examples, how the environment may affect the phenotype of an organism. [8]

- 11 The two strands of a DNA molecule are held together by hydrogen bonds between complementary base pairs.

- (a) Explain why the hydrogen bonding between the two strands of DNA is important for it to carry out its functions.

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.....[4]

Switching genes on and off allows proteins to be synthesised only when required.

Processes P and Q occur when a gene is switched on, as shown in Fig. 4.1.

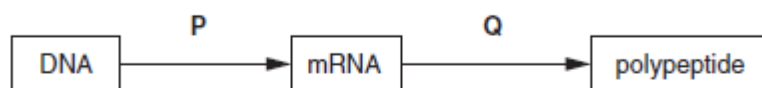


Fig. 4.1

- (b) Name processes P and Q.

P
Q[1]

DNA is a very stable molecule. This means that it is not broken down either chemically or by enzymes during the normal life of the cell.

In contrast, mRNA is described as being highly labile. This means that most mRNA molecules are broken down in the cytoplasm within a few hours of their release from the nucleus.

(c) Suggest the significance of:

(i) DNA being very stable

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

(ii) mRNA being highly labile.

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.....[2]

[Total: 9]

12

a) Outline how electrophoresis is used to obtain a genetic fingerprint.

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.....[3]

b) State why gene probes can be used to locate specific alleles of genes.

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.....[1]

c) State what conclusions can be drawn about the alleles of the genes located in Fig. 3.1.

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.....[2]

[Total: 8]

- 13 (a) Describe the structure of a motor neurone. [7]
 (b) Explain how an action potential is transmitted along a motor neurone. [8]

[Total: 15]

- 14 (a) Explain the role of isolating mechanisms in the evolution of new species. [8]
 (b) Describe and explain, using an example, the process of artificial selection. [7]

[Total: 15]

- 15 The HIV/AIDS pandemic has had a very large impact on life expectancy in many African countries.

Table 3.1 shows estimated data for seven African countries for

- the average life expectancy of an individual born in 2002
- the percentage of the population testing positive for HIV in 2002
- the average life expectancy of an individual born in 2002 **if there was no HIV/AIDS pandemic.**

Table 3.1

country	life expectancy / years		percentage of population testing positive for HIV
	without HIV/AIDS	with HIV/AIDS	
Botswana	72.4	33.9	35.8
Côte d'Ivoire	55.6	42.8	10.8
Kenya	65.6	45.5	14.0
Malawi	56.3	38.5	16.0
South Africa	66.3	48.8	19.9
Zambia	55.4	35.3	20.0
Zimbabwe	69.0	40.2	25.1

- (a) Using the 'without HIV/AIDS' and 'with HIV/AIDS' data shown in Table 3.1, calculate the percentage decrease in life expectancy for Botswana.

Show your working and give your answer to the nearest whole number.

Answer = % [2]

- (b) Suggest two reasons for the differences shown in estimated life expectancy **without** HIV/AIDS between the different African countries.

1.
.....
.....
2.
.....
.....[2]

- (c) After studying the data in Table 3.1, a student concluded that:

"There is a correlation between the percentage of the population testing positive for HIV and the decrease in estimated life expectancy with HIV/AIDS."

- (i) With reference to Table 3.1, explain why the data do not fully support the student's conclusion.

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.....[2]

- (ii) List two factors in the prevention and control of HIV/AIDS that would help to improve average life expectancy in the African countries shown in Table 3.1.

1.
.....
2.
.....[2]

- (d) A person who is confirmed as HIV-positive has tested positive for the presence of antibodies to HIV.

Outline the events that occur in a newly-infected person, which lead to the production of antibodies to HIV.

[5]

[Total: 13]

Fig. 3.1 is an electron micrograph of a lymphocyte in the process of cell division during an immune response.

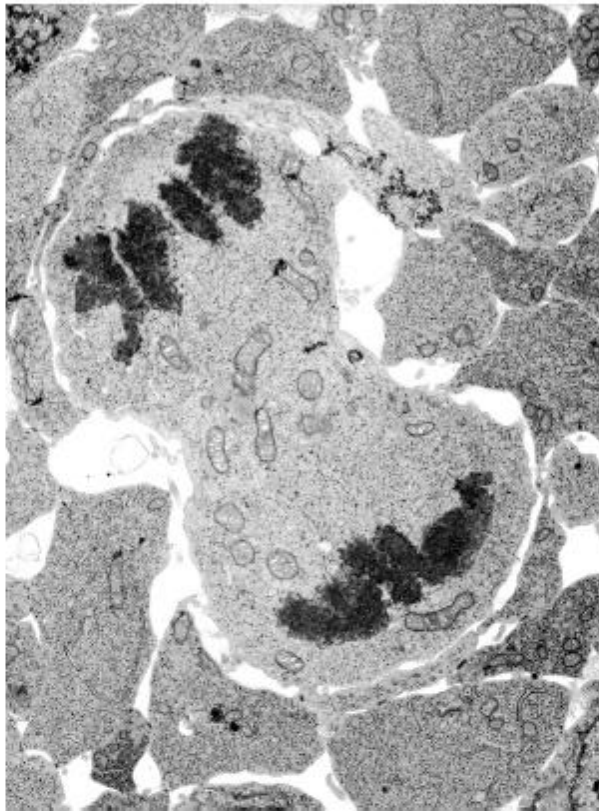


Fig. 3.1

(a) With reference to Fig. 3.1,

(i) name the stage of mitosis shown;

.....[1]

(ii) describe what is happening during this stage of mitosis;

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.....[2]

(iii) suggest the **disadvantages** of using an electron microscope to study mitosis.

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..... [2]

b) Tumours may form inside the lungs of long-term smokers.

(i) Describe how a tumour develops in the lungs.

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..... [3]

(ii) Describe two signs or symptoms of lung cancer.

1
.....
2
..... [2]

[Total: 10]

