AQA A-Level Biology Year 2

Student Book Answers

Chapter 1: Photosynthesis

Assignment 1

A1. Blue and orange light.

A2. Chlorophyll does not absorb green light; it reflects it. The green light that it reflects enters our eyes, so it looks green.

A3. The action spectrum should be the same shape as the absorption spectrum for chlorophyll a.

A4. Having several different pigments allows the plant to absorb a wider range of wavelengths of light, increasing the efficiency of photosynthesis. It is also probable that some of the other pigments absorb wavelengths of light that might otherwise damage the chlorophyll molecules.

A5. Seaweeds that live deep in the water will receive only short-wavelength light, so they need pigments that will allow them to absorb these wavelengths.

Red pigments reflect only red light, and can absorb all of the short-wavelength colours, ranging from blue through to green. This means they can absorb more of the available light than a green pigment could, which – although good at absorbing blue and red light – cannot absorb green light.

Required Practical 7

P1. a. In order to be able to calculate Rf values, we need to know the distance travelled from the origin. The line is drawn in pencil because this is not soluble in the solvent used.

b. In order to calculate Rf values, we need to have a precise starting point for the pigments, so the spot must be small. The spot is made as concentrated as possible so that there is enough pigment to show up on the paper when it has been carried upwards by the solvent.

c. We do not want the pigments to dissolve in the solvent in the base of the container; they must only dissolve as the solvent is moving upwards through the paper.

d. The solvent will quickly evaporate, and if the line is not drawn while we can still see where the solvent front is, we would then not know how far up the paper it has travelled and would not be able to calculate Rf values.

P2. The type of plant is the independent variable, and it would be best to try control most other variables. Leaves should be collected from similar aspects of the plants (e.g. both on the side that gets most sun), at the same time of day and in similar weather conditions. The same solvent should be used to extract the pigments and run the chromatogram for both plants.

P3. a. A: 0.99; B: 0.73; C: 0.45; D: 0.38; E: 0.99; F: 0.46; G: 0.32; H 0.01.

b. A: carotene; B: xanthophyll; C: chlorophyll a; D: chlorophyll b; E: carotene; F: chlorophyll a; G: fucoxanthin; H: chlorophyll c.

Assignment 2

A1. Two substances might end up quite close together on the chromatogram when they are run with the first solvent. Using a second solvent, and running the chromatogram in a different direction, can separate them more clearly.

A2. X – triose phosphate. This is formed by the reduction of glycerate 3-phosphate, which is why only a tiny amount is present on the five-second chromatogram, only appearing in large quantity on the thirty-second one.

Y – glycerate 3-phosphate, as this is the first compound to be formed in the light-independent reaction, and will be the first to contain radioactive carbon from the carbon dioxide.

A3. a. The curve falls because ribulose bisphosphate accepts radioactive carbon dioxide to form glycerate 3-phosphate. However, this cannot be reduced to triose phosphate because there is no supply of reduced NADP or ATP from the light-dependent reaction. So no triose phosphate molecules are available for recycling to ribulose bisphosphate.

b. It rises because ribulose bisphosphate accepts radioactive carbon dioxide to form glycerate 3-phosphate, which cannot enter the next step of the reaction because there is no reduced NADP or ATP from the light-dependent reaction.

c. It levels off when all the ribulose bisphosphate has been used up, so no more glycerate 3-phosphate can be made.

Required Practical 8

P1. a. To prevent damage to enzymes (particularly dehydrogenase) and other proteins, which could be denatured at high temperatures.

b. To prevent damage to enzymes (particularly dehydrogenase) and other proteins, which could be denatured at a pH above or below 7.

c. To prevent absorption or loss of water from the chloroplasts, which could disrupt their structure.

P2. a.



b. Chlorophyll in the chloroplasts absorbed energy from light, and emitted electrons. These were picked up by the DCPIP, which therefore became reduced and lost its colour.

c. The loss of colour in the supernatant was slower than in the resuspended chloroplasts. This indicates that the reducing power of the chloroplast suspension was greater than the supernatant. However, the supernatant still did reduce the DCPIP, so it must have still contained some chloroplasts.

Assignment 3

A1. a. The temperature in environment T1 was always greater than that in T2. The difference was smallest in March (about 0.5 °C) and greatest in May and September (just over 1 °C).

b. T2 had shading, whereas T1 did not. Less light therefore entered the T2 environment, so less long wavelength radiation was produced inside the glasshouse and the air was not warmed as much.

A2. The greatest yield was obtained in the T2 environment, in which the temperature ranged from 32 °C to 39 °C.

A3. Other factors could be:

• carbon dioxide concentration – if this were lower in the open air than in the glasshouse, this would reduce the rate of photosynthesis

• wind speed – this would be greater outside than in the glasshouse, which could cause the plants to lose more water vapour from their leaves, or could cause physical damage to leaves

• humidity – could be higher or lower outside than in the glasshouse, which could affect the rate of water loss from the plant

• water content of soil – could be higher or lower outside than in the glasshouse, which could affect the rate of water uptake by the plant

• soil conditions – could contain more mineral ions in the glasshouse than in the soil

• more insects or other pests feeding on the plants, reducing their productivity

• more competition with weeds for light, water or mineral ions

• more diseases such as fungi, thus reducing productivity.

You may be able to think of others.

These factors could indeed be very significant, and they do mean that we cannot draw any firm conclusions about the effect of temperature when comparing the results for T1 and T4.

A4. The results could be used by growers in a temperate country, who could ensure that they maintain a temperature in the glasshouse within a range that is shown to produce high yields. However, they should balance costs of heating against expected increases in yields. It may, for example, prove more economical to provide a temperature nearer to the conditions of the T3 environment (between 31 °C and 38 °C) than the higher temperatures in T4, unless the increase in yield for the higher temperatures outweighs the extra heating costs.

Practice questions

1. a.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CO2 concentration (mmol mol-1)** | **Day/night temperature / ºC** | **Grain yield per plant / g** | **Above-ground biomass per plant / g** | **Harvest index** |
| 330 | 26/19 | 9.0 | 17.1 | 0.53 |
| 31/24 | 10.1 | 19.8 | **0.51** |
| 36/29 | 10.1 | 22.2 | **0.45** |
| 660 | 26/19 | 13.1 | 26.6 | **0.49** |
| 31/24 | 12.5 | 27.6 | **0.45** |
| 36/29 | 11.6 | 30.1 | **0.39** |

b. i. The higher carbon dioxide concentration produces a greater yield per plant. For example, at the lowest temperature range, doubling the carbon dioxide concentration produces a rise of 4.1 g per plant, which is a 45.6% increase.

ii. Increasing the carbon dioxide concentration reduces the harvest index. For example, at the lowest temperature range, doubling the carbon dioxide concentration produces a decrease of 0.04 in the harvest index.

c. i. At low carbon dioxide concentration, increasing the temperature range from 26/19 ºC to 31/24 ºC results in an increase in yield of 1.1 g per plant. Increasing the temperature further has no effect. At high carbon dioxide concentration, increasing the temperature range from 26/19 ºC to 31/24 ºC results in a decrease in yield of 0.6 g per plant, and there is a further decrease of 1.1 g per plant if the temperature is increased to 36/29 ºC.

ii. Increasing the temperature, at both carbon dioxide levels, decreases the harvest index.

d. Carbon dioxide concentration appears to be a limiting factor, so that increasing it always results in greater grain yield per plant, and greater above-ground biomass per plant. However, the increase in above-ground biomass is greater than in grain yield, which results in a lower harvest index at higher concentrations.

Increasing temperature tends to decrease grain yield but increase above-ground biomass. It appears that higher temperatures result in more growth of stems and leaves, but less grain.

e. Farmers grow cereal crops to harvest and sell grain. The stems and leaves are not useful, and use up resources (such as water and minerals in the soil) for no financial return. Having a higher grain yield per plant is good, but not at the expense of an even greater increase in useless growth of stems and leaves, as this could increase costs in replenishing used-up minerals in the soil.

2. a. i. To ensure that carbon dioxide concentration was not a limiting factor.

ii. To control any variables that might otherwise affect results – e.g. quantity of chlorophyll in the leaves.

iii. To ensure that triose phosphate would all be used up, with none in the leaves before the experiment began.

b. In the light-dependent reaction, the electron transport chain is needed for the production of ATP from ADP and Pi. If this cannot occur, then there is no ATP for use in the light-independent reaction, and no triose phosphate can be formed from GP.

c. During the light-independent reaction, carbon dioxide combines with ribulose bisphosphate. This substance is regenerated by conversion of five-sixths of the triose phosphate formed in the Calvin cycle. If less triose phosphate is formed, then less ribulose bisphosphate is regenerated, so less carbon dioxide will be used.

3. a. i. In the stroma of the chloroplasts.

ii. 2

b. The higher the concentration of oxygen, the lower the rate of absorption of carbon dioxide. This is because oxygen competes with carbon dioxide for the active site of rubisco. Oxygen is effectively a competitive inhibitor, reducing the rate at which rubisco catalyses the reaction with carbon dioxide to form GP.

c. Less GP will be formed at high concentrations of oxygen, and so less triose phosphate and other organic compounds will be formed. This will result in slower growth of the plant, and lower yields of soya beans.

4. a. ribulose bisphosphate

b. The light-dependent reaction takes place on the grana, where the absorption of light energy results in the formation of ATP and reduced NADP. Therefore, tube A would be able to produce these substances. Both of these substances are then used in the light-independent reaction, in which carbon dioxide is used.

c. The value would be 4000 or less. In the dark, no ATP of NADP would be made, so once the plant has used up any supplies remaining in the stroma, the light-independent reaction cannot take place and no more carbon dioxide will be taken up.

d. Tube C contained only stroma, so could not use light energy to make ATP or NADP, and therefore the light-independent reaction could not take place.

e. In the light-dependent reaction, the electron transport chain is needed for the production of ATP from ADP and Pi. If this cannot occur, then there is no ATP for use in the light-independent reaction, and no triose phosphate can be formed from GP. During the light-independent reaction, carbon dioxide combines with ribulose bisphosphate. This substance is regenerated by conversion of five-sixths of the triose phosphate formed in the Calvin cycle. If less triose phosphate is formed, then less ribulose bisphosphate is regenerated, so less carbon dioxide will be used.

5. a. Rubisco catalyses the reaction in which carbon dioxide combines with ribulose bisphosphate, to form GP.

b. In the stroma.

c. The rubisco activity is always greater in the GM plants than in the normal plants. An increase in carbon dioxide concentration reduces the activity of rubisco in normal tobacco plants, but increases it in the genetically modified plants. At a carbon dioxide concentration of just over 100 µmol dm-3 activity is approximately 1 unit greater in the GM plants, but at 650 µmol dm-3 it is about 5 units greater.

d. A greater rate of fixation of carbon dioxide means a greater rate of production of carbohydrates, which can then be converted to lipids and proteins. This will result in greater growth rates and therefore greater crop yields.

Chapter 2: Respiration

Required practical 9

P1. a. Movement of the liquid, time, mass/volume of yeast. (If the tube is not calibrated with volume measurements on it, you need to calculate the volume of gas used by the formula ‘pi r squared h’ where r is the radius of the tube and h is the distance moved by the fluid/bubble.)

b. Add a syringe or other measuring device that can inject air and move the bubble/fluid back to the start.

c. Keep the algae in the dark, to prevent photosynthesis.

P2. a. Temperature.

b. Rate of respiration (time taken for the blue colour to disappear).

c. Any three from:

* + volume of yeast
	+ concentration of yeast
	+ volume of methylene blue
	+ concentration of methylene blue.

P3. It is difficult to tell when the blue colour has completely gone. Human error/judgement can skew the results.

P4. A control, to show that the colour change is due to the respiration of the yeast and not some other factor.

P5. It is fuel for respiration (a respiratory substrate).

P6. The yeast was still respiring, suggesting that the yeast had some stored sugar.

P7. Air/oxygen is being mixed with the methylene blue, which is becoming oxidised again.

Assignment 1

A1. 16/23 = 0.70 (rounded up)

A2. Measure gas exchange twice – once with and once without the KOH. For example: when done with the KOH, 10 units of oxygen used. When done without the KOH you get a reading of 2 unit of oxygen used, which means that 8 units of carbon dioxide must have been made. The RQ is therefore 8/10 which is 0.8.

A3. It was respiring a mixture of carbohydrate and another substrate (lipid/protein).

A4. No. There is no oxygen used, and you can’t divide by zero.

A5. Different proteins have different amino acids, and so have different formulae.

A6. If their diet is working they will be respiring lipid, so their RQ will be lower than one/approaching 0.7.

Assignment 2

A1. Swimming and running (especially middle distance or long distance) are good aerobic exercises. Weight lifting is not, as it requires short bursts of intense activity.

A2. The myoglobin curve should lie to the left of that for haemoglobin, because it has a higher affinity.

A3. The myoglobin would provide an extra store of oxygen in the muscle, which could be used before anaerobic respiration had to begin. This could provide the runner with just a little more energy for muscle contraction, which might just give him or her the edge.

A4. Succinate dehydrogenase is one of the enzymes involved in the Krebs cycle. An increase in its activity means that the Krebs cycle could take place faster, or that more circuits of it could be completed in the same time span. This would provide more ATP and reduced coenzyme and therefore make more energy available to the athlete’s muscles.

A5. Marathon athlete maximum = 3.9

Untrained person maximum = 1.6

3.9 as a percentage of 1.6 is (3.9 − 1.6) ÷ 1.6 × 100 = 143.75%.

A6. More myoglobin – greater oxygen store and therefore more aerobic respiration possible before anaerobic respiration is required. More mitochondria – more aerobic respiration (Krebs cycle and oxidative phosphorylation) so a greater rate of ATP formation. More activity of Krebs cycle enzymes – a greater rate of the Krebs cycle reactions and therefore a greater rate of ATP formation. More glycogen stores in the muscle – more glucose can be produced more quickly, so more substrate is available for respiration.

A7.

|  |  |
| --- | --- |
| **Short term** | **Long term** |
| Increase in ventilation rate | Increase in haematocrit (the volume of red blood cells in the blood) |
| Increase in cardiac output | Increase in stroke volume |
| Increase in oxygen usage | Increase in vital capacity |
|  | Increase in the mitochondrial density in the muscle fibres |
|  | Increase in succinic dehydrogenase level in the muscles |
|  | Increase capillarisation (more blood vessels in the muscles) |

PRactice questions

1. a. Completion of diagram to show the number of carbon atoms present in one molecule of each compound:

**6** carbon compound

**3** carbon compound

**2** carbon compound

**4** carbon compound; **6** carbon compound

**5** carbon compound

b. Three of the other products that are produced in the Krebs cycle in addition to the carbon compounds shown in the diagram are:

* reduced NAD *or* NADH *or* NADH2
* reduced FAD *or* FADH *or* FADH2
* ATP.

2. a. They provide a larger surface area – for electron transport chain *or* more enzymes for ATP production *or* oxidative phosphorylation. Muscle cells use more ATP (than skin cells).

b. i. Substance **X** = pyruvate.

ii. Your answer should include two of the following points:

* + carbon dioxide is formed *or* decarboxylation
	+ hydrogen is released *or* reduced NAD is formed
	+ acetyl coenzyme A is produced.

c. NAD *or* FAD reduced *or* hydrogen attached to NAD *or* FAD; H+ ions *or* electrons transferred from coenzyme to coenzyme *or* carrier to carrier *or* series of redox reactions. Energy is made available as the electrons are passed on. Energy is used to synthesise ATP from ADP and phosphate *or* by using ATPase. H+ *or* protons are passed into the intermembrane space. H+ *or* protons flow back through stalked particles *or* enzyme.

3. a.

|  |  |  |  |
| --- | --- | --- | --- |
| **Statement** | **Glycolysis** | **Krebs cycle** | **Light-dependent reaction of photosynthesis** |
| NAD is reduced | 🗸 | 🗸 | × |
| NADP is reduced | × | × | 🗸 |
| ATP is produced | 🗸 | 🗸 | 🗸 |
| ATP is required | 🗸 | × | × |

 b. i. Pyruvate *or* succinate *or* any suitable Krebs cycle substrate.

ii. ADP and phosphate forms ATP. Oxygen is used to form water *or* as the terminal acceptor.

 iii. Order: Y, X, W, Z.

Reason: The order of carriers is linked to the sequence of reduction *or* reduced carriers cannot pass on electrons when inhibited.

4. a. i. Molecule X = pyruvate *or* pyruvic acid.

 ii. Molecule Y = carbon dioxide.

 b. Glycolysis occurs in the cytoplasm *or* cytosol of a cell.

c. i. ATP production is inhibited or stops.

ii Your answer should include any threeof the following points:

* + no reduced NAD (is released)
	+ no pyruvate *or* link reaction *or* Krebs cycle inhibited
	+ movement of electrons, protons, hydrogens (down the chain) stops *or* no electrochemical gradient
	+ no release of free energy to phosphorylate ADP.

5. a. Inorganic phosphate was added to the medium because it was needed to make ATP *or* for phosphorylation.

 b. Your answer should include three of the following points: oxygen is needed for the formation of ATP *or* for phosphorylation; oxygen is used so its level falls; oxygen reacts with ‘H’ to produce water; in the electron transport chain *or* at the terminal acceptor; allows recycling of reduced coenzymes *or* NAD *or* FAD.

 c. Equal amounts of ADP were added.

 d. Less oxygen is available in the medium at Z than at Y *or* because oxygen is all used up *or* ‘runs out’.

e. i. The glucose cannot enter the mitochondria because they are too large orthere is no carrier system for it *or* glucose cannot be metabolised (or something similar) because the necessary enzymes are not present.

ii. Your answer should include one of the following points: label the glucose and determine why it cannot enter the mitochondria; ‘break’ the mitochondrial membrane to allow the glucose to enter; ‘release’ the appropriate enzymes from the mitochondrion; add glycolytic enzymes *or* ‘cytoplasm’ to the medium in advance.

6. a. Electrons are transferred down the electron transport chain; provides energy to take protons/H+ into space between membranes; protons/H+ pass back, through membrane/into matrix/through ATPase. Energy is used to combine ADP and phosphate/to produce ATP.

b. i. To prevent damage (swelling/shrinkage) to mitochondria caused by water, osmosis, differences in water potential.

ii. Glucose is used or broken down during glycolysis. The breakdown of glucose/glycolysis occurs in the cytoplasm (not in mitochondria) because glucose cannot cross the mitochondrial membrane / does not enter mitochondria.

 iii. Terminal/final acceptor (in electron transport chain); it is used to make water.

7. a. i. Oxygen is taken up or used by the woodlouse. The carbon dioxide given out is absorbed by the solution/potassium hydroxide, which causes a decrease or change in pressure.

ii. The distance the drop moves and time; mass of the woodlouse; diameter/radius/bore of tubing/lumen / cross-sectional area.

b. There is less or no proton/H+ movement so less or no ATP is produced. Heat released from the electron transport/redox reactions or energy not used to produce ATP is released as heat. Oxygen is used as the final electron acceptor (or oxygen combines with electrons and protons).

8. a. 0.8

b. i. During aerobic respiration, there is an increase in the uptake of oxygen with growth/reproduction/division of yeast cells until glucose or nutrients becomes limiting (oxygen levels decrease) causing cells to die. Ethanol and toxins form, heat is produced and anaerobic respiration occurs.

ii. Ethanol produced by anaerobic respiration (or from pyruvate in anaerobic conditions) increases as oxygen uptake (or concentration) decreased. Decreases as glucose is used up / ethanol kills cells.

c. Oxygen uptake decreases/stopped. Oxygen is final (electron) acceptor/combines with electrons (and protons). Ethanol produced sooner / more ethanol produced.

Chapter 3: Energy and ecosystems

Assignment 1

A1. 5.5%

A2. 23%

A3. 59.8%

A4. a. Large numbers of chloroplasts in palisade cells; densely packed chlorophyll-containing thylakoid membranes in chloroplasts; several layers of mesophyll cells.

b. Other pigments (carotenoids) absorb green wavelengths and transfer energy to chlorophyll.

c. Chlorophyll molecules arranged in layers in lamellae, which avoids random shading.

A5. The rate of photosynthesis will be less than the maximum for most of the time. Light intensity may only be at its optimum level for short periods during the day. Other factors, such as temperature and carbon dioxide concentration, may limit the rate of photosynthesis. Growth rates may be restricted by shortages of water or mineral nutrients.

A6. a. Only a small proportion of the energy in crop plants is transferred to biomass in primary consumers such as cattle. People therefore obtain more energy from a given area of land when they are primary consumers rather than when they are secondary consumers.

b. Animals such as cattle and sheep can feed on plants such as grass that humans are unable to use. On marginal land these may be the only plants that grow. Also, humans use only some parts of crop plants and animals may make efficient use of the rest.

Assignment 2

A1. 10 000

A2. a. 0.2%

b. It mimics grazing. It just removes the upper parts/leaves, leaving the roots.

A3. To avoid bias / the conscious choice of the scientist.

A4. Give each square metre a number. Select 20 using a random number generator.

A5. To make sure all the water was removed.

A6. 38.3% (Calculated as 0.46 ÷ 1.25 × 100)

A7. Sample is burnt in oxygen. The energy given off heats up the surrounding water.

A8. N = 160 kJ

A9. 160 as a % of 5000 is 3.125%.

A10. Meat is much more digestible than plant material. Less is wasted in faeces (in un-digestible cellulose, etc.).

Practice questions

1. a. The starfish is a secondary consumer in the following food chain: algae → limpet → starfish *or*plant plankton → mussel → starfish.

The starfish is a tertiary consumer in the following food chain: plant plankton → animal plankton → barnacle

*or* mussel → starfish.

b. With the use of random numbers; by using a large number of quadrats; by counting the number of dead and live mussels in a unit area.

c. i. Barnacles are different-sized organisms *or* they have a different composition of carbohydrate, fat and protein *or* they have low digestibility *or* the whole barnacle cannot be eaten.

 ii. A starfish would have to eat 14 limpets to match the energy it would get from one chiton.

2. a. i. 63 (kJ m–2 day–1)

 ii. The percentage of solar energy that is fixed by photosynthesis (divide the products by radiation):

125 ÷ 5150 × 100 = 2.42718 = 2.43 or 2.4%.

b. Some light is reflected *or* not absorbed *or* refracted back into the atmosphere; some light misses the chloroplasts *or* chlorophyll; only certain wavelengths of light are used in photosynthesis.

c. Range of temperatures over which the leaves will show the greatest increase in biomass: 20 or 21 to 27 or 28 °C; greatest difference between photosynthesis and respiration.

3. a. kJ m–2 year–1 (it’s always: units of energy per unit area per unit time).

 b. i. 0.64/ 0.636 (%)

ii. Heat or respiration or movement or muscle contraction; faeces or indigestible material or food not eaten; excretion.

c. i. Some light is reflected *or* not absorbed or refracted; some light misses the chloroplasts *or* chlorophyll; only certain wavelengths of light are used.

ii. Light energy excites electrons from chlorophyll; electrons pass down carriers; energy is released during transfer; ADP + P forms ATP.

4. a. Transmission reflected *or* misses chlorophyll *or* chloroplasts *or* wrong wavelength.

b. The energy is transferred to, or absorbed by, or incorporated into the decomposers, such as plankton; stored in, or used in the growth of decomposers; respiration (of decomposers); released as heat; energy is stored in fossil fuels; combustion; released as heat.

c. The larger area enables seaweed to absorb light and carbon dioxide. There is a short diffusion pathway for gases or oxygen or CO2. Light is able to penetrate to all the cells.

d. There is less light underwater, as light is absorbed by the water, and the wavelength of light is different. Both the temperature and availability of the water could have an effect. In addition, the availability of carbon dioxide could vary underwater.

5. a. i. Stickleback + caddis fly (larva) + stonefly (larva).

ii. With fewer fish, there will be reduced predation – not being eaten results in more freshwater shrimps. Increased competition for food/resources / more producers eaten by shrimps / more shrimps eating producers means less food or resources for the mayfly.

b. i. Answer in the range of 16.8–18.9. (One mark for incorrect answer in which candidate divides 19–21 by 111–113.)

ii. Single-celled producers are more digestible as they contain less cellulose than plants; therefore, there is less energy lost in faeces. All of the producer is eaten whereas parts of the plant are not eaten; therefore, less heat/energy lost / less respiration.

c. Overall idea: the carbon dioxide is fixed into organic molecules in photosynthesis. Photosynthesis/light-dependent reaction/light-independent reaction; carbon-containing substances.

6. a. F – E – R/ F – (E + R)

b. i. Increase because fed concentrates/food with high nutritive value/food with high digestibility/food with little waste/because less egested.

 ii. Decrease because movement restricted/heat loss reduced.

c. i. 0.98 : 1 or 98 : 100.

ii. Mammals maintain (body) temperature/have high (body) temperature.

d. Results show a positive correlation. Most/higher values close to the line; lower values less close to line/less correlation; generally predicted values are higher (or actual values are lower).

7. Animals are slaughtered when still growing/before maturity/while young so more energy is transferred to biomass/tissue. They are fed on a concentrated or controlled diet so a higher proportion of food absorbed/digested/assimilated is used for biomass/tissue (or a lower proportion is lost in faeces). Their movement is restricted so there is less heat/energy lost (or less respiratory loss). Their surroundings are heated so they are kept warm so less heat/energy/respiratory loss/maintain body temperature. Genetically selected / selective breeding (for high productivity).

Chapter 4: Nutrient cycles

Assignment 1

A1. a.

 

b. The soil in the field must already contain some nitrogen in a form that is available to plants.

c. The increase is less at high nitrogen fertiliser levels than at lower ones. It is probable that at low nitrogen levels, nitrogen is the limiting factor for growth. Once nitrogen levels reach higher levels, then other factors become limiting so adding more nitrogen cannot cause yield to increase accordingly.

d. At 200 kg ha–1, cost of fertiliser is £80 per hectare. Return for grain is £960 per hectare.
Profit = £880 per hectare.

At 150 kg ha–1, cost of fertiliser is £60 per hectare. Return for grain is £940 per hectare.
Profit = £880 per hectare.

At 100 kg ha–1, cost of fertiliser is £40 per hectare. Return for grain is £860 per hectare.
Profit = £820 per hectare.

The farmer will therefore get most profit using either of the two higher values of fertiliser application.

Assignment 2

A1. In 2000, agriculture was responsible for approximately one-fifth of the total pollution. This proportion fell gradually, until in 2006 it was just over one-tenth.

A2. A high BOD means that there is a large population of aerobic microorganisms that are using up oxygen from the water. This indicates that nutrients have been added to the water, a sign of pollution.

A3. a. We want to know how rapidly oxygen is being used up from the water. If there is air in the tube, this supplies extra oxygen, so it will take longer for the oxygen concentration in the water to drop and we will get a smaller difference in oxygen concentration at the end of five days than we should.

b. We do not want any algae or phytoplankton in the water to be able to photosynthesise, as this would supply extra oxygen and skew the results.

A4. Samples of water could be taken from various points in the watercourse, and their BOD measured. If there is a sample with a high BOD downstream of one with a low BOD, this would suggest that pollutants have entered the water somewhere between them.

A5. Site 1 must be above the source of pollution, as it contains many organisms with a high biotic index (that is, organisms that require a high concentration of dissolved oxygen). Site 2 has very few of these organisms, suggesting that the oxygen concentration here is much lower.

Indicator species can be captured and identified on the spot, and give an instant set of results. There is no need for access to a laboratory. Measuring BOD, however, requires a laboratory and takes five days. On the other hand, using indicator species might not pick up some types of pollution, if these do not affect the oxygen content of the water. For example, it is possible that some industrial chemicals or heavy metals might cause harm to the community, but not affect the relative proportions of organisms with high or low biotic indices.

A7. Biotic factors such as predation (by fish, for example), competition are the likely reason for the absence of bloodworms and rat-tailed maggots from well-oxygenated water.

Practice questions

1. a. i. Nitrogen-fixing bacteria convert nitrogen in the air into ammonium compounds.

 ii. Nitrifying bacteria convert nitrites into nitrates.

b. i. Growing legumes, such as beans, peas or lentils ploughed in or allowed to decompose or nitrogen-fixing bacteria in nodules. Allow cattle (or other species) or farm animals to graze; add dung or urine. Spread or add manure or slurry; decomposed to release nitrates or ammonia or nitrites.

ii. Bare soil or fallow in winter or hedge removal; leaching of nitrates or soil erosion. Uptake of nitrates or ammonium compounds by crop; harvesting crop (or named crop), which would be harvested. Farm animals eat the plants in the field, then the animals are removed.

2. a. Nodules contain nitrogen-fixing bacteria or Rhizobium; atmospheric nitrogen into ammonia or ammonium ions.

b. Waterlogged soil results in anaerobic conditions, which favour growth of denitrifying bacteria, which convert nitrates to atmospheric nitrogen.

3. a. i. The process represented by carbon output: respiration or decomposition.

ii. The process represented by nitrogen input: nitrogen fixation *or* death of animals or organisms *or* excretion.

 b. An increase in temperature causes an increase in photosynthesis; as enzyme activity increases.

c. The plant roots took up nitrate more slowly than those in a control solution due to: secretion or release of enzymes; extracellular digestion; absorption of soluble products, e.g. glucose, amino acids.

4. a. There is a decrease in BOD from site X to site Y because: sewage contains organic content; bacteria or microorganisms break down organic matter; use of oxygen during respiration.

b. There is an increase in the concentration of ammonium ions and nitrate ions from site X to site Y because: ammonium ions are produced from the breakdown of protein or amino acids; deamination; ammonium ions are converted to nitrite; nitrite is converted to nitrate by nitrifying bacteria.

5. a. Shortage of nitrogen-containing compounds could limit plant growth by:

* reduced or unable to synthesise protein or amino acids – lack of enzymes for metabolism
* reduced or unable to synthesise DNA or nucleic acids or organic bases – mitosis or cell division is reduced
* reduced NADP or less chlorophyll causes reduced photosynthesis
* reduced levels or less NAD causes reduced respiration.

b. i. The water potential of the soil is reduced or more negative or there is a reduced water potential gradient; therefore, less water moves into the roots/water moves out of the roots by osmosis.

ii. Nitrate is washed or runs off or leaches from fields; algal bloom results or there is an increase in algal growth, which results in reduced light to other producers; death of algae or producers; increase in decomposers or decomposition; aerobic respiration or requirement of oxygen (O2) or increased BOD.

c. Uptake by active transport; oxidative phosphorylation or electron transport chain stops, slows down or glycolysis only occurs; Krebs cycle provides reduced NAD or FAD produces ATP; less ATP.

6. a. i. Substance X = ammonia or ammonium ions/compound.

 ii. Substance Y = glucose.

 b. In aerobic respiration, oxygen is the final acceptor for hydrogen; to form water.

c. Glycolysis can continue; and NAD can accept more hydrogen.

d. The secondary or tertiary structure produces the particular shape of the active site. *or* The shape of the active site is complementary to the shape of the substrate.

e. Sodium ions (or non-competitive inhibitor) bind to the enzyme at a site other than the active site. This results in a change of shape of the active site so it is no longer complementary. The substrate can no longer bind with the enzyme or the enzyme–substrate complexes are no longer formed.

7. a. i. Excessive use of fertilisers in farming; loss of minerals from run-off or leaching.

 ii. Description of the effect the nitrate concentration may have in the river at point Y:

* growth of algae or plants are stimulated or increased
* death of algae or plants
* more bacteria or decomposers or decomposition
* respiration
* decomposers or bacteria remove oxygen
* animals die because of lack of oxygen.

b. No membrane-bound organelles, for example, lysosome; circular DNA; plasmids; cell wall made of murein or peptidoglycan or capsule; flagella; mesosomes; smaller or 70S ribosomes; size – qualified.

8. a. i. Nitrification/oxidation.

 ii. Denitrification.

b. They can convert nitrogen to ammonia/NH3/ammonium to produce protein/amino acids/named protein/DNA/RNA.

c. Adding a high quantity of fertiliser would cause the soil to have a low(er) water potential (or plant/roots have higher water potential); therefore, it would result in osmosis (or diffusion) of water from the plant into the soil.

Chapter 5: Survival and response

Required practical 10

P1. Woodlice do not show a preference for any particular conditions.

P2. Between 0.02 and 0.01.

P3. Between 1 and 2%.

P4. Our results are significant, beyond the 5% threshold. We can reject the null hypothesis.

Assignment 1

A1. a. The receptor is in the tip region.

b. The effector is in the region just behind the tip region.

A2. Yes, because when the chemical messenger was prevented from reaching the effector by the mica there was no response.

A3. A chemical diffused from the tip into the block. This chemical then diffused from the block into the decapitated coleoptile, stimulating growth.

A4. By measuring the angle of curvature – the greater the concentration of auxin, the greater the angle.

A5. To prevent lateral diffusion of the hormone.

A6. Photo-destruction of the hormone on the illuminated side of the tip. Movement of hormone away from the illuminated side of the tip.

A7. Gravity results in hormone moving towards the lower side of the stem. The increased concentration of auxin on the lower side stimulated growth there, so the stem curves upwards.

Assignment 2

A1. Poor features of the design included:

* germination rate on Earth had not been tested before the experiment – in the event less than 50% of the seeds germinated in space and only 50% on Earth
* only three seeds were planted in each compartment and some of these did not germinate
* there is no indication that the intensity of light reaching the seedlings was measured – only that it was different.

A2. The low germination rate and the apparently random growth meant that no valid conclusion could be reached.

A3. The response to different light intensities may be affected by lack of gravity. Growth in space was generally irregular indicating that gravity affects the translocation of growth hormones. Some seedlings grew away from directional light, the opposite to the response on Earth, indicating that both light and gravity are involved in the phototropic response. The taller growth of plants in space and the irregular growth might be explained by growth hormone remaining near its site of production at the tip rather than moving down the stem (towards the stimulus of gravity).

Assignment 3

A1. Red and green.

A2. Because of the stimulation of red- and green-sensitive cones.

A3. White light stimulates all three types of cone. Black objects do not reflect light, so none of the cones are stimulated.

A4. These people lack red-sensitive cones, but the green-sensitive cones are stimulated by red light, so all the dots will appear green.

A5. Genetic diagram. If B = allele for normal vision and b is the allele for colour blindness.

A male can inherit colour blindness from two normal sighted parents as follows:

Mum’s genotype was XBXb and Dad’s genotype was XBY–

The colour blind male is XbY–. He gets Y from dad (otherwise he wouldn’t be a male), and gets the X chromosome with the b allele from mum.

A6. Mutation of the gene for rhodopsin could have resulted in a different nucleotide sequence in the DNA. This would add a different sequence of amino acids during protein formation. The resulting protein would have a slightly different shape and so would absorb different frequencies of light.

A7. The pigment in the red cones becomes broken down faster than it is resynthesised. When you look at a white area, only the green and blue cones from this part of the retina send impulses to the brain, so the paper is seen as green-blue.

Practice questions

1. a. The apparatus was illuminated only from above to attract midges towards the junction or towards the ‘choice area’.

b. The type of behaviour that the midges displayed is called: taxis or chemotaxis.

c. Independent variable, e.g. spraying one arm with extract, the other not or spraying some volunteers, and not others.

Dependent variable, e.g. compare or count the bites.

Reliability addressed, e.g. large number; several trials.

2. a. i. Heart rate = 75 beats per minute.

 ii. Hours that the ventricular muscle would be contracting:

0.3 ÷ 0.8 × 12 = 4.5 hours.

b. i. Your answer should include five points from: the cardiac muscle is myogenic; sinoatrial node (SAN); wave of depolarisation or impulses or electrical activity across atria; initiates contraction of atria; atrioventricular node (AVN); bundle of His or Purkyne tissue spreads impulse across ventricles; ventricles contract after atria or time delay enables the ventricles to fill.

ii. Your answer should include five points from: pressure receptors; in the aorta or carotid artery or sinus; send impulses; to the medulla; along parasympathetic or vagus pathway; this slows the heart rate.

c. It will cause the mixing of oxygenated and deoxygenated blood; blood flow from the left to the right ventricle; there will be higher blood pressure on the left side.

3. a. i. There are no sense cells or no rods and/or cones at point P.

 ii. The maximum number of cones are at the part of the retina labelled Q.

b. Rod cells allow us to see objects in dim light because: they have connections with one neurone or bipolar cell; idea of summation of generator potentials; exceed threshold; individual generator potentials do not exceed threshold.

4. a. They are hidden from predators; helps to prevent desiccation.

b. Gravity, water/humidity/moisture, temperature/warmth/heat/cold.

c. i. The dishes were arranged as shown to ensure that directional light does not influence the results / provides random arrangement with respect to light / control for responses to compass direction.

ii. Animals aggregate in shade or away from light; irrespective of the orientation of the dish.

iii. Random or non-directional movement until in shade; animals wander less in shade, so they are more likely to stay there.

5. a. Three changes described; e.g. formation/growth of vacuole; formation of starch grains/amyloplasts; movement of grains/amyloplasts towards bottom of cell; cells get longer/wider/larger.

b. Your answer should include some or all of these points: grows sideways before starch grains form; bending starts when/as grains form; more bending as grains increase in number; more elongation (of cells)/growth (of roots) downwards as starch grains increase/move; bending starts before grains move down; could be related to vacuole.

c. There is greater elongation growth on top of root/less growth on bottom of root; IAA at bottom of root/where IAA concentration high inhibits expansion/elongation (of cells); IAA at top of root/where IAA concentration is low leads to expansion/elongation of cells.

6. a. Taxis is movement towards/away from a stimulus / a directional response/movement (to a stimulus); move towards temperature they were used to/cultured in.

b. Hungry, so seeking food / in absence of food respond to temperature; move towards temperature they were used to/cultured in; associate (this temperature) with food; then stay in this temperature.

c. Dim worms live in soil/dark/ affected by bright light / dim light is like normal environment/what they are used to; even because worms might move towards/away from bright light / to avoid creating light gradient / prevent worms showing phototaxis/ all parts of surface exposed to same light. Dim light ensures heat from light not a variable / heat from lamp could kill/dry out worms.

7. a. Oxygen/carbon dioxide is detected by chemoreceptors; pressure is detected by baroreceptors. The medulla/cardiac centre involved. There are more impulses to SAN/along the sympathetic nerve.

b. i. To ensure results are due to omega-3/fatty acids only; i.e. not due to something else in

the oil. Placebo linked to mental/psychological effect.

ii. Lower/greater change of heart rate for Group A. The differences are real (reliable, significant) and not due to chance because the bars do not overlap (values are not shared).

8. a. Diffusion.

b. Causes plant to bend/grow towards light / positive phototropism; and light is required for photosynthesis.

c. More kinetic energy so faster movement of molecules; therefore, more diffusion.

d. i. Thick cuticle on upper surface (or thin cuticle on lower surface) and few or no stomata on upper surface so there is more diffusion (or a shorter diffusion pathway on the lower surface).

ii. Different species have different (qualified) properties.

Chapter 6: Nerves and synapses

Assignment 1

A1. For both types of neurone, the greater the axon diameter, the faster the speed of conduction. Myelinated nerves conduct impulses faster. Myelinated nerves are generally greater in diameter. There is a greater range of diameters in myelinated nerves.

A2. 33 m s–1

A3. 12/22 × 100 = 54.5% increase.

A4. 96 m s–1 / 33 m s–1 = 2.9 times faster (or 63 m s–1 faster)

A5. Faster transmission of responses to allow rapid reactions to stimuli. Communication between different parts of vertebrates to give a coordinated response as multiple processes occurring at the same time.

Assignment 2

A1. As an electrical current – a flow of electrons.

A2. Receptor.

A3. Motor neurone.

Assignment 3

A1. Discussion question.

Assignment 4

A1. Dopamine is released into the synapse at the presynaptic membrane. After binding with the dopamine receptor on the postsynaptic membrane, dopamine returns to the synapse where it is reabsorbed via dopamine reuptake receptors in the presynaptic membrane. The dopamine is then degraded by monoamine oxidase in the mitochondria.

A2. Dopamine will accumulate in the synapse, resulting in continuous depolarisation of the postsynaptic membrane.

A3. The change is not due simply to chance.

A4. Increase in use of cocaine; decrease in use of LSD; decrease in use of cannabis in 16–24 group. Overall decrease in drug use, bigger decrease in 16–24 group.

A5. Drug use generally higher in 16–24 group than in rest of population, in most cases at least twice as prevalent.

A6. The actual numbers were not measured but estimated from data obtained only from people who had been in contact with ‘authorities’.

A7. People were asked about drug use in surveys. Their answers may not always be truthful since use of many types of drugs constitutes an offence.

Practice questions

1. a. i. The sodium ion channels open; this allows rapid influx of sodium ions.

ii. Sodium ion channels close and potassium ion channels open; this allows efflux of potassium ions.

2. a. The action potential arrives or depolarisation occurs; calcium ions enter the synaptic knob; vesicles fuse with the membrane; acetylcholine diffuses across the synaptic cleft and binds to receptors on the postsynaptic membrane.

 b. The inside becomes more negatively charged or hyperpolarised; stimulation does not reach threshold level or action potential not produced; depolarisation does not occur or reduces effect of sodium ions entering.

c. i. Vigabatrin inhibits the enzyme, which breaks down GABA so more GABA is available to inhibit the neurone. *Or* Vigabatrin binds to GABA receptors and inhibits neuronal activity or chloride ions enter the neurone.

ii. Because the GABA receptors will have a different tertiary or 3D structure or the shape may not be complementary so GABA cannot bind. Inhibition of neuronal activity does not occur (or chloride ions do not enter).

3. a. i. The receptors for the reflex are in the retina or fovea.

ii. The sympathetic nervous system causes the pupil to dilate or radial muscles of the iris to contract. The parasympathetic system causes the pupil to constrict or circular muscles of iris to contract. The sympathetic and parasympathetic systems have antagonistic or opposite effects.

 b. Both pigments are found on lamellae, both break down or bleach in presence of light. Rods have rhodopsin; cones have iodopsin. Rhodopsin, pigment, rods are sensitive to white light and have a wide range of wavelengths. Rhodopsin, pigment, rods are sensitive to lower light intensities than iodopsin or cones. Three types of pigment or iodopsin or cone are sensitive to red, blue or green light.

c. i. All or more cones are in the central region of the retina in humans (or converse).

ii. Dogs have limited colour vision or can distinguish fewer colours and they are unable to distinguish two of either green, yellow, orange, red or they are red–green colour blind. Only one type of cone is stimulated over this range, i.e. there is no overlap in absorption spectra so a dog has better vision in dim light. A dog has a higher frequency of rods, and therefore lower visual acuity as a dog has a higher convergence (or summation occurs with rods) (or converse). A dog has better peripheral or all round vision, i.e. a wider field of view. Binocular vision is limited to directly in front.

4. a. The membrane is relatively impermeable or less permeable to sodium ions – gated channels are closed/have fewer channels. Sodium ions are pumped or actively transported out by a sodium ion carrier or intrinsic proteins. There is a higher concentration of sodium ions outside the neurone. Inside is negative compared with the outside – three sodium ions out for two potassium ions in.

 b. i. 1.6 ms.

 ii. 18 ÷ 1.6 = 11.25 mm ms–1 – then multiply by 1000 to convert from ms to s = 11 250 mm s–1.

 iii. The value would be an underestimate of the speed of transmission of an impulse along a neurone because it does not take into consideration time for transmission or diffusion across the neuromuscular junction or synapse, or the time it takes for muscle fibrils to contract.

c. Acetylcholine moves by diffusion into the neuromuscular junction, then binds to receptors on the postsynaptic membrane, causing sodium channels to open and allow sodium ions to move in to the muscle cell, causing the cell membrane of a muscle fibre to depolarise.

d. i. The cobra’s toxin binds to, competes for, or blocks the acetylcholine receptors; therefore, acetylcholine cannot depolarise the membrane or the toxin does not cause depolarisation (or allow action potentials to be generated).

ii. The muscles stay contracted because acetylcholinesterase is unable to break down the acetylcholine so the acetylcholine is still available to depolarise the membrane or generate action potentials in the membrane.

5. a. Active transport of sodium and potassium ions – D; Diffusion of sodium ions – B; Diffusion of potassium ions – C.

 b. i. Myelin insulates or prevents ion movement and facilitates saltation or ‘leaping node to node’.

ii. The cat has a higher body temperature; and therefore has faster diffusion of ions or faster opening of ion pores, gates or channels.

 c. Your answer should include the following points: increasing stimulus (potential) causes decrease in potential difference or rise in potential at P; 1 or 2 is sub-threshold or 1 or 2 does not give an action potential; 3 or 4 is above threshold or 3 or 4 does give an action potential; influx of Na+ ions; voltage-gated channels (in axon membrane) opens or opens Na+ channels or membrane more permeable to Na+; sufficient for stimulation of adjacent region of axon; impulse propagated (from P to Q); reference to ‘all-or-nothing’ law.

 d. Your answer should include the following points: X or acetylcholine → opening of Na+ channels or increases Na+ permeability; X or acetylcholine → Na+ ion entry into Z; X or Na+ entry – raises potential or reduces potential difference or makes potential less negative; Y or Cl entry – lowers potential or increases potential difference or makes potential more negative; X stimulates, and Y inhibits (Z); balance of impulses from X and Y determines whether Z fires action potential or determines whether potential rises above threshold.

6. a.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Resting** | **Starting to depolarise** | **Repolarising** |
| **Membrane potential / mV** | –70 | –50 | –20 |
| **Na+ channels in axon membrane** | Closed | Open | Closed |
| **K+ channels in axon membrane** | Closed | Closed | Open |

 b. Active transport or pump of Na+ out of axon; diffusion of K+ out of axon or little diffusion of Na+ into axon.

 c. They cannot pass through the phospholipid bilayer; this is because they are water soluble, not lipid soluble/charged/hydrophilic/hydrated.

7. a. Causes sodium ion channels to open; sodium ions then enter (cell and cause depolarisation).

 b. (If not removed) keeps binding (to receptors) and keeps causing action potentials/depolarisation (in postsynaptic membrane), which prevents information being carried across synapse/described consequence.

c. Movement in all groups (about) same before MDMA; MDMA increases movement in Group L; Group K shows MDMA causes movement; no/little increase in mice without receptor/Group M.

8. a. In myelinated neurones, action potential/depolarisation only at node(s). In myelinated, nerve impulse jumps from node to node/saltatory. In myelinated, action potential/impulse does not travel along whole length.

 b. The probability of obtaining this difference by chance is less than 5%/less than 0.05/less than one in 20; the difference is significant.

 c. All dementia results lower than control group (or non-dementia result higher). The error bars do not overlap so differences are (possibly) significant. However, dementia may be due to other factors / not only due to a lack of myelin; (Because) big/significant differences in myelin in different dementia; only small sample sizes/only one study/ more data required.

Chapter 7: Muscle power

Assignment 1

A1. Temporal summation, since impulses are arriving more rapidly from the same neurone to the muscle fibre.

A2. Increasing the frequency of nerve impulses to a muscle fibre increases the strength of contraction; for a nerve fibre the number of action potentials produced would increase, but every action potential would be the same size. The nerve fibre has a refractory period but the muscle goes into tetanus if the time interval between impulses is very short.

A3. Spatial – since it depends on the number of neurones feeding in impulses.

Assignment 2

A1. Yes – endurance athletes such as long distance runners, canoeists and triathletes have the highest proportion of slow-twitch fibres in relevant muscles; short-event athletes such as shot putters and weight lifters have the lowest proportion.

A2. Study A does not support the hypothesis, but study B does. However, both studies involved too few athletes to give reproducible results.

A3. There is insufficient evidence to support the hypothesis, but some indication that fibre conversion may take place under some circumstances.

Practice questions

1. a. i. The A band remains unchanged in length when the muscle fibre contracts.

 ii. The H zone *and* the I band decrease in length when the muscle fibre contracts.

b. The filaments in I *or* thin filaments *or* actin filaments slide in between the myosin or thick filament. Thin filaments enter the H zone *or* meet in the middle of the A band *or* pull the Z lines closer, accounting for the decrease in length in the H zone and I band.

c. The length of the contracted muscle fibre is 22.5 mm *or* The relaxed sarcomere length is 24 ÷ 8 = 3 μm.

d. i.

|  |  |
| --- | --- |
|  | **Type of muscle fibre** |
|  | Type 1 | Type 2 |
| **Number of mitochondria** | low | high |
| **Activity of Krebs cycle enzymes** | low | high |
| **Rate of fatigue** | high | low |

ii. The overall rate of contraction is limited by the rate of ATP-splitting. ATPase splits ATP *or* hydrolyses ATP *or* converts ATP to ADP (+ phosphate). ATP-splitting provides energy for: myosin–actin interaction, myosin head movement *or* actin to move relative to myosin to ‘cock’ myosin head.

iii. Type 2 muscle fibres: lactate is the product of anaerobic respiration. Type 1 muscle fibre has a higher activity of glycolytic enzymes *or* has lower activity of Krebs cycle enzymes *or* has fewer mitochondria.

2. a. i.



ii. The electron microscope has greater resolution or one can distinguish between two close objects. Electrons have a shorter wavelength or higher frequency.

 b. Answer: 37.65

Calculation: Measured diameter of myofibril = 8.5 mm × 1000 = 8500 µm

 8500/8000 (magnification) = 1.0625 µm

40/1.0625 = 37.65 = number of myofibrils that would fit into one muscle fibre.

 Allow correct calculation based on original measurement of 8–9 mm.

3. a. i. The main protein in structure B is actin or tropomyosin.

 ii. The structure in box A is the myosin head.

b. i. Ca2+ binds to part of the actin or troponin, which causes tropomyosin to be displaced, and then uncovers myosin binding sites on the actin or allows actin to bind.

ii. Myosin heads bind to actin *or* cross-bridge formation *or* actomyosin is formed. The cross-bridges swivel *or* there is a ratchet mechanism, which causes actin to slide relative to the myosin. Energy is provided by hydrolysis of ATP.

c. i. To calculate the percentage of fast-twitch muscle fibres in this bundle: (the number of lightly stained fibres ÷ total number of fibres) × 100; the actual numbers are: 10 ÷ 18 × 100.

 ii. The sample is not large enough, i.e. not representative. Individual muscle fibres are different sizes – they contain different number of myofibrils.

d. All fibres should be drawn with the same shading. All fast-twitch fibres should show a high concentration of stain (blocks) and all the slow-twitch fibres should show a medium concentration of stain (vertical lines).

e. There could have been a change in the base sequence in the DNA. Addition, deletion or substitution of a base in the DNA of the gene that codes for myosin. This could have led to a change in amino acid sequence or primary structure. This would cause a different tertiary structure and would then alter the binding properties of myosin.

4. a. The protein found in the H zone is myosin.

 b. i. When the muscle contacts, the A band stays the same width (i.e. there is no change).

 ii. When the muscle contracts the I band becomes narrower, shorter or smaller.

 c. The magnification of the diagram is: 50 × 1000 *or* equivalent (allow measured width of 49–51 mm)

 1.6

Correct answer = × 31 250 (allow ×30 265–31 875)

5. a. You should include four of the following points in your answer: calcium ions bind to troponin; this removes the blocking action of tropomyosin or exposes actin binding sites; ATP allows myosin to join or bind to actin *or* form a cross-bridge; this re-cocks the myosin cross-bridge or allows detachment from the actin; calcium ions can be pumped back in; phosphocreatine allows regeneration of ATP without respiration; phosphocreatine releases Pi to join ADP.

b. Endurance athletes exercise for long periods of time; while exercising, these athletes respire or release energy aerobically. If they did not respire or release energy aerobically, too much lactate would accumulate. Slow-twitch fibres are adapted to aerobic metabolism because they have many mitochondria. At the site of Krebs cycle a series of reactions, and the electron transport chain, a large amount of ATP is formed; resistance to fatigue.

c. Following vigorous exercise, receptors in the hypothalamus detect the increase in core temperature or temperature of the blood. This stimulates the heat loss centre. Skin arteries or arterioles dilate – called vasodilation. Shunt vessels or pre-capillary sphincters constrict, allowing more blood to flow to the surface, i.e. capillaries. Heat loss takes place by radiation and by evaporation of sweat – this produces a reduced metabolic rate. Removal of clothing, finding shade or a cooler area and having a cold drink also help to restore normal body temperature.

6. a. i. Moves out of the way when calcium ions bind, allowing myosin to bind (to actin)/cross-

 bridge formation.

 ii. The head of myosin binds to actin and moves/pulls/slides actin past; myosin then detaches from actin and re-sets/moves further along the actin – this process uses ATP.

b. i. Glycogen broken down gives (lots of) glucose for glycolysis/anaerobic respiration; but glycolysis/anaerobic respiration is not very efficient – it only yields 2 ATP per glucose.

 ii. Many capillaries give high concentration of oxygen or shorter diffusion pathway for oxygen/large surface area for oxygen exchange or diffusion. A good glucose supply with little glycogen present allows a high rate of aerobic respiration *or* prevents build-up of lactic acid or muscle fatigue.

7. a. i. Decreases

 ii. Nothing – it stays the same length.

b. Two marks for correct answer of 14 091–14 545. One mark for incorrect answers in which measured width (31–32 mm) is clearly divided by actual width.

31 000 / 2.2 = 14 091

32 000 / 2.2 = 14 545

c. Idea that ATP is needed for: attachment/cross-bridges between actin and myosin; ‘power stroke’/movement of myosin heads/pulling of actin; detachment of myosin heads; myosin heads move back to original position – ‘recovery stroke’.

8. a. Phosphocreatine provides phosphate/phosphorylates to make ATP.

b. One suitable suggestion; e.g. genetic differences; level of fitness/amount of regular exercise done/mass of muscle; sex; ethnicity; metabolic rate; number of fast/slow muscle fibres.

c. From the graph, phosphocreatine takes longer to remake as people get older. Fast muscle fibres used for rapid/brief/powerful/strong contractions. Phosphocreatine is used up rapidly during contraction/to make ATP. Anaerobic respiration is involved. As people get older, they have a slower metabolic rate/slower ATP production/slower rate of respiration. ATP is used to reform phosphocreatine; there is lots of phosphocreatine in fast fibres.

Chapter 8: Homeostasis

Assignment 1

A1. Chain of amino acids held together by peptide bonds.

A2. Endopeptidase, which hydrolyses peptide bonds deep within the molecule.

A3. Both the types of amino acid and their sequence.

A4. 86 amino acids × 3 nucleotides = 258.

Required practical 11

P1.

|  |  |  |
| --- | --- | --- |
| **Concentration of final solution****/ mmol dm–3** | **Volume of** **water / cm3** | **Volume of glucose****standard / cm3** |
| 0.0 | 2.0 | 0.0 |
| 2.0 | 1.6 | 0.4 |
| 4.0 | 1.2 | 0.8 |
| 6.0 | 0.8 | 1.2 |
| 8.0 | 0.4 | 1.6 |
| 10.0 | 0.0 | 2.0 |

P2. It is pure water and should have 100% transmission and 0% absorbance.

P3. Three sources of error:

* incorrect measuring of the glucose
* incorrect measuring of the volume of Benedict’s solution
* Benedict’s solution not made up correctly
* incorrect calibration of the colorimeter
* damages/old/scratched cuvette
* the fact that both Benedict’s solution and the product of the reaction are coloured.

P4. Glucose is not the only reducing sugar. There are others – notably fructose – in fruit juice.

P5. Interpolation is estimating values that lie between known values; extrapolation is estimating values beyond known range – i.e. ‘carrying the line on’.

Assignment 2

A1. A lack of blood pressure prevents ultrafiltration in the Bowman's capsule.

A2. Urea is made from excess protein. Minimising protein prevents urea build-up.

A3. Fluid intake needs to be limited to the amount lost in exhaling, sweating, etc. Otherwise, fluid builds up and alters the water potential of the blood and body fluids.

A4. a. Diffusion.

b. It’s a counter-current system that maintains a diffusion gradient all along the artificial capillaries.

c. If the dialysate was just pure water, (1) a lot of water would enter the blood by osmosis, making the water potential too low, and (2) a lot of useful substances (glucose, amino acids, etc.) would diffuse out of the blood and be lost.

d. So there is equal diffusion in both directions and these important substances are not lost.

e. So that all diffusion of urea is out of the blood and into the dialysate, removing as much as possible.

A5. a. 200 cm3 per minute × 60 = 12 000 cm3 per hour × 4 = 48 000 cm3 (or 48 litres) processed in 4 hours.

b. To prevent blood clotting in the machine.

c. To give the machine a chance to remove the heparin from the blood, so that it doesn’t remain in the blood and impair blood clotting after dialysis.

d. To catch any blood clots or tiny pieces of plastic that might be in the machine.

e. Bubbles can form emboli (plural of embolism) and block blood vessels.

f. That there is a break/tear/hole in the dialysing membrane, allowing blood cells to escape.

g. So that it returns to the body at the correct temperature (37 °C); to maximise diffusion/exchange.

h. Increasing the amount of glucose in the dialysing fluid lowers the water potential and draws more water out of the blood by osmosis.

i. The clamp increases the hydrostatic pressure, so that more water is removed by ultrafiltration (filtration under pressure).

Practice questions

1. a. i. Glucagon.

 ii. Liver.

b. A change to the normal level initiates a response which reduces the effect *or* reverses/acts against the change.

c. It is highly branched; therefore, lots of ends for condensation/hydrolysis. *Or* it is a polymer/polysaccharide of (alpha) glucose; therefore, can release (lots of) glucose. *Or* glyosidic bonds are easily broken/hydrolysed to release glucose.

2. a. Formation of glycogen: The glucose concentration in the cell/liver falls below that in blood (or plasma) (or the concentration is higher in the blood), which creates/maintains glucose concentration/diffusion gradient. Glucose enters cell (or leaves the blood) by facilitated diffusion/via carrier (protein)/channel (protein).

 b. Their insulin sensitivity is similar to/not (significantly) different from those with diabetes; as there is an overlap of standard deviations (SDs). In addition, their sensitivity to insulin is also improved by gastric bypass surgery (GBS).

 c. Sensitivity (to insulin) does increase; but there is large SD/large variation (after GBS), so some showing no or little change (or get worse). We do not know what the sensitivity to insulin is of non-diabetics (who are not obese).

3. a. Increase in blood sugar leads to lower blood sugar (homeostatic principle) or more insulin secreted. Insulin binds to specific receptors on liver or muscle cells, which leads to more glucose entering cells (or carrier activity/increased permeability to glucose). Glucose leaves the blood and upon entering the cell is converted to glycogen.

 b. Keeps glucose in muscle cells – glucose phosphate cannot cross cell membranes; muscle cells need glucose for respiration.

 c. The sympathetic nervous system is active, so adrenaline is released. Adrenaline binds to receptors/acts on muscle cell, causing increased glycogen phosphorylase activity, which releases more glucose (phosphate) for respiration. Calcium ions enter muscle cells and glycogen is broken down/there is an increase in phosphorylase activity. The blood sugar level is lowered as glucose is used by muscles; this causes glucagon to be released. Glucagon binds to receptors on liver cells, causing glycogen to be broken down to glucose (or glycogen breakdown increases).

4. a. i. The antibody molecule cannot get through the pores and attack the cells. The glucose molecule is small enough to diffuse or enter (or hormones can leave); this protects the transplant from lymphocytes (or there is no antigen on the silicon box).

ii. Many people are against killing animals to use for human transplant. Some people may have religious objections. Any other valid suggestion, for example, fears that a test or drug that may produce good results in an animal may not necessarily work on or agree with humans.

b. The rise (or fall) in rat blood sugar means that more (or less) glucose enters or diffuses into the box. It is detected by the animal pancreas cells that release insulin (or glucagon). Insulin then diffuses into the rat’s blood. Insulin (or glucagon) makes rat’s cells take up (or release) more glucose.

5. a. Maintaining a constant internal environment.

b. Glucagon binds to specific receptor on muscle or liver cell, which activates enzymes in the liver. There is hydrolysis of glycogen; then facilitated diffusion of glucose out of liver cells, which increases blood glucose levels.

6. a. The process involves insulin and glucagon. Insulin or glucagon is secreted by the pancreas or islets of Langerhans and binds to hormone receptors in the membrane of target cells. Insulin stimulates the conversion of glucose to glycogen (*or* glycogenesis activated *or* involves enzymes). This stimulates uptake by cells. Conversion of glucose to lipid or protein takes place. Glycogenesis *or* glucagon stimulates conversion of glycogen to glucose. Gluconeogenesis *or* glucagon stimulates conversion of lipid or protein to glucose.

 b. The individual should feed on polysaccharides such as starch and glycogen. This will result in slower digestion and therefore no surge in the blood sugar level. The individual should do exercise that will increase respiration or their basal metabolic rate (BMR).

 c. All the glucose is reabsorbed; this involves active transport in the proximal convoluted tubule.

7. a. i. Renal capsule/Bowman’s capsule/glomerulus/basement membrane.

 ii. Blood cells/platelets/proteins/named plasma protein.

 b. Answer = 125 (75 ÷ 60 = 1.25; 1.25 ÷ 0.01 = 125 or 75 ÷ 0.01/60 = 125).

 c. Many mitochondria provide ATP/energy for active transport. Many carrier proteins for active transport/channel proteins for facilitated diffusion. Microvilli/brush border provide a large surface area (for absorption).

8. a. i. Receptors in the hypothalamus.

ii. The pituitary is stimulated by the hypothalamus, causing ADH to be released. There is increased permeability to water of collecting ducts/distal tubule (walls); (accept role of aquaporins); leading to increased uptake of water from collecting duct/distal tubule.

 b. i. Greater urine production than water intake.

 ii. Low volume of concentrated urine.

c. A high concentration of sodium ions (or chloride ions/salts) surrounding the loop leads to active removal of ions from the ascending limb, which is impermeable to water/due to the counter-current multiplier. With long loops there will be a greater gradient/difference in water potential between the collecting duct and medulla; and therefore, greater uptake of water from the collecting duct.

Chapter 9: Genes and inheritance

Assignment 1

A1. Two of Beatrice’s children did not have Huntington’s disease. She must, therefore, have carried the normal allele, which she passed on to these children. Since the normal allele is recessive, unaffected individuals must receive one normal allele from each parent.

A2. Her children will not develop Huntington’s disease.

A3. A 50% chance, since he carries the normal allele.

A4. Discussion question – student answer.

A5. The symptoms of the disease do not develop until relatively late in life. A person with Huntington’s disease could have children before he or she knows that he or she has the faulty allele and will pass on the disease.

Assignment 2

A1. a. Siamese CsCs; Burmese CbCb.

b. All black coated as they will all be heterozygous (CCCs) and black coat is dominant.

A2. a. CbCs.

b. Yes, because the heterozygote has a different phenotype from either of the homozygotes.

c. The proportions of the kittens would be 50% pale brown, 25% Burmese and 25% Siamese.

d. She will have to breed a Burmese with a Siamese each time.

A3. a. 1 : 2 : 1

b. 50%. The Manx cat must have the genotype Mm, and the tailed cat mm. All the gametes of the tailed cat will have the genotype m, whereas the gametes of the Manx cat will be 50% M and 50% m.

Assignment 3

A1. 45, because there is only one X chromosome and therefore one fewer than the normal complement of 46.

A2. a. XXY – expected to have male characteristics, since Y-chromosome present so will possess the SRY gene.

b. XXX would be female.

c. XYY– expected to have male characteristics, since Y-chromosome present so will possess the SRY gene.

d. XXXY– expected to have male characteristics, since Y-chromosome present so will possess the SRY gene.

A3. Discussion question – answers will vary depending on personal response.

Practice questions

1. a. There is a greater environmental influence than genetic.

b. Identical twins have the same genotype (or converse for non-identical). Compare identical and non-identical twins or identical twins who have been separated or non-identical twins in the same environment. If genetic, the similarity between identical twins (or converse). Large sample required or use of a statistical test.

2. a. Changes base sequence/named mutation in different places within a gene.

b. The effect of the recessive allele will not be seen when the dominant allele is present. The recessive allele codes for or produces no/non-functional protein. The dominant allele codes for or produces a functional protein.

c. i. Homologous chromosomes have the same genes at the same positions/loci. They may or may not have the same alleles and can pair during meiosis.

ii. The gametes have different allele combinations as chromosomes are shuffled/combined in different ways. One from each pair is taken at random.

3. a. A dominant allele is always expressed in the phenotype *or* it produces functional proteins.

 b. Codominance.

 c.

|  |  |  |
| --- | --- | --- |
| *Parental phenotypes* | Horned, roan | Hornless, white |
| *Parental genotypes* | hhCRCW | HhCWCW |
| *Gametes* | hCR hCW | HCW hCW |
| *Offspring genotypes* |  HhCRCW : hhCRCW : HhCWCW : hhCWCW |
| *Offspring phenotypes* | hornless, roan : horned, roan : hornless, white : horned, white |
| *Ratio of offspring phenotypes* |  1 : 1 : 1 : 4 |

d. i. Sperm (with more DNA) have an X chromosome, which is larger (or has more genes) than Y chromosomes.

 ii. Female for milk; males for meat; male or female for breeding.

4. a. i. The paternal grandmother has two possible genotypes (see diagram below):

 ii.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Grandmother (has antigen G) | Grandfather | Grandmother | Grandfather |
| *Genotypes* | XGXG *or* XGXg | XgY | XgXg | XgY |
| *Gamete genotypes* | XG and Xg, *or* XG only | Xg and Y | Xg | Xg and Y |
|  | Father(has antigen G) | Mother |
| *Genotypes* | XGY |  XgXg |
| *Gamete genotypes* | XG and Y | Xg |
|  |  | Daughter (has antigen G) |  |
| *Genotypes* |  | XGXg |  |

iii. The probability of the son inheriting antigen G: nil possibility because the X chromosome, without the G allele, inherited from mother *or* Y must be inherited from the father (not XG).

b. X and Y chromosomes are different sizes *or* shapes; therefore, the chromatids are unable to line up and form bivalents *or* only short pairing region *or* most of length not homologous.

5. a. Codominance or incomplete or inheritance without dominance.

 b. The genotype of the male parent is: XBY *or* B(–).

 c.

|  |  |  |
| --- | --- | --- |
| *Parental phenotypes* | Round-eyed female | Bar-eyed male |
| *Parental genotypes* | XRXR | (XBY) |
| *Offspring 1 genotypes* | Wide bar-eyed female: XRXB | Round-eyed male: XRY |
| *Gametes* | XR XB | XR Y |
| *Offspring 2 genotypes* | XRXR  XRXB XR Y XBY |
| *Offspring 2 phenotypes and ratio* | round-eyed : wide bar : round-eyed : bar eyefemale female male male1 : 1 : 1 : 1 |

6. a. A sex-linked gene means a gene located on X *or* Y *or* one sex chromosome.

 b. i. Black.

 ii. XGXg

 iii.

|  |  |  |
| --- | --- | --- |
| *Parents* | Male | Tortoiseshell female |
| *Parental genotypes* | XgY | XGXg |
| *Parental gametes* | Xg Y | XG Xg |
| *Offspring genotypes* |  XgXg  XGXg  XGY XgY |
| *Offspring phenotypes* |  black female : tortoiseshell female : ginger male : black male |
| *Ratio*  |  1 : 1 : 1 : 1 |

7. a. hhDD, hhDd

 b. Epistasis – one gene controlling/inhibiting the expression of another.

 c.

|  |  |  |
| --- | --- | --- |
| *Parental phenotypes* | Wiry-haired male  | Non-wiry, long-haired female |
| *Parental genotypes* | HhDd | hhdd |
| *Gametes* | HD, Hd, hD | hd, hd |
| *Offspring genotypes* | HhDd : Hhdd : hhDd : hhdd |
| *Offspring phenotypes* | wiry : wiry : non-wiry short : non-wiry long |
| *Ratio of offspring phenotypes* |  2 : 1 : 1 |

8. a. Mutations, which are different/at different positions in the gene/different parts of the base sequence.

 b. i. Either a dominant or recessive allele.

 ii. ahah BB, ahaBB, ahah Bb, ahaBb.

 iii. Temperature is lower at extremities so the enzyme is active/not denatured.

c. If allele A is present (normal) tyrosinase/enzyme is produced, so it does not matter what other allele is present (*or* explanation of why). Heterozygote is same phenotype as double dominant in terms of enzyme produced; phenotype/rabbit is black as both have alleles A and B.

Chapter 10: Populations

Required Practical 12

P1. Sampling without bias/without the conscious choice of the experimenter.

P2. To allow statistical tests to be applied.

P3. The use of herbicide will have no effect on the diversity/distribution of named species.

P4. Light; soil minerals (or named mineral); soil pH; temperature; humidity; wind.

Assignment 1

A1. The two populations treated with the worm-killing drug in 1989 (represented by curves b and c) did not crash, while the untreated one (curve a) did. In 1993, the two untreated populations (curves a and b) did crash, while the population that was treated with the drug (curve c) did not.

A2. In those populations that were treated with the drug, the numbers still dropped a little in the years when a crash was expected. This can be seen in curve b in 1989 and in curve c in both 1989 and 1993.

Assignment 2

A1. High temperatures in the deposits; lack of water; instability; lack of shelter from wind.

A2. It has parachute-like fruits, which help the seeds to disperse far and wide on the wind. It is rapidly growing, so it can complete its life cycle quickly, producing new seeds within a few months of germination. It has woolly, silver-grey foliage – this is caused by a waterproof covering on the leaves, which cuts down transpiration and so allows the plant to live in very dry soils. It produces stolons, which rapidly grow sideways from the plant and then grow into new individuals, allowing it to colonise large areas rapidly. The foliage seems to be unattractive for insects and other animals to eat. It is not very tall, and so can escape the strongest winds.

A3. Virtually no plants grew at the site for the first three years following the eruption (due to high temperatures in the deposits; lack of water; instability; lack of shelter from wind). There was then a rapid and fairly steady (but note that the *x*-axis does not have a linear scale) increase in cover over the next 15 to 16 years (initially wind-dispersed, fast growing species). By 20 years after the eruption, plants covered almost 70% of the ground (species were able to take advantage of more stable ground and shelter provided by early colonisers).

A4. Species diversity increased gradually from years 1 to 14 after the eruption. This happened as pioneer plants first became established. Over time, their presence altered the abiotic conditions (more nutrients in soil, more water-holding capacity, more protection from wind) allowing other species to grow there. New colonisers would arrive by chance, so the longer the time period the more species would be expected to arrive.

 Species diversity fell from year 14. This is probably because some plants were now growing strongly and out-competing other species for light or water. Another possibility is that the greater quantity of vegetation would allow more herbivores to live in the area, and they might graze some species in preference to others.

A5. Lupines are probably too large to be able to survive in the harsh conditions that the small pearly everlasting is able to withstand. They would be more exposed to drying winds. They are also not well adapted for conserving water.

A6. The substrate would initially not contain nitrate or ammonium ions. Nitrogen-fixing plants are able to survive in these conditions, because their symbiotic bacteria use nitrogen gas to synthesise ammonium ions. Plants need these to produce amino acids and proteins.

A7. Western hemlock is not a nitrogen-fixer, and so needs a source of nitrate or ammonium ions in the soil. Alders are nitrogen-fixers, and their presence gradually adds these ions to the soil, allowing other plants to grow.

Assignment 3

A1. It requires closely grazed chalk downland. There are now fewer sheep and rabbits to graze downland, so the vegetation grows taller and the low-growing thyme – the food plant of the caterpillars – is outcompeted.

A2. Examples of its required habitat are becoming increasingly few and far between. It has not been able to adapt to live in different habitats.

A3. Left alone, short turf on chalk downland will gradually undergo succession to scrub and finally woodland. Management therefore involves cutting down bushes before they have a chance to establish. Some gorse has been left to provide shelter, as the red ants require well-drained and sheltered places to make their nests. Thyme seeds have been sown to increase the food available for caterpillars.

A4. There will be natural variation among thyme plants. The plants in a particular area may have slightly different collections of alleles – gene pools – than those from other areas. Sowing locally collected seeds means that the plants are more likely to have a collection of alleles that adapts them well for growing in local conditions.

Practice questions

1. a. The frequency or proportion of alleles of a particular gene will stay constant from one generation to the next/over generations (or no genetic change over time). Providing no mutation/no selection/population large/population genetically isolated/mating at random/no migration.

 b. White/deaf cats are unlikely to survive or are selected against; and therefore will not pass on the allele for deafness/white fur to the next generation/will reduce frequency of allele.

 c. In Paris/London, frequencies of these alleles add up to more than 1.

 d. Two marks for correct answer of 44(.22), One mark for incorrect answer in which p/frequency of H determined as 0.67 and q/frequency of h as 0.33. Or answer given as 0.44(22).

2. a. i. Two marks for correct answer of 4. One mark for calculation involving 0.2 × 0.2 or 0.04.

 ii. 0.2 – the frequency remains the same.

 b. There is a probability of 5% or 0.05 that difference in the frequencies is due to chance.

3. a. *Ulva lactuca*.

b. i. Difficult – too many to count; individual organisms are not identifiable or are too small to identify; it grows in clumps.

 ii. Any described feature of concrete e.g. texture/flat/composition chemicals/nutrients, etc.

c. Pioneer species/Ulva increases then decreases; principle of a species changing the conditions or a species makes the conditions less hostile; new/named species is a better competitor or previous/named/pioneer species is outcompeted; *G. coulteri/Gelidium* increases and other/named species decreases.

4. a. All the fish/all the species/all the populations/all the organisms.

b. i. Capture sample, mark and release. Appropriate method of marking suggested, e.g. cutting a fin/attaching a tag/paint/marker, or method of marking that does not harm the fish. Take a second sample and count the number of marked organisms: no. in population = sample1 × sample2

 no. marked in sample2.

 ii. One suitable reason; e.g. population increases/changes (between first and second sample).

c. With different shape of mouth, eats different food/has different way of feeding/specific mouth shape for specific food. Competition between species/interspecific competition is reduced.

5. a. Reference to optimum pH or proteins, enzymes and the named metabolic process.

b. Any three of the following points should be used to explain the difference in the results: interspecific competition (in a community); sorrel competes well at optimum pH; sorrel is outcompeted at lower and higher pH; fescue competes best at lower and higher pH; it does not compete well at the optimum pH; fescue is better adapted than other species to low pH and high pH.

6. a. Interspecific competition.

b. i. The population declines because the experimental area has a higher number than the control
 area.

 ii. The population is not affected because the number is similar in both areas.

c. Referring to Figure Q3b, there is a large population decrease and increase for canyon lizards.

d. There was more intraspecific competition (the high density is linked to competition).

7. a. A climax community.

b. Regular grazing/cutting – young shoots eaten or prevents succession; Herbicides – kill herbaceous plants; Ploughing/burning – destroys seedlings/ plants.

c. Your answer should include any three points from: it is a rapid process; a large number is produced; only one plant is required. No variation linked to advantageous characteristics.

8. a. i. A climax community.

ii. Your answer should include any two points from: growth of large trees/tall producers; better competitors for light, mineral ions, and idea of shading out; reduced range of niches or habitat; fewer or smaller herbaceous plants can grow.

b. Soil conditions – one of the following: it is dry; there is a lack of water; the water is saline; the soil doesn’t hold water; the water drains through. Plus, twoof the following: reduced rate of transpiration *or* evaporation *or* diffusion; reduced surface area; decrease in water potential gradient *or* humid air trapped; this reduces diffusion *or* air movement *or* increases diffusion pathway.

9. a. Use tapes, string, axes laid out at right angles or grid area. Use a method to obtain random coordinates (not random number generator).

b. i. They decrease; then remain constant. From 200 cm *or* over 150 cm.

ii. Your answer should include any two of the following: the oxygen decreases because soil becomes more compacted or is not replaced; a decrease in oxygen leads to survival of fewer aerobes; respiration.

c. You should include any three points in your answer: anaerobic bacteria replace aerobic bacteria; this is because the oxygen is decreased by aerobic bacteria; this removes competition; aerobic bacteria are no longer able to survive in these conditions.

d. i. Near the surface; in the top 50 cm. The table shows a decrease with time at greater depths.

ii. It would decrease, as there would be fewer aerobic bacteria with depth. Oxygen concentration would decrease, and less oxygen at depth.

e. Probability would be greater than 95% or 0.95. Results are not due to chance; they are significant because bars do not overlap.

f. Plot the data as a graph. Draw the line of best fit. Read off the appropriate value.

Chapter 11: Natural selection and speciation

Assignment 1

A1. a. i. *q*2 = 0.02, so *q* = 0.14 This is the frequency of the sickle-cell allele in the population.

 So *p* = 1 – 0.14 = 0.86

 ii. Proportion with sickle-cell trait, 2*pq* = 0.86 × 0.14 × 2 = 0.24

So almost one-quarter of the population (nearly 25%) have the sickle-cell trait.

b. We must assume that there is no significant immigration or emigration into or out of the population. All genotypes have an equal chance of survival. All genotypes have an equal chance of breeding with all other genotypes.

A2. Both parents: HSHA

Gametes: HS,HA, HS,HA,

Offspring genotypes: 1 HSHS  : 2 HSHA  : 1 HAHA

Offspring phenotypes: 1 normal : 2 carriers : 1 with sickle-cell anaemia

Therefore, the probability of their first child having sickle-cell anaemia is 1 in 4 (25%).

A3. a. The allele is relatively common because it was an advantage for people in West Africa to have the sickle-cell trait, as they were less likely to die from malaria.

A3. b. The allele is becoming rarer because it is no longer an advantage, as malaria is not common in the USA. The selective advantage of possessing a sickle-cell allele has been lost.

Assignment 2

A1. a. i. *A. porcatus*

ii. *A. porcatus*

iii*. A. porcatus*

iv. *A. porcatus*

A2. A few lizards from Cuba may have accidentally spread to another island, for example clinging to a floating log after a storm. These lizards would have bred, producing a population. The conditions on the newly colonised island may have been different from the conditions on Cuba; so different characteristics were selected for. Over time and many generations, random genetic variation and natural selection would produce a population of lizards with a different set of alleles from the original population. Eventually, the lizards on the new island could become so different from the original population on Cuba that they could no longer interbreed successfully, even if they were brought together again. As conditions on each island are likely to be slightly different, selection pressures would also be different and so the characteristics of the populations on each island would not be the same.

Another contributory factor would be the set of alleles possessed by the original colonisers. By chance, the few lizards that initially colonised an island might not have all the different alleles in the original population on Cuba. This would affect the final mix of alleles in the population that grew on that island.

A3. The colour of the dewlap could be important in courtship, in attracting a female lizard to a male and allowing him to mate with her. So if the males in one population have a different colour of dewlap from those in another population, the females would mate only with males from their own population.

A4. They could bring together males and females of different species and see if they can interbreed to produce fertile offspring.

A5. More DNA analysis – perhaps of different regions of DNA – should be made of more individuals within the lizard populations, and also of more species of lizards in the islands of the Caribbean. This would give a fuller and more accurate picture of the relationships between the different species, which could then be used to determine the probable sequence in which one species arose from another. If it were still found that each species had DNA that was more similar to the Cuban lizards than to other species, then the hypothesis would be supported.

A6.Reasons for using mitochondrial DNA to study evolutionary relationships:

* There are many copies in a cell, because there are many mitochondria.
* It is not subject to recombination by the process of meiosis between generations.
* Most species get their mitochondria from their mothers – they arise from the mitochondria in the egg.
* It has a high mutation rate, so clear differences in base sequences accumulate over the generations.

Practice questions

1. a. Include two of the following points in your answer: principle of intraspecific competition; for amount of food available; more energy needed to find food or less energy to produce eggs. *Or*: number of territories; more energy spent fighting or defending territory. *Or*: availability as prey; predators spend less time searching for nests.

b. i. Your answer should include any one of the following: age – young or old birds produce fewer eggs; time – early or late breeding less food available/temperature effect; genotype – variation in genetic ability to produce eggs; quality of territory – description of some relevant resource in territory (but not ‘food as resource in territory’ if already discussed in (a); predation of eggs – lays more to replace eaten eggs.

ii. Many eggs result in each offspring receiving less food; few eggs could be affected by mortality rates due to disease and/or predators. In both cases few young will reach maturity or survive – so will be less likely to pass on genes or alleles.

2. a. Variation is present in the original population. Individuals who are tolerant of copper are more likely to survive. Surviving individuals reproduce and pass on genes to the next generation, or offspring. There will be more, or an increase in the frequency of copper tolerance alleles or genes.

 b. A new species of the plant might be produced for the following reasons: being reproductively isolated or no interbreeding due to different flowering times; conditions different for two populations or different selection pressures; different features *or* plants are selected *or* survive *or* different adaptations; populations become different genetically; they will be unable to produce fertile offspring.

3. a. Scientists can find out whether the cichlids from two populations belong to the same species by breeding together. If the offspring are fertile, then they are the same species.

b. Speciation may have occurred following the formation of separate, smaller lakes, as follows: isolation of two populations; variation already present due to mutations; different environmental conditions *or* selection pressures; selection of different features and so different alleles; different frequency of alleles; separate gene pools *or* no interbreeding.

c. Selection of mate dependent on colour pattern. Prevents interbreeding or keeps gene pools separate.

4. a. The banding of the shells shows discontinuous variation, as discrete groups.

b. i. In the woods there is a low percentage of banded yellow shells; in grassland/hedgerows there is a high percentage of banded yellow shells.

ii. Due to natural selection, in their habitat the snails are better camouflaged, so there is less predation by birds. The result is that a higher proportion of these survive and pass on their alleles/genes.

5. a. i. Many genes or polygenes genes control the length; each gene may have different alleles (additive effects). *Or*: environmental factors – provide a named factor and description of how the named factor may affect the growth of seeds.

ii. You answer should include any four points from: selection of large seeds for sowing; a higher proportion of alleles for long length; the loss of alleles for short seeds from population; distribution curves, for example, lower end is ‘cut off’; new alleles through mutation (possible appearance of); over many generations, the process is repeated.

b. Your answer should include any six points from: isolation of ancestral finches on different islands; range of habitats or environmental conditions; competition for seeds (food); variation among the finches; some of the finches are more suited to different food sources or differential survival; alleles/genes for specific adaptations or features passed on; different selection in separate populations, for example, on different islands; different populations unable to interbreed.

6. a. No interbreeding – gene pools are separate – geographic(al) isolation; mutation; different selection pressures or different foods/niches/habitats; adapted organisms survive and breed or differential reproductive success; change/increase in allele frequency/frequencies.

 b. Similar/same environmental/abiotic/biotic factors / similar/same selection pressures or no isolation or gene flow can occur (within a species).

7. Variation/variety; mutation; some plants have allele to survive/grow/live in high concentration of copper/polluted soils; differential reproductive success or adapted organisms reproduce; increase in frequency of allele; no interbreeding with other populations or separate gene pool (or gene pool differs from other populations).

8. Variation/variety in pest population; due to mutation; allele for resistance; reference to selection; pests with resistance (survive and) breed / differential reproductive success; increase in frequency of allele.

Chapter 12: The control of gene expression

Assignment 1

A1. siRNA prevents a protein from being expressed by guiding an enzyme to destroy the mRNA before it is transcribed.

A2. *In vitro* means 'in glass' while *in vivo* means 'in life'.

A3. A vector is a carrier; a means of getting DNA into a cell.

A4. Polar molecules are soluble in water, not in lipid. Cell membranes are made from lipid. Thus siRNA cannot pass across.

A5. A few genes, made from RNA or DNA, surrounded by a protein coat (or 'capsid'). Outside the capsid there is usually a layer of attachment proteins.

A6. Viruses have evolved to enter cells and deliver their nuclear material so they have great potential as vectors of DNA.

A7. Viruses have the potential to cause disease. They can damage/destroy cells and the DNA they deliver can disrupt existing genes, causing mutations that can lead to tumours or other problems.

A8. Liposomes are lipid soluble, so can easily pass across the cell membrane.

A9. Polyethylene glycol – protects the particles from the immune system.

siRNA – can target specific mRNAs, bringing about their destruction before they can be transcribed.

Specific antibodies – can seek out and bind to specific cell surface proteins, allowing the nanoparticle to attach to specific cells in the body.

Cell penetrating peptide – gets the nanoparticle into the cell, by disrupting the cell membrane.

A10. Similarities: both are a similar size; both consist of nuclear material surrounded by an outer coat; both deliver nucleic acid into eukaryotic cells.

Differences: liposomes are surrounded by lipid, viruses by protein; viruses can contain extra/unwanted DNA/genes, liposomes do not.

Practice questions

1. a. RNA polymerase.

b. i. The receptor or transcription factor binds to the promoter, which stimulates RNA polymerase/enzyme X to transcribe the gene (or increase transcription).

 ii. Other cells do not have the/oestrogen/ ERα receptors.

c. It’s a similar shape to oestrogen so it binds to the receptor/prevents oestrogen binding. The receptor is therefore not activated/will not attach to promoter/no transcription.

2. a. Stem cells will replace themselves/keep dividing/replicate; they are undifferentiated/can differentiate/develop into other cells/totipotent/multipotent/pluripotent.

 b. Reverse transcriptase.

c. i. Alters base/nucleotide sequence/causes frame shift, giving rise to a different sequence of amino acids in the polypeptide/protein/primary structure, and therefore alters the tertiary structure.

 ii. Affects tumour suppressor gene – inactivates it; therefore, the rate of cell division is increased (or tumour cells continue to divide).

d. Yes, SCID patients unlikely to survive/quality of life poor unless treated. Cancer that develops is treatable/only affects 25%/five children. *Or*: No, risk of developing cancer is high/25%. Cancer may recur/may not be treated successfully in future/only short time scale so more may develop cancer.

3. a. Gives rise to new plants/plantlets, so must be able to develop into different tissues or other specialised cell types (or differentiate).

 b. Two marks for 5 : 1 / 50 : 10 / 1 : 0.2. One mark for ratio correctly identified but expressed incorrectly as 1 : 5 / 10 : 50 / 0.2 : 1.

c. i. Meiosis; independent assortment/crossing over; fusion of genetically different gametes/random fertilisation.

 ii. Will be clones / produced by mitosis / will be genetically identical / less variation / all plants will have desired characteristics.

4. a. Protein/molecule that moves from cytoplasm to DNA; transcription factor binds to specific gene/genes to specific part of/site on DNA/ binds to promoter/RNA polymerase; leads to/blocks (pre)mRNA production or allows/blocks binding of RNA polymerase (to DNA)/allows RNA polymerase to work.

 b. Binding to CREB prevents transcription/mRNA formation. Binding of huntingtin prevents production/translation of protein (that removes electrons/protons from NAD). Therefore, there are fewer electrons to electron transport chain/electron transport chain slows/stops, which stops or leads to slower oxidative phosphorylation, and there are fewer protons for a proton gradient; so not enough ATP produced/energy supplied to keep cells alive or anaerobic respiration not enough to keep the cell alive.

 c. CREB/protein is too large/is water soluble so cannot cross the membrane/phospholipid bilayer. Mitochondrion has two membranes – inner and outer membranes, and for each membrane a different carrier is required.

5. a. Cytosine with Guanine and (Adenine) with Uracil.

 b. Only the infected cells will have HIV protein on surface, so carrier only attaches to/is specific to these cells/siRNA can only enter these cells. *Or*: siRNA (base sequence) is complementary/specific to one mRNA, so only infected cells contain mRNA of HIV/this gene stops translation of this gene/only binds to this mRNA /destroys this mRNA.

 c. Carrier binds to protein on HIV, which prevents HIV/it binding to its receptor on human cells.

6. a. Mutation in E produces highest risk/1.78; 2. (Mutation) in D produces next highest risk/1.45; (Mutation) in C produces least risk/1.30.

 b. 180 cells per day (720 ÷ 4).

 c. **Similarities**: Same/similar pattern / both decrease, stay the same then increase; number of cells stays the same for same length of time.

 **Differences**: Per unit volume of blood greater/faster decrease in number of healthy cells / more healthy cells killed / healthy cells killed faster; greater/faster increase in number of healthy cells / more healthy cells replaced/divide / healthy cells replaced/divide faster.

d. More/too many healthy cells killed so will take time to replace/increase in number. The person may die/have side effects.

Chapter 13: Gene technologies

Assignment 1

A1. BamHI C and CTAGG

 GGATC and C

EcoRII C and GGACCG

 GCCTGG C

HindIII T and TCGAA

 AAGCT T

PstI G and ACGTC

 CTGCA and G

A2. Eight fragments produced:

TCC and AGGCCTGG – EcoRII

GGACCG and CTGCA – PstI

ACGTCGGT and GCCAAGCT – HindIII

TCGAATC and TAG – BamHI

A3. a. 1124

b. Seven fragments: 30, 346, 1071, 622, 179, 1366, 748 bases.

 c. BalI and SnaI.

A4. The sequence reads the same on one strand as on the other strand reading in the opposite direction.

Assignment 2

A1. Because they have complementary base sequences, so A links to U, etc.

A2. The normal mRNA does not attach to the ribosomes. Therefore, the enzyme polygalacturonase is not made. The pectin in the cell walls is not broken down, so the cells do not separate and make the tomatoes go soft.

Assignment 3

A1. Student answer (presentation).

Practice questions

1. a. Restriction (enzyme) or endonuclease.

b. Unpaired bases; corresponding sticky ends join by means of complementary base pairing (and attaching by the enzyme, ligase).

c. The three drawings should show: a plasmid with foreign DNA joined in ring; a ring with plasmid only; a ring of foreign DNA only.

2. a. Your answer should include six points from: the DNA is cut; this is done using a restriction enzyme; electrophoresis is used to separate the DNA fragments according to length, mass or size; the DNA that is made is single-stranded; it is then transferred to a membrane or sheet; and a is probe applied; radioactive or single-stranded or detected on film or fluorescent dye; process is repeated until enough DNA is made; the pattern that emerges is unique to every individual.

 b. Cells could have been left on the toothbrush. DNA would be present in the cells.

c. i. Toothbrush gives small sample of DNA and you would need more DNA for analysis – PCR provides many copies of the DNA.

ii. PCR uses heat to separate the DNA strands. PCR replicates pieces of DNA; as DNA has been cut, primer is added in PCR to initiate replication.

 d. i. Because PCR or amplification is needed.

ii. Because other DNA may be present, and it is necessary to identify the ‘required’ DNA from other DNA.

3. a. Enzyme 1 = (restriction) endonuclease or restriction (enzyme); enzyme 2 = (DNA) ligase.

b. You should include two of the following points in your answer: there are many bacteria or the cells do not take up the plasmid or gene; only bacteria with the plasmid or modified or transformed will survive or grow or multiply; since the plasmid or bacterium has the gene for ampicillin resistance.

c. i. C

ii. Your answer should include two points from: the gene for growth hormone is inserted into the gene for tetracycline resistance; for tetracycline resistance cannot be expressed or unmodified; have intact tetracycline resistance gene; bacteria or cells with the hGH gene are killed by tetracycline or unmodified bacteria or cells are not killed by tetracycline.

d. They may pass on antibiotic resistance to others or pathogenic bacteria, which means that they can no longer prevent or cure disease, i.e. one would not be able to treat a patient (with this antibiotic).

4. a. i. A vector transfers or carries genes from one organism to another, or into bacteria, or cells.

ii. Cut open the plasmid; cut the donor DNA to remove gene or length of DNA; cut donor DNA and plasmid with the same enzyme or enzyme that cuts at the same base sequence. This will produce sticky ends or overhanging ends, with a single strand or bases exposed. This allows association or attachment or pairing of complementary strand.

iii. Annealing or splicing or backbones joined or phosphodiester bonds.

 b. i. L and M.

 ii. Because the fragments are 64 and 36 (kilobases obtained).

5. a. Carriers are heterozygous/have one normal copy and one mutant copy of gene/have one recessive allele/don’t have the condition. Both have DNA that binds about half/50% amount of probe (that non-carrier does). The probe binds to the dominant/healthy allele, so have only one copy of the exon in their DNA or have one copy of gene without exon/base sequence for probe to bind to.

b. Include the following points in your answer: introns are not translated/not in the mRNA; exons code for amino acids/introns do not code for amino acids; mutations of these exons affect amino acid sequences; that produce faulty protein/change tertiary structure of protein; so important to know if parents’ exons are affected, rather than any other part of DNA/introns.

6. a. Restriction enzyme/endonuclease.

b. i. Acts as a marker gene – it shows that the (human) gene has been taken up or expressed. Only the implant cells/embryos that show fluorescence or contain the jellyfish gene.

ii. Factor IX is present in (or extracted from) milk. The gene is only expressed in mammary glands/udder (or gene is not expressed elsewhere); therefore, you do not need to kill the sheep to obtain Factor IX.

c. i. Mutation – nucleus/chromosomes/DNA may be damaged or disrupts genes; may interfere with proteins produced/gene expression/translation; Or the embryo or antigens are foreign so the embryo is rejected or attacked by the immune system.

ii. It saves time/money for others – so the same work is not repeated and methods can be compared/improved/amended (or same errors are not made).

7. a. i. Has the restriction site (cut by Kpn1); once; 1000 bp from Kpn1 on site of plasmid (or ⅓ way along).

ii. Most of the plasmid and rest of unknown DNA or the rest of the recombinant plasmid or the rest of the plasmid but not the 1000 bp part.

 b. 2

c. i. One mark for answer confined to smaller fragments move further/faster. Two marks for comparing with distance/speed moved by fragments of known size/markers / DNA ladder.

ii. Large pieces of DNA present; add up to more than total length of original DNA or plasmid plus inserted DNA; because this would add undigested to the total (original) length.