# Oxford Resources for IB

## Biology – 2023 Edition

## Answers

## Topic C1 – Molecules

**Page 341 Data-based questions: the effectiveness of enzymes**

**1.** the speed at which a chemical reaction takes place;

measured by the increase in the concentration of a product per unit time or the decrease in the concentration of a reactant per unit time;

**2.** reaction 4 has the slowest rate without an enzyme;

**3.** reaction 4 has the fastest rate with an enzyme;

**4** reaction 2: $3.8 \times 10^{11}$;

reaction 3: $5.6 \times 10^{20}$;

reaction 4: $1.4 \times 10^{24}$;

**5.** OMP decarboxylase is the most effective catalyst as this reaction has the slowest rate without the enzyme but the fastest rate with the enzyme;

**6** the substrate binds to the active site of the enzyme and this binding leads to structural changes in the enzyme;

these changes strain the bonds in the substrate, making it more reactive / an enzyme makes collisions between substrate molecules more effective in terms of promoting a reaction;

**Page 345 Data-based questions: Biosynthesis of glycogen**

**1.** anabolic, because glucose monomers are built up into glycogen macromolecules;

**2.** one enzyme catalyses the formation of 1,4 bonds;

the other enzyme catalyses the formation of 1,6 bonds;

enzymes are substrate-specific;

**3.** branch formation by 1,6 bonding creates extra points where glucose can be added to the glycogen;

at the end of each branch, glucose can be added by 1,4 bonding;

**4.** heat-treatment denatures the enzyme;

curve A shows no enzyme activity / no enzyme-catalyzed conversion of glucose phosphate into glycogen;

**5. a.** increasing rate of conversion at first / until 45 minutes;

then rate of conversion levels off;

**b.** formation of 1,6 bonds leads to more and more branching in glycogen molecules over time, so the rate at which glucose is used up increases;

until falling glucose concentration limits the rate;

**Page 347 Data-based questions: Adenylate kinase**

**1. a.** 47 °C

**b.** 55 °C

**2. a.** 68 at 15 °C;

123 at 25 °C;

243 at 35 °C;

536 at 45 °C;

**b.** ×1.78 from 15 to 25 °C;

×1.98 from 25 to 35 °C;

×2.21 from 35 to 45 °C;

not exactly doubling but close to this;

**3. a.** faster molecular motion as temperature rises;

ore substrate–active site collisions (per unit time) as temperature rises;

more substrate molecules with enough energy to react / activation energy;

**b.** high temperature causes denaturation;

structure of enzyme/active site is altered so substrate cannot bind/reaction is not catalysed;

bonds broken / new intramolecular bonds made within the enzyme;

**4.** little difference between 15 and 40 °C;

optimum for WT is lower / 2 °C lower / 47 °C versus 45 °C;

WT totally denatured at 55 °C whereas V135G already totally denatured at 52 °C;

WT has higher activity at all temperatures above 40 °C;

**5.** increases enzyme activity;

higher optimum temperature / optimum increase from 47 °C to between 47 and 50 °C;

**Page 351 Data-based question: Calculating rates of reaction**

**1. a.** 100 mL of 1% starch solution contains 1 g of starch so 10 mL contains 0.1 g;

**b.** 0.1 g = 100 mg because there are 1000 mg in one gram;

**c.** $\frac{100\text{ mg}}{8\text{ min}} = 12.5\text{ mg min}^{-1}$

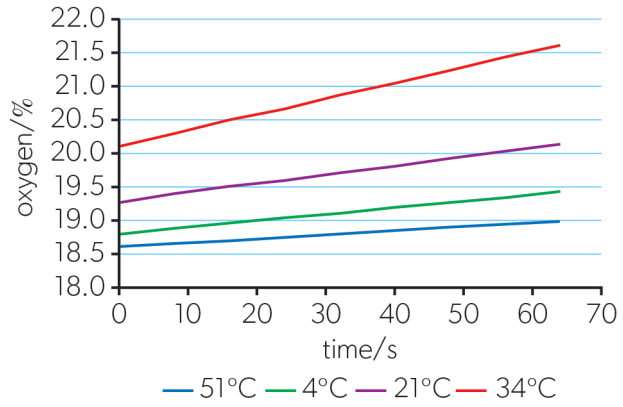
**d.** $\frac{12.5}{60} = 0.21\text{ mg s}^{-1}$

**2. a.** appears to be independent of temperature, so must be part of the uncertainty of the measuring device;

**b.**

| Temperature / °C | Reaction rate / % $s^{-1}$ |
|---|---|
| 4 | 0.01 |
| 21 | 0.013 |
| 34 | 0.23 |
| 51 | 0.007 |

**c.**




**d.** logarithmic scale is useful because it allows the graph to show differences between low reaction rates;

**Page 352 Data-based question: Interactions between temperature and enzyme activity**

**1.** allows the graph to clearly show the wide range of reaction rates;

shows that the relationship is exponential;

**2. a.** *Sulfolobus tokodaii*

**b.** *Saccharomyces cerevisiae*

**3.** as denaturation temperature increases, reaction rate at 25 °C decreases;

decrease in reaction rate is exponential because with a log scale the trend line is straight;

**4. a.** enzyme would denature;

reaction catalyzed by isopropylmalate dehydrogenase would not happen;

**b.** reaction catalyzed by isopropylmalate dehydrogenase would be very slow;

*Sulfolobus tokodaii* would have insufficient product of the reaction catalyzed by this enzyme;

**Page 365 Data-based questions: Energy in respiratory substrates**

**1.** canola oil has a higher fat/lipid content;

syrup has more sugar/carbohydrate than canola oil;

both have a low salt/protein content;

**2.** $\frac{1380}{325} = 4.2$ kcal

3. $\frac{3397\ \text{kJ}}{0.93} = 3653\ \text{kJ}$

   $\frac{92}{0.93} = 98.9\ \text{g}$

4. $\frac{1380}{80.5} \times 100 = 1714\ \text{kJ}$

5. fats have the higher energy content;

   3653 kJ is more than twice as much as 1714 kJ;

**Page 367 Data-based questions: Oxygen consumption in tobacco hornworms**

1. **a.** respiration rate increases;

   **b.** all cells/tissues in the larva are respiring;

   so respiration rate increases as number of respiring cells/mass of respiring tissue increases;

2. **a.** slight increase in 3rd and 4th instar larvae as larval weight increases;

   slight decrease/no significant change in 5th instar larvae;

   changes may not be statistically significant;

   **b.** oxygen consumption is proportional to the mass of respiring tissue below critical weight;

   above critical weight the supply of oxygen by the tracheal system reaches a maximum because tracheae are part of the exoskeleton and cannot grow;

3. lower maximum rate of oxygen supply by the tracheal system;

   oxygen supply to the larva becomes insufficient at a lower mass;

   the insect has to moult and develop a larger tracheal system at a lower mass;

**Page 368 Data-based questions: Respirometers**

1. absorbs carbon dioxide;

   ensures that volume changes are due only to oxygen uptake;

2. upwards, towards the animal tissue in the tube;

   volume of air inside the tube reduces due to oxygen uptake;

3. oxygen used by the organism/tissue/cells;

   by aerobic respiration;

4. **a.** keeps temperature constant;

   prevents volume changes due to temperature changes;

   heat produced by respiration;

   external temperature may change during an experiment;

   **b.** seals the apparatus to prevent external pressure changes having an effect;

   counteracts changes in external temperature because both tubes affected equally so manometer fluid shouldn't move;

5. all close enough so results are reliable;

**6.** calculated using the equation volume of a cylinder = $\pi r^2$ × length but as radius is 1, volume = π × length;

| Temperature / °C | Volume of oxygen used / $mm^3$ $min^{-1}$ | | | |
|---|---|---|---|---|
| | 1st reading | 2nd reading | 3rd reading | Mean |
| 5 | 6.28 | 4.71 | 6.28 | 5.76 |
| 10 | 7.85 | 7.85 | 9.42 | 8.38 |
| 15 | 11.00 | 12.57 | 12.57 | 12.04 |
| 20 | 17.28 | 15.71 | 18.85 | 17.28 |
| 25 | 20.42 | 25.13 | 23.56 | 23.04 |
| 30 | 36.13 | 34.56 | 29.85 | 33.51 |

**7.** temperature on the *x*-axis and volume of oxygen on the *y*-axis;

scales and legends correct on both axes;

data points plotted correctly and joined with a curve;

**8.** positive correlation / higher rate with higher temperature;

non-linear / larger increase with each 5 °C rise in temperature;

**9. a.** (560−544) g;

15–16 g total mass loss divided by 13 days;

1.2 g per day;

**b.** anaerobic cell respiration / alcoholic fermentation;

$CO_2$ is a waste product;

release of $CO_2$ leads to loss of mass from the solution;

**10.** population growth of yeast / more yeast respiring;

positive feedback / increasing amounts of $CO_2$ from higher population leads to lower solubility / higher rate of release;

waste heat decreases $CO_2$ solubility;

**11.** substrate has run out;

death of yeast (from high alcohol);

**12.** divide mass decrease values by time units;

**Page 381 Data-based questions: Water production in kangaroo rats**

**1. a.** more water production from lipids than carbohydrates;

both with starch and sugar as the carbohydrate;

**b.** more hydrogen per gram in lipids than carbohydrates;

water is produced from (electrons in) hydrogen in food;

**2. a.** more oxygen used when lipids rather than carbohydrates are the respiratory substrate;

more than twice as much;

**b.** lipids have more hydrogen (and carbon) per gram; which is converted to water (and $CO_2$) in respiration;

carbohydrates contain more oxygen per gram than lipids; so require less oxygen for conversion to water and $CO_2$;

**3.** water is lost from the lungs;

more evaporation if dry air is inhaled than humid;

**4.** carbohydrates better than lipids in dry air because net water yield is higher;

lipids better than carbohydrates in humid air because net water yield is higher;

proteins always worst because there is net water loss;

**5.** cooler at night;

relative humidity is likely to be lower;

less need for sweating to maintain body temperature;

**Page 383 Data-based questions: Cellular respiration in shaker muscles**

**1.** 0.8 mmol $dm^{-3}$ $s^{-1}$

**2.** $O_2$ content increases by 0.4 mmol $dm^{-3}$;

lactate content increases by 2.0 mmol $dm^{-3}$;

**3.** ATP demand is higher than that provided by glycolysis alone;

ATP demand is also higher than that provided by chemiosmosis alone;

so anaerobic respiration provides some of the ATP required;

**4.** three of the four data points show a lot of variability;

lactate data at rest varies from 1.6 to 4.0 mmol $dm^{-3}$ $s^{-1}$, so the calculated increase is within the margin of error;

more accurate measurements and replicate measurements are required to know that the results are reliable;

**Page 388 Data-based questions: Determining $R_F$ values for photosynthetic pigments**

**1.** line / cross / x for the origin;

line for the solvent front;

five spots for pigments;

cross / x in the centre of each spot;

colours of spots indicated;

**2.** **a.** beta carotene;

chlorophyll *a*;

**b.** presence of fucoxanthin which is orange−brown;

**c.** **i.** *Porphyra* is adapted to deeper water than *Fucus*;

where red and green light do not penetrate;

so a brown pigment that absorbs these wavelengths is not useful;

**ii.** blue;

**Page 393 Data-based questions: Photosynthesis rates in red light**

1. with increasing wavelength there is limited effect up until about 680 nm;
   then there is a significant decrease in yield as wavelength increases;
2. supplementary light has limited effect up to about 680 nm;
   above 680 nm supplementary light increases oxygen yield / rate of photosynthesis;
3. error bars show the variability of the data;
   where the error bars overlap up to 680 nm;
   suggest that there is no significant difference; up to 680 nm;
4. $\frac{1 \text{ photon}}{8 \text{ molecules}} = 8$ photons per molecule
5. eight photons produce one oxygen molecule;
   eight electrons are excited per oxygen molecule;
   eight electrons are excited per four electrons produced by photolysis;
   so each electron must be excited twice;

**Page 397 Data-based questions: Photosynthesis in artificial light**

1. spectra for daylight and white LED lamps both contain wavelengths in the range 420−780 nm;
   daylight has a more even distribution of wavelengths / white LED lamps have marked peaks;
   more light of wavelengths below 420 nm/UV in sunlight than in white LED lamps;
2. small amounts of blue light so not the combination of blue and red that is best for photosynthesis;
   low levels of light overall at sunset;
   possibly low temperatures;
3. warm white more suitable as closer to the range of wavelengths at sunset;
   helps to promote melanin production and sleep;
4. green light not used much for photosynthesis;
   more efficient to supply all light energy as blue and red;
5. not enough carbon dioxide diffuses into the leaves because the stomata are not fully open;
   Calvin cycle slows down due to insufficient carbon dioxide for fixation;

**Page 399 Data-based questions: Changes in atmospheric oxygen**

1. before 2.3 mya, oxygen levels are negligible;
   increased to about 4% and then relatively stable for approximately 1 my;
   rapid rise to a peak and then decline to about 20%;
2. approximately 32% at about 400 000 ya;
3. evolution of photosynthetic cyanobacteria followed by photosynthetic eukaryotes;
   then escape of oxygen to the atmosphere;

4. Venus and Mars have far higher levels of carbon dioxide;

   Earth has much higher levels of nitrogen and oxygen;

5. higher rates of oxygen due to photosynthesis by plants;

**Page 401 Data-based questions: Evidence for chemiosmosis**

1. **a.** the higher the pH of ADP solution, the more rapid the rate of ATP production;

   this is a direct relationship at lower pH but rate of increase increases with pH;

   **b.** because the magnitude of concentration gradient between inside and outside is being increased;

2. the lower the incubation pH, the higher the yield of ATP;

   this also increases the magnitude of the concentration gradient / difference in concentration;

3. ATP production powered by movement of $H^+$ down concentration gradient; once movement occurs, concentration difference is lowered so less ATP production;

4. in the presence of light, photolysis occurs, which generates $H^+$ and therefore affects concentration gradient;

**Page 407 Data-based questions: The effect of light and dark on carbon dioxide fixation**

1. the dark period causes the concentration of glycerate 3-phosphate to rise;

the dark period causes the concentration of ribulose bisphosphate to fall;

2. in the light reactions energy for Calvin cycle is produced;

   in the dark, RuBP is converted to glycerate 3-phosphate;

   glycerate 3-phosphate cannot be converted to RuBP;

   some of the glycerate 3-phosphate is converted to carbohydrate;

3. RuBP concentration would rise;

   glycerate 3-phosphate levels would fall;

4. **a.** lower concentration of glycerate 3-phosphate;

   **b.** lower concentration of RuBP;

**Page 411 End of chapter questions**

1. **a.** 0600 (morning)

   **b.** +2.2 mg $CO_2$ $h^{-1}$

   **c.** $CO_2$ uptake is higher in daylight than in darkness for both temperatures;

   In daylight, $CO_2$ uptake is higher at 15 °C than at 30 °C;

   In darkness, $CO_2$ uptake is higher at 30 °C than at 15 °C;

   **d.** $CO_2$ is released by the shrub during cellular respiration;

2. **a.** increasing substrate concentration results in an increase of the initial rate of reaction;

   the increases in rate of reaction decreases as the concentration increases;

   **b.** **i.** 0.7 arbitrary units

   **ii.** 0.55 arbitrary units

**c.** competitive inhibitor binds to the active site of an enzyme;

substrate cannot bind to the active site of the enzyme to catalyse the reaction;

reaction rate decreases**;**

**3. a.** rubisco activity increases as temperature increases;

**b.** $\frac{6.0-1.3}{6.0}\times 100\% = 78\%$**;**

**c.** activase;

**d.** at these temperatures molecules of activase begin to denature;

fewer molecules available for catalysis;

**e.** rate of photosynthesis increases from 35 °C to 42 °C;

rate decreases overall from 42 °C to 48 °C (as activase activity decreases more than Rubisco activity increases);

rate increases from 48 °C to 50 °C (as Rubisco activity increases more than activase activity decreases);

# Topic C2 – Cells

**Page 418 Data-based questions: Nitrous oxide and mating in newts**

**1. a.** by chemical signalling/smell/odorants binding to chemoreceptors;

**b.** by how hard he can hit her with his tail;

by the size of tail;

by the style of tail waving;

**2.** levels rise with each stage of courtship;

levels fall after completion of courtship;

**3.** female causes increase in level;

nitric oxide (NO) level increases if female remains motionless;

female causes a decrease if she moves away;

**Page 421 Data-based questions: Treatments for hypoglycemia**

**1. a.** both rise to a maximum and then fall;

more rapid rise / maximum reached sooner;

glucagon rises to a higher concentration / 2700 nanograms versus 3600 picograms;

**b.** error bars show changes are significant;

**2. a.** already some rise after 5 minutes;

but takes 40 minutes to reach maximum;

**b.** transport to liver cells by blood;

binding to glucagon receptors in liver cell plasma membrane;

release of second messenger inside liver cells;

activation of enzymes that break glycogen down to glucose;

release of glucose from liver cells;

**3.** not very effective;

little change in blood glucose level after injection;

**Page 431 Data-based questions: Energy for the sodium–potassium pumps in the brain**

**1. a.** reduces oxygen consumption;

by (about) 50% / from 16/17 to 7/8 μmol $L^{-1}$;

**b.** ATP consumption by sodium–potassium pumps is reduced;

ATP production by cell respiration is reduced;

oxygen consumption by aerobic respiration is reduced;

**2. a.** no further decrease in oxygen consumption / oxygen consumption is constant at 7/8 μmol $L^{-1}$;

**b.** sodium–potassium pumps fully inhibited at 5 μmol $L^{-1}$;

ATP is used for other processes in brain cells (that are not inhibited by ouabain);

**3.** 50% as oxygen consumption dropped by up to this with sodium–potassium pumps inhibited;

**4.** minimize the number of rabbits that were used in the experiment;

**Page 434 Data-based questions: Conduction velocities of nerve fibres and muscle**

**1.** up to 5 marks for quality and appropriateness of graph or bar chart, with:

diameter on x-axis;

velocity on y-axis;

myelinated and non-myelinated fibres clearly distinguished by data point symbols or colours;

a logarithmic scale on the x-axis would help with the very wide range of diameters;

**2. a.** faster conduction in wider than narrower non-myelinated neurons;

faster conduction in wider than narrower myelinated neurons;

faster conduction in wider than narrower muscle cells/fibres;

data provides (strong) support for hypothesis;

**b.** data supports the hypothesis with a trend for myelinated fibres to have faster velocities;

but no direct comparisons possible as no data for non-myelinated and myelinated fibres with the same diameter

**Page 441 Data-based questions: Analysing an oscilloscope trace**

**1.** −72 mV;

**2.** −30 mV;

because the membrane potential starts to rise very steeply on the trace when this potential is reached;

**3.** depolarization takes approximately 2 ms according to the graph;

repolarization takes approximately 2−3 ms; depolarization and repolarization together take 4−5 ms;

**4.** more than 65 ms because the graphs shows that the resting potential has not been reached after than time;

estimates between 80 and 500 ms are reasonable;

**5.** assuming a refractory period of 60 ms after the action potential during which impulses cannot be initiated, there could be one action potential per 80 ms;

$\frac{1000}{80} = 12$ action potentials per second

**6.** pulse of current that was given to stimulate impulses has not yet finished and causes the membrane potential to rise briefly after the repolarization;

**Page 448 End of chapter questions**

**1. a.** when the odorant binds to the receptor;

as the rest of the mechanism is in common;

**b.** activated G protein activates adenyl cyclase;

which converts ATP to cyclic AMP;

**c.** cyclic AMP binds to the calcium channel;

which causes it to open;

allowing passage of calcium ions onto the cell;

the calcium binds to the calcium dependent chloride channel;

which allows chlorine to exit the cell;

triggering olfactory neurons;

**2. a. i.** as (log of) body size increases, (log of) brain size increases;

**ii.** primate brains are larger (on average) in relation to body mass;

but there is much variation / a few primates have relatively small brains;

largest primates (and smallest) have relatively small brains;

**iii.** scattergram shows that human brain has the largest size (to body mass ratio);

primates with a larger body mass have lower brain mass;

human brain size is furthest above the line of best fit;

**b.** easier to climb trees / speed of movement /less food needed / greater agility;

**3.** curare and atropine would be antagonistic to ACh;

nicotine and muscarine would be agonistic to ACh;

# Topic C3 – Organisms

**Page 460: Data-based questions: Nerve and nerve fibres**

**1.** C

**2.** B

**3.** A

**4.** D

**5.** some are myelinated and some non-myelinated;

some are wider so the impulse is carried faster;

speed of impulse matters more with some nerve fibres than others;

**6.** count numbers in small sample areas/quadrats;

calculate the cross-sectional area of the whole nerve;

multiply the numbers in sample areas to estimate the numbers in the whole nerve;

count the number of fibres along a line along the diameter of the nerve;

calculate the square of this count;

multiply by the area of a circle ($\pi r^2$) and then divide by the area of a square ($d^2$);

**Page 466: Data-based questions: Exercise and training**

**1.** any method of data display that makes it easy to appreciate the differences is appropriate;

an obvious approach is to plot four bar charts, one above another, with level of exercise on the *x*-axis and the parameters such as heart rate on the *y*-axes;

the two training groups should be shown with paired bars, with different colours of fill and ideally a whistler above the bar to indicate the standard deviation;

**2.** there are many trends that are worth analysing;

training increases epinephrine secretion and lowers heart rate at rest and during warm-up but hardly at maximal exercise levels, but that may be due to more intense maximal exercise;

training increases arterial blood pressure, despite lowering heart rate;

training lowers oxygen uptake at rest but increases it at maximal exercise levels;

**3.** increases in epinephrine secretion in minimally trained athletes are positively correlated with heart rate, arterial blood pressure and oxygen uptake;

but the relationship is not directly proportional for any of these variables;

increased epinephrine secretion with more intensely trained athletes is not associated with higher heart rate or oxygen uptake but is positively correlated with increases in arterial blood pressure;

again, the relationship is far from being directly proportional;

**Page 470 Data-based questions: Exercise and ventilation**

**1. a. i.** falls from pH 7.41 to 7.37;

**ii.** rises from 0.2 to 2.2 litres per minute;

**iii.** rises from 10 to 55 litres per minute;

**b.** decrease in blood pH due to increase in blood carbon dioxide concentration;

increase in minute volume due to increased rate/depth of ventilation;

decrease in blood pH causes increase in ventilation (rate);

increase in ventilation rate causes increase in carbon dioxide output via the lungs/alveoli;

decrease in pH shows that not all extra carbon dioxide produced by respiration is removed;

**2. a.** not enough ATP/energy from aerobic respiration when the exercise is very vigorous;

increasing amounts of anaerobic respiration;

producing lactate;

which is acidic;

and cannot be metabolized until there is oxygen available;

**b.** minute volume rises higher with no $HCO_3^-$; because lower blood pH detected by chemoreceptors;

so ventilation is increased more;

but minute volume rises even with no $HCO_3^-$;

so blood pH is not the only factor increasing ventilation;

carbon dioxide output rises less with no $HCO_3^-$;

**Page 489 Data-based questions: Prevalence of HIV/AIDS**

**1. a.** USA:

$$43\,000 \times \frac{100\,000}{282\,000\,000} = 15.2$$

South Africa

$$665\,000 \times \frac{100\,000}{45\,000\,000} = 1478.8;$$

**b.** less education/understanding of risks in South Africa;

false theories about causes in South Africa;

less use of condoms in South Africa;

**2. a.** both rise to a peak and then fall;

much earlier peak in USA / 1995 versus 2008;

much higher peak in South Africa / 320 000 versus 45 000;

**b.** HIV spread to USA earlier;

infection rate higher in South Africa;

better health care/more money for health care in USA;

antiviral drugs introduced earlier in USA;

**3. a.** increase in behaviour associated with infection risk;

due to diminishing fear of infection because of successful drug treatments;

**b.** decreasing numbers of new infections;

due to better education and therefore less risky behaviour;

**Page 492 Data-based questions: Penicillin resistance**

**1.** Taiwan 55%; Norway 0.5%;

**2.** **a.** positive correlation / the higher the antibiotic use the higher the resistance;

**b.** use of an antibiotic causes natural selection of bacteria that are resistant;

only resistant bacteria survive and spread;

more intense natural selection with more use;

spread of antibiotics to natural environment;

**3.** how far from the correlation curve the true relationship might be;

how much variation/uncertainty there is in the data;

that we can be very confident that there is a positive correlation;

**4.** reduce use of penicillin / use other antibiotics;

develop new antibiotics;

only prescribe penicillin for bacterial infections that need to be treated;

do not use penicillin in agriculture;

ensure patients complete courses of penicillin;

**Page 498 End of chapter questions**

**1.** **a.** As the volume of grey matter increases, the volume of white matter increases.

**b.** cortex is the outermost layer of the cerebrum;

cortex is the grey matter

folded into peaks and grooves;

separated into right and left;

**c.** nerve function is dependent on active transport;

vesicle traffic at synapses requires energy;

**2.** **a.** the highest cardiac output is 25 $dm^3$ $min^{-1}$;

**b.** both rise as ventilation rate increases;

up to ventilation rate of 40;

*Note that comparisons only seek similarities*

as ventilation rate increases, heart rate rises and then plateaus;

as ventilation rate increases, stroke volume increases steadily;

**c.** $VO_2$ max is the volume of oxygen per minute in L $min^{-1}$;

ventilation rate of 150 gives the maximum cardiac output which would yield the maximum volume of oxygen exchanged;

**d.** With an increase in work rate, the ventilation rate increases;

the heart rate increases;

the stroke volume increases;

the increase in both heart rate and stroke volume increases the total cardiac output;

# Topic C4 – Ecosystems

### Page 504 Data-based questions: Population distributions

1. **a.** random, uniform, clumped;

   **b.** clumped, uniform;

2. **a.** uniform;

   **b.** so that as many nests as possible can be packed into the area while maintaining at least the minimum spacing the birds are happy with between them;

   **c.** low;

3. **a.** figure 8 distribution is clumped and figure 9 is random;

   **b.** population in figure 8 reproduces asexually because there are groups of plants all derived from one original bulb;

   population in figure 9 reproduces sexually because seed from the plants will be randomly dispersed;

### Page 516 Data-based questions: Barnacles

1. *C. montagui* yellow; *C. stellatus* red; *Semibalanus* green; *Elminius* blue;
2. 24 mm;
3. both interspecific and intraspecific;

   competition for food;

   competition for space on the rock;

4. rocks either have crowded barnacles or none;

   suggests they cannot live alone so are cooperating;

   more shelter from wave action if growing together;

### Page 523 Data-based questions: Chi-squared testing

1. $H_0$: two species are distributed independently (the null hypothesis);

   $H_1$: two species are associated (either positively so they tend to occur together or negatively so they tend to occur apart);

2. observed numbers:

| | Grey squirrel present | Grey squirrel absent | Row totals |
|---|---|---|---|
| **Red squirrel present** | 141 | 205 | 346 |
| **Red squirrel absent** | 145 | 100 | 245 |
| **Column totals** | 286 | 305 | 591 |

3. expected numbers:

| | Grey squirrel present | Grey squirrel absent |
|---|---|---|
| **Red squirrel present** | 167.44 | 178.56 |
| **Red squirrel absent** | 118.56 | 126.44 |

4. one degree of freedom;
5. critical region is >3.84 at a significance level of 5%;
6. chi-squared = 4.17 + 3.91 + 5.90 + 5.53 = 19.51;
7. calculated value of chi-squared is in the critical region;

   so there is evidence at the 5% level for association between red and grey squirrels;

   we can reject the hypothesis $H_0$;
8. fewer than expected occurrences of both species being present;

   more occurrences than expected of one species being present but not the other;

   suggesting competitive exclusion;

   similar niches so results not explained by factors such as the amount of woodland in a 10 km square;

   but other factors could be at work / not direct proof;

**Page 541 Data-based questions: Finding the energy content of biomass**

1. 10 × 80 × 4.2 J;

   = 3360 J for the whole cashew nut;

   $\frac{3360}{1.6} = 2100 \text{ J g}^{-1}$;

   = 2.1 kJ $g^{-1}$;
2. **a.** experimental result is 210 kJ for 100 g of cashew nuts;

   which is much less than the value of 2320 on the food label;

   **b.** incomplete combustion of the cashew nut;

   some heat transferred to the glass of the tube/thermometer;

   not all heat in the flame passed to the tube;

   temperature cannot rise above 100 °C because the water boils;

**Page 543 Data-based questions: Finding the energy content of biomass**

1. bar chart with seven bars correctly plotted;

   gaps between bars as the data is categoric;

   range bars to show highest and lowest values;

   correct legends and units on the axes;

2. factors that affect photosynthesis;

   light intensity;

   temperature;

   water availability/rainfall;

3. values converted to percentages of total global production;

   pie chart with seven sectors based on these percentages;

   sectors clearly labelled with biome names;

4. most production in tropics;

   larger area of tropical/temperate grassland and shrubland than forest;

   much of the Earth's primary production is in tropical rainforest;

   important to protect tropical forests; other valid conclusion;

**Page 550 Data-based questions: Keeling Curves**

1. **a.** cleaner air / less carbon dioxide recently produced by humans;

   away from dense vegetation which would increase short-term fluctuations;

   **b.** compare N and S hemisphere;

   check findings

2. **a.** all show annual rises and falls;

   amount of annual fluctuation varies / higher at Barrow / lower at South Pole;

   annual maximum at a different time of year at the South Pole;

   **b.** more photosynthesis near Barrow;

   greater difference between photosynthesis in summer and winter at Barrow;

   summer and winter at different times of year in N and S hemispheres;

**Page 555 End of chapter questions**

1. **a.** A number of possibilities, e.g. 1E, 2C, 5E

   **b.**

| | Together | SA alone | AB alone | Neither |
|---|---|---|---|---|
| Row 1 | 1 | 5 | 3 | 1 |
| Row 2 | 2 | 5 | 2 | 1 |
| Row 3 | 3 | 7 | 0 | 0 |
| Row 4 | 1 | 8 | 1 | 0 |
| Row 5 | 6 | 3 | 1 | 0 |
| Row 6 | 4 | 2 | 4 | 0 |
| Row 7 | 3 | 4 | 3 | 0 |
| Row 8 | 4 | 3 | 3 | 0 |
| Row 9 | 4 | 5 | 1 | 0 |
| Row 10 | 2 | 8 | 0 | 0 |

| | AB present | AB absent | Row total |
|---|---|---|---|
| **SA present** | 30 (38) | 50 (42) | 80 |
| **SA absent** | 18 (10) | 2 (10) | 20 |
| **Column total** | 48 | 52 | 100 |

The chi-square statistic is 17.7. The p-value is 0.00003. The result is significant at $p < 0.05$.

Expected results (rounded to whole numbers) are in brackets

**c.** A type of interaction where a plant produces a chemical that limits the growth of another plant.

**d.** competition, mutualism, commensalism, parasitism (dodder)

**e.** growing conditions are poor in other quadrants / mutualistic relationship / commensalistic relationship / parasitic relationship;

**f.** allelopathy of one toward the other;

significantly different niches;

**2. a.** *Compare requires similarities*

the average is 1.6 and all four are within the range of the average;

the saltwater irrigated plants have intermediate biomass to the freshwater irrigated plants;

**b.** *Contrast requires similarities and differences*

similar levels of weight gain to controls;

higher water intake compared to controls;

salt bite had greater weight gain and water intake;

**c.** requires greater water supply;

no loss in meat quality;

requires greater food intake because of food conversion ratio;

trade off: salt bite gives greater weight gain but more water intake;

**d.** food conversion efficiency is the ratio of weight gain compared to feed intake;

typically, a ratio of between 6:1 and 8:1;

**e.** variables affecting productivity include: temperature, precipitation and insolation;