1.1 Numbers and units

pages 6–7

PRACTICE QUESTIONS

1 **a** 4 mm **b** 130 s
c 31 300 μl **d** 0.000 104 mg

2 **a** 2 500 000 cm^3
b 3000 m^3
c 5000 mm^3

3 **a** 57 μm **b** 8.6 L or 8.6 dm^3
c 68 s **d** 0.09 mm

4 **a** 0.0032 m^2
b 800 000 mm^2

5 **a** 105 **b** 2433
c 6.1 **d** 0.0051
e 0.00046

1.2 The arithmetic mean

pages 8-9

PRACTICE QUESTIONS

1 **a** $\frac{(342+289+401+321+392)}{5} = \mathbf{349}$

b $\frac{(44+32+54+41+43+52)}{6} = 44.33333 = \mathbf{44}$

This should be rounded to a whole number as all individual measurements are whole numbers.

c $\frac{(30+50+104+29+54+65+84+57+31)}{9} = \mathbf{56}$

d $\frac{(250.2+312.4+458.7+104.6+89.6)}{5} = \mathbf{243.1\ ng}$

The average figure should be given to the same level of precision as the original measurements.

e $\frac{(0.11+0.09+0.07+0.13+0.08)}{5} = 0.096 = \mathbf{0.1}$

The mean should be rounded to the same level of precision as the measurements.

2 **a** 752 s + 716 s + 722 s + 840 s + 793 s = 3823 s

$\frac{3823}{5} = 764.6 = 765\ s$

= **12 m 45 s**

b 1600 + 1200 + 800 + 960 + 2300 = 6860

$\frac{6860}{5} = 1372\ mm = 1.372\ m = \mathbf{1.4\ m}$

Rounded to 1.4 m as the individual data, in metres, were given to one decimal place.

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1.3 Arithmetic mean of grouped or tallied data

pages 10-11

PRACTICE QUESTION

1 **a** $= \frac{(0\times9)+(1\times23)+(2\times27)+(3\times40)+(4\times18)+(5\times5)}{9+23+27+40+18+5} = \frac{294}{122}$ = 2.41 = **2 bands**

b We assume the central value for each band applies to all of individuals recorded:

$\frac{(12\times22.5)+(25\times27.5)+(13\times32.5)+(5\times37.5)+(2\times42.5)}{12+25+13+5+2} = \frac{1652.5}{57}$ = 28.99 mm **= 29 mm**

c $\frac{(0\times3)+(1\times7)+(2\times16)+(3\times46)+(4\times11)}{3+7+16+46+11} = \frac{221}{83}$ = 2.66 = 3 spots

d $\frac{(12.5\times23)+(37.5\times45)+(62.5\times19)+(87.5\times8)+(112.5\times4)}{23+45+19+8+4} = \frac{4312.5}{99}$ = 43.56 = **43.6 mm**

1.4 Median and modal values

pages 12–13

PRACTICE QUESTIONS

1 **a** Rearrange the numbers into numerical order:

56, 78, 82, 95, 98, 99, 104, 107

There are eight numbers in the dataset, therefore the median will fall between the 4th and 5th, in this instance 95 and 98.

$\frac{(95+98)}{2}$ = **96.5**

b First rearrange the numbers into numerical order:

5, 8, 12, 13, 14, 17, 22

In this instance there are seven numbers in our dataset – the middle value will therefore be the fourth number:

13

c First rearrange the numbers into numerical order:

0.2, 0.8, 0.8, 1.3, 2.1

Although two of the numbers in this dataset are the same, the procedure for choosing the median is the same as previous examples.

In this instance there are five numbers in our dataset; the middle value will be the third number:

0.8

d First rearrange the numbers into numerical order:

4, 5, 6, 7, 7, 8, 10, 10, 12, 14

There are ten numbers; the median will fall halfway between the 5th and 6th numbers.

$\frac{(7+8)}{2}$ = **7.5**

2 **a** 11 **b** 0.6

c **45** and **54 –** both occur three times, but 45 also occurs three times. This dataset is bi-modal.

3 **a** **blue flowers** - 45 **b** **shoe size 40** – 6 people **c** **brown hair** – 10 people

d **clover** (15 flowers) *and* **speedwell** (15 flowers)

4 **a** mode: **8**, median: **6.5**, mean: **6**

b mode: **0.09**, median: **0.45**, mean: **0.47**

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1.5 Rearranging formulae

pages 14-15

PRACTICE QUESTIONS

1 cardiac output = stroke volume x heart rate

stroke volume = $\frac{2.7}{77}$ = **0.035 dm^3**

2 N_0 = 24

7 days = 7 x 24 hours = 168 hours

so n = 168 ÷ 20 = 8.4

Nt = 24 x 28.4 = **8107 cells**

3 N = 96 + 4 + 22 + 3 = 125 animals found

$$so\ D = 1 - \sum\left(\frac{n}{N}\right)^2$$

inner brackets:

$$D = 1 - \left(\left(\frac{96}{125}\right)^2 + \left(\frac{4}{125}\right)^2 + \left(\frac{22}{125}\right)^2 + \left(\frac{3}{125}\right)^2\right)$$

indices:

$$D = 1 - (0.768^2 + 0.032^2 + 0.176^2 + 0.024^2)$$

addition:

$$D = 1 - 0.6224$$

$D = 0.3776$ = **0.38** (to 2 d.p.)

4 Substitute in the known values:

$$0.84 = \frac{\text{biomass transfer}}{25} \times 100$$

Rearrange the equation to give:

$\text{biomass transfer} = \frac{0.84}{100} \times 25$ = **0.21 kg**

1.6 Percentages

pages 16-17

PRACTICE QUESTIONS

1 a Both parents heterozygous for the gene that causes albinism: 'Aa'
therefore 50% of the gametes produced from each parent will carry 'A' and 50% 'a'.
Offspring could have any of three genotypes AA, Aa, aa in a 1:2:1 ratio.
Albinism is a recessive trait. This means that while there is a 75% or 3:1 chance of a child carrying at least one copy if this allele, there is only a **25% or 1 in 4** chance of a child expressing the trait of albinism.

		Mother	
		A	**a**
Father	**A**	AA	Aa
	a	Aa	aa

b 67/0.27 = 248.15 = **248 people**

c $\frac{34}{670} \times 100$ = 5.07% or **5.1%**

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2 a 19.9% b 7.5%
c 62.5% d 23%

3 a 65% b 9% c 152%

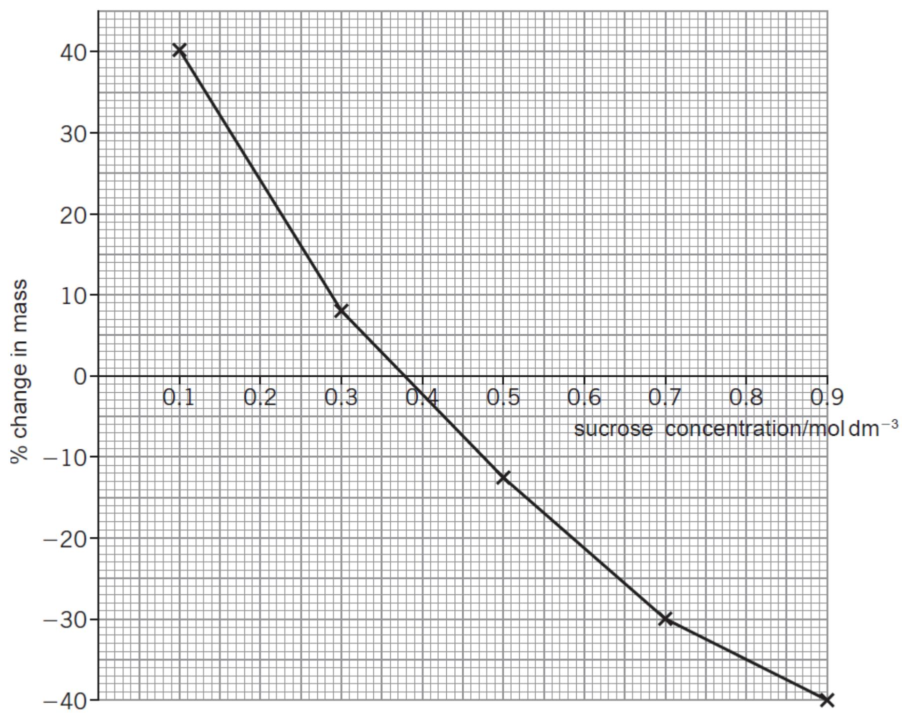
4 a 33.3% b 40% c 25%

5 a $\frac{3}{4}$ b $\frac{2}{3}$ c $\frac{1}{8}$

6

	Mass change / g	Percentage change in mass
	+0.73	+40.1%
	+0.13	+8.0%
	−0.25	−12.8%
	−0.56	−30.1%
	−0.73	−40.8%

Change in mass against sucrose concentration



1.7 Measurement uncertainties

pages 18-19

PRACTICE QUESTIONS

1 a 0.5 mm b 1 cm^3
c 0.005 g d 0.005 s
e 0.005 cm^3 f 0.05°C

2 a 47 cm^3 ± 0.5 cm^3
b 14.6 g ± 0.05 g
c 14.678 g ± 0.0005 g

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1.8 Calculating percentage error

pages 20-21

PRACTICE QUESTION

1

	Absolute error	Relative error
	0.5 mm	$\frac{0.5}{6} \times 100 = 8.3\%$
	0.5 mm	$\frac{0.5}{152} \times 100 = 0.3\%$
	0.5 mm	$\frac{0.5 \times 2}{47} \times 100 = 2.1\%$
	0.25 cm^3	$\frac{0.25}{12} \times 100 = 2.1\%$
	0.005 g	$\frac{0.005}{0.6} \times 100 = 0.8\%$
	0.005 g	$\frac{0.005 \times 2}{1.6} \times 100 = 0.6\%$
	0.5 m	$\frac{52.75}{2666} \times 100 = 2.0\%$

1.9 Decimals and standard form

pages 22-23

PRACTICE QUESTIONS

1 **a** 1×10^{2}
b 1×10^{3}
c 1×10^{4}
d 1×10^{-1}
e 1×10^{-2}
f 1×10^{-3}
g 2.1×10^{7}
h 4.35×10^{14}
i 3.9×10^{-9}

2 **a** 1 000 000
b 4 700 000 000
c 1 200 000 000 000
d 0.000 796
e 0.0083
f 0.000 000 000 0041
g 0.000 000 0039

3 **a** 1×10^{-3} m
b 1×10^{-9} m
c 1×10^{-6} m
d 1×10^{-2} m
e 2.7×10^{-2} m
f 5.647 ($\times 10^{0}$) m
g 3.99×10^{-1} m
h 2.9×10^{1} m

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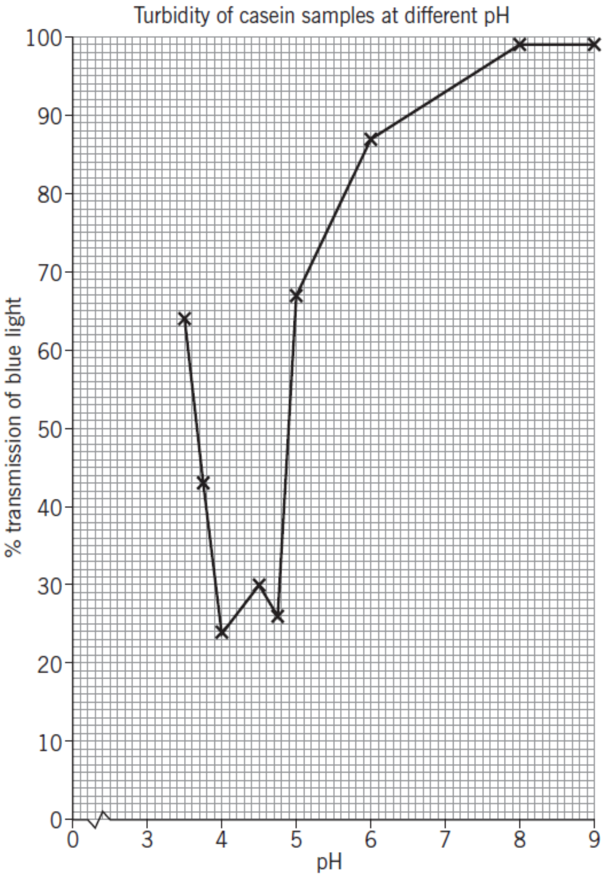
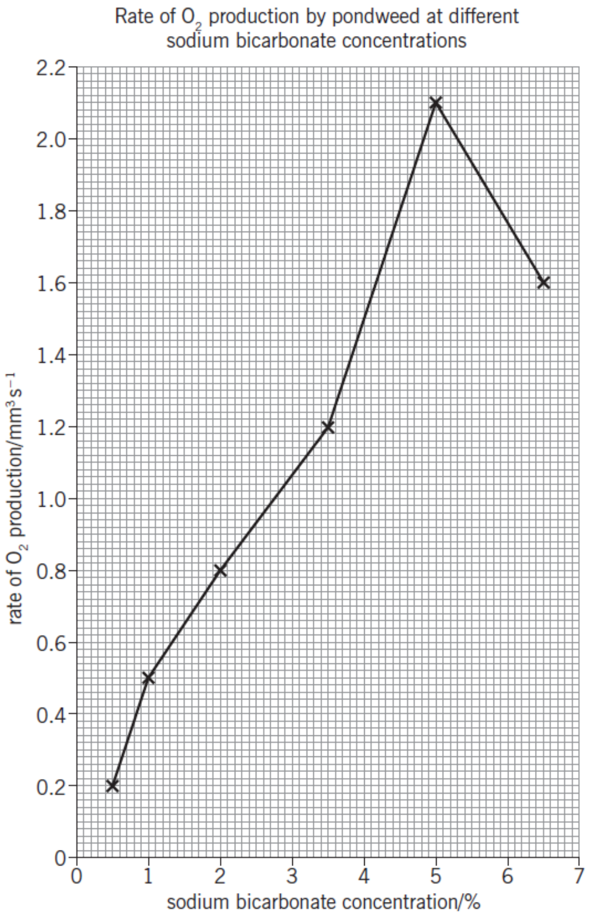
1.10 Data in line graphs

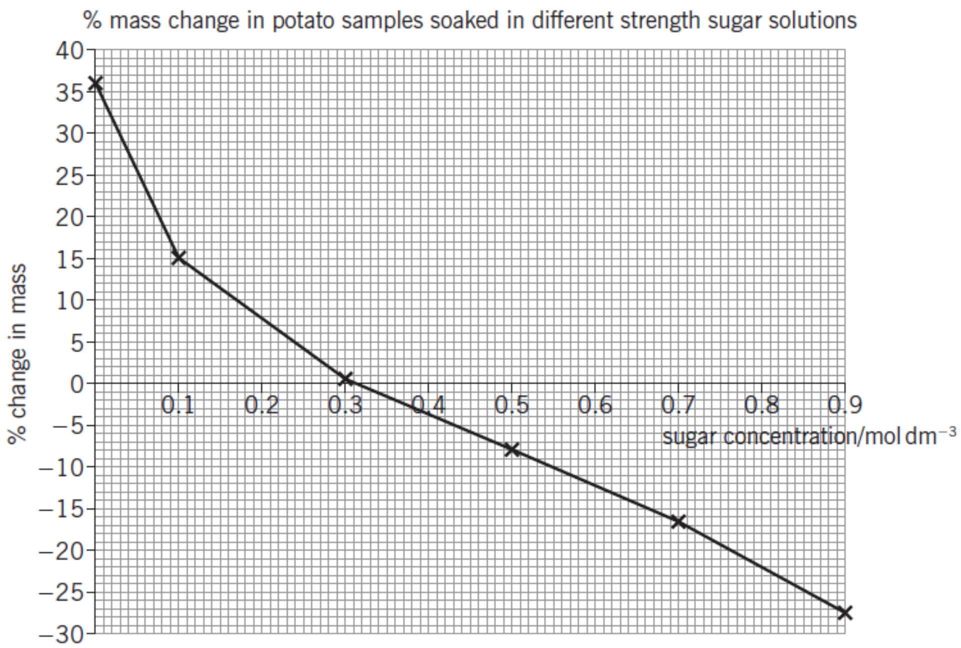
pages 24-25

PRACTICE QUESTIONS

1







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2 pH 4 is the best estimate but pH 4 looks anomalous. An acceptable answer in this case is to say **between pH 4 and 4.75**.

3 Best estimate is to use the intercept, so **0.315 mol dm^{-3}**.

Acceptable to give an answer in the range 0.31–0.32 mol dm^{-3}.

4 Suggested optimum is **5% sodium bicarbonate**.
To find this more precisely the experiment should be repeated using small intervals of sodium bicarbonate concentration between 4% and 6.5%.

1.11 Y = mx + c

pages 26-27

PRACTICE QUESTIONS

1 **a** $x = y - 3$

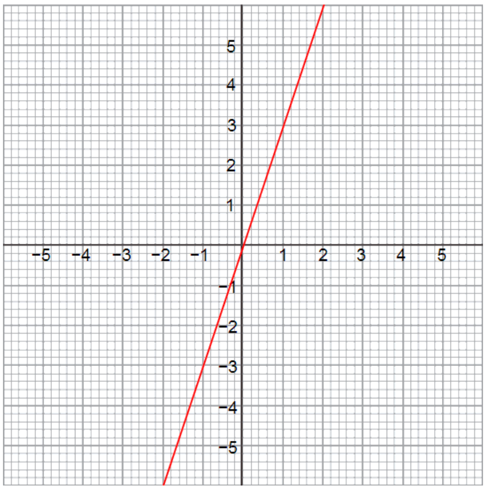
b $x = \dfrac{y}{m}$

c $3x - 2 = y$

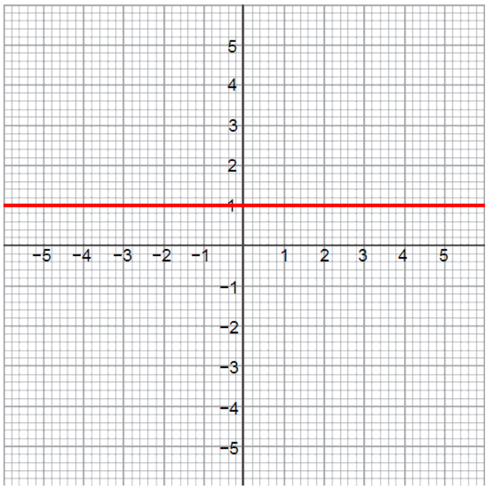
$3x = y + 2$

$\mathbf{x = \dfrac{y+2}{3}}$

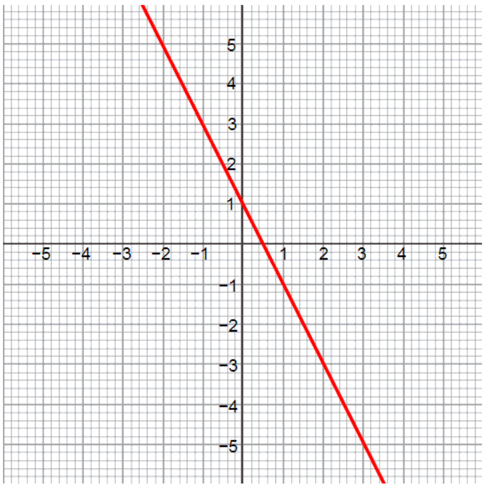
2 **a** $y = 3x - 3$



b $y = 1$



c $y = -2x + 1$



3 Highest birthweight = **Newt C**
Fastest growth rate = **Newt B**

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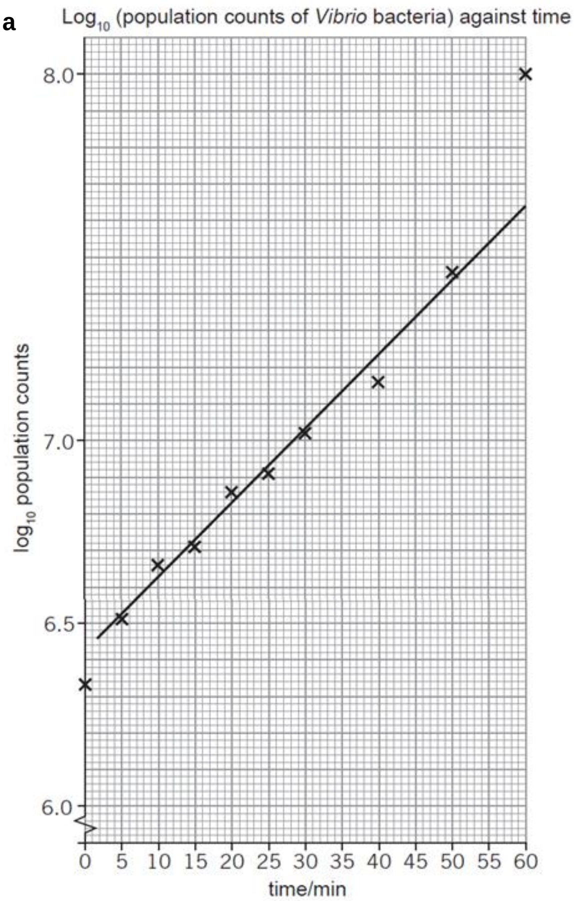
1.12 Exponential data in line graphs

pages 28–29

PRACTICE QUESTIONS

1 a

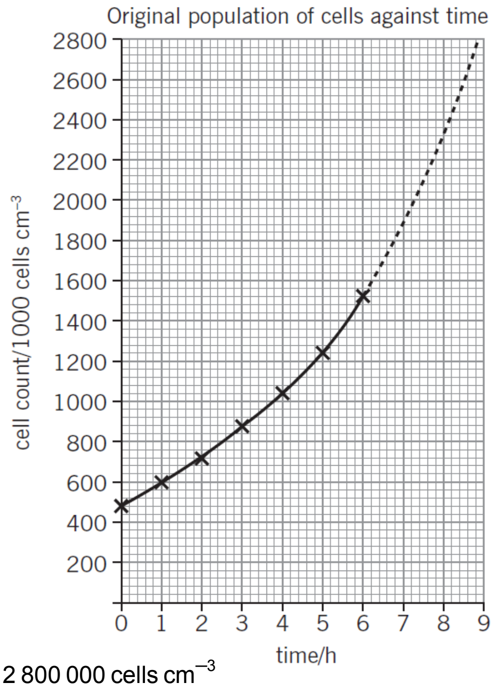


b **approximately 9 million cells (± 3 million)**.

The figure at 60 minutes should be treated as an anomaly.

c **approximately 7 × 10^8 cells** (depending on line of best fit)

2 a



b 2 800 000 cells cm^{-3}

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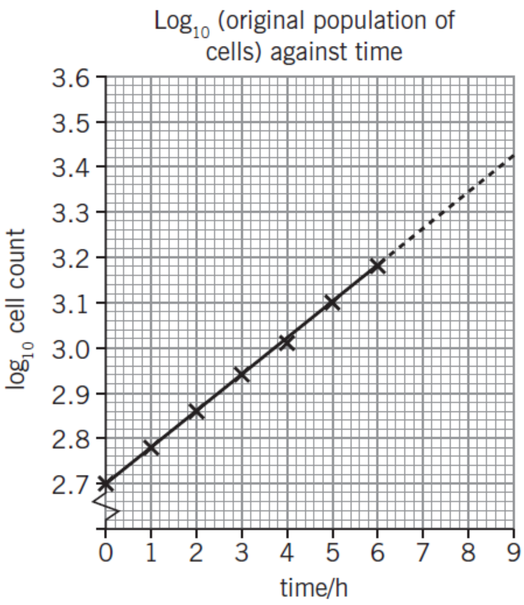
c



d 2 630 000 cells cm^{-3}

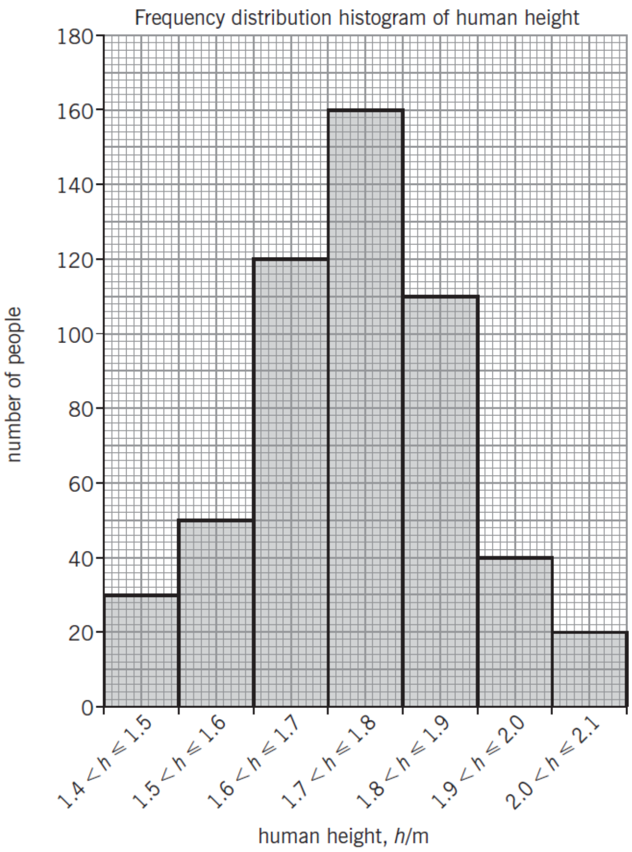
e Estimate is much easier using logs; it is much easier to extrapolate a straight line.

1.13 Normal distribution

pages 30-31

PRACTICE QUESTIONS

1



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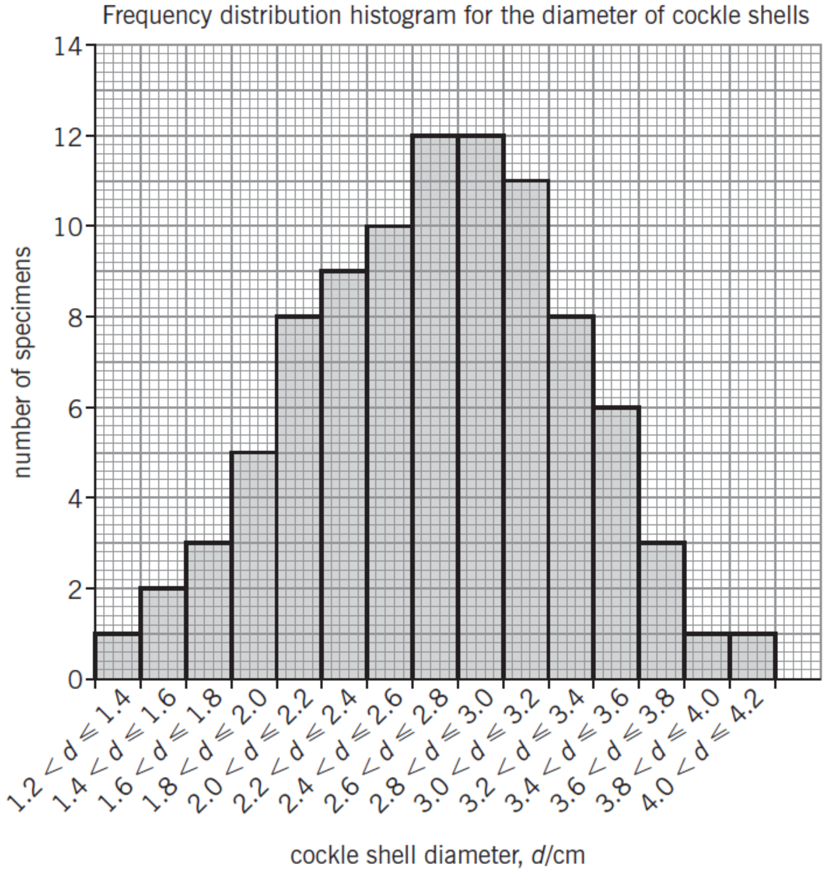

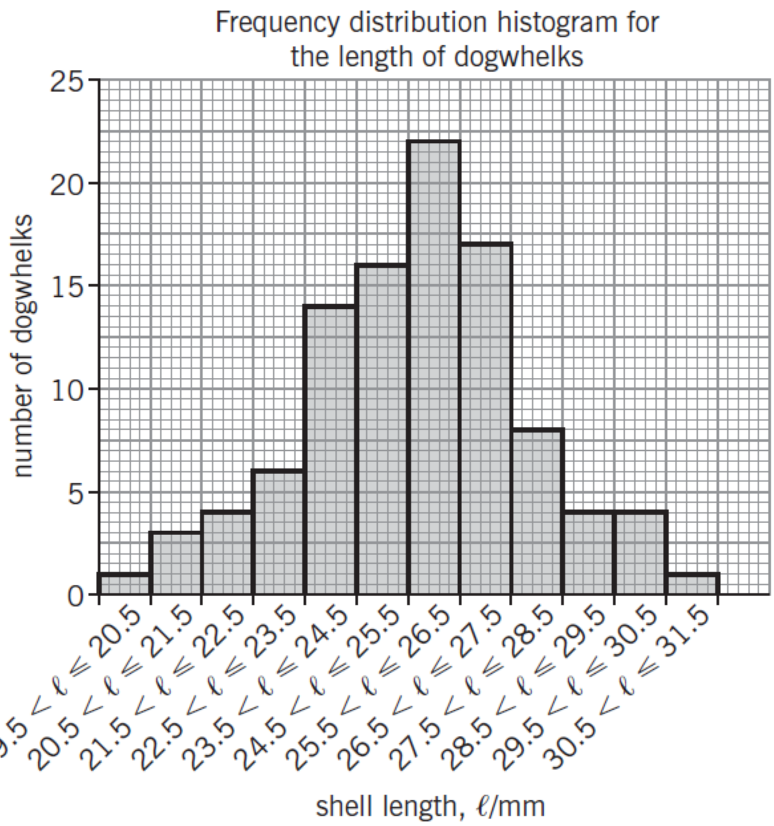

The dogwhelks have the widest spread (SD = 2.34)

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1.14 Standard deviation

pages 32–33

PRACTICE QUESTIONS

1

Mean	SD
3.0	2.0
14.6	3.8
20.0	3.8
22.0	6.1
33.0	5.7

The top row has the least spread.

2

Mean	SD
5.2	1.3
10.2	1.6
26.2	3.3
41.8	2.6
30.2	3.8

1.15 Simple probability and normal distribution

pages 34–35

PRACTICE QUESTIONS

1 **a** $\frac{70-59}{11.9} = 0.92$

0.92 on the *z*-score table gives a probability above the mean of 32.1

Therefore the chance of a horn length > 70 cm is 1 — (50 + 32.1) **= 17.9%**

b **2.2%**

c **3.5%**

2 **a** Value of z = 1.685

Then multiply this by the standard deviation 11.8 × 1.685 = 19.883

Subtract 19.833 from the sample leaf width at 160 mm:
160 – 19.833 = 140.1 mm

b Use the mean leaf width value, 140.1 mm

SD = 11.8

140.1-130 = 10.1

10.1/11.8 = 0.86

140.1-120 = 20.1

20.1/11.8 = 1.7

Z score 0.86 = probability 0.3051

Z score 1.7 = probability 0.4554

0.4554-0.3051 = 0.1503 or 15%

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1.16 Confidence intervals and reliability of the mean

pages 36–37

PRACTICE QUESTIONS

1 5.51
3.13
4.65
4.77

2 ± 15.3
± 8.7
± 12.9
± 13.3
Most certain: **25°C**
More repeats advised: **15°C**

1.17 Surface areas and volumes

pages38–39

1 **a** 3
b 1.5
c 1

2 **a** SA = 1767 cm^2
volume = 5301 cm^3
b 0.33
c 0.00126 cm^2
d **i** 605 000 cm^2
ii 114:1

3 Area = πr^2

= π x 45 x 45

= 6361.72 mm

= **6362 mm^2 (round to whole mm) or 63.62 cm^2**

Circumference = 2 πr

= 2π x 45

= 282.74 mm – round to whole mm

= **283 mm or 28.3 cm**

4 V = 4/3 πr^3 = 4/3 π × 2.2^3

= (4/3 x π) x 2.2 x 2.2 x 2.2

= **44.60 μm^3**

2.1 Magnification

pages 40–41

PRACTICE QUESTIONS

1 **a** ×120
b ×600
c ×1200
d ×200
e ×2000

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2.2 Graticules and stage micrometers

pages 42–43

PRACTICE QUESTIONS

1 5 µm **2** 0.14 mm

3 20 µm **4** 310 µm

5 **a** 0.000 25 mm **b** 250 µm

c 5.25 µm **d** 15 µm

e 0.0012 mm

2.3 Magnification of images

Pages 44–45

PRACTICE QUESTION

1 **a** ×28 000 **b** ×700 **c** ×36.7 **d** ×0.015

2.4 Magnification factors and real dimensions

pages 46–47

PRACTICE QUESTION

1 **a** 0.42 mm long **b** 11 µm long **c** 0.77 µm long

d 18 µm long **e** 170 µm long

2.5 Scale bars

pages 48–49

PRACTICE QUESTION

1 **a** 66 µm long **b** 42 µm across

c 1.0 mm wide **d** 7.4 µm (including the bud)

2.6 Haemocytometers

pages 50–51

PRACTICE QUESTIONS

1 Using the dimensions given previously, the volume of a single square of the haemocytometer is:

$0.05 \times 0.05 \times 0.1 = 0.00\,025\ \text{mm}^3$

So the number of squares required to produce a volume of 1 mm^3 is $\frac{1}{0.00025} = 4000$.

4000 **×** 17 cells = a concentration of 68 000 cells mm^{-3} applied to the haemocytometer.
This was a 1:1 dilution of the original culture with a sterile broth, so:
68 000 × 2 = **136 000 cells mm^{-3}** in the original culture.

2 **a** 20 000 000 cells cm^{-3} **b** 53 hours

3 12×10^6 **=** 12 000 000 cells per mm^3 in the original culture.
This is diluted to 2% of the original concentration 12 000 000 **×** 0.02 **=** 240 000 cells per mm^3.
The number of squares of a haemocytometer required to hold a volume of 1 mm^3 is:

$$\frac{1}{0.00025} = 4000$$

Therefore the number of cells in a single square would be $\frac{240000}{4000} =$ **60 cells**.

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2.7 Water potential

pages 52–53

PRACTICE QUESTIONS

1 **a** From cell B to cell A

b From cell A to cell B

c From cell B to cell A
From cell B to cell C
From cell C to cell A

2 **a** A: –700 kPa
B: –800 kPa
C: –700 kPa
D: –300 kPa

b Into cells A, B, and C.
Out of cell D.

c A: $\psi = 0$: $\psi_p = 1400$ kPa
B: $\psi = 0$: $\psi_p = 800$ kPa
C: $\psi = -500$ kPa: $\psi_p = 600$ kPa
D: $\psi = -400$ kPa: $\psi_p = 500$ kPa

3 –400 kPa: water leaves cell.

4 Water enters until $\psi_{cell} = -800$ kPa and $\psi_p = 1200$ kPa.

2.8 Pie charts: the cell cycle

pages 54–55

PRACTICE QUESTIONS

1 G1 = 112.5° S = 157.5°
G2 = 67.5° M = 22.5°

2 6.8 hours

3 320°

4 335°

5 **a** 8 hours

b Pie chart showing:
G1 = 154.3°
S = 90°
G2 = 102.9°
M = 12.9°

Summary questions for chapters 1 and 2

pages 56–57

1 *one mark each for:*

- axes correct orientation, scaled with equidistant divisions
- both axes labelled with title and units
- points correctly plotted
- sensible best fit trend line for each trend
- graphs use at least half of the space on the paper.

2 **a** Image size of the nucleus is ≈ 6 mm = 6000 µm.
Actual size is therefore 6000 ÷ 750 = **8 µm**

b mitotic index = $\frac{7}{34} \times 100 =$ **79.4**

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3 a & b

Temperature / °C	Rate of reaction / gas volume mm^3 per minute					Mean	SD
0	4.0	2.0	3.0	5.0	6.0	**4.0**	**1.6**
5	14.0	12.0	16.0	13.0	14.0	**13.8**	**1.5**
10	21.0	25.0	21.0	12.0	22.0	**20.2**	**4.9**
15	24.0	16.0	23.0	14.0	32.0	**21.8**	**7.2**
20	24.0	33.0	34.0	33.0	35.5	**31.9**	**4.5**

c The mean at 5°C is the most reliable / at 15°C is the least reliable;
because SD is smallest at 5°C / largest at 15°C;
data at 5°C are less spread / have less variation / are less dispersed from the mean.

d Upper limit = 13.8 + 1.5 = **15.3** lower limit = 13.8 — 1.5 = **12.3**

e volume = $\pi r^2 h$

$24 = 3.142 \times 0.5^2 \times h$

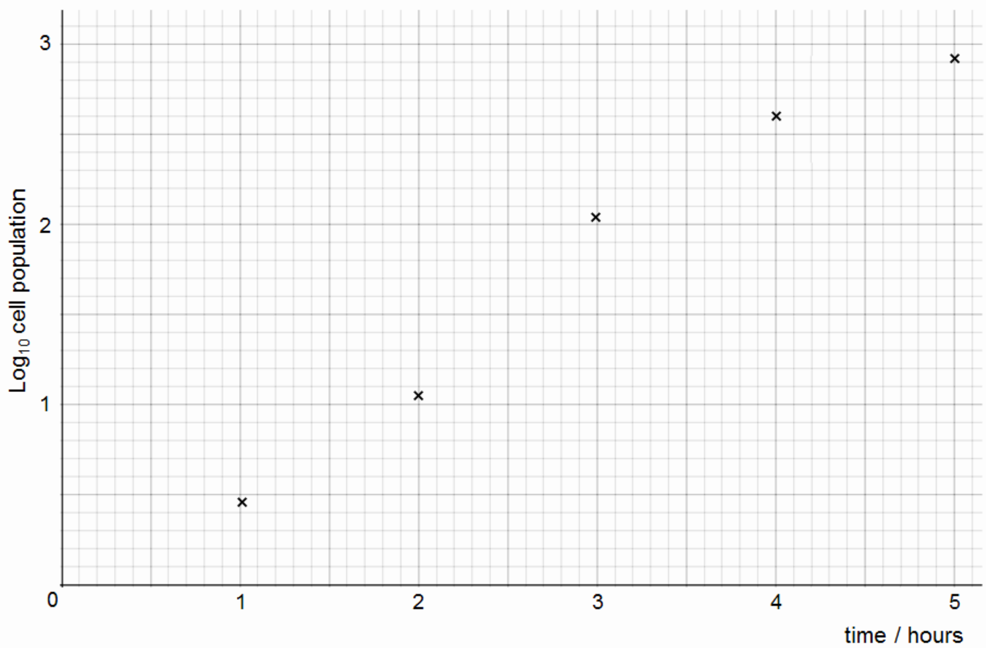
Rearrange to give $h = \dfrac{24}{(3.142 \times 0.5^2)}$ = 30.55 which rounds to **31 mm**.

f absolute error = 0.5mm

so % uncertainty = $\dfrac{0.5}{31} \times 100$ = **1.6%**

4 a 0.5 l = 500 cm^3 with 12.8 cells per cm^3
so the population is now 12.8 × 500 = 6400 cells = **6.4 x 10^3 cells**

b



c between 10 000 and 100 000 (depending on line of best fit)

5 a 23.3

b 4800 nl

c $a = \dfrac{\left(\dfrac{34}{100}\right) \times 135}{2} = 22.95$

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3.1 Working with molar and percentage solutions

pages 58–59

PRACTICE QUESTIONS

1 58.4 g NaCl plus 1 dm^3 distilled water

2 2.25 g glucose + 25 cm^3 distilled water

3 0.42 g $NaHCO_3$ + 50 cm^3 distilled water

4 5 g amylase + 495 cm^3 distilled water

5 2.6 g invertase + 62.4 cm^3 distilled water

6 7.50 g starch + 742.5 cm^3 distilled water

3.2 Serial dilutions and very small concentrations

pages 60–61

PRACTICE QUESTIONS

1 **a** 8.55 g sucrose + 25 cm^3 distilled water gives stock solution A. Then:
9 cm^3 A + 1 cm^3 distilled water = 0.9
7 cm^3 A + 3 cm^3 distilled water = 0.7
5 cm^3 A + 5 cm^3 distilled water = 0.5
3 cm^3 A + 7 cm^3 distilled water = 0.3
1 cm^3 A + 9 cm^3 distilled water = 0.1

b

volume of mineral solution / cm^3	Volume of distilled water / cm^3	Total volume (mineral solution + distilled water) / cm^3	Final volume after a sample has been removed for the next dilution / cm^3	Final concentration
56 of stock	504	560	504	A = 10^{-1}
56 of A	504	560	504	B = 10^{-2}
56 of B	504	560	504	C = 10^{-3}
56 of C	504	560	510	D = 10^{-4}
50 of D	450	500	500	E = 10^{-5}

Allow some variation in the exact volumes used to create the dilution series.
e.g., 60 cm^3 stock could be added to 540 cm^3 to make a total of 600 cm^3, and so on.

2 0.05 g dm^{-3}

3

Volume/cm^3	Broth volume/cm^3	Final concentration	Cells per mm^3
1 of stock	9	A = 10^{-1}	100 000
1 of A	9	B = 10^{-2}	10 000
1 of B	9	C = 10^{-3}	1 000
1 of C	9	D = 10^{-4}	100
1 of D	9	E = 10^{-5}	10
1 of E	9	F = 10^{-6}	1

4 Dissolve 0.01 g cytokinin in 10 cm^3 ethanol to make solution A.
Take 1 cm^3 of A and add 100 cm^3 distilled water (alcohol evaporates) to give 0.001 g in 100 cm^3 (B).
Take 1 cm^3 of B and add 99 cm^3 distilled water to give 0.0001 g in 100 cm^3 (C).
Take 1 cm^3 of C and add 99 cm^3 distilled water to give 0.000 01 g in 100 cm^3.

5 3 ng μl^{-1} × 4 = 12 ng μl^{-1}

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3.3 Calorimetry and energy values for food

pages 62–63

PRACTICE QUESTIONS

1 **a** 4.2 × 1000 × 3.6 = 15 120 J **b** $\frac{15120}{1.1}$ = 13 745 J = 13.75 kJ g^{-1}

2 **a** 7400 J g^{-1} **b** 12080 J g^{-1} **c** 16 000 kJ kg^{-1}

3 **a** 10.5 kJ = 10 500 J

$\frac{(10500 \div 4.2)}{1000} = 2.5$

Therefore original temperature = 19.5 — 2.5 = **17°C**

b 17.5 kJ g^{-1} = 17 500 J g^{-1}

$\frac{10500}{17500}$ = **0.6g**

4 **a** 4.2 × 500 × 1.9 = 3990 J

b $\frac{3990}{0.25}$ = 15 960 = 15.96 kJ g^{-1}

3.4 Chromatography and R_f values

pages 64–65

PRACTICE QUESTIONS

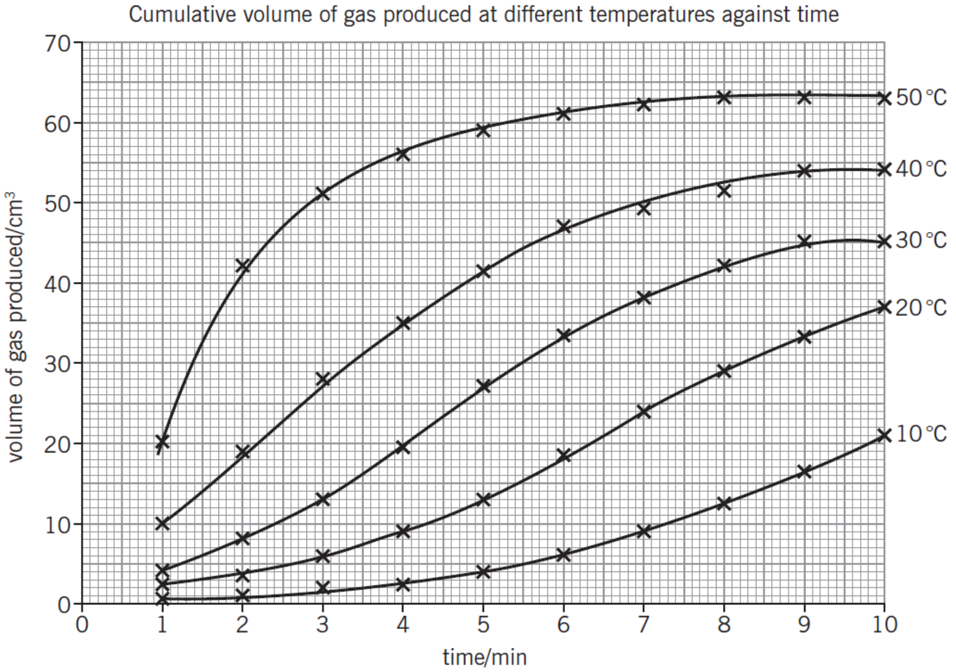
1	**a** 0.72	**b** 0.38	**c** 0.24	**d** 0.55	**e** 0.30
2	**a** isoleucine	**b** alanine	**c** aspartic acid	**d** methionine	**e** glutamic acid
3	**a** 91.8	**b** 69.6	**c** 23.5	**d** 429	
4	**a** carotene	**b** chlorophyll a	**c** chlorophyll b	**d** xanthophyll 1	

3.5 Rates of reaction 1

pages 66–67

PRACTICE QUESTIONS

1 **a**



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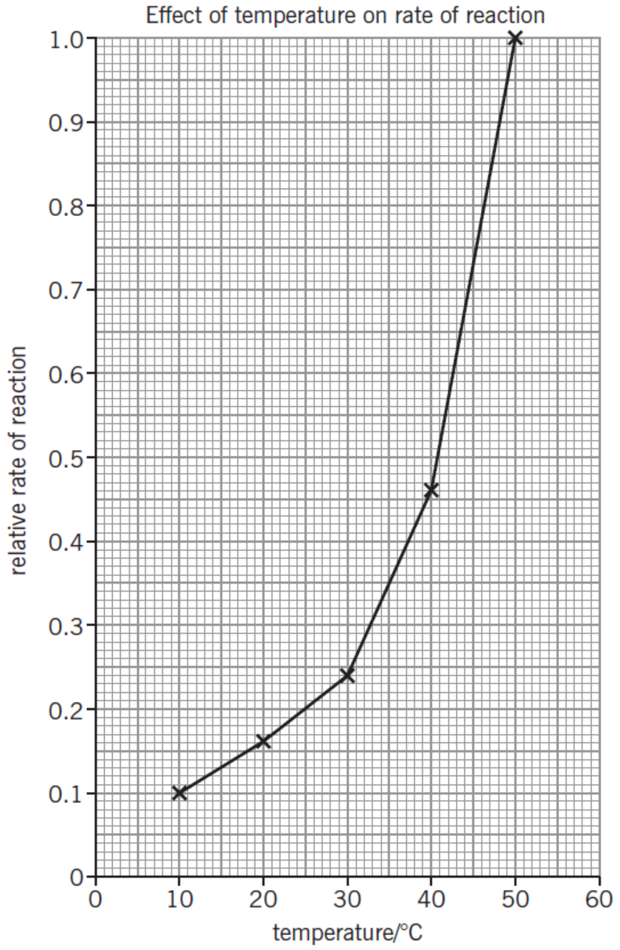
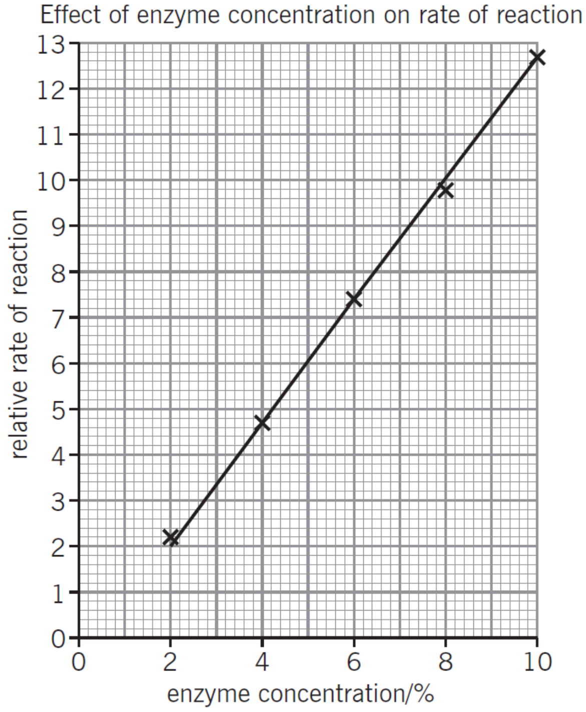
b Relative rates calculated using time to collect 20 cm^3: 10°C = 0.10; 20°C = 0.16; 30°C = 0.24; 40°C = 0.46; 50°C = 1.0.

c



2 a Relative rates: 2% = 0.0022; 4% = 0.0047; 6% = 0.0074; 8% = 0.0098; 10% = 0.0127.

b



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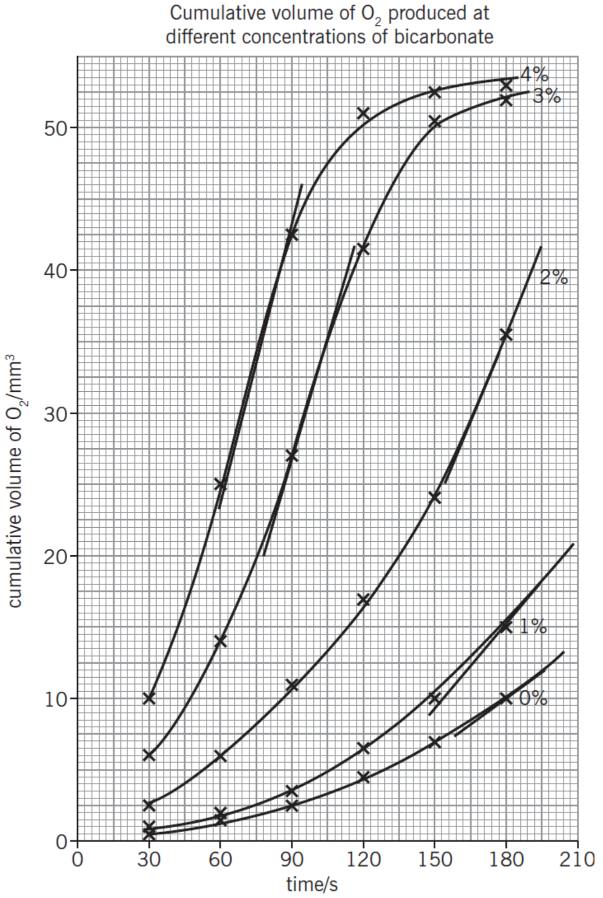
3.6 Rates of reaction 2

pages 68–69

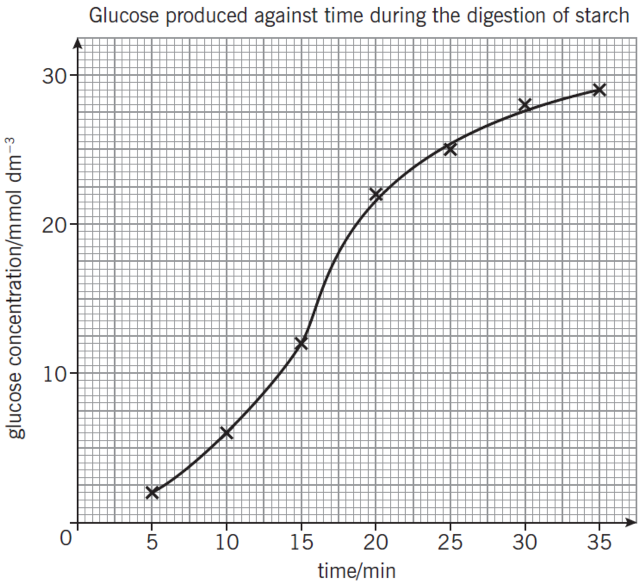
PRACTICE QUESTIONS

1 a



Rates (approximate): 0% = 0.13 mm^3 s^{-1}; 1% = 0.19 mm^3 s^{-1}; 2% = 0.47 mm^3 s^{-1}; 3% = 0.60 mm^3 s^{-1}; 4% = 0.63 mm^3 s^{-1}.

2 a



b 2.3 mmol dm^{-3} min^{-1} (2.7 at steepest point on this curve)

c **i** 0.9 mmol dm^{-3} min^{-1}
ii 0.3 mmol dm^{-3} min^{-1}

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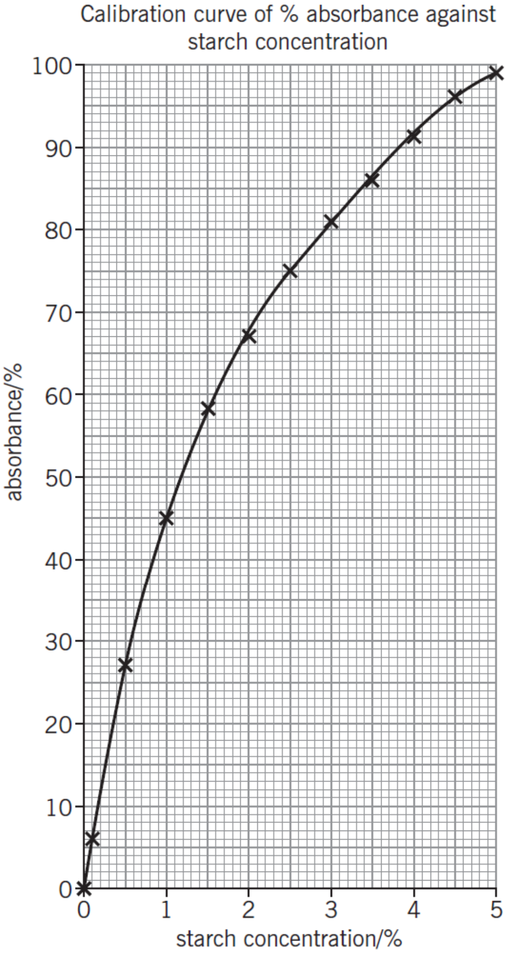
3.7 Colorimeters

pages 70–71

PRACTICE QUESTIONS

1



2 **a** 0.75%
b 1.15%
c 3.65%

3 **a** 6.95 million mm^{-1}
b 1.65 million mm^{-1}
c 8.15 million mm^{-1}

3.8 Respiratory quotient

pages 72–73

PRACTICE QUESTIONS

1 **a** 9; RQ = 0.8
b 39; RQ = 1; carbohydrate metabolised
c 29; 0.7; fat metabolised
d 76; 0.7

2 **a** 21.2
b 61.23
c 0.79

3 RQ is infinity during anaerobic respiration because CO_2 is continuously produced but O_2 is not utilised.

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4.1 Spirometer data

pages 74–75

PRACTICE QUESTIONS

1 **a** 1 dm^3

b 30 breaths per minute

c 30 dm^3 min^{-1}

d 6 dm^3 min^{-1}

2 **a** 9 dm^3 min^{-1}

b 2.7 dm^3

c 0.1 dm^3 min^{-1}

3 **a** 12 breaths per minute

b 28 breaths per minute

c increases by 300%

4.2 Electrocardiograms

pages 76–77

PRACTICE QUESTIONS

1 **a** 1.02 s

b 58.8 beats per minute

c 0.24 s

2 Trace b is 55.6 beats per minute.

Trace c is 176.5 beats per minute (average distance between R peaks = 8.5 mm).

3 **a** Output for trace b is 3.9 dm3 per minute.

Output for trace c is 15.9 dm3 per minute.

4 **a** 0.43 s and 1.02 s

b 0.34 s and 0.91 s

4.3 Oxygen dissociation curves

pages 78–79

PRACTICE QUESTION

1 **a** 90%

b extra 5%

c 52%

d 513 cm^3

e 100% decrease

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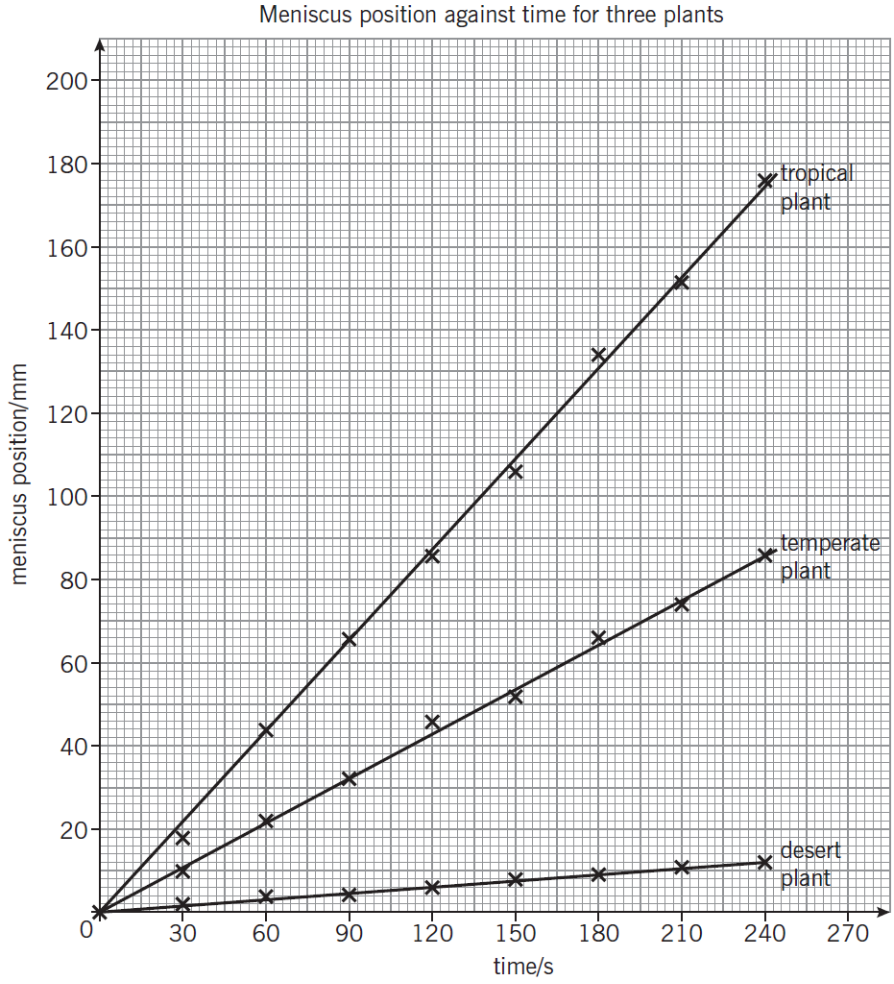
4.4 Water uptake rate

pages 80–81

PRACTICE QUESTIONS

1



2 temperate 0.28 $mm^3\ s^{-1}$
desert 0.04 $mm^3\ s^{-1}$

3 **a** 113 mm^3 **b** 0.94 $mm^3 s^{-1}$

4 366.9 mm

4.5 Oxygen release from photosynthesis

pages 82–83

PRACTICE QUESTIONS

1 **a**

Lamp distance d / cm	Light intensity ($1000/d^2$)
15	4.44
20	2.50
25	1.60
30	1.11
35	0.82
40	0.63

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b

Bubble lengths collected in 60 s / cm			
1	**2**	**3**	**Mean**
7.9	8.7	8.6	8.40
7.9	7.7	7.9	7.83
6.6	6.8	6.4	6.60
5.1	5.2	4.8	5.03
4.2	4.1	4.2	4.17
2.7	2.8	2.7	2.73

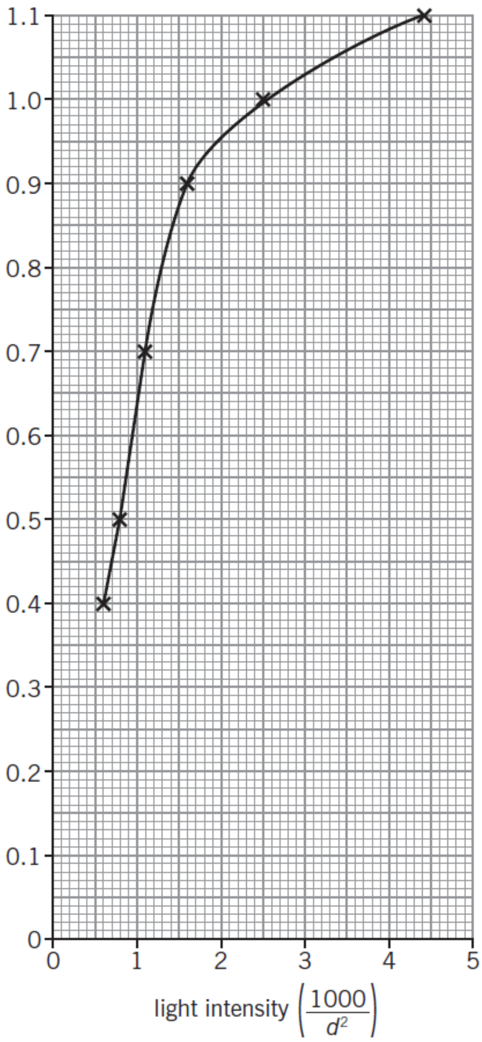
c

Bubble volumes collected in 60 s/mm^3			
1	**2**	**3**	**Mean**
62.0	68.3	67.5	65.9
62.0	60.4	62.0	61.5
51.8	53.4	50.2	51.8
40.0	40.8	37.7	39.5
33.0	32.2	33.0	32.7
21.2	22.0	21.2	21.5

2

Lamp distance d / cm	Rate / mm^3 s^{-1}
15	1.10
20	1.03
25	0.86
30	0.66
35	0.55
40	0.36

3



The optimum light intensity may be higher than those tested (the curve may continue to rise).
Do further repeats of the same experiment at higher light intensities until the graph levels off to find the optimum.

4 **a** 16.8 mm^3

b 21.4 mm (2.14 cm)

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Summary questions: chapters 3 and 4

pages 84–85

1 **a** Molecular weight of sodium bicarbonate $NaHCO_3$ = 23 + 1 + 12 + 48 = 84
so 84 g $NaHCO_3$ plus 1 litre of distilled water.

b

Required concentration of sodium bicarbonate (moles per litre)	Parts 1 molar sodium bicarbonate	Parts water
0.1	1	9
0.2	2	8
0.3	3	7
0.4	4	6
0.5	5	5
0.6	6	4

c

Concentration of sodium bicarbonate (moles l^{-1})	Meniscus movement (mm min^{-1})					
	1	2	3	4	**mean**	**SD**
0.1	33	32	36	35	**34**	**1.8**
0.2	71	69	73	67	**70**	**2.6**
0.3	115	119	114	124	**118**	**4.5**
0.4	145	151	152	144	**148**	**4.1**
0.5	159	157	156	160	**158**	**1.8**
0.6	172	166	168	174	**170**	**3.7**

d Error bars should be mean ± 1 SD for each point.

e This will be a value read from the graph at the point where the curve begins to level. It is likely to be around 0.3 molar.

2 **a** 4000 lux
b 9 µmol m^{-2} s^{-1}

3 In aerobic respiration the reaction is $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$. One mole of CO_2 is produced for every mole of oxygen absorbed. Any extra O_2 absorbed for oxidising fat or protein will show up when the respirometer is used with no soda lime, because this is not replaced by CO_2.
The volume of O_2 absorbed for respiration, and hence the volume of CO_2 produced, may be assumed as the difference between these two figures.
For maggots the volume of CO_2 evolved must be 39 and the RQ = 1
For the castor oil seeds extra O_2 is absorbed so volume of O_2 absorbed with soda lime must be 54 + 22 = 76 and the RQ = 0.7.

4 **a** upper trace shows 4 beats in 3 s, so rate = 60/3 × 4 = **80 bpm**
lower trace shows 3 beats in 6 s, so rate = 60/6 × 3 = **30 bpm**

b upper trace cardiac output = 80 × 70 cm^3 per min^{-1} = 5600cm^3 min^{-1}
lower trace cardiac output = 30 × 70 cm^3 per min^{-1} = 2100cm^3 min^{-1}

percentage reduction therefore = $\frac{(5600-2100)}{5600} \times 100 = 62.5\%$

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5.1 Quadrat data

page 86–87

PRACTICE QUESTIONS

1 **a** 78%
b 22%

2 4

3 **a** 10.2 m^{-2}
b 42.7 m^{-2}

4 **a** 13824
b 2304

5 22%

5.2 Species diversity

pages 88–89

PRACTICE QUESTION

1 **a** **Method 1:**
meadow = 0.84
rocky shore = 0.73
wheat field = 0.37

Method 2:
meadow = 6.62
rocky shore = 3.70
wheat field = 1.58

b meadow = 10
rocky shore = 9
wheat field = 5

5.3 Species richness and species evenness

pages 90–91

PRACTICE QUESTION

1 Species richness = 3
Species evenness:
1946 = 0.35
1956 = 0.73
1966 = 0.95
1976 = 0.98

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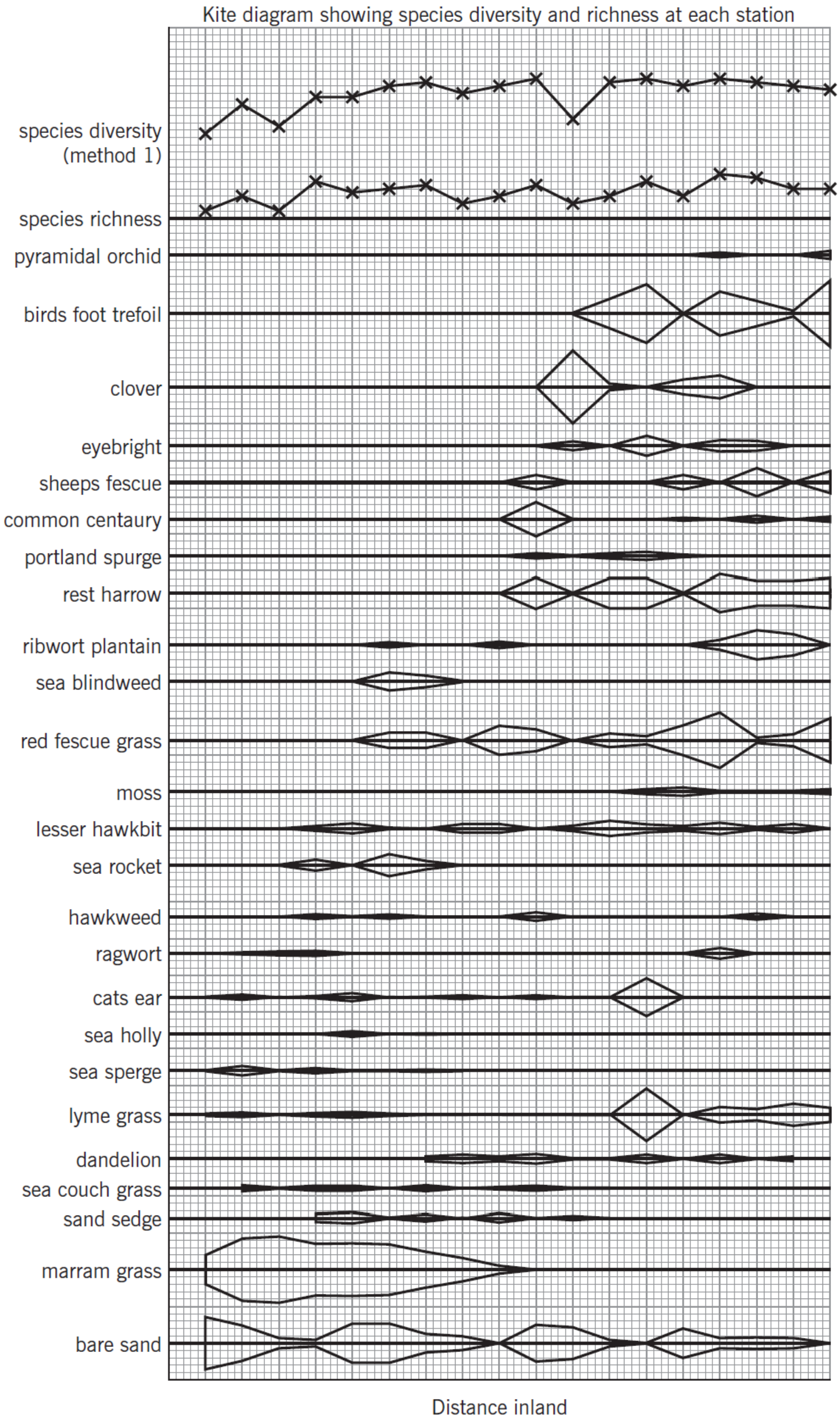
5.4 Transects and kite diagrams

pages92–93

1

Distance inland/m	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
Species richness	2	6	2	10	7	8	9	4	6	9	4	7	10	7	12	11	8	8
Species diversity method 1	0.05	0.45	0.12	0.65	0.63	0.71	0.78	0.61	0.72	0.81	0.26	0.77	0.83	0.73	0.85	0.84	0.81	0.78
Species diversity method 2	1.05	1.83	1.13	2.87	2.75	3.53	4.59	2.61	3.64	5.51	1.36	4.56	5.90	3.88	6.99	6.58	5.30	4.59



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5.5 Mark-release-recapture

page 94–95

PRACTICE QUESTION

1	**a** 107		**b** 2794		**c** 76		**d** 97	
	e 3		**f** 123		**g** 12		**h** 7	

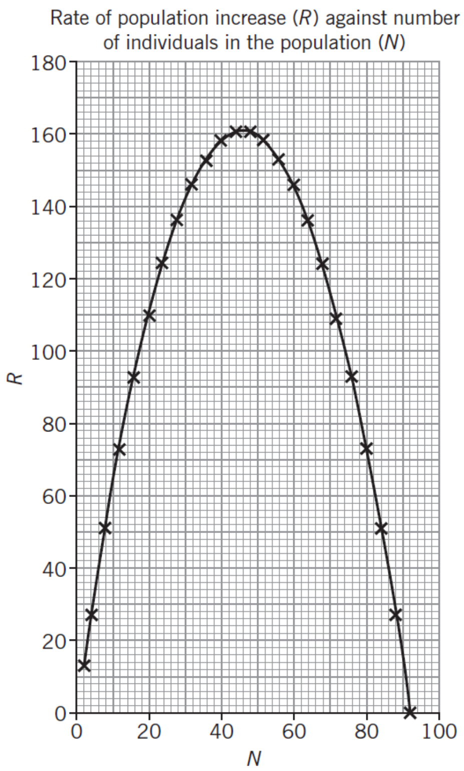
5.6 Population growth curves 1

pages 96–97

PRACTICE QUESTIONS

1 8, 32, 44, 68 **2** 26.8, 92.5, 158.3, 73.0

3



4 When population is low, R is small as not many adults to reproduce.
As population increases, R rises as more individuals are breeding.
Initially there is no/low competition or environmental resistance to its growth until R reaches a maximum.
Beyond this point competition for resources begins to limit population growth.
The bigger the population the larger this effect and the smaller R becomes until population reaches the carrying capacity and stops increasing.
R reaches zero, births + immigration = deaths + emigration.

5 304.9

5.7 Population growth curves 2

pages 98–99

PRACTICE QUESTIONS

1 20480

2 **a** 30 minutes **b** 2 generations hour^{-1}

3 4.72×10^{27}

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5.8 Logarithms

pages 100–101

PRACTICE QUESTIONS

1 a

Time (hours)	Population of bacteria (cells / cm^3)
0	40
1	113
2	320
3	905
4	2560
5	7241
6	20480
7	57926
8	163840
9	463410
10	1310720

c Approximately 12 hours

5.9 Energy flow between trophic levels

PRACTICE QUESTIONS

pages 102–103

1 a 4.1%

b 62.5%

c There are three losses of energy: egesta, urine and respiration. It is unlikely that egesta or urine loss can be changed.
Energy lost to respiration may be reduced by modifying the conditions experienced by the bullock – any sensible examples accepted that rationalise reduced energy expenditure by the bullock.
For example, checking if raising the temperature of the barn reduces respiration, or keeping the bullock in a smaller pen.

2 a $\frac{87403}{7100000} \times 100 = 1.2\%$

b 7 100 000 × 0.005 = 3550

$\frac{1609}{3550} \times 100 = 45.3\%$

c $\frac{3550}{87403} \times 100 = 4.1\%$

d $\frac{88}{87403} \times 100 = 0.1\%$

6.1 Statistical tests

pages 104–105

PRACTICE QUESTIONS

1 Mann–Whitney *U* test (low sample frequency and uneven sample numbers)

2 unpaired t-test (comparing two populations but not same individuals)

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3 unpaired t-test (comparing two populations but not same individuals).
4 chi-squared (four categories, test how well observed fits expected).
5 Spearman ranked correlation (test trend between two variables that do not show normal distribution)
6 chi-squared (four categories, test how well observed fits expected)
7 paired sample t-test (compares same individuals)
8 correlation coefficient (test trend between two variables that do show normal distribution)
9 unpaired t-test (comparing two populations but not same individuals)
10 correlation coefficient (test trend between two variables that do show normal distribution)
11 paired sample t-test (compares same individuals)
12 Mann–Whitney *U* test (low sample frequency and uneven sample numbers)
13 Spearman ranked correlation (test trend between two variables that do not show normal distribution)
14 chi-squared (four categories, test how well observed fits expected)
15 Spearman ranked correlation (test trend between two variables that do not show normal distribution)
16 chi-squared (four categories, test how well observed fits expected)

6.2 Tests of association

pages106–107

PRACTICE QUESTIONS

1 a

	Dog whelk present	Dog whelk absent	Totals
Barnacle present	19	5	24
Barnacle absent	7	9	16
Totals	26	14	40

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
both present	19	15.6	3.4	11.56	0.74
dog whelk	7	10.4	-3.4	11.56	1.11
barnacle	5	8.4	-3.4	11.56	1.38
neither	9	5.6	-3.4	11.56	2.06
					χ^2 = 5.29

χ^2 = 5.29

df = (2–1) ×(2–1) = 1

0.05 < P < 0.01

A significant association

b

	Ladybird present	Ladybird absent	Totals
Aphid present	21	9	30
Aphid absent	2	12	14
Totals	23	21	44

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
both present	21	15.68	5.32	28.3	1.8
ladybird	2	7.32	–5.32	28.3	3.87
aphid	9	14.32	–5.32	28.3	1.98
neither	12	6.68	5.32	28.3	4.24
					χ^2 = 11.89

χ^2 = 11.89

df = (2-1) × (2-1) = 1

$p < 0.001$

A significant association

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c

	Dock present	Dock absent	Totals
Nettle present	10	7	17
Nettle absent	8	8	16
Totals	18	15	33

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
both present	10	9.27	0.73	0.53	0.057
dock	8	8.73	–0.73	0.53	0.061
nettle	7	7.73	–0.73	0.53	0.069
neither	8	7.27	0.73	0.53	0.073
					$\chi^2 = 0.26$

$\chi^2 = 0.26$

df = (2-1) × (2-1) = 1

$0.50 < p < 0.90$

no association

6.3 Correlation coefficient

pages 108–109

PRACTICE QUESTIONS

1 **a** strong positive correlation

b strong negative correlation

c no correlation

2 The two scores are highly correlated (but not perfect), therefore as a quick measure of infant health this appears to be highly consistent (at least between these two doctors).

3 Thorns on brambles r = 0.53; 1% < p < 5% ⇒ association.

Alcoholic liver disease r = 0.97; p < 0.1% ⇒ strong association (use means for alcohol ranges).

Trout skin spots r = 0.43; 5% < p < 10% ⇒ no association (use means for body length ranges).

6.4 Ranked correlation coefficient

pages 110–111

PRACTICE QUESTIONS

1 Yes – significant positive correlation

2 *Fucus* r_s = –0.98 $p < 0.5\%$ ⇒ very strong negative correlation.

Leaf size r_s = 0.64 $p \approx 5\%$ ⇒ moderate positive correlation.

Elodea r_s = 0.91 $p < 0.5\%$ ⇒ very strong positive correlation.

6.5 Tests of difference: unpaired *t*-tests

pages 112–113

PRACTICE QUESTIONS

1 $t = 1.58$; $p < 10\%$

2 $t = 4.86$, df = 28, $p > 0.10$

These two sets of apples should not be used in the same experiment as they differ significantly in mass.

3 $t = 17.21$

df = (289+265) – 2 = 552

$p < 0.001$

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6.6 Differences in data: paired *t*-tests

pages114–115

PRACTICE QUESTIONS

1 df = n –1 = 27
Use the table row for df = 28.
$0.01 < p < 0.05$
There is a less than 5% probability of the samples differing just by chance.

2 A: $0.10 < p < 0.05$
B: $0.001 > p$
C: $0.10 < p < 0.05$
Treatments A & C show a pattern that is likely due to chance only
Treatment B has a probability of < 0.001 that the observed effect was due to chance only.

3 **heart rates:** $t = 9.6$, $p < 0.001$
hormone levels: $t = -10.77$, $p < 0.001$

6.7 The Mann–Whitney *U* test

pages 116–117

PRACTICE QUESTIONS

1 $U_1 = 10 \times 10 + 5(10 + 1) - 55 = 100$
$U_2 = 10 \times 10 + 5(10 + 1) - 155 = 0$
Critical value for U when both sample sizes are 10 is 23
0 < 23
Therefore $p < 0.05$.
There is a significant difference in the colony numbers between the two agar plate treatments.

2 $U_1 = 10 \times 10 + 5(10+1) - 64.5 = 90.5$
U2 = $10 \times 10 + 5(10+1) - 145.5 = 9.5$
Critical value for U when both sample sizes are 10 is 23
9.5 < 23
Therefore $p < 0.05$.
There is a significant difference between the number of yellow banded snails in hedges and woodland.

3 **Limpets** $U_{crit} = 11$
8.3 < 11 so difference is significant.
Beetles $U_{crit} = 55$
72 > 55 so difference is not significant.
Ivy $U_{crit} = 22$
8.5 < 22 so difference is significant.

7.1 Chi-squared goodness of fit test in genetics

pages118–119

PRACTICE QUESTIONS

1 **a** $\chi^2 = 0.47$
$0.9\% < p < 0.95\%$
No significant difference between *O* and *E* so the data fits the ratio.

b $\chi^2 = 35.9$
$p < 0.1\%$
Data do not differ by chance; there is a significant difference between observed and expected.

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2 $\chi^2 = 0.24$

$90\% < p < 95\%$

No significant difference between *O* and *E* so the data fits the ratio.

3 **a** $\chi^2 = 7.25$

$0.1\% < p < 1\%$

Data differ significantly from the expectation of chance.

b All 36 tall

7.2 The Hardy–Weinberg equation

PRACTICE QUESTIONS

pages 120–121

1 **a** The Frequency of people displaying the albinism phenotype can be calculated as follows

$1/17000 = 5.88 \times 10^{-5}$

The frequency of phenotypes is calculated from $p^2 + 2pq + q^2$

Therefore the frequency of the allele *q* is the square root of the recessive phenotype.

$\sqrt{5.88 \times 10^{-5}} = 0.0077 = q$

$1 - q = p$

$1 - 0.0077 =$ **0.9923 or 0.99(2 s.f.)**

b 1.5% or a frequency of 0.15

We now know the values of *p* and *q* as 0.9923 and 0.0077 (when rounding $p + q$ must add up to 1). If we define carriers as those with the allele for albinism, but not expressing the phenotype, then this would cover all heterozygotes. The frequency of heterozygotes can be expressed as 2*pq.*

$2 \times 0.9923 \times 0.0077 = 0.01528$ or 0.015 (2 s.f.)

c 945 000 (1.5% of 63 million)

2 **a** $\frac{1}{1000000} = q^2$

$q = \sqrt{\frac{1}{1000000}} = 0.001$

$1 - q = p = 0.999$

2*pq* is the representation of the carrier genotype.

$2 \times 0.999 \times 0.001 = 0.002 = 0.2\%$

b The population without the recessive allele q, will be everyone that is homozygous for p

Frequency of homozygotes for p = p2

$p = 0.999$

$p^2 = 0.998$ or 99.8%

3 **a** **African Americans:**

$1/500 = q^2 = 0.002$

$\sqrt{0.002} = q = 0.04472$

$1 - q = p = 0.95528$

Carriers are heterozygotes 2*pq*

$2 \times 0.95528 \times 0.04472 =$ **0.08544 or 8.54%**

in West Africa:

$2\% = 1/50 = q^2 = 0.02$

$\sqrt{0.02} = q = 0.14142$

$1 - q = p = 0.85858$

$2 \times 0.85858 \times 0.14142 =$ **0.24284 or 24.28%**

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b In West Africa the population is selected for resistance to malaria, which causes an increase in the carrier genotypes. The descendant population in North America would have begun with a similar genotype ratio but in the absence of malaria selection pressure no longer acts against the homozygous normal blood groups, which has had a diluting effect on the carrier prevalence in the gene pool.

4 **a** Dominant (p) = 0.004%

Recessive (q) = 99.996%

7/100,000 = p^2+2pq = 0.00007

1 – 0.00007 = q^2 = 0.99993

$\sqrt{0.99993} = q = 0.99996$

$1 - q = p$

1 – 0.99996 = 0.00004

b 99.998% of sufferers

Summary questions for Chapters 5–7

pages 122–123

1 **a** **i** t = 1.671 **ii** t = 1.571

b At 58 degrees of freedom the critical value of t at the 5% level is 1.671.

Without rounding the intermediate steps, t =1.671 which is equal to the critical value, so p < 5% of the data being chance. There is a significant difference between the mean values.

With intermediate rounding t is now 1.571 which is < the critical value, so p > 5% of the data being chance. There is NO significant difference between the mean values.

2 **a** position up the shore has no effect on limpet abundance.

b 21

c 3

d χ^2 = 35.52 gives p < 0.001 that the data are due to chance, so you can conclude that position up the shore does influence abundance.

3 **a** (11/482) × 100 = 2.3%

b 10^6 m^2 are in one km^2, so 482 x 10^6 kJ m^{-2} $year^{-1}$

4

species	number collected (n)	$n(n - 1)$
a	12	132
b	3	6
c	7	42
d	9	72
	31	252
	N = 31	$\sum n(n - 1)$ = 252

$N(N - 1)$ = 930

D = 3.69

5 **a** p = 0.983

b $2pq$ = 2(0.017 × 0.983) = **0.03**

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