

Oxford Resources for IB

Biology – 2023 Edition

Application of skills: Answers

B – Form and Function

1 – Molecules

B1.1 – Carbohydrates and lipids

Page 184 – Use of molecular models: Modelling glucose

- OH groups on C1, C2, and C4 are below the plane. OH groups on C3 and C6 are above the plane.
- The model has OH groups down-down-up-down, so is α -glucose. The OH groups on C1 and C4 face the same way, so a chain of alpha glucose forms a helix rather than a zigzag.

B1.2 – Proteins

Page 197 – Computer modelling

- Oxygen is red, carbon is black, nitrogen is blue, and hydrogen is white.
- The R-group of glycine is a hydrogen atom – the smallest of all R-groups and suitable where no extra chemical properties are required in a protein, or where space constraints prevent the use of any other amino acid which would take up more space.

The R-group of alanine is a methyl group ($-\text{CH}_3$), which is the second smallest. The molecular mass of alanine is 89, whereas that of glycine is only 75, and the molecular mass of tryptophan (the largest amino acid) is 204.

C – Interaction and interdependence

1 – Molecules

C1.1 – Enzymes and metabolism

Page 350 – Collecting and processing data: Measuring catalase activity

- Increases in the volume of oxygen in the inverted measuring cylinder give a measure of activity of catalase. Measure the volume at the start and end of a timed period. Subtract the initial volume from the final volume to get the increase in volume. Divide this by the time period to get the rate. The time should be measured in seconds and the volumes in millilitres, so the units for rate are millilitres per second (ml s^{-1}). For example, an increase in volume of oxygen in the measuring cylinder from 17 to 32 ml in 30 seconds would be a rate of $(32 - 17)/30 = 0.5 \text{ ml s}^{-1}$.

An alternative method of measuring the rate is to time how long it takes (in seconds) for a certain increase in volume to occur. For example, the time taken for the volume to increase by 10 ml could be timed. If this took 40 seconds, the rate would be $10/40 = 0.25 \text{ ml s}^{-1}$.

- Any factor that could affect the rate should be kept constant, apart from the dependent variable being investigated. The factors that affect the rate of an enzyme-catalysed reaction are

temperature, substrate concentration, enzyme concentration and pH. If substrate concentration is being investigated, enzyme concentration should be kept constant by using the same volume of yeast suspension with every trial and the suspension should be kept well mixed. Temperature should be kept constant by keeping the reaction tube in a thermostatically controlled water bath or hot block. If it is likely that the pH could vary, a pH buffer can be used to ensure that it remains constant.

- To dilute from 0.8 mol dm^{-3} to 0.2 mol dm^{-3} mix one volume of 0.8 mol dm^{-3} hydrogen peroxide with three volumes of water. For example, mix 100 ml of $0.8 \text{ mol dm}^{-3} \text{ H}_2\text{O}_2$ with 300 ml of water.

To dilute from 0.8 mol dm^{-3} to 0.4 mol dm^{-3} mix one volume of 0.8 mol dm^{-3} hydrogen peroxide with one volume of water.

To dilute from 0.8 mol dm^{-3} to 0.6 mol dm^{-3} mix three volumes of 0.8 mol dm^{-3} hydrogen peroxide with one volume of water.

- Maceration releases catalase enzymes from the cells, so that collisions can occur between molecules of hydrogen peroxide and the active sites of the enzymes.

Page 352 – Mathematics: Using logarithmic scales

1.

Temperature (°C)	Activity	Base 10 logs
15	68	1.833
25	123	2.090
35	243	2.386
45	536	2.729

- It is not possible to draw a straight line through the data points so the increase in rate with temperature is not exponential.

C1.3 – Photosynthesis

Page 391 – C1.3.7 Experimental techniques: Techniques for varying concentrations of carbon dioxide, light intensity or temperature experimentally to investigate the effects of limiting factors on the rate of photosynthesis

1.

- Boiling and cooling the water removes dissolved gases so the carbon dioxide concentration is zero. Other carbon dioxide concentrations can then be made by adding measured quantities of sodium hydrogen carbonate.
- 25°C and bright light are supplied because they provide ideal conditions for photosynthesis in pondweed, ensuring that temperature and light will not limit photosynthesis, and other limiting factors can be investigated.
- Repeating measurements allows the reliability of results to be assessed and also allows anomalous results to be identified. It ensures that a steady rate of photosynthesis has been achieved and there are neither slow initial readings nor a fall-off in rate as substrate becomes used up.

2.

- Light intensity – use different numbers of LEDs to generate different light intensities, or move the light source to different distances from the plant, using a light meter to measure the light intensity at each distance. Relative light intensity = $1/d^2$, where d is the distance between the light source and the plant.
- Temperature – use a thermostatically controlled water bath to keep the plant at desired temperatures such as 5°C to 40°C at 5°C intervals.

- Hydrogen carbonate concentration – start with the plant in boiled cooled water which has a concentration of zero and then add equal amounts of dissolved sodium hydrogen carbonate, measuring the rate of photosynthesis after each addition. (Hydrogen carbonate is used as a carbon source instead of carbon dioxide in many aquatic plants.)
3. Capture the oxygen produced by the pondweed and measure its volume. This can be done using an inverted water-filled measuring cylinder or syringe, or special apparatus can be used that allows the oxygen to be drawn into a graduated capillary tube.

Page 408 – Experimental techniques: Creating and interpreting absorption spectra

1. Similarities: both curves on the graph have peaks for absorbance at about 460 and 670 nm; both have a higher peak at 460 than 670 nm; both have lower absorbance at 500 to 600 nm.

Differences: one curve has higher absorbance at 500 to 600 nm than the other.

2. The curve with higher absorbance at 500 to 600 nm is *Acer* and the one with lower absorbance at these wavelengths is *Fagus*. The reason for deducing this is that the *Acer* leaf contained a red pigment which absorbs light with a wavelength of 500 to 600 nm.
3. The sunlight that reaches the Earth's surface has a range of wavelengths, but most of the radiation is in the 400 to 700 part of the range, so by using pigments that absorb in that range, plants maximize energy capture by photosynthesis.
4. The absorption spectrum shows high levels of absorbance from 400 nm (violet) to 700 nm (red). The reason for this prediction is that brown pigments have a dark coloration because they reflect little light of any wavelength, from violet to red.

2 – Cells

C2.2 – Neural signalling

Page 435 – Mathematics: The correlation coefficient and the coefficient of determination

1.
 - a. Negative correlation
 - b. Both of the r values are negative, indicating a negative correlation.

The r value for the median sensory nerve is larger (more negative) than the r value for the ulnar sensory nerve, so the negative correlation is stronger.

3 – Organisms

C3.1 – Integration of body systems

Page 464 – Mathematics: Regression analysis

1. There is positive correlation between mean sleep duration and overall score in semester grades, so there is some tendency for students who sleep longer to achieve higher scores.
2. The probability of getting a sample correlation coefficient as high as $r=0.38$ when in fact there is no correlation in the population is (less than) 0.0005.

The probability of getting a sample correlation coefficient as negative as $r=-0.36$ when in fact there is no correlation in the population is (less than) 0.001.

3.
 - a. A high standard deviation indicates that the student's length of sleep was very variable from one night to another

- b. Not having a daily routine; staying up late to binge-watch something; living in a noisy place; other factors affecting nightly sleep patterns.
4. The data shows that semester grades tend to be higher with longer sleep per night and less variation in sleep from night to night, so on average sleeping 7 hours on average is better than sleeping 6 hours on average, and on average having SD 1.5 is better than 2, from the point of view of scores in assessments; but high correlation does not imply causation; there might be something else involved; for example abler students might plan their revision ahead of the assessments so their sleep patterns didn't change at the time of the assessments.

Page 471 – Collecting and processing data: Interpreting spirometer data

1. resting ventilation rate is 18 breaths per minute
2. running ventilation rate is 21 breaths per minute
3. In several ventilations 2 dm^3 of air is inhaled in 2 seconds, so the calculated values for mean peak air flow rate should be approximately $1 \text{ dm}^3 \text{ s}^{-1}$.
4. Sit or lie down; use a spirometer to take repeated measurements of tidal volume; continue until repeated readings are steady indicating that the measurements are reliable.
5. Tidal volume is larger during exercise.
6. Forced vital capacity is reduced; residual volume is greater so less air is exhaled.

Page 471 – Technology: Using a smartphone as a data logger

1. 12 breaths over 70 seconds
2. at 20 seconds and 40 seconds

Page 475 – Exploring and designing: Colour of light and phototropism

1. The angle of bending can be measured in degrees using a protractor, where 0° is a shoot growing vertically upwards and 90° is a shoot that has bent so much that it is growing horizontally towards the light source.
2. Precision is how close measurements are to each other, so depends on resolution of the meter – greater precision can be achieved in measurements of mass with a meter that gives readings in milligrams than in grams.

Accuracy is how close a measurement is to the true value, so it depends on a lack of errors in the methods of measurement used. Systemic errors, such as meters not being calibrated properly, must be avoided to achieve accuracy.

Reliability is a measure of how much measurements can be trusted, and is demonstrated by repeating measurements and showing that they are close to each other.

3. Colour of light is measured using a spectrophotometer, which can measure either absorbance (in optical density units) at each wavelength, or % transmittance (percentage of light not absorbed).

D – Continuity and change

2 – Cells

D2.3 – Water potential

Page 654 – Mathematical tools: Standard deviation and standard error of the mean

- a. Assuming that the population mean is 3.1, 68% of the values are within one standard deviation of the mean, which is characteristic of the normal distribution.
- b. Assuming that population means are normally distributed, the probability (confidence) of one population mean lying being between 2.96 and 3.24 is 68%.

3 – Organisms

D3.1 – Reproduction

Page 671 – Use of a spreadsheet: Changes in the concentrations of FSH

1. 27 to 33 days
2. The answer depends on which online graphs of FSH concentration are chosen.
3. Days should be on the x-axis and FSH concentration on the y-axis.
4. 12, 15, 20, 14, 12
5. Ovulation

Page 681 – Designing methods: Seed dispersal

1. Drop height is the independent variable; distance travelled is the dependent variable.
2. Continuous data, as any distance (and drop height) is possible.
3. Wind speed; size of samaras; whether single or double-bladed.
4. Relationship between distance travelled and mass of samara/surface area of wing/double versus single wings/effect of wind speed.

D3.2 – Inheritance

Pages 708–709 – Continuous and discrete variables

1.
 - a. Discrete, as numbers of whole plants were counted.
 - b. Total of the 30 counts is 448; mean is $448/30 = 14.93$; median is 15; mode is 15; all the averages are close.
2.
 - a. Continuous – although the values are given to the nearest second, any time is possible.
 - b. Mean is 56; median is 63 (average of 61 and 65); mode is 23.
 - c. The data is bimodal, with five values between 20 and 23 and another group of values ranging from 58 to 92. For this reason, the modal value of 23 lying in the lower part of the range and median value of 63 lying in the upper part of the bimodal range do not represent the overall pattern of the data. The mean is therefore preferable, though it lies in the gap between the lower and upper parts of the range.

Pages 709–710 – Working with box-and-whisker plots

1. Mean is 176.75.
2. Minimum value is 152; Q_1 is 167.5; median is 176.5; Q_3 is 185; maximum value is 201.
3. Interquartile range is $185 - 167.5 = 17.5$.
4. Height of 210 would be an outlier.
5. x
 - a. The median maternal blood vitamin D is about 18 ng mL^{-1} in the no seizures group and is lower at about 9 ng mL^{-1} in the seizures group. This supports the hypothesis that babies with rickets experiencing seizures are breastfed by mothers with lower vitamin D levels.
 - b. The IQR is $30 - 14 = 16$ for the no seizures group compared with $16 - 5 = 11$ for the seizures group. Therefore, the spread of values is larger for the no seizures group.

- c. An upper range outlier for the seizures group would be a value greater than 1.5 times the IQR plus the Q_3 value: $(11 \times 1.5) + 16 = 32.5$.
- d. 50%, as 9 ng mL^{-1} is the median value of maternal vitamin D for infants in the seizures group.

4 – Ecosystems

D4.1 – Natural selection

Page 749 – Analysing data: John Endler’s simulation of natural selection leading to evolution

1.
 - a. Six generations during the first phase of the study with no predators; 14 generations during the phase when there were predators.
 - b. The average number of spots increased; from 10.15 to 11.85/increased by 1.7 spots.
2.
 - a. Further increase in number of spots with a weak predator/killifish; reduction with strong predator/pike-cichlids.
 - b. Spots make fish more visible to predators; in the presence of strong predators natural selection favours fish with fewer spots; spots make fish more attractive during mate-selection; in the presence of no predators/only weak predators natural selection favours fish with more spots.
3.
 - a. 5.2 mm^2
 - b. Increase of 5.4 mm^2
 - c. Natural selection favoured fish with smaller area of spots in Stream A where there was a strong predator; fish with more spots had higher chance of being predated than fish with fewer spots; natural selection favoured fish with more spots in Stream B where there was only a weak predator; fish with more spots were more successful at finding a mate and so produced more offspring.
4. The number of spots would decrease.

Page 750 – Using a database to explore allele frequencies

1. Commonest in China, South Korea and Japan; fairly common in other parts of Asia and in northern Europe.
2. Rice can be used to produce alcoholic drinks/rice wine; *2 allele selected for if the population drinks alcohol.
3.
 - a. Chromosome 4, band position 4q21–q23
 - b. *2allele(T) is common in Asian, East Asian and Other Asian populations; *2allele(C) is common in European, African, African American and Latin American populations.

D4.2 – Stability and change

Page 760 – Calculating percentage change

Rondonia: -20.3%

Para: -9.4%

Pages 760–761 – Extracting data from a database

- England and Scotland show a gain between 1880 and 2020; India shows a gain between 1970 and 2020.

- Brazil, Indonesia, Paraguay, and Nicaragua show a decrease between 1990 and 2020; India shows a decrease between 1880 and 1970.
- In none of the countries showing a decrease is there a clear trend for a decreasing rate of loss.

D4.3 – Climate change

Page 782 – Activity: upslope migration of bird species

1.
 - a. Montane regions are on mountains below the treeline.
 - b. Upslope migration is a change in the distribution of a population to higher altitudes on a mountain.
2.
 - a. 1250 metres
 - b. Negative correlation between upper elevation limit in 1969 and magnitude of the change in upper elevation limit / smaller changes in upper elevation limit with higher upper elevational limit in 1969.
 - c. Lack of suitable habitat above 1425 metres.
3. The competitive exclusion principle means that two species cannot occupy the same niche for an indefinite time. If two species have an overlapping fundamental niche then one species would be expected to outcompete and exclude the other from that part of its range.
4.
 - a. Impossible to migrate to higher altitude on Mount Karimui as the birds are already at the summit; climate becomes too warm for this species on the summit of Mount Karimui.
 - b. Other mountains might have higher summits so there would still be habitats with suitable temperatures for this species.

Page 786 – Activity: To what extent are plant life cycle processes affected by temperature?

1. R^2 is the proportion of variation that can be predicted from the independent variable, which in this case is temperature.
2. Flowering/leaf senescence/leaf abscission because photoperiod allows the ideal time of year for the process to be identified.
3. Germination/bud burst/leaf out because temperature allows the time in spring when conditions are warm enough for growth to be identified.
4. Producers are autotrophs who make their own carbon compounds using external energy sources.
5. Producers are at the start of food chains and are the original source of carbon compounds for other organisms in the food chain; producers provide a source of energy because energy flows from producers to other organisms in the food chain.
6. Longer growing season; bud burst/leaf out will happen earlier in spring; leaf senescence will happen later; more change in date of bud burst/leaf out than leaf senescence.