Duncanrig Secondary School
Biology Department

A Toolkit for Tackling Problem Solving in Biology

Contents

Calculating an average:

An average is the result that you get when you add two or more numbers together and divide the total by the number of numbers you added together.

1. Add (total) all of the numbers in the set you want to average.
2. Count how many individual values are in the set of numbers.
3. Divide step 1 by step 2

Example 1

House	**Number of pupils**
Kestrel	190
Falcon	231
Merlin	180
Osprey	200
Harrier	199

Step 1. Total 190+231+180+200+199 = 1000

Step 2 We have 5 groups of numbers

Step 3 1000 ÷ 5 =200

Example 2

Name of pupils	Height (cm)
Blair	125
Grant	134
Emma	123
Naomi	131
Colin	148

Total (step 1)	661
Groups of numbers (step 2)	5
Average (step 3)	661 ÷ 5

Average =	132.3 (to one decimal place)

(If you are calculating an average that may have a decimal place i.e. height, age, time ect, then your answer must be expressed to the **first decimal place**)

Averages questions to try

1. I added up the heights of boys in a 4th year class and found they were 156cm, 148cm, and 2 at 152cm. What was the average height?

   _____cm

2. Looking at seed germination in 3 experiments:
   5 seeds germinated in the first, 7 in the second and 3 in the third. What was the average number of seeds fertilised?

   _____

3. The number of household gas accidents in Canada was found to be 12 last year, 15 in Britain and 3 in France. What was the average number of accidents?

   _____

Calculating a Ratio:

A ratio is a comparison between two quantities and is always expressed as a simple whole number ratio i.e. 1:2 rather than 2:4

Distance (miles)	2	4	6	8	10	12
Number of pupils	600	200	120	80	44	6

Q- Calculate the ratio of pupils that live 2 miles away from school to those that live 12 miles away:

Number of pupils that live	
2 miles away	12 miles away
600	6
600 ÷ 6*	6 ÷ 6*
100	1
100:1	

Example 2

Total oxygen stored (%)			
	In the lung capillaries	In muscles	In the rest of the body
King Penguins	10	25	65
Humans	75	3	22

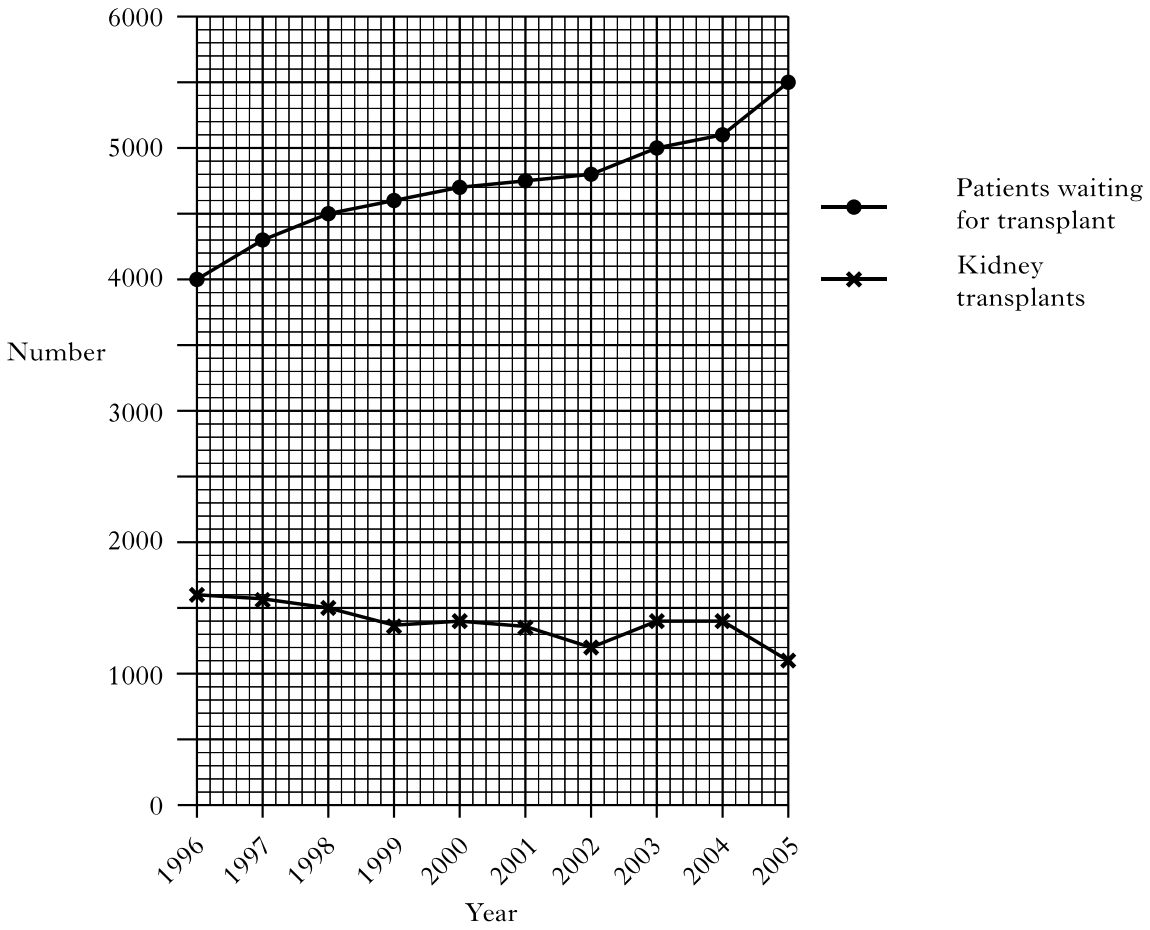
Q- Calculate the ratio of oxygen stored in the **lung capillaries** of humans to that stored in the lung capillaries of the King Penguin. Express as a simple whole number ratio.

Lung capillaries	
Human	King Penguin
75	10
75 ÷ 10	10 ÷ 10
7.5	1
7.5 :1 not a simple WHOLE number ratio	
15:2	

* Divide both by the smaller number. However, sometimes the smallest **whole** number ratio will be, for example 15:2 rather than 7.5:1, as 7.5 is not a whole number.

Ratio questions to try

Question 1



This is a slightly different average question

i) Calculate the average yearly increase in the number of patients waiting for a transplant from 2000 to 2005

Average yearly increase _____ patients per year

ii) Calculate the simple whole number ratios of patients waiting for a transplant to the number of kidney transplants carried out for 1996 and for 2005

1996 _____ : _____

2005 _____ : _____

patients waiting for for a transplant	transplants carried out

Question 2

You may also be asked to calculate an average increase or decrease over a set period of time. You must first calculate the increase or decrease and then divide by the length of time.

Time (minutes)	Glucose concentration (mg/ml)
0	12
5	27
10	40

Calculate the average increase in glucose concentration per minute.

Question 3

Christine measures the heights of the members of the eco-group and produces them in the tables below. There are 6 girls and 2 boys in the eco-group.

Height (cm)							
150	147	175	163	146	158	145	167

a) Calculate the average height of the eco-group?
b) What is the simple whole number ratio of boys to girls in the eco-group?
c) What is the simple whole number ratio of the first height measured to the third height measured?
d) Calculate the difference in height between the tallest and the shortest person in the eco-group.

Ratio quick questions

4. What is the ratio between 15 diabetic, 10 anaemic and 25 leukaemia sufferers?

_____ : _____ : _____
Diabetes Anaemia Leukaemia

5. The biology department spends £160 a week, the chemistry department spends £120 a week and physics department spends £160 a week. Write these as a ratio.

_____ : _____ : _____
Biology Chemistry Physics

6. After exercising for 4 minutes, Al's breathing rate is 16bpm but Louise's is 24 bpm. What is the ratio of Louise's breathing rate to Al's?

Calculating a percentage

A percentage is a way of expressing a number as a fraction (per cent meaning per hundred).

Divide the given number by the total number and then multiply the answer by 100 to get the percentage.

Example 1

House	Number of goals scored in inter-house football
Kestrel	20
Falcon	17
Merlin	29
Osprey	12
Harrier	14
Total	**92**

Q-Calculate the percentage of goals scored by pupils in Falcon house.

Divide the number of goals scored by Falcon house (17) by the total number of goals scored (92) then multiply by 100.

17 ÷ 92 x 100 = 18.5% (to one decimal place)

Example 2

Stage	A	B	C	D
Time (minutes)	88	33	25	54

Q-What percentage of the total time for mitosis is spent in stage C?

Stage C= 25 min

Total stages = 200 min

25 ÷ 200 = 0.125

0.125 x 100 = 12.5% (to one decimal place)

Percentage questions to try

Question 1

The following table gives information on the reproduction rates for various animals

Eggs or young	Animal	Average number produced per year
Eggs	Cod	6 million
	Frog	800
Young	Blackbird	5
	Robin	4

1a) On average, two eggs from each female frog must survive to breeding age to keep the population constant.
What percentage of this frog's total egg production does this represent?

_____ %

1b) On average a Robin lays 5 eggs per year. Use the information from the table to calculate the % of young Robin that survive.
_____%

1c) On average 200,000 of the eggs produced by a cod per year will be fertilised. What percentage of the total eggs produced per year is this?
_____%

Question 2

2 out of 50 people are likely to develop high blood pressure in Scotland. What percentage is this?

_____%

Calculating a percentage change:

A percentage change can be positive (% increase) or negative (% decrease)

1. Find the difference between the two values by subtracting the starting (initial) value from the final value, or the final value from the starting value to get the difference between the two values.
2. Divide the difference (amount of change) by the starting value
3. Multiply by 100 to give a percentage

Final Value - Starting value = Difference
Difference ÷ Starting value x 100

Example 1

Up until the 1970s the words population remained steady at around 2.5 billion. It is rapidly increasing and by 2050 the projected figure is 8.7 billion.

Q- Calculate the percentage increase

Step 1. Final value (8.7) - staring value (2.5) = difference (6.2)

Step 2. Difference (6.2) ÷ starting value (2.5) = 2.48

Step 3. Multiply by 100 to get % = 248% increase

Example 2

The table below shows how exercise at different work rates affects heart rate, breathing rate and the lactic acid concentration in the blood.

Work rate (watts)	Heart rate (beats/min)	Breathing rate (breaths/min)	Lactic acid concentration (mg/l)
0	76	12	1.0
40	92	13	1.5
80	112	15	1.8
120	132	16	3.5
160	156	18	4.5
200	172	30	9.0

Q- Calculate the percentage increase in lactic acid concentration as the work rate increases from 0 to 200 watts.

Watts	Lactic acid concentration
0	1.0
200	9.0

0 ----- 200
1.0-----9.0

Final Value - Staring value = difference
Difference ÷ Starting value x 100

9.0 - 1.0 =8.0 (difference)

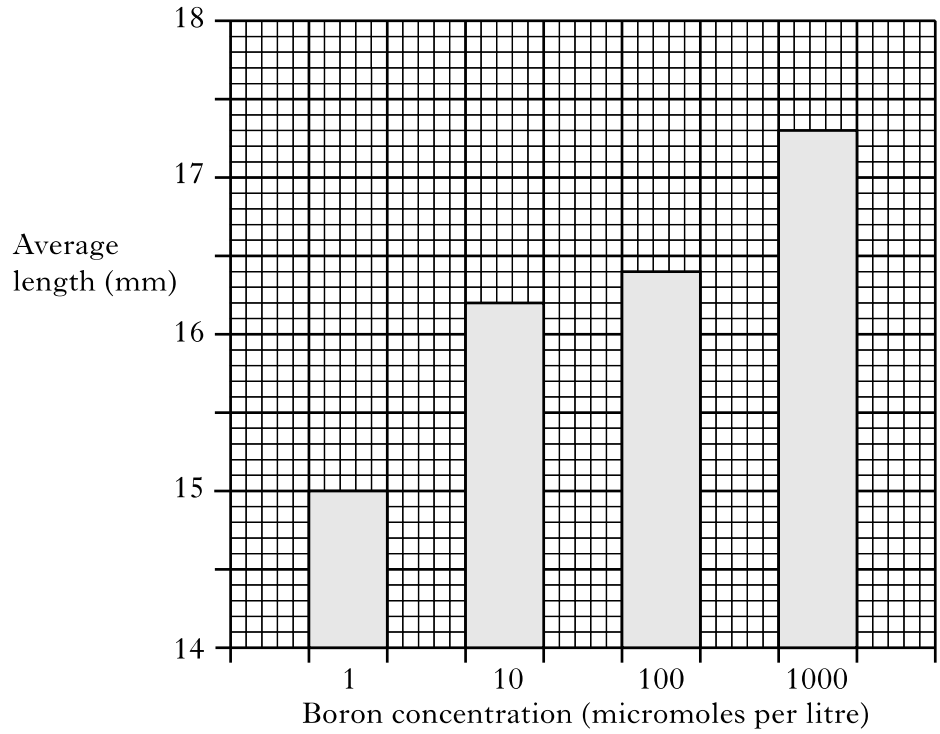
8.0 ÷ 1.0 =8.0 (difference ÷ start)

8x100 = 800% increase

Percentage change questions to try

Question 1

The graph shows the average lengths of the young trout three weeks after hatching.



i) Calculate the percentage change in the average fish length when the boron concentration is increased from 1 micromole per litre to 10 micromoles per litre.

_____%

ii) Calculate the percentage change in the average fish length when the boron concentration is increased from 10 micromoles per litre to 100 micromoles per litre.

_____%

Question 2

In an investigation into the elasticity of tendons and ligaments, weights were hung on a sample of each. The length of the tendon and ligament was measured each time a weight was added.

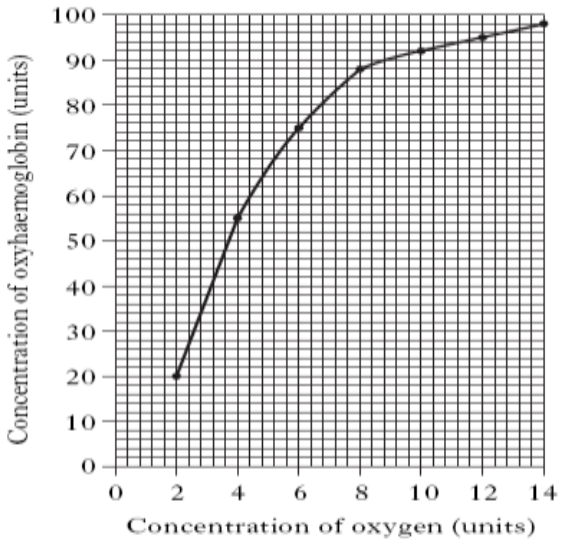
The results are shown in the table.

Number of weights	*Length of tendon* (mm)	*Length of ligament* (mm)
0	50	50
1	51	51
2	51	52
3	52	53
4	52	53
5	52	54
6	52	54

Calculate the percentage increase in the length of each tissue at the end of the investigation.

Question 3

21. The graph below shows the relationship between oxygen concentration and the concentration of oxyhaemoglobin.



What is the percentage increase in the concentration of oxyhaemoglobin when the concentration of oxygen increases from 2 units to 4 units?

A 2

B 35

C 55

D 175

Common question…
Why was a percentage change calculated?
A percentage change is calculated if the starting numbers are different which **allows you to compare the results.**

Converting a percentage

(To convert a percentage back into a value)

Step 1. Divide the percentage by 100
Step 2. Multiply by the total number.

Example 1.

Q- There are 185 forth year pupils at Alva Academy, 60% of them at taking standard grade Biology. 75% of S4 pupils are taking Biology and Chemistry. However, only 0.5% of S4 pupils are taking all 3 sciences. Calculate the number of S4 pupils taking Biology and Chemistry.

75% of 185
75 ÷ 100 = 0.75
0.75 x 185 = 138.25
= 138 pupils

Questions to try

1.

Eggs or young	Animal	Average number produced per year
Eggs	Cod	6 million
	Frog	800
Young	Blackbird	5
	Robin	4

1a) Only 2% of the eggs produced per year by a female cod survive to breeding age. Calculate the exact number of cod that survive.

Drawing Graphs:

[[ALWAYS USE A RULER AND A PENCIL]]

When you are drawing graphs you must make sure that you;

1) Draw axes clearly with a ruler

2) Label axes including the quantity involved (e.g: mass, distance, time etc) AND include units (e.g: kg, m, s etc).

3) Use an appropriate and even scale.

4) Fill over 50% of the graph paper.

5) Plot points on the graph using small and neat points.

6) Join plotted points with a ruler.

BUT!!! How do I know when to use a line graph or a bar graph??

Answer:

Line graphs should be used when comparing two sets of numbers e.g.: number of bacteria in a culture over time.

Bar graphs should be used to compare different 'things' or groups.

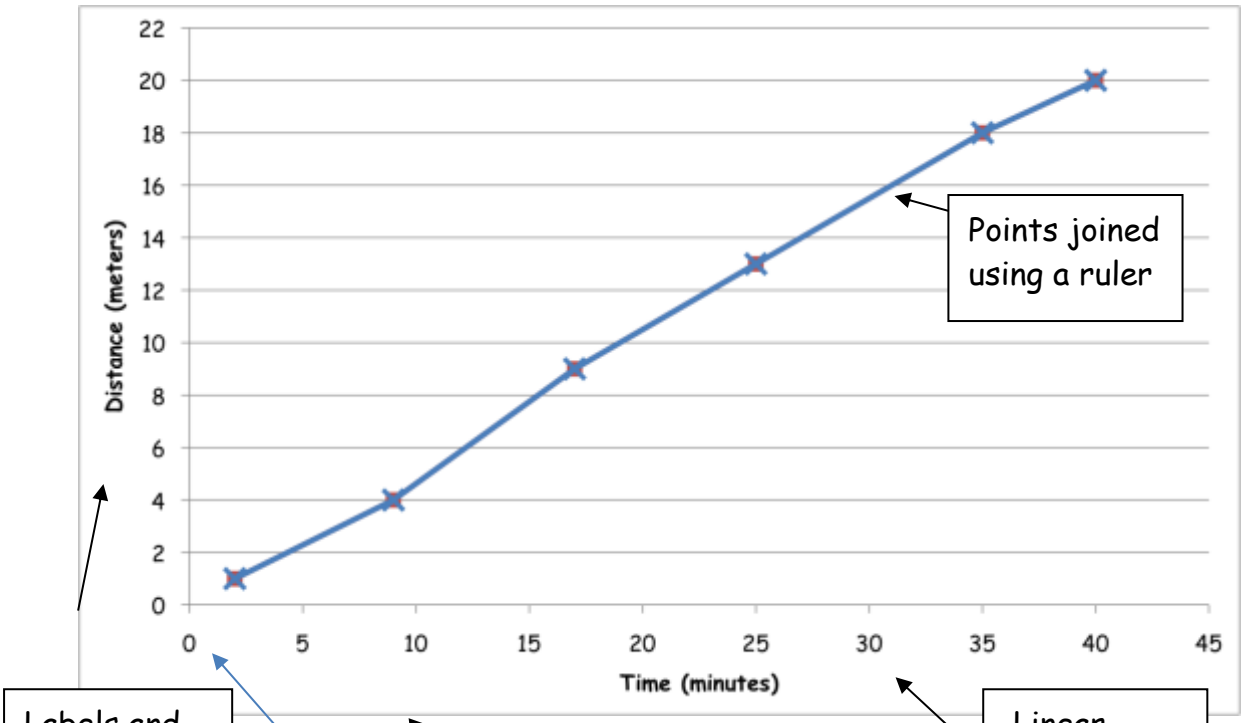
Graph Checklist
S- Scale and size
L- Labels (get your label from the table)
U- Units
R- Ruler
P- Plotting

Line graphs

Points should be clearly marked with an X

In biology always join points up using a ruler.

Only join the points that you have plotted. This means do not join your line to the origin (0) unless a value for 0 has been given.



Question

An investigation was carried out into the effect of temperature on the rate of respiration by yeast.

Results:

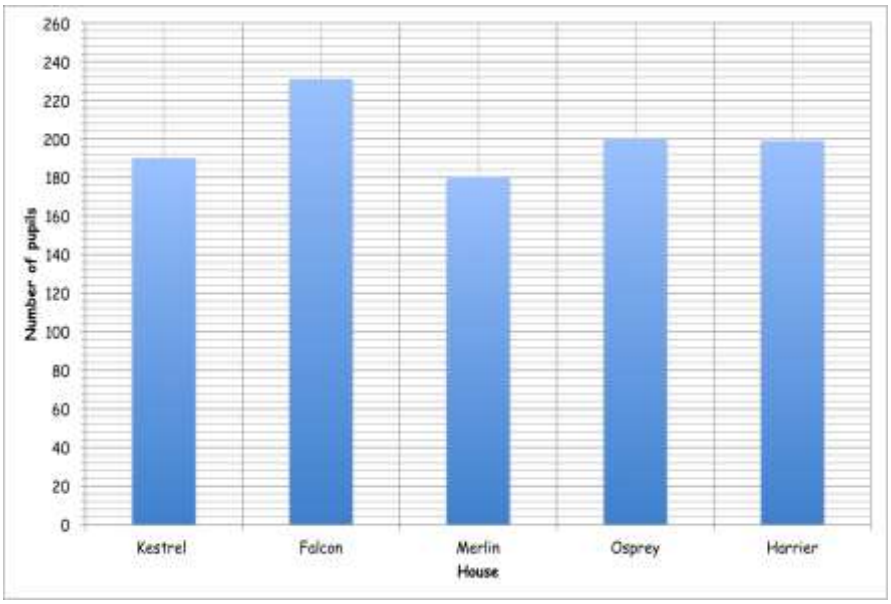
Temperature (°C)	10	20	30	40	50
Volume of gas produced in 1 hour (cm^3)	9	18	36	48	5

i) Use the results to complete a line graph to show the volumes of gas produced in one hour over a range of temperatures.

Bar charts

The top of each bar should show the value exactly.

The labels for each bar should be between the lines on the graph paper (as shown) not on the lines as the scale.

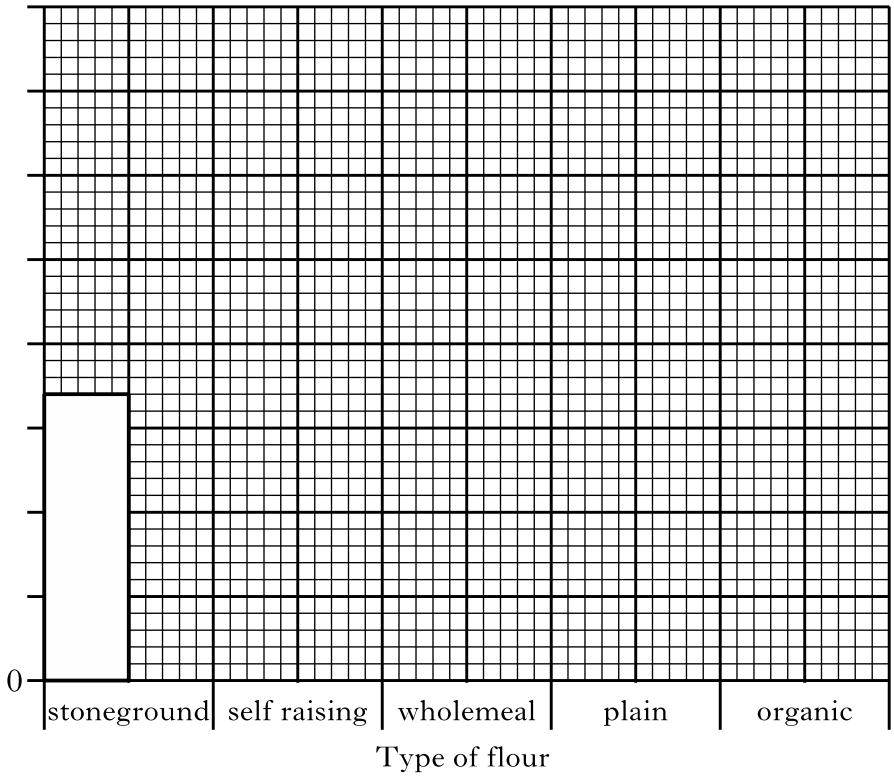


Questions to try (*Your Teacher will check your graphs!)*

Five groups of pupils carried out an investigation into flour types. Dough was made by mixing flour, sugar, water and yeast. It was then rolled into a ball which was put into a glass container and its height measured. After 24 hours the height of the dough was re-measured.

The table below shows the results. Using this table copy and complete the bar graph on graph paper from your teacher.

Type of flour	Average increase in height of dough (%)
Stoneground	34
Self raising	76
Wholemeal	68
Plain	42
Organic	56



From Paper 2008

6. The table shows the number of pilot whales caught in the Faroe islands between 1994 and 2000.

Year	*Number of pilot whales caught*
1994	1200
1995	228
1996	1500
1997	1170
1998	820
1999	610
2000	580

(*a*) (i) Construct a **bar graph** of the results given from **1996** to **2000**.

From paper 2009

The time taken to collect 1cm^3 of oxygen was recorded and the results are shown in the table below.

pH of hydrogen peroxide solution	*Time to collect 1 cm^3 of oxygen* (seconds)			*Average time to collect 1cm^3 of oxygen* (seconds)
	Trial 1	*Trial 2*	*Trial 3*	
7	76	77	81	78
8	56	58	57	57
9	50	45	40	45
10	53	50	53	52
11	59	69	70	66

(*d*) Construct a line graph of the **average** time taken to collect 1 cm^3 of oxygen against pH of hydrogen peroxide solution.

(Additional graph paper, if required, will be found on *Page thirty-two*)

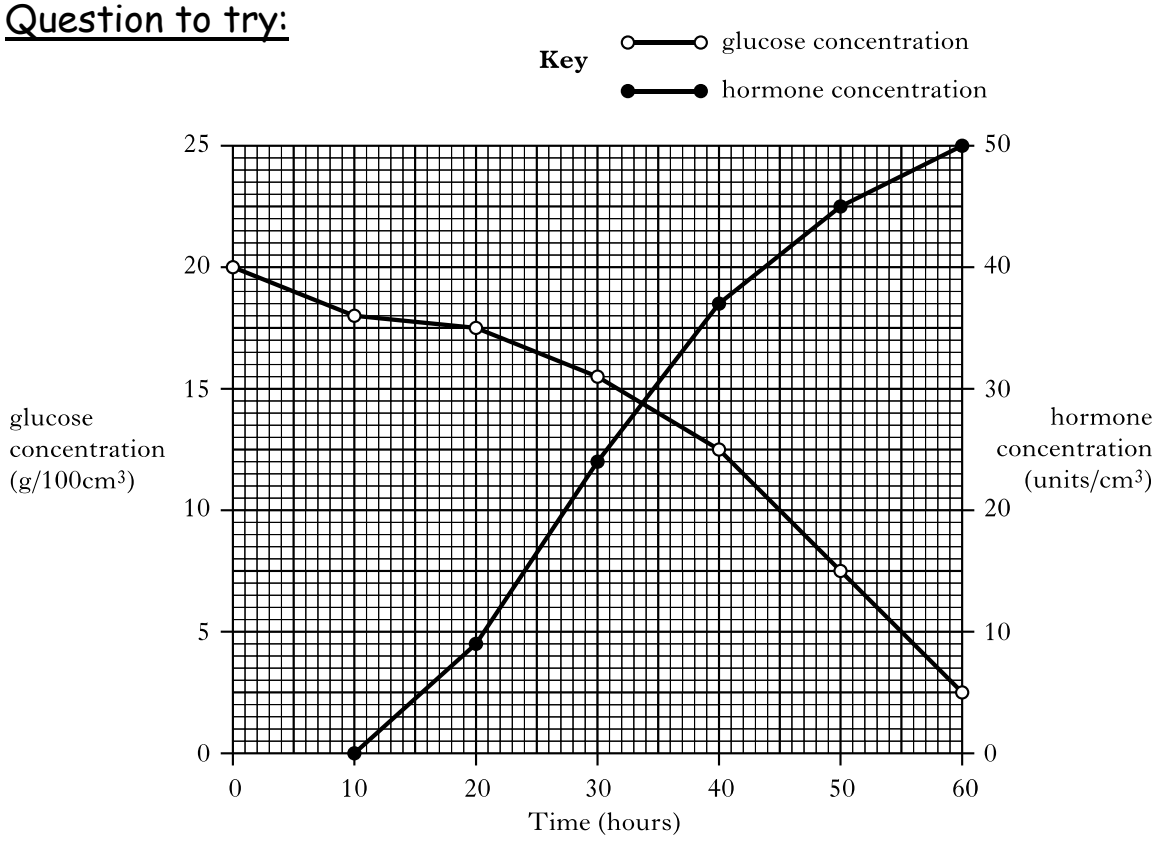
Reading from graphs/tables

Work out the scale. Is it going up in 2s, 5s, 10s?

Read the correct point in the graph. Use a ruler to accurately read the correct point.

When answering graph questions always include figures and units from the graph. Do NOT simply say the graph increased; describe the graph increased from 100 beats per minute (bpm) to 200 bpm after 5 minutes of exercise.

Question to try:



i) How many hours did it take for 50% of the glucose to be used up by the bacteria?

_____ hours

ii) During which 10-hour period was secretion of hormone the greatest?

(tick ( ) the correct box

☐ 20 – 30

☐ 30 – 40

☐ 40 – 50 hours

☐ 50 – 60 hours

iii) Calculate the total decrease in glucose concentration over the 60 hour period.

_____ g/100 cm^3

iv) If glucose continues to be used at the same rate as between 50 and 60 hours, predict how many more hours it would be before all the glucose would be used up.

_____ hours

v) During the first 10 hours of the process, energy was being used for functions other than the synthesis of the hormone.

Give two pieces of evidence from the graph to support this statement.

1 _____

2 _____

Question 2

The average production of sperm cells by a bull throughout the year is shown in the table below.

Month	Average sperm production (millions/day)	Month	Average sperm production (millions/day)
January	14,000	July	10,500
February	13,500	August	10,000
March	13,000	September	10,500
April	12,500	October	11,500
May	12,000	November	12,000
June	11,000	December	14,500

(a) Describe the pattern of sperm production over one year.

_____

(c) In May, bulls produce a daily average of 8 cm3 of fluid containing sperm cells. How many sperm cells would be contained in 1 cm3 of this fluid?

_____million

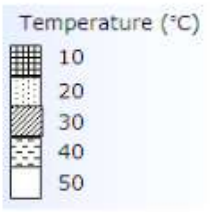
Pie charts

A pie chart is a way of illustrating a percentage.

When working out each percentage label the chart, the full chart should add up to 100%

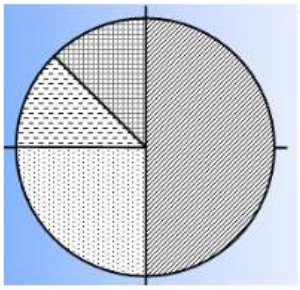
Example 1.

Temperature (°C)	10	20	30	40	50	Total
Bubbles (number/s)	3	6	12	3	0	**24**



1. Find the total =24
2. Calculate the fractions

Fraction	3/24	6/24	12/24	3/24	0/24
Simplified fraction	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{8}$	0

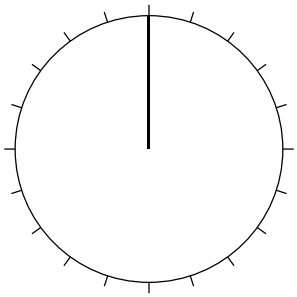


3. Mark off the sections
4. Make a key or label the sections

Question

i) The table shows the methods of disposal of the sludge obtain from sewage treatment. Use the information on the table to complete a pie chart from your teacher.

Methods of disposal of sludge	Percentage
Spread on farmland	50
Landfill	10
Dumped at sea	15
Incinerated	20
Other disposal	5



Understanding Experimental technique

Q- i) What feature of an investigation is designed to increase the reliability of the results.

_____

The experiment will be **RELIABLE** if it has been repeated exactly, it reduces the chance of an atypical result.

The experiment will be **ACCURATE** if the measurements from the equipment have been taken carefully.

The experiment is **VALID/FAIR** if only one factor has been changed and everything else has stayed the same.

Interpreting information from a passage

1) Read the passage through.
2) Read the questions, making note if it is PS or KU (in PS questions, the answer is **always** and **only** in the text, KU questions require knowledge not in the text).
3) Go back to question one and make sure you understand the key words in the question, so you can find words in the passage that mean the same (synonyms).
4) Link the question to a section in the text eg the first paragraph or lines 5—9.
5) Relate the meaning of words from the passage to the question or the synonyms you have thought of.

Key words

Words like STATE, NAME and GIVE are looking for short- one or a few word answers. –Usually worth only one mark.

Words like EXPLAIN and DESCRIBE require detailed answers- usually worth more than one mark.

Question 1

Read the following passage and answer the questions that follow.

Genetic modification (GM) of crops began with the discovery that the soil bacterium Agrobacterium could be used to transfer useful genes from unrelated species into plants. The Bt gene is one of the most commonly inserted. It produces a pesticide toxin that is harmless to humans but is capable of killing insect pests. Many new crop types have been produced. Most of these are modified to be pest, disease or weedkiller resistant, and include wheat, maize, oilseed rape, potatoes, peanuts, tomatoes, peas, sweet peppers, lettuce and onions.

Supporters argue that drought resistant or salt resistant varieties can flourish in poor conditions. Insect-repelling crops protect the environment by minimising pesticide use. Golden rice with extra vitamin A or protein-enhanced potatoes can improve nutrition.

Critics fear that GM foods could have unforeseen effects. Toxic proteins might be produced or antibiotic-resistance genes may be transferred to human gut bacteria. Modified crops could become weedkiller resistant "superweeds". Modified crops could also accidentally breed with wild plants or other crops. This could be serious if, for example, the crops which had been modified to produce medicines bred with food crops.

Investigations have shown that accidental gene transfer does occur. One study showed that modified pollen from GM plants was carried by the wind for tens of kilometres. Another study proved that genes have spread from the USA to Mexico.

(a) What role does the bacterium Agrobacterium play in the genetic modification of crops?

_____

(b) Crops can be genetically modified to make them resistant to pests, diseases and weedkillers. Give another example of genetic modification that has been applied to potatoes.

_____

Scientific Literacy

Adapted from Biological Sciences Review, Volume 30(1), September 2017

Allergy to peanuts is one of the most common allergies in the world and there is no cure. Scientists have a theory that if individuals are exposed to increasing quantities of peanuts they will build up tolerance and not develop an allergy.
In a recent trial 600 babies were given a skin test to see if they reacted to peanuts. Babies who had a negative reaction were split into two groups. Group 1 avoided eating peanuts completely and group 2 ate 6 grams of peanuts per week. Babies were retested for their reaction to peanuts when they were 5 years old.
When they were retested 3% of the children who had eaten the 6g of peanuts per week had developed an allergy to peanuts compared with 17% of children who had avoided eating peanuts completely.
This result shows that children in group 2 had developed tolerance to peanuts and that regular exposure to peanuts could be used as a preventative treatment for peanut allergies.

Questions

1. **Suggest the aim of the research described in the passage**

2. **An independent variable is one that scientists change so they can measure or observe the effect of the change.**
   Identify the independent variable in this investigation

3. **Complete the table, with suitable headings, to show the results of the investigation;**

4. **State the conclusion the scientists drew from this study.**

5. **Give a reason why it could be suggested that the results of the investigation are reliable.**

ANSWERS

Averages p2

1. 152 cm
2. 5
3. 10

Ratios p4-6

1. i. 160 ii. 1996- 5:2 2005- 5:1
2. 2.8 mg/ml
3. a. 156.4cm b. 1:3 c. 6:7 d. 30cm
4. 3:2:5
5. 4:3:4
6. 3:2

Calculating a percentage p8

1. a. 0.25% b. 80% c. 3.3%
2. 4%

Percentage change p11-12

1. i. 8% ii. 1.2%
2. tendon 4% ligament 8%
3. D

Converting a percentage p13

1. 120,000

Graphs- teacher will check!!!

Reading from graphs/tables p19-20

Question 1

i. 45 hours
ii. 20-30
iii. 17.5
iv. 5
v. 1. Glucose concentration is decreasing during this period
2.Hormone is not being produced during this period

Question 2

a. Sperm production decreased from 14000 in January to 10000 in August before increasing again to 14500 in December.
b. 1500 million

Pie charts- teacher will check!!!

Experimental technique p22

i. Reliability of the results in an investigation can be increased by repeating the experiment several times and calculating an average result.

Interpreting info from a passage

Q1

a) Agrobacterium could be used to transfer useful genes from unrelated species into plants.
b) Potatoes have been genetically modified to enhance their protein content to improve nutrition.

Scientific literacy p24

1. **Suggest the aim of the research described in the passage**
   To investigate whether/to find out if .. exposure to increasing quantities of peanuts prevents children developing a peanut allergy
   1 mark
2. **An independent variable is one that scientists change so they can measure or observe the effect of the change.**
   Identify the independent variable in this investigation
   Whether the babies were given peanuts to eat or not
   1 mark
3. **Complete the table, with suitable headings, to show the results of the investigation;**

Mass of peanuts eaten per week (grams)	*Percentage of children who developed a peanut allergy*
0/none	*17*
6	*3*

   Suitable headings and units – 1 mark, All info given in correct columns of table – 1 mark
4. **State the conclusion the scientists drew from this study**
   Eating (6 grams of) peanuts (each week)/regular exposure to peanuts …reduces the chances of a child developing a peanut allergy (from 17% to 3%)
   1 mark
5. **Give a reason why it could be suggested that the results of the investigation are reliable**
   600/many babies were tested
   1 mark