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BIOLOGY **9700/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2019**

1 hour 15 minutes

Candidates answer on the Question Paper.

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Answer **all** questions.

Electronic calculators may be used.
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[Turn over

1 A group of six students carried out an experiment to determine their reaction times using a ruler.

Fig. 1.1 shows the basic procedure used for the experiment.

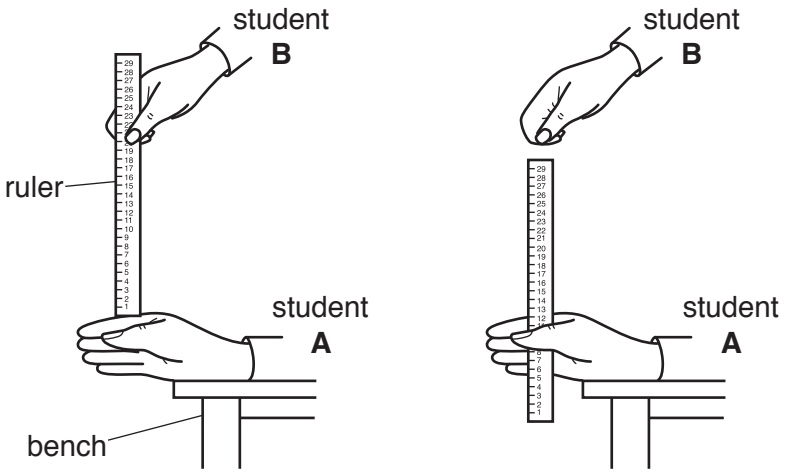


Fig. 1.1

The students worked in pairs.

- Student **A** rested their hand on a bench.
- Student **B** then dropped a ruler from a set height.
- Student **A** had to catch the ruler as quickly as possible.
- The distance the ruler had dropped was measured and recorded.
- The students calculated their reaction times.

The formula for calculating reaction time in seconds is shown in Fig. 1.2.

$$\text{reaction time} = \sqrt{\frac{2 \times D}{g}}$$

D = distance ruler had dropped in metres
$g = 9.8\,\text{m}\,\text{s}^{-2}$

Fig. 1.2

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Table 1.1 shows the results for the six students.

Table 1.1

student	distance ruler had dropped / m	reaction time / s
1	0.17	0.19
2	0.10	0.14
3	0.16	0.18
4	0.08	
5	0.16	0.18
6	0.35	0.27

(a) (i) Use the formula in Fig. 1.2 to complete Table 1.1. [1]

(ii) Predict what would happen to the reaction time if the ruler was held higher than the original set height.

.....

..... [1]

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[Turn over

There was some background noise in the classroom when the students carried out their experiment. The students thought that this noise might have affected their reaction times. They decided to modify their original experiment to find out if the presence or absence of background noise affects reaction time.

(b) (i) Identify the dependent variable in this investigation.

..... [1]

(ii) Using the procedure shown in Fig. 1.1, describe a method that the students could use to find out if the presence or absence of background noise affects reaction time.

Your method should be set out in a logical order and be detailed enough for another person to follow.

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Fig. 1.3 shows some results for a reaction time test that the students found on the internet.

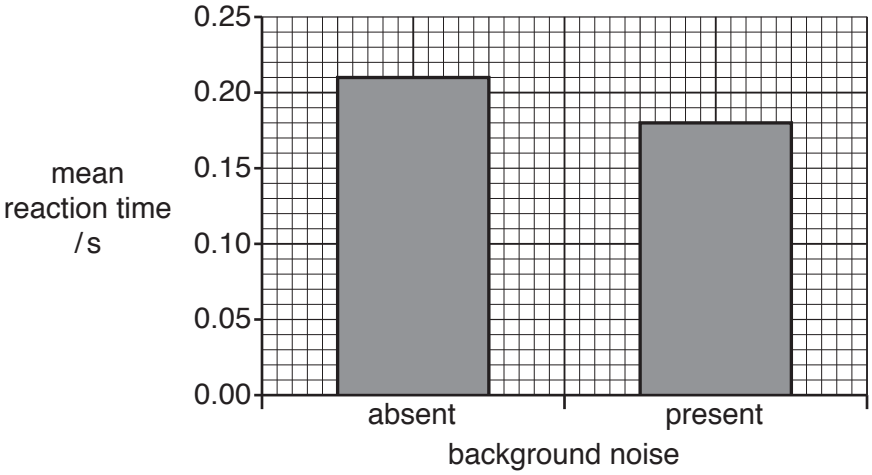


Fig. 1.3

(c) State why a bar chart is a suitable way to show the data.

.....

..... [1]

(d) **(i)** Suggest **one** conclusion the students could have made based on these results.

.....

..... [1]

(ii) The students decided to carry out a *t*-test to find out if the difference in reaction time was significant.

State why a *t*-test is suitable for these data.

.....

..... [1]

(iii) State a null hypothesis for this test.

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.....

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..... [1]

Table 1.2 shows some probability values of *t*.

Table 1.2

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

(iv) The students used 16 degrees of freedom and calculated $t = 2.05$.

State **and** explain what the value of *t* indicates about the difference in mean reaction times shown in Fig. 1.3.

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.....

.....

..... [1]

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Another student, when carrying out the ruler experiment shown in Fig. 1.1, noticed that the more repetitions carried out, the faster the reaction time became.

The student decided to carry out a different experiment to investigate the effect of repetition on the accuracy of carrying out a task.

Five students, **V**, **W**, **X**, **Y** and **Z** were tested.

- Each student was given a picture of a star, as shown in Fig. 1.4.
- Each student sat at a desk so that the star was only visible in a mirror, as shown in Fig. 1.5.
- Each student was asked to draw between the double lines of the star when looking at it **only** in the mirror. Fig. 1.6 shows a star diagram completed by a student.
- The students recorded the number of times their lines went outside the double line of the star.

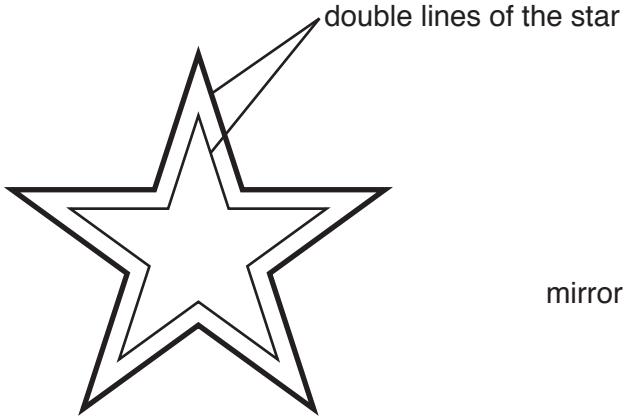


Fig. 1.4

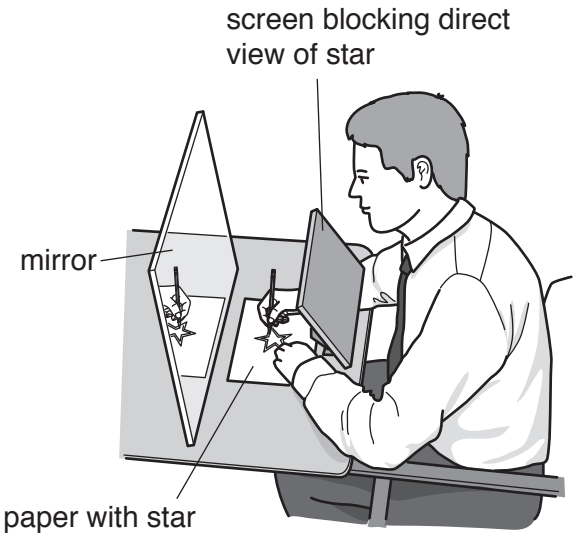


Fig. 1.5

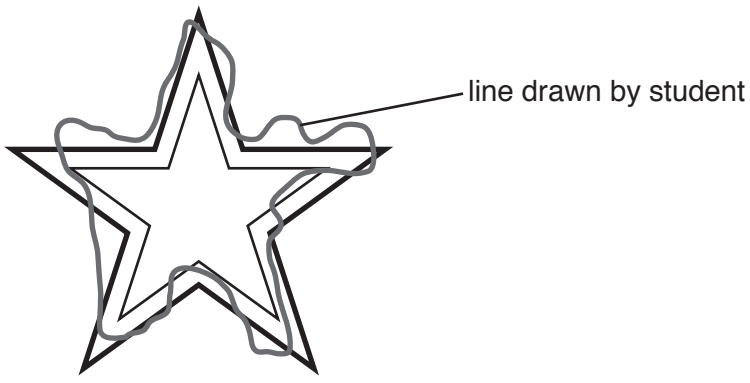


Fig. 1.6

Each student repeated the task nine times on the same day. The results are shown in Table 1.3.

Table 1.3

student	number of times the students' lines went outside the double lines of the star								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
V	48	48	46	44	42	40	41	41	41
W	45	42	43	40	38	35	36	35	35
X	38	37	34	32	31	30	28	28	28
Y	31	30	31	29	44	28	26	25	25
Z	41	40	38	37	35	35	33	33	32

(e) (i) Identify the independent variable in this experiment.

..... [1]

(ii) Suggest the hypothesis that was tested in this experiment.

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..... [1]

(iii) A person walked into the room and started talking to one of the students who was carrying out the test.

Circle the result in Table 1.3 that was affected by this. [1]

(iv) One of the students had previously carried out a similar task.

Identify this student **and** give a reason for your answer.

student .....

reason .....

..... [1]

(f) State **two** conclusions based on the data in Table 1.3.

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..... [2]

[Total: 21]

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2 Artificial insemination (AI) is one method used in assisted reproduction programmes for large mammals.

For many years, horse breeders have collected semen samples from male horses and used these to inseminate female horses. Success rates have been good. However, due to the sample containing live sperm cells, the process needed to be carried out quickly.

New technologies exist to allow horse semen to be frozen in small plastic straws. Semen samples can now be stored for many years and transported all over the world.

- Each 0.5 cm^3 straw can hold 7.5×10^7 sperm cells.
- A typical sample of horse semen contains 7.5×10^9 sperm cells.

(a) (i) Calculate the volume of a typical horse semen sample.

..... cm^3 [1]

(ii) To inseminate one female horse, 5.0×10^8 sperm cells are needed.

Calculate the minimum number of straws needed to carry out this process.

minimum number = ... [1]

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[Turn over

The semen from a horse is analysed by technicians to determine its quality before the horse is accepted onto the assisted reproduction programme.

Technicians use microscopy to look at the appearance and motility of the sperm cells and to estimate the sperm count.

Fig. 2.1 shows the surface view of a haemocytometer used to estimate the number of sperm cells in a sample.
Each number represents a sperm cell which was counted in the sample.
Each star (*) represents a sperm cell **not** counted in the sample.

The depth of the haemocytometer is 0.1 mm.

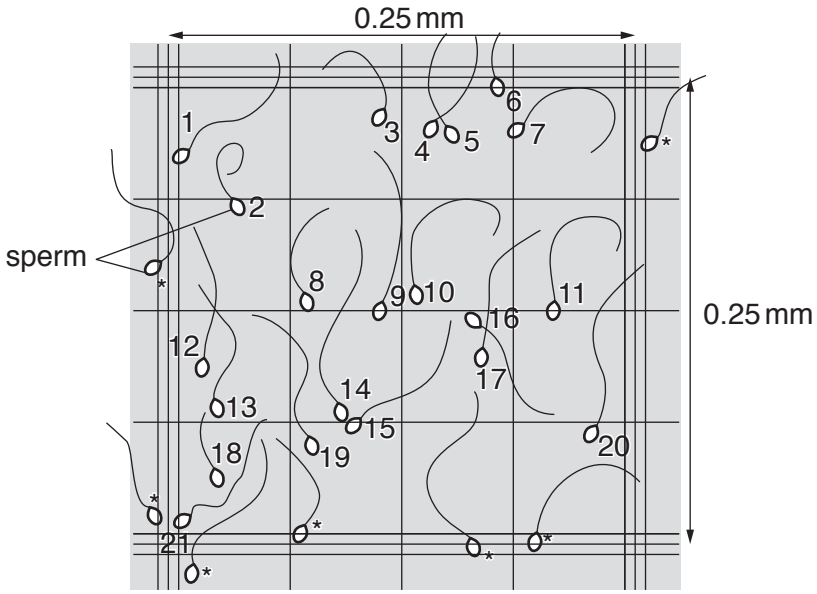


Fig. 2.1

(b) Suggest how this apparatus could be used to estimate the number of sperm cells per cm^3 of semen **and** describe how the technician decided which sperm cells to include in the count.

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..... [4]

(c) To ensure that the sperm cells remain viable after they have been frozen, a solution is added to the sample **before** freezing the semen in the straws.

The solution contains:

- a sugar
- a buffer to maintain pH
- antibiotics.

Explain why it is necessary for the solution to contain these three substances.

sugar .....

.....

buffer .....

.....

antibiotics .....

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[3]

[Total: 9]

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BIOLOGY **9700/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2019**

1 hour 15 minutes

Candidates answer on the Question Paper.

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1 **(a)** Some students wanted to determine the reaction time of a sample of people aged from 5–80 years.

The students found three different methods of testing reaction time, as described in Fig. 1.1.

Method 1: Ruler test	Method 2: Computer click timer	Method 3: Light board test
• The subject rests their elbow on a table so that their wrist extends over the side. • The assessor holds the ruler vertically in the air between the thumb and first finger of the subject. • The zero mark on the ruler is lined up with the first finger of the subject. The ruler is released without warning. • As soon as the subject sees the ruler fall, they catch it as quickly as possible. • The distance the ruler falls is recorded in metres.	• The subject looks at a computer screen and clicks a **start** button on the screen and waits for the background colour to change. • As soon as the background colour changes the subject clicks a **stop** button on the screen. • The reaction time, in seconds, appears on the screen.	• The subject stands in front of a board with buttons arranged in a pattern. The buttons light up randomly. • As soon as a button lights up the subject presses the button to turn it off. • As soon as a button is pressed another button lights up. • The number of lights turned off in a set time is recorded.

Fig. 1.1

(i) The students decided that Method 2 was the most suitable to use for testing subjects aged from 5–80 years.

Suggest **two** reasons why Method 2 is the most suitable.

.....

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..... [2]

(ii) State the independent variable **and** the dependent variable in Method 2.

independent variable .....

.....

dependent variable .....

.....
[2]

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(iii) Describe how the students could investigate the reaction time of a sample of people aged from 5–80 years, using Method 2.

Your description should be set out in a logical order and be detailed enough to let another person follow it.

Details of Method 2, as described on page 2, are **not** required.

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(b) The students found some results on the internet for a reaction time test, as shown in Fig. 1.2.

The error bars show ± 1 standard deviation (*s*).

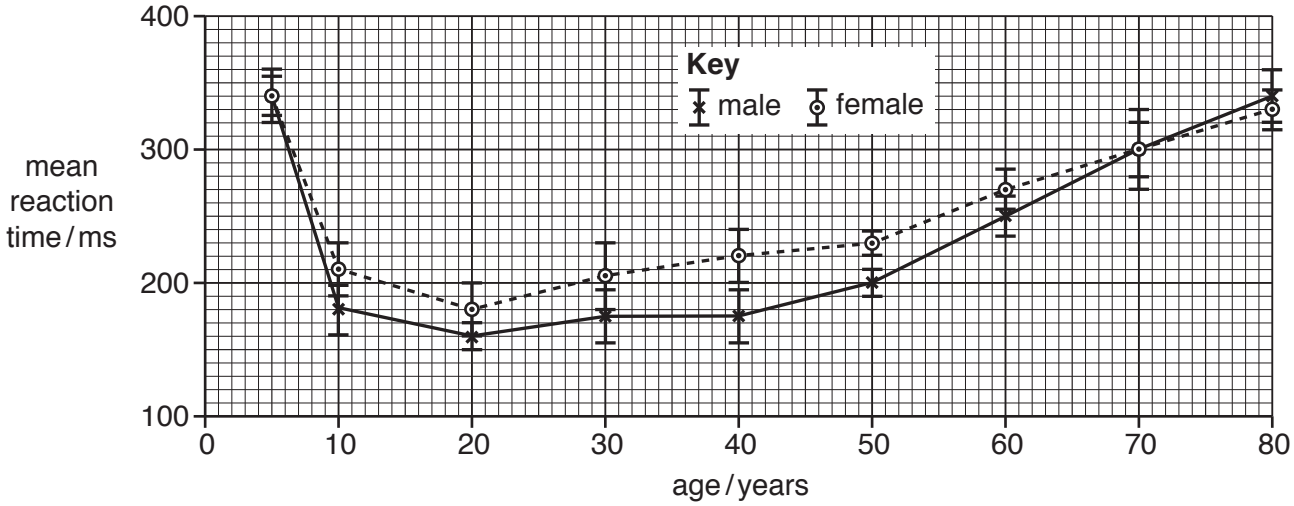


Fig. 1.2

(i) The percentage change in mean reaction time for males between the ages of 5 years and 10 years is 47%.

Calculate the percentage change in mean reaction time for **females** between the ages of 5 years and 10 years. Show your working and give your answer to the nearest whole number.

.....% [2]

(ii) State **two** conclusions about the trends shown by the results in Fig. 1.2.

1 .....

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2 .....

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[2]

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(iii) State a suitable statistical test that the students could use to find out if the difference in reaction times between males and females of the same age was significant.

Give a reason for your answer.

name of test .....

reason .....

.....

.....

[2]

(iv) Suggest a null hypothesis for the test that you have chosen in **(iii)**.

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..... [1]

[Total: 17]

2 Sperm production in humans is controlled by the hormones FSH and LH. These hormones are released from the pituitary gland in males to maintain a constant concentration in the blood.

Research has shown that sperm production in humans has decreased during the last 75 years. This research has highlighted concern about the fertility of future generations.

(a) Assessments of fertility are carried out on diluted semen samples. The samples are checked for number of sperm per mm^3, motility and abnormal structure.

Fig. 2.1 shows sperm in one part of a haemocytometer grid used for counting sperm. The microscope illumination causes the sperm heads to fluoresce.

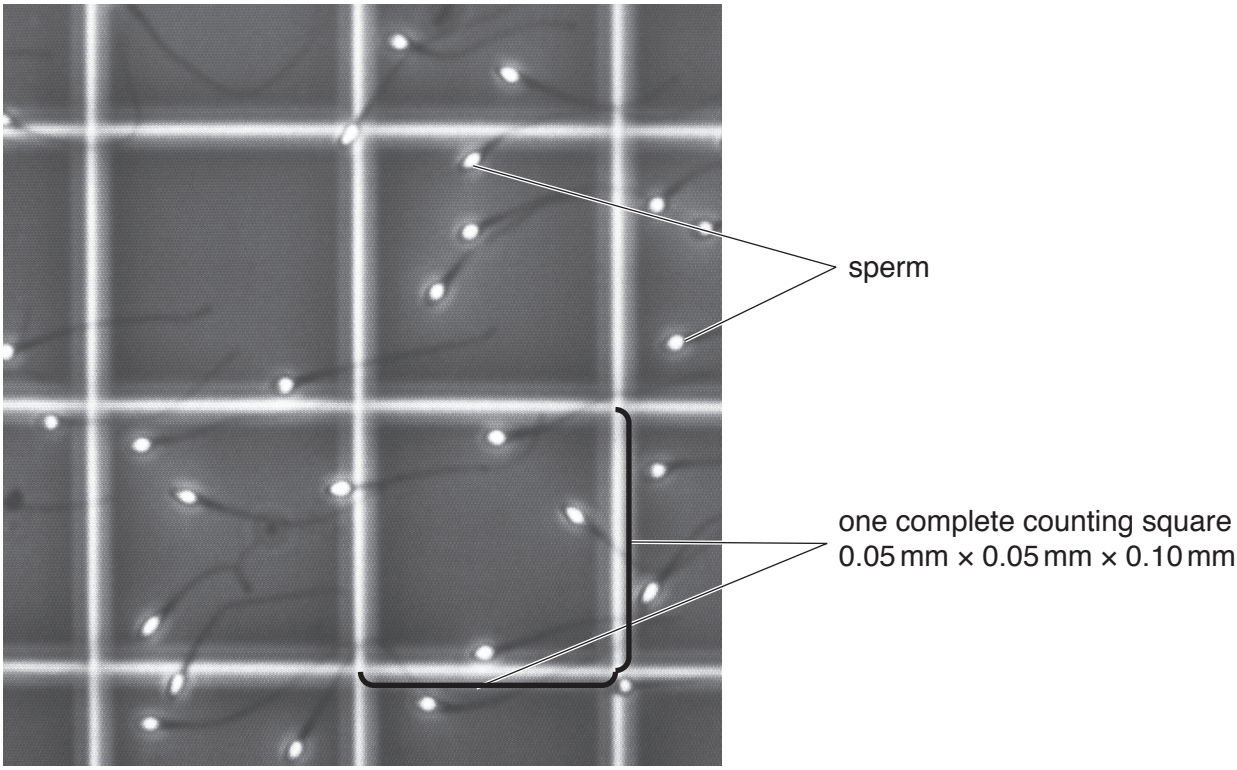


Fig. 2.1

The semen sample shown in Fig. 2.1 was diluted by a factor of 100.

(i) Describe a method by which the number of sperm present in this **diluted** sample could be estimated.

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..... [2]

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(ii) Describe how you could estimate the number of sperm per mm^3 in the original, **undiluted** semen sample.

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..... [3]

(iii) Suggest why this method of counting sperm may not represent the actual number of sperm in the original, **undiluted** semen.

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..... [2]

(b) Hormone imbalances can result in reduced sperm production and immobile sperm, leading to infertility.

A study was carried out on 120 men with different causes of infertility.

All the subjects were non-smokers, did not drink alcohol and did not take any medication for 6 months before the study.

The concentrations of the hormones FSH and LH were measured in each man.

Semen samples were collected and tested within 2 hours of collection. The number of sperm per mm^3 were estimated and the motility of the sperm assessed.

(i) Identify **two** variables that **have been** standardised in this study.

1 .....

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2 .....

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[2]

Fig. 2.2 shows the concentration of FSH and LH in four test groups. In one test group, the men are fertile and in the other three groups, the men show different types of infertility.

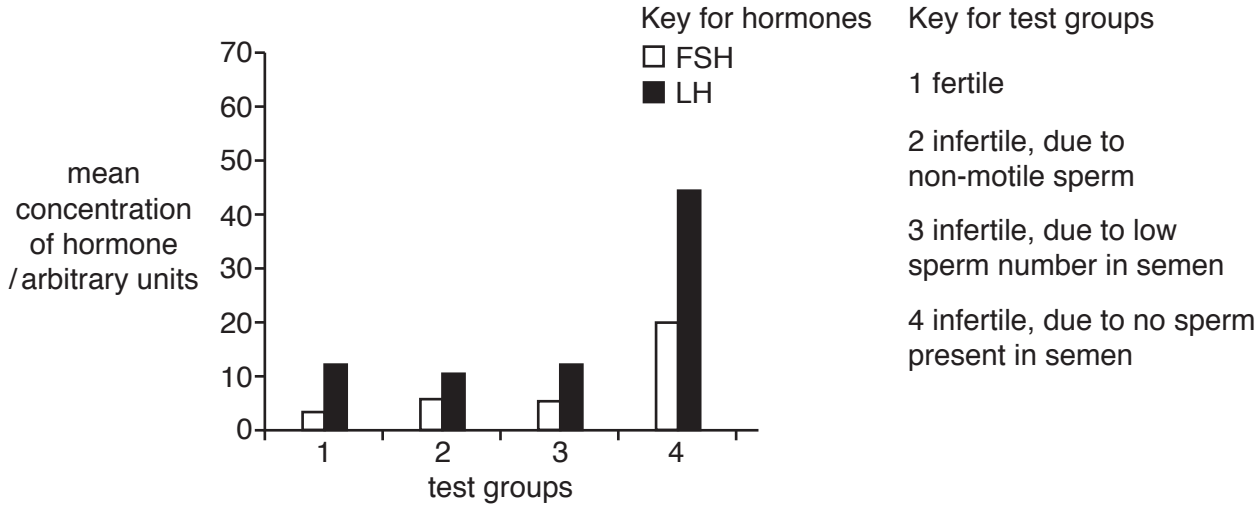


Fig. 2.2

(ii) State the reason for including the hormone concentrations of fertile men in Fig. 2.2.

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..... [1]

(iii) State **one** conclusion about the effect of FSH and LH on infertility in men that is consistent with the results of this investigation.

.....

..... [1]

(c) Semen samples may also be tested for viability of sperm. Viability is the proportion of live sperm present in semen samples.
Viability of sperm can be tested using a chemical which stains living cells a different colour to dead cells.

Suggest a method, using this stain and a haemocytometer, that could be used to test the viability of sperm in a semen sample.

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..... [2]

[Total: 13]

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BIOLOGY **9700/53**

Paper 5 Planning, Analysis and Evaluation **May/June 2019**

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1 One method of testing a person's reaction time is to use an online, computer click timer test. Some students carried out a test using the method described.

- Each student looks at a computer screen and clicks a **start** button on the screen and waits for the background colour to change.
- As soon as the background colour changes the student clicks a **stop** button on the screen.
- The reaction time appears on the screen.

A student in the class thought that boys had a faster reaction time than girls.

A group of students from the class decided to repeat the test to investigate the hypothesis:

Boys have a faster reaction time than girls.

(a) (i) Identify the independent variable **and** the dependent variable in this investigation.

independent .....

dependent ..... [2]

(ii) State the type of qualitative variable which best describes the independent variable.

..... [1]

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(iii) Describe a method the students could use to collect the data needed to test their hypothesis.

Your method should be set out in a logical order and be detailed enough for another person to follow.

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(iv) Suggest **one** feature of the online test which may be a source of error.

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..... [1]

Another group of students decided to test the hypothesis:

Right-handed people have a faster reaction time with their right hand than with their left hand.

Table 1.1 shows their results.

Table 1.1

student	reaction time using right hand / s	reaction time using left hand / s
A	0.26	0.28
B	0.23	0.23
C	0.22	0.25
D	0.25	0.22
E	0.26	0.27
F	0.24	0.24
G	0.28	0.26
H	0.25	0.30
I	0.21	0.25
J	0.26	0.29
K	0.27	0.31
mean	**0.25**	**0.26**
mode	**0.26**	
median		**0.26**

(b) Complete Table 1.1 to show the mode and median values. [1]

(c) **(i)** The students decided to carry out a *t*-test to find out if the difference in reaction time was significant.

State why a *t*-test is suitable for these data.

.....

..... [1]

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(ii) State a null hypothesis for this test.

.....

.....

.....

..... [1]

(iii) State the number of degrees of freedom for this *t*-test.

.....

..... [1]

Table 1.2 shows the probability values of *t*.

Table 1.2

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

(iv) The students concluded that the difference in reaction time was **not** significantly different.

State what this tells you about their calculated value of *t*.

.....

..... [1]

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One student noticed that the more repetitions of the online test that were carried out, the faster the reaction time. The student decided to carry out a different test to investigate the effect of repetition and feedback on the accuracy of carrying out a task.

Three students each carried out a task which involved drawing straight lines, without using a ruler, on sheets of paper.

The three students did the task in separate rooms.

- Each student drew 20 straight lines, as close as possible to 7.5 cm long, on separate pieces of paper.
- The teacher measured all the lines and recorded the lengths to the nearest 0.1 cm in a table.
- The teacher gave feedback to each student by telling them the actual length of line 20.
- Each student then drew another 20 lines which were measured by the teacher and recorded in the table.

Table 1.3 shows the data that the teacher recorded.

Table 1.3

line	length of measured line before feedback / cm				length of measured line after feedback / cm		
	student 1	student 2	student 3		student 1	student 2	student 3
1	7.2	5.0	7.3		7.9	7.5	5.2
2	7.5	4.3	7.4		7.0	7.2	5.2
3	7.4	4.0	7.7		7.5	7.7	5.2
4	7.5	3.9	7.9		7.3	7.6	4.9
5	8.0	4.2	8.2		7.0	7.3	6.3
6	7.5	4.3	8.8		7.2	7.7	6.5
7	7.5	4.0	8.8		7.0	7.4	6.3
8	7.2	4.0	9.5		7.2	8.0	6.2
9	7.1	4.4	9.3		7.0	7.6	6.2
10	7.4	3.8	9.0		7.1	7.2	5.7
11	7.2	7.9	9.3		7.0	7.5	6.7
12	7.4	4.0	8.8		7.0	6.8	6.6
13	7.5	4.2	9.7		7.6	7.2	6.6
14	7.5	4.0	9.7		8.0	7.6	6.6
15	7.4	4.2	10.0		8.0	7.4	6.4
16	6.5	4.1	10.0		8.2	7.4	6.6
17	6.7	4.4	9.6		7.9	7.0	6.5
18	6.8	4.0	9.8		8.5	7.5	6.2
19	7.9	4.2	9.7		7.8	7.7	6.9
20	7.5	4.0	10.2		7.5	7.6	6.1
mean ± *s*	**7.3 ± 0.36**	**4.2 ± 0.26**	**9.0 ± 0.90**		**7.5 ± 0.47**	**7.4 ± 0.27**	**6.1 ± 0.59**

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(d) When one of the students was drawing one of their lines, a person entered the room and distracted them. It was decided this result was anomalous.

(i) Indicate, by drawing a circle on Table 1.3, the length which is an anomalous result. [1]

(ii) Suggest what the students should do with the anomalous result.

.....

..... [1]

(iii) Identify the student who drew lines that were most **inconsistent** in length **and** give a reason for your choice.

student .....

reason ..... [1]

(iv) The student concluded that receiving feedback on performance leads to an improvement in accuracy.

State **one** way in which the data support the conclusion **and** one way in which it does not.

supports .....

.....

.....

does not support .....

.....

.....
[2]

[Total: 20]

2 For many years, farmers have used artificial insemination (AI) as a method to improve the milk yield of dairy cattle.

In cattle, sperm cells carrying the X chromosome contain 3.8% more DNA than the sperm cells carrying the Y chromosome. Female cattle have the sex chromosomes XX.

Assisted reproduction programmes allow dairy farmers to increase the number of female offspring produced.

One technique used to identify which sex chromosome a sperm cell contains is centrifugation.

Some semen samples were collected from male cattle.

- 10 cm^3 samples of semen were placed in centrifuge tubes with 15 cm^3 of a buffer solution added to each tube.
- The tubes were placed in a centrifuge and left to spin for 20 minutes at 1275 revolutions per minute.
- The spinning causes the sperm cells containing the X chromosome to fall to the bottom of the tubes. The sperm cells containing the Y chromosome remain in the fluid at the top.

Semen samples which have been processed in this way are referred to as sexed samples.

(a) (i) State **three** variables which were standardised in this technique.

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2 .....

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3 .....

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..... [3]

(ii) Suggest **one** reason why it is important that the semen sample is **not** spun at a very high speed.

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..... [1]

Another method of sexing semen samples is to use a technique called flow cytometry as shown in Fig. 2.1.

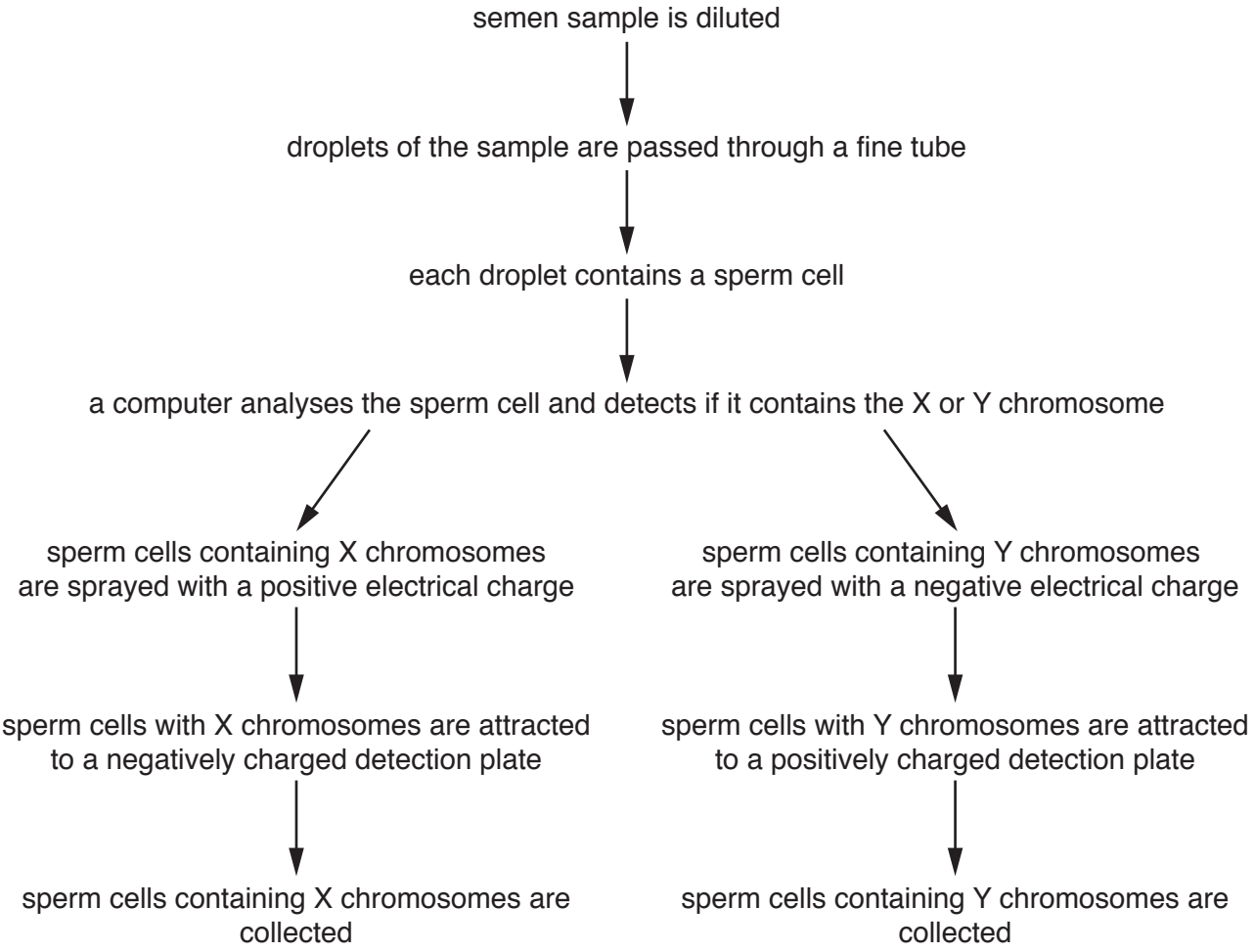


Fig. 2.1

The samples containing X chromosomes are frozen in small plastic straws, allowing semen samples to be stored for many years and transported all over the world.

- Flow cytometry can process 8000 sperm cells every second.
- One straw can hold 2.0×10^6 sperm cells.

(b) Calculate how many straws can be filled every hour by flow cytometry.

Number of straws filled every hour = ... [1]

The semen is analysed by technicians to determine its quality before it is sexed.

Technicians use microscopy to look at the appearance and motility of the sperm cells and to estimate the sperm count.

Fig. 2.2 shows the surface view of a haemocytometer used to estimate the number of sperm cells in a sample.

The depth of the haemocytometer is 0.1 mm.

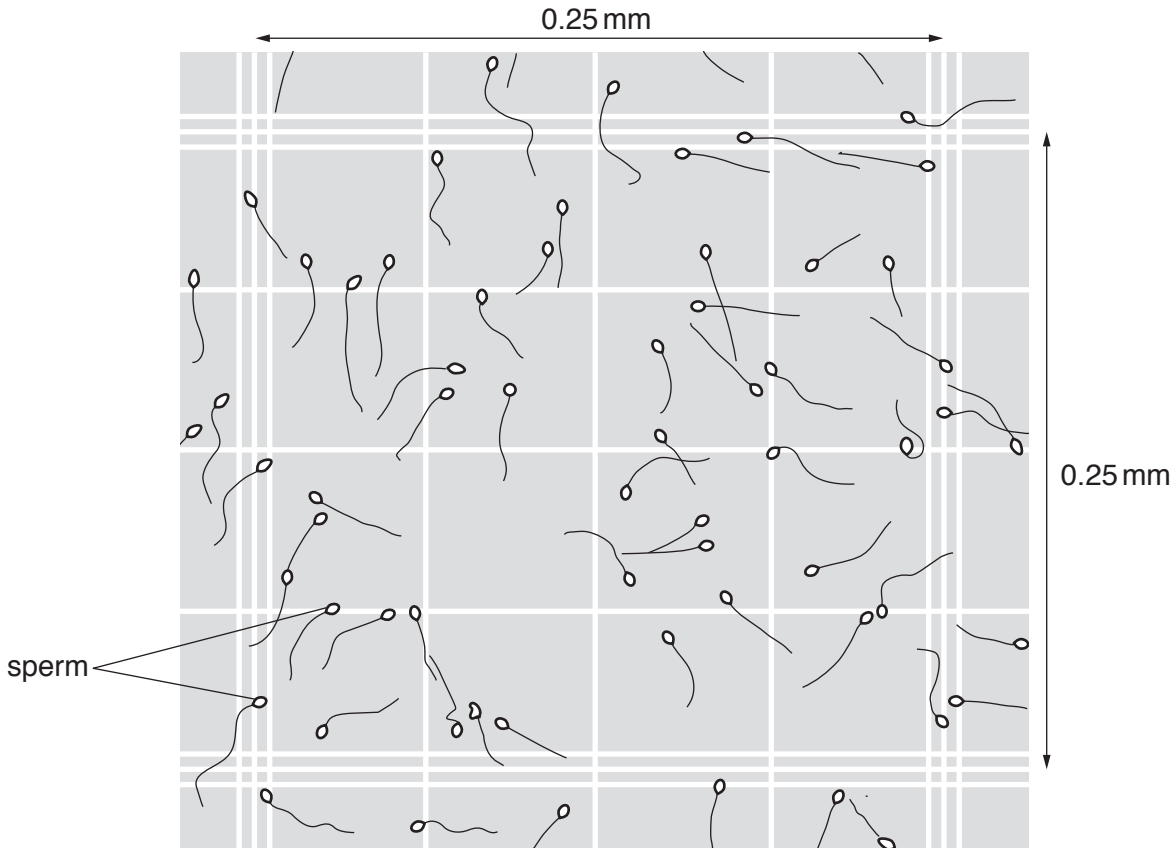


Fig. 2.2

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(c) Suggest how this apparatus could be used to estimate the number of sperm cells per cm^3 of semen **and** describe how the technician decided which sperm cells to include in the count.

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..... [5]

[Total: 10]

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