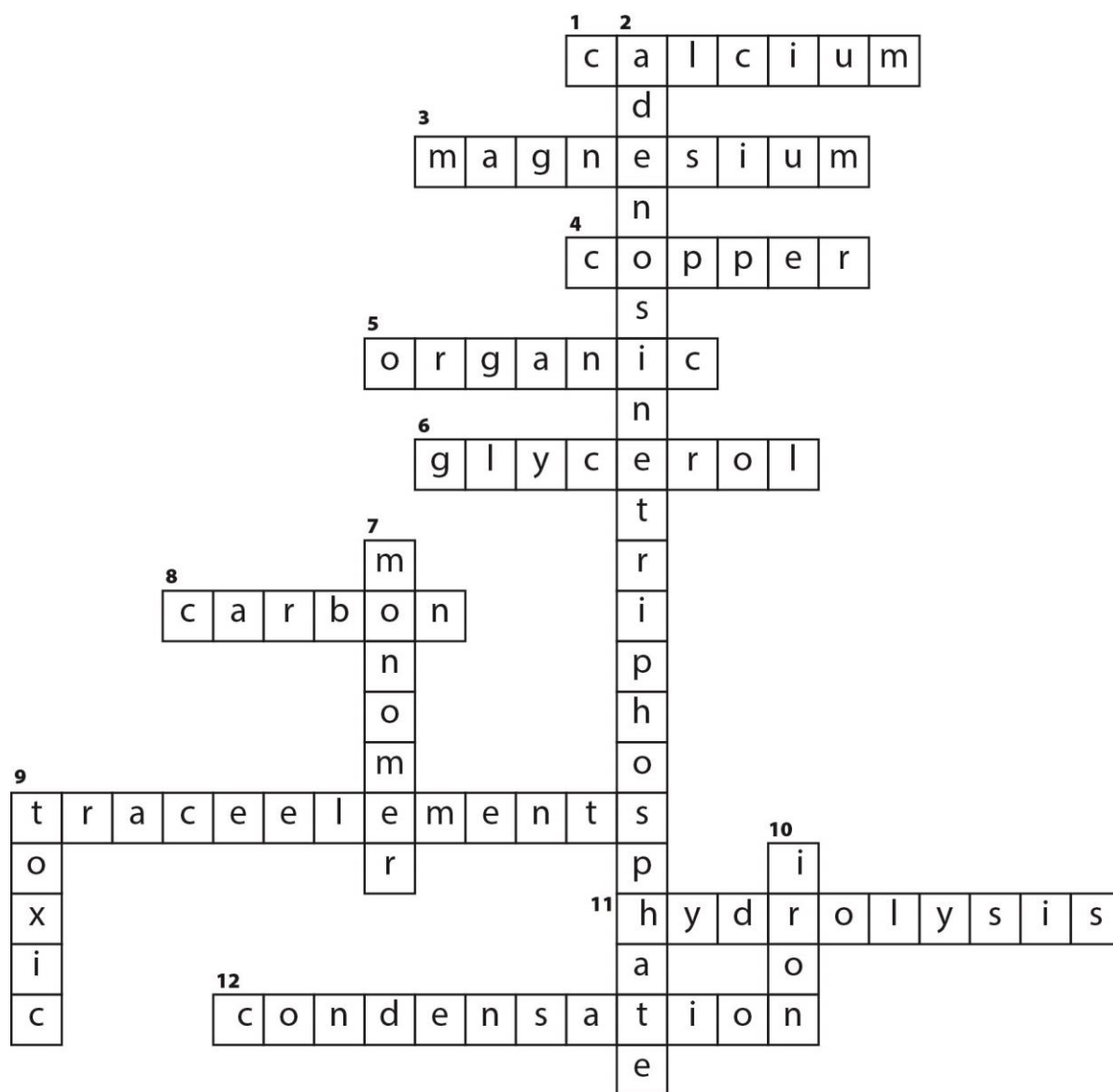


# 1.1 Key terms crossword



## Across

- 1 An inorganic element used in mollusc shells. (**calcium**)
- 3 An inorganic element found in chlorophyll. (**magnesium**)
- 4 A trace element found in some enzymes. (**copper**)
- 5 A complex molecule containing carbon. (**organic**)
- 6 A product of the hydrolysis of a triglyceride. (**glycerol**)
- 8 An element which forms four covalent bonds. (**carbon**)
- 9 Specific types of atom found in extremely small quantities. (**trace elements**)
- 11 A reaction catalysed by enzymes that uses water and forms smaller molecules. (**hydrolysis**)
- 12 A reaction catalysed by enzymes that forms larger molecules and water. (**condensation**)

## Down

- 2 The molecule which acts as a source of energy for all living organisms. (**adenosine triphosphate**)
- 7 Small units that can be used to build polymers. (**monomer**)
- 10 Describes the effect of high doses of copper on the human body. (**toxic**)
- 10 A trace element used to make hemoglobin. (**iron**)

# 1.2 Translating for a scientist

Everyday definition	Key term	Scientific definition
A food group containing starchy foods like rice and potatoes.	Carbohydrates	Molecules containing carbon and a 2:1 ratio of hydrogen and oxygen.
The formation of moisture/ water droplets.	Condensation	A chemical reaction, catalysed by enzymes, which forms a larger molecule from two smaller molecules by forming a covalent bond between them and releasing water.
A sweet food.	Sugar	Sweet, soluble monosaccharides and disaccharides. Table sugar is the disaccharide sucrose.
A food group which helps build muscle.	Protein	Polymers formed from amino acid monomers, containing the elements oxygen, nitrogen, carbon, hydrogen and sometimes sulphur.
A thing used to tie something or to fasten things together.	Bond	A lasting attraction between atoms, ions or molecules that enables the formation of chemical compounds, such as hydrogen bonds or covalent bonds.
A food group which makes people put on weight.	Fat	A sub-group of lipids: molecules containing carbon, hydrogen and a relatively small number of oxygen atoms. This group is solid at room temperature.
Relating to the North or South Pole.	Polar	A molecule with regions of different charges. E.g. water molecules have slightly negative oxygen atoms and slightly positive hydrogen atoms.
A clear, hydrating liquid which is good to drink.	Water	A molecule with the chemical formula $H_2O$ .
Homegrown without artificial chemicals.	Organic	A complex biological molecule containing carbon.
A drug sometimes used by athletes to enhance performance in sports competitions.	Steroid	A type of lipid with a four-ring structure.
Made of threads or filaments.	Fibrous	An elongated form of protein which is often structural and usually insoluble.

Everyday definition	Key term	Scientific definition
Something in the body that gives you your characteristics.	DNA	Deoxyribonucleic acid. A nucleic acid polymer formed of nucleotide monomers, with two strands arranged in a double helix. Its nucleotides contain a ribose sugar and one of four nitrogenous bases; adenine, thymine, guanine or cytosine.

# 1.3 Emergent properties of water

- 1 The properties of water are essential for life. A water molecule is **polar** because the uneven distribution of electrons means that one side is slightly more positive and the other is slightly more negative. The **emergent** properties of water are so called because they only emerge when many water molecules join together and form **hydrogen bonds** with each other.
- 2 The three columns in the following table are all mixed up. Chose a different colour for each of the properties. Shade or highlight the boxes in the columns so that each colour matches the correct property of water.

Property of water	Explanation of property	Significance for life
High specific heat capacity	Many hydrogen bonds require high amounts of energy to be broken. Therefore water requires a high energy input to increase in temperature.	Water inside living organism allows them to maintain a stable temperature. Water also provides a thermally stable habitat for aquatic organisms.
Cohesive (Cohesion – The binding together of two molecules of the same type.)	The polarity of water results in hydrogen bonds between the oxygen of one molecule and the hydrogen of another. This sticks the water molecules together.	Water stick together in continuous columns which do not break as they transport water and minerals in the xylem of plants. Cohesive forces are responsible for surface tension. This enables many organisms to rest and move on the surface of water.
Solvent	Its polarity means it is a good solvent for other charged or polar substances as negative and positive charges attract.	Water is an effective medium for transporting polar molecules such as glucose (in the blood) and ions such as nitrates (in xylem plant sap).
Adhesive (Adhesion – The binding together of different types of molecule.)	The polarity of water means that it is attracted to other polar substances Water forms hydrogen bonds with these substances and sticks to them.	Water can adhere to xylem in the stem of a plant so it can travel in continuous columns to the top of plant more easily. The movement of blood in capillaries is also due to adhesion, allowing exchange of gases, nutrients and waste products in the organs and tissues of animals.

Property of water	Explanation of property	Significance for life
High latent heat of vaporisation	Many hydrogen bonds require high amounts of energy to be broken. Therefore water requires a high energy input to evaporate.	Water can act as a coolant. The high energy required for evaporation makes sweating (in animals) and transpiration (in plants) effective ways of losing heat as it uses heat energy from the organism's tissues.
Formation of ice crystals	At temperatures below 0 °C, hydrogen bonds remain permanent creating a hexagonal framework of molecules with an open structure. This takes up more space than the volume of water that formed it, so ice is less dense than water.	Ice floats on the surface of aquatic habitats. It insulate the water below so that it stays liquid allowing animals and plants to survive when the air temperature drops below 0 °C.
Transparency	Water does not absorb much light in the visible range of the electromagnetic spectrum.	In shallow water, aquatic plants can absorb light and carry out photosynthesis. As water gets deeper, more light is absorbed so photosynthesis is not possible.

# 1.4 Water as a solvent and a metabolite

1

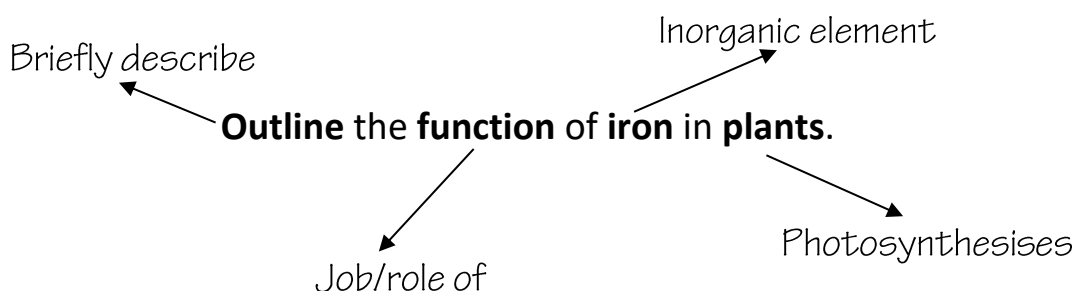
Substance	Hydrophilic or hydrophobic? Give brief details	Method of transport in blood in animals or sap in plants
<i>Example:</i> Ions such as sodium, chloride, nitrate, magnesium	Hydrophilic. Sodium and magnesium ions are positively charged and chlorine and nitrate ions are negatively charged.	<b>Blood:</b> dissolves in the plasma <b>Plant sap:</b> dissolved and transported in the xylem.
Amino acids	Hydrophilic. Solubility varies due to R group.	<b>Blood:</b> dissolves in the plasma <b>Plant sap:</b> dissolved and transported in the phloem.
Glucose	Hydrophilic.	<b>Blood:</b> dissolves in plasma.
Sucrose	Hydrophilic.	<b>Plant sap:</b> dissolved and transported in the phloem
Oxygen	Hydrophobic.	<b>Blood:</b> only a very small amount of oxygen can dissolve in blood plasma so oxygen binds to hemoglobin in red blood cells.
Fat molecules	Hydrophobic.	<b>Blood:</b> Carried in lipoprotein complexes. The fat molecules are surrounded by a layer of amphipathic phospholipids with integral proteins between them.
Cholesterol	Hydrophobic. (Very small hydrophilic region but not enough to dissolve in water.)	<b>Blood:</b> Carried in lipoprotein complexes between the phospholipids with its hydrophilic region pointing outwards towards the plasma and its hydrophobic regions inwards towards the fat molecules.

2

Question	Answer
Definition of the word metabolite.	A substance that is formed in or needed for metabolism.
Two examples of where water is a reactant in biochemical reactions.	Photosynthesis Hydrolysis reactions (e.g. digestion of starch to maltose)
Two examples of where water is a product in biochemical reactions.	Respiration Condensation reactions (e.g. formation of a dipeptide from two amino acids)

# 1.5 Reading exam questions

- 1 Identify the sentence which has been underlined most helpfully.  
Explain why the underlining of remaining sentences is less helpful.
  - a Most helpful. [1 mark]
  - b Underlining all the words only shows you have read the questions, not that you have picked out the most important parts. [1 mark]
  - c Has not underlined the most important parts, such as the command word or the important information. [1 mark]
- 2 Annotating the underlined key terms can help you map out ideas for your answer.  
Match the annotations below with the relevant underlined key word. [1 mark]



- 3 Use the underlining and matched annotations above to answer the question:  
**Outline the function of iron in plants.** [1 mark]  
*Iron is an inorganic element, which helps transport electrons in photosynthesis.*
- 4 Use the underlining and annotating technique to answer the questions below:
  - a **Describe the formation of triglycerides.** [3 marks]  
*Formed by condensation reaction;*  
*Releasing three molecules of water;*  
*Using glycerol and three fatty acids.*
  - b **Outline the formation of smaller molecules from larger molecules, using two examples.** [3 marks]  
*Smaller molecules are formed by hydrolysis reactions;*  
*Which require/use water molecules;*  
*Two valid examples/word equations (e.g. dipeptide + water → amino acid + amino acid).*



# 1.6 Elements and molecules loop quiz

Question	Answer
1 Which element is found in all organic molecules and allows them to form long polymer chains?	Carbon
2 Apart from carbon, hydrogen, oxygen, nitrogen and sometimes sulphur, which element is found in organic molecules?	Phosphorus
3 What is the role of iron in animals?	Transports oxygen in hemoglobin.
4 How many covalent bonds can carbon form?	Four
5 Name another group of carbon compounds apart from proteins, lipids and nucleic acids.	Carbohydrates
6 What are polymers made of?	Monomers
7 What is formed in a condensation reaction?	A larger molecule and water
8 What is formed in a hydrolysis reaction?	Smaller molecules
9 What are triglycerides composed of?	Fatty acids and glycerol.
10 Which molecule is a source of energy for all living organisms?	Adenosine triphosphate
11 What do all organisms use to synthesise nucleic acids?	Nucleotides

# 1.7 Extended response practice

## Interpreting command words

Command word	Definition
Describe	Give a detailed account. Say 'what' something is or 'what' happens.
Explain	Give a detailed account including reasons or causes. Say 'why' something is the way it is or 'why' something happens.
Compare and contrast	Give an account of the similarities and differences between two (or more) items or situations, referring to both (all) of them throughout.
Distinguish between	Give an account of the differences between two (or more) items or situations, referring to both (all) of them throughout.

### Distinguish between

- 1 *Apples are round whereas bananas are yellow.* These are not opposing points. One part of the sentence refers to shape whilst the other refers to colour. There should be two separate sentences here; one about shape and one about colour.
- 2 Practice writing sentences to connect opposing points using the sentences below:
  - a Cellulose is a structural carbohydrate whereas starch is an energy storage carbohydrate.
  - b Cellulose is found in plant cell walls whereas starch is found in organelles in the cytoplasm of plant cells.
  - c Cellulose is a straight chain of glucose molecules whereas glucose molecules in starch form a helical chain.
- 3 It is a good idea to plan your extended response before writing it. For a *distinguish between* question, a table of opposing points is a good essay plan. Complete the table in preparation for the following extended response:

Distinguish between monosaccharides and polysaccharides.

**[5 marks]**

Feature	Monosaccharides	Polysaccharides
Size	Small	Large
Solubility	Soluble	Insoluble
Function	Metabolism/respiration	Energy storage/structural
Example	Glucose/ribose/fructose/galactose	Starch/amylose/amylopectin/cellulose/glycogen
Taste	Sweet	Not sweet

4 Now write your extended response, remembering to use the word *whereas*.

- Monosaccharides are small molecules *whereas* polysaccharides are large molecules.
- Monosaccharides are soluble *whereas* polysaccharides are insoluble.
- Monosaccharides used in metabolic reactions, like respiration, *whereas* polysaccharides are used for energy storage/structural uses.
- An example of a monosaccharide is glucose *whereas* an example of a polysaccharide is cellulose.
- Monosaccharides have a sweet taste *whereas* polysaccharides do not have a sweet taste.

## 1.8 Extracting DNA from peas

### Questions and further work

- 1 Is the material you have extracted likely to be pure DNA? What other substances might be present?  
The material is unlikely to be pure DNA.  
RNA is also likely to be present.  
Some protein may still be present, as eukaryotic cells contain DNA associated with (histone) proteins.  
(But most of this protein will have been broken down earlier in the practical or will not dissolve well in ethanol.)
- 2 Why would the material you extracted not produce a good result if it were used in this raw state for DNA profiling?  
DNA profiling requires DNA fragments of varying lengths;  
These are formed using PCR, STRs and primers (older techniques use restriction endonucleases).  
The DNA extracted will be each cell's entire genome.  
The DNA extracted will be too long to move through the gel and separate into fragments.  
Bands will not be clearly visible (so a profile cannot be formed).

## 2.1 Metabolism and enzymes key terms bingo

Game between classmates. The definitions to the terms can be found in the coursebook or the glossary.

## 2.2 Decoding compound words

- 1 **Prokaryote:** Before (the evolution of) the nucleus.
  - 2 **Eukaryote:** True nucleus.
  - 3 **Intracellular:** Inside the cell.
  - 4 **Extracellular:** Outside the cell.
  - 5 **Amylase:** An enzyme which uses amylose/amylopectin as the substrate.
  - 6 **Triphosphate:** A molecule containing three phosphorus atoms.
  - 7 **Hydrolysis:** Using water to break/split molecules.
  - 8 **Adenosine diphosphate:** A molecule containing two phosphorus molecules.
  - 9 **Respirometer:** A piece of equipment to measure respiration.
  - 10 **Carbon dioxide:** A molecule containing one carbon atom and two oxygen atoms.
  - 11 **Phosphate:** A molecule of phosphorus combined with lots of oxygen atoms.
- 
- 1 **Phosphorylation:** Adding phosphorus to a molecule.
  - 2 **Decarboxylation:** Removal of carbon.
  - 3 **Glycolysis:** Splitting/breaking up glucose.
  - 4 **ATP synthase:** An enzyme which catalyses the making of ATP.
  - 5 **Dehydrogenation:** Removal of hydrogen.
  - 6 **Photolysis:** Splitting/breaking a molecule using light.
  - 7 **Carboxylase:** An enzyme which catalyses a reaction involving carbon.
  - 8 **Triose phosphate:** A molecule containing a sugar with three carbons and phosphorus with lots of oxygen.
  - 9 **Intermembrane:** Between membranes.
  - 10 **Photophosphorylation:** Adding phosphorus to a molecule using light.
  - 11 **Photoactivation:** Activating something using light.

## 2.3 Calculating rates and interpreting graphs

1 X should be 3 cm closer to the small organisms.

2 a 1 mark for equation stated;  
1 mark for valid explanation;

Example:

$$\text{Average rate of reaction} = \frac{\text{Measure of quantity of reactant used or product produced}}{\text{Time}}$$

because the liquid provides an accurate proxy for the volume of oxygen used in the reaction.

b 3/1.5;

2 cm/min or 0.33 cm/s (units required)

c Average rate of reaction chosen as pH change provides accurate proxy for concentration of carbon dioxide used;

OR

Relative rate of reaction used as pH is a logarithmic scale which does not have units to be expressed as a rate; (*students are not expected to know that pH is a logarithmic scale*)

7.2 – 6.5;

0.7/5;

0.14 pH h<sup>-1</sup>

OR

1/5;

0.2 h<sup>-1</sup>

d Use relative rate of reaction;

as substrate concentration unclear (volume of milk is an inaccurate proxy as milk contains protein and carbohydrates, as well as lipids) and product is not measured;

1/9 or 1/540;

0.11 min<sup>-1</sup> or 0.002 s<sup>-1</sup>; (units required)

**3 a i** Explanation

**ii** Description

**iii** Description

**iv** Explanation

**b i** Initially, as temperature increases, the rate of reaction increases;

After the optimum temperature, as temperature increases, the rate of reaction decreases.

**ii** Initially, as substrate concentration increases, the rate of reaction increases; As the substrate concentration increase further, the rate of reaction plateaus/levels off.

**c i** The rate of reaction initially increases as the substrate and enzyme molecules have more kinetic energy;

So there are more successful collisions between enzymes and substrates (which increases the rate of reaction);

The rate of reaction decreases after the optimum temperature as the enzyme denatures;

Because bonds within the enzyme break (due to higher kinetic energy);

Causing a change in the active site;

So the substrate can no longer bind;

**ii** The rate of reaction initially increases as the number of substrate molecules increases;

So there are more successful collisions between enzymes and substrates (which increases the rate of reaction);

The rate of reaction plateaus as the number of substrate molecules exceeds the number of available active sites/the enzymes are saturated.



## 2.4 Investigating the effect of temperature on enzyme activity

### Questions and further work

- 1** At which temperature was starch broken down by amylase most quickly?

One would expect 35 °C, although students should look carefully at the data collected to answer this question.

- 2** If starch was not broken down by amylase in one or more of the tubes, explain why not.

The amylase and starch at lower temperatures may not have enough kinetic energy for successful collisions to occur/for enzyme-substrate complexes to form.

The amylase at temperatures past the optimum would denature due to disruption to the bonds holding the enzymes tertiary structure together.

- 3** Suggest a suitable control for the experiment. Why is it important to have a control?

Setting up a test tube with starch but no amylase, then testing the solution in the spotting tiles as per the procedure.

In this case, a control provides evidence that the enzyme is the molecule causing the break down of starch.

- 4** Plan an investigation to determine the optimum temperature for amylase activity.

Answers should include:

A clear independent variable, with range and intervals;

A clear dependent variable and how this will be measured;

Relevant control variables;

A clear and detailed method;

A risk assessment.

Students should use their results from the practical procedure to determine a suitable range and suitable intervals for their temperatures (this is likely to be between 35 °C and 60 °C).

## 2.5 Investigating the conditions needed for the action of a protease enzyme

### Questions and further work

- 1** Why does a clear solution indicate that digestion has occurred?

The albumin solution should initially be purple (due to the Biuret's reagent), indicating the protein is present;

If the solution becomes clear, this suggests there is no protein;

So this indicates that the protein has been digested.

- 2** In which tube(s) was the protein digested?

Tube C (pepsin is found in the stomach so it requires an acidic optimum pH).

- 3** In which tube(s) was protein not digested?

Tubes A (not at optimum pH), B (no enzyme present) and D (enzyme denatured by boiling).

- 4** What effect does boiling have on pepsin solution?

It denatures the pepsin enzyme, changing the shape of its active site so it can no longer bind to the albumin and can no longer catalyse its digestion.

- 5** Why was the water bath used in this experiment?

This would provide the optimum temperature for the pepsin enzyme to catalyse the reaction.

- 6** Design a similar experiment that you could use to determine the optimum pH for pepsin activity.

Answers should include:

A clear independent variable, with range and intervals;

A clear dependent variable and how this will be measured;

Relevant control variables;

A clear and detailed method;

A risk assessment.

## 2.6 Immobilised enzymes

### Questions and further work

- 1 Design a similar investigation to determine the effect of substrate concentration on the concentration of product.

Answers should include:

A clear independent variable (different concentrations of lactose solution), with range and intervals;

A clear dependent variable (glucose concentration) and how this will be measured;

Relevant control variables (e.g. flow rate, temperature, pH);

A clear and detailed method;

A risk assessment.

- 2 List any factors that may affect the accuracy of your experiment and suggest ways to overcome them.

Examples:

The colour scale on the glucose sticks is subjective. Using a quantitative Benedict's reagent test with a colorimeter would provide more objective and accurate results;

Measuring out volumes using syringes is not as accurate as using volumetric pipettes.

## 2.7 Using a redox indicator to show the activity of dehydrogenase enzyme

### Questions and further work

- 1 What conclusions can you draw about the effect of temperature on the activity of dehydrogenase in yeast?

The answers here will depend on the data collected.

One would expect that the activity of the enzyme would increase as temperature initially increases. After an optimum temperature, any further increases in temperature should result in decreased enzyme activity.

- 2 Why is step 6 in the procedure important to your conclusion?

This allows anomalies to be spotted (and potentially be removed from the data set);

Ensures more reliable data.

- 3 Why is a margin of error of  $\pm 30$  s shown in the sample table above? Is this a suitable margin?

This indicates that the data stated may be inaccurate by up to 30 seconds;

It may account for the reaction time in stopping the stopwatch;

Whether it is a suitable margin or not depends on the data collected. The greater the length of time the reaction took, the smaller the impact of this uncertainty.

- 4 What procedure could you adopt to confirm the optimum temperature for dehydrogenase activity?

Carry out the same procedure using smaller intervals between the range of possible optimum temperatures determined by the initial experiment.

## 2.8 Investigating the rate of fermentation in yeast

### Questions and further work

- 1** Comment on your results and evaluate your procedure.

Answers should include:

A clear description of the trend of the data collected;

An explanation for the trend (referring to enzymes, kinetic energy, an optimum temperature and denaturation);

Descriptions, explanations and evaluations of at least two strengths of the method;

Descriptions, explanations and evaluations of at least two weaknesses of the method.

It is important that students understand how to evaluate procedures. This should include an assessment of the degree to which a strength or weakness has an impact on the conclusion, and to what extent the conclusion can still be trusted in light of the evaluative point.

- 2** Why was it necessary to take three readings at each temperature?

This allows anomalies to be spotted (and potentially by removed from the data set);

Ensures more reliable data.

- 3** Why were the yeast suspension and the glucose solution made up with water that had been previously boiled?

This removes carbon dioxide from the water;

Ensuring that the gas produced is carbon dioxide produced from anaerobic respiration (rather than carbon dioxide already present in the water).

## 2.9 Chromatography with nettle leaves

### Questions and further work

- 1 Present your results as a table.

Example table structure:

Spot	Distance travelled/cm	R <sub>f</sub> calculation	R <sub>f</sub> value
1	1.4	$\frac{1.4}{7.7}$	0.18
2	4.1	$\frac{4.1}{7.7}$	0.53
3	6.0	$\frac{6.0}{7.7}$	0.78

- 2 Use reference sources to deduce the identity of the different pigments that are present in the chloroplasts of leaves that you have used.

Students could use an online search engine to find a suitable reference source. It is important that the reference uses the same solvent to ensure the R<sub>f</sub> values match.

- 3 Outline the reasons for the presence of different pigments in the leaves.

This allows absorption of light energy from a wide range of wavelengths.

- 4 Compare the R<sub>f</sub> values you have calculated for each pigment with published data for the pigments you have identified. Try to account for any differences between your values and published values.

Students should consider possible inaccuracies with their dataset. E.g. how confident can they be about the measurement of their starting point, spot distances and solvent front.

- 5 Why do some pigments move further up the chromatogram than others?

Those that move further are more soluble in the chosen solvent than those that move less far.

- 6 Suggest why temperature may be a key variable that must be considered when comparing laboratory values with published data.

Solutes often dissolve better in the solvent at higher temperatures, so may travel further;

A higher temperature may also allow the solvent to travel more quickly along the chromatography paper, resulting in a higher value for the solvent front.

## 2.10 Light intensity and photosynthesis in algae

### Questions and further work

- 1 Outline the conclusions you can draw from the graph of absorbance (or pH) against light intensity.

The answers here will depend on the data collected.

One would expect a greater increase in absorbance (or a greater increase in pH) as light intensity increases, due to increased rates of photosynthesis removing carbon dioxide from the solution surrounding the algal balls.

- 2 What are the key variables in this experiment? Which variables should be kept constant?

**Independent:** Light intensity

**Dependent:** Rate of photosynthesis (determined by change in pH/absorbance)

Control examples include: Algal species, temperature, initial carbon dioxide concentration of water.

- 3 Evaluate the procedure. How could it be made:

- a more accurate?

Measuring the change in pH with a digital pH probe might provide more accurate results.

- b more reliable?

Ensure repeats are collected for each light intensity, in order to spot and remove anomalies from the data set, then calculate a mean average.

## 3.1 Definitions – true or false?

Key term	Proposed definition	True or false? Remember to correct the false ones
Chromatid	The structure into which DNA is packaged.	A molecule of replicated DNA which makes up part of a chromosome.
Chromosome	A molecule of replicated DNA which makes up part of a chromosome.	The structure into which DNA is packaged.
Codon	A sequence of three mRNA bases that code for an amino acid.	True
Epigenome	All the chemical compounds that have been added to a genome to regulate the expression of all the genes within the genome.	True
Gene	A section of DNA that makes a specific amino acid.	A section of DNA that codes for the production of a protein or RNA molecule.
Gene expression	The mechanism by which genetic information affects the phenotype of an organism	True
Gene knockout	A method that is used to damage specific genes so that they no longer function	True
Genome	All of the genes in a cell or organism.	All of the genetic information of a cell or organism, including non-coding sections of DNA.
Lagging strand	The new strand that is synthesised in short fragments in the opposite direction to the movement of the replication fork.	True
Leading strand	The new strand that is synthesised continuously and follows the replication fork.	True
Oncogene	A gene which leads to cancer.	A gene that has the potential to cause cancer.
PCR	A process in which small quantities of DNA are artificially amplified for research and diagnosis.	True
Proteome	The complete set of proteins expressed by an organism	True
Transcriptome	All the mRNA molecules expressed from the genes of an organism	True



## 4.1 Using chi-squared

1

Parent phenotypes:	White, long × White, long
Parent genotypes:	FfHh × FfHh
Gametes:	FH Fh fH fh × FH Fh fH fh

Punnett square:

	FH	Fh	fH	fh
FH	FFHH	FFHh	FfHH	FfHh
Fh	FFHh	FFHh	FfHh	Ffhh
fH	FfHH	FfHh	ffHH	ffHh
fh	FfHh	Ffhh	ffHh	ffhh

**F2 genotype ratio:** FFHH : FFHh : FfHH : FfHh : Ffhh : ffHH : ffHh : fhh

1 : 3 : 2 : 4 : 2 : 1 : 2 : 1

**F2 phenotype ratio:** White, long : White, short : Gold, long : Gold, short

9 : 3 : 3 : 1

2 16 : 5 : 5 : 1

3

Phenotype	White, long	White, short	Gold, long	Gold, short
Expected value	$\frac{9}{16} \times 190 = \mathbf{106.875}$	$\frac{3}{16} \times 190 = 35.6325$	35.6325	11.875

- 4**  $H_0$  (null): There is no significant difference between the observed and expected ratios for unicorn phenotypes.

$H_1$  (alternative): There is a significant difference between the observed and expected ratios for unicorn phenotypes.

**5**  $4 - 1 = 3$

- 6** The critical value circled in the table should be 7.815.

Step 1. For the white, long phenotype:

$$O = 114 \quad E = 106.875$$

$$\frac{(114 - 106.875)^2}{106.875} = 0.475$$

Step 2. For the white, short phenotype:

$$O = 35 \quad E = 35.625$$

$$\frac{(35 - 35.625)^2}{35.625} = 0.011$$

Step 3. For the gold, long:

$$O = 33 \quad E = 35.625$$

$$\frac{(33 - 35.625)^2}{35.625} = 0.193$$

Step 4. For the gold, short phenotype:

$$O = 7 \quad E = 11.875$$

$$\frac{(7 - 11.875)^2}{11.875} = 2.001$$

Step 5. Calculate the sum of your answers to steps 1 to 4.

$$\chi^2 = 0.475 + 0.011 + 0.193 + 2.001 = 2.68$$

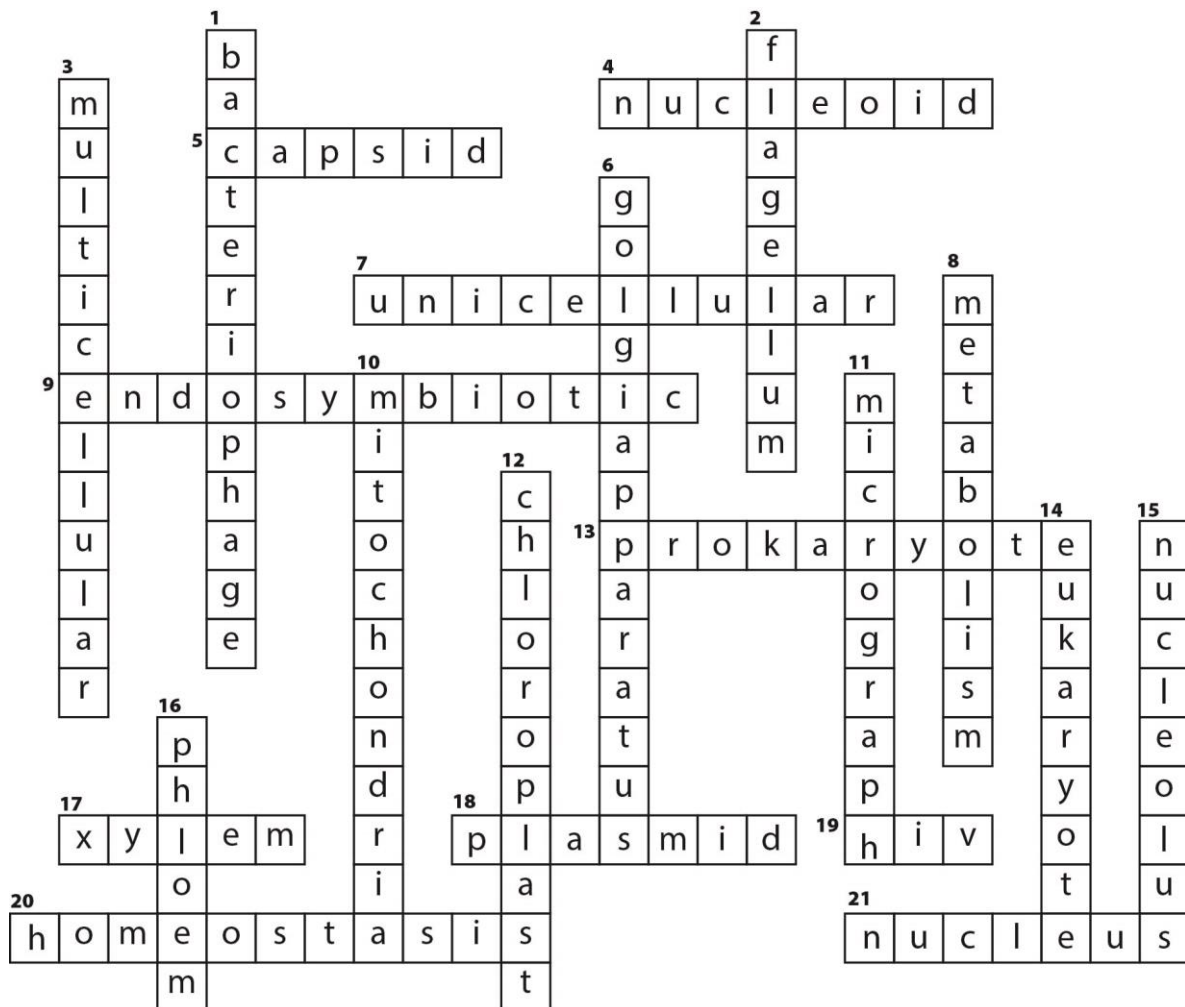
- 7**  $2.68 < 7.815$

Accept the null hypothesis: there is no statistically significant difference between the observed and expected results.

## 5.1 Key concepts bingo

No answers required.

## 5.2 Cell structure crossword



### Across

- 4 A circular chromosome, not associated with proteins, found free in the cytoplasm of prokaryotes. (**nucleoid**)
- 5 The protein coat of a virus. (**capsid**)
- 7 Made of just one cell. (**unicellular**)
- 9 The theory which suggests eukaryotes evolved by engulfing prokaryotes. (**endosymbiotic**)
- 13 A non-compartmentalised cell, with no membrane-bound organelles. (**prokaryote**)
- 17 A plant tissue made of tube-like structures for transporting water. (**xylem**)
- 18 Small loop of additional DNA found in prokaryotes. (**plasmid**)
- 19 The virus that causes AIDS. (**hiv**)
- 20 Keeping internal conditions constant. (**homeostasis**)
- 21 A cellular structure composed of a double membrane, containing DNA. (**nucleus**)

### Down

- 1 A virus that infects bacteria. (**bacteriophage**)
- 2 A structure which helps the cell to move. (**flagellum**)
- 3 Composed of many cells. (**multicellular**)
- 6 A eukaryotic organelle responsible for processing and packaging proteins. (**golgiapparatus**)
- 8 All the chemical reactions occurring in the cells of an organism. (**metabolism**)
- 10 An organelle with a double membrane. The inner membrane is folded into cristae. (**mitochondria**)
- 11 A picture formed using a microscope (**micrograph**)
- 12 An organelle with a double membrane. The site of photosynthesis. (**chloroplast**)
- 14 A compartmentalised cell with membrane-bound organelles. (**eukaryote**)
- 15 Site of ribosome synthesis. (**nucleolus**)
- 16 A plant tissue made of tube-like structures for transporting sap. (**phloem**)

## 5.3 Identifying cells and their structures

No answers required.

## 5.4 Measuring cells and their nuclei

### Questions and further work

- 1 Is there a correlation between the length and width of a cell and the diameter of the cell nucleus?

Although there is evidence suggesting a positive correlation between cell *volume* and nuclear volume, students are unlikely to find a correlation in their dataset.

- 2 Can you account for your answer to question 1?

We might expect a positive correlation between cell volume and nuclear volume but this is not what we have been able to measure. We have not been able to measure cell height, or get an accurate measurement of volume due to the irregular shape of the cell and its 2D appearance down the microscope lens.

- 3 Why was it necessary to measure ten cells?

To obtain repeats, which allow us to spot anomalies, remove them from the dataset and calculate a more reliable mean average.

- 4 Evaluate the procedure you have used. Are there any alterations you could suggest to improve the accuracy or reliability of your data?

Accept any relevant answers.

Answers should show a clear understanding of the difference between accuracy (how close data collected are to the true value we are trying to measure) and reliability (consistency of data obtained).

Answers should also clearly evaluate the procedure. In other words, they should include an assessment of the degree to which a strength or weakness has an impact on the conclusion, and to what extent the conclusion can still be trusted in light of the evaluative point.

Improvements should be realistic and detailed.

## 6.1 Decoding compound words

- 5 **Aquaporin:** water + pore; A pore that lets water through.
- 6 **Depolarisation:** reversing + regions of different charges; Reversing the difference in charges (of the axon's membrane).
- 7 **Diploid:** two + chromosome sets; Containing two sets of chromosomes.
- 8 **Endocytosis:** inside + cells; Moving substances into a cell.
- 9 **Eukaryote:** True nucleus.
- 10 **Exocytosis:** outside + cells; Moving substances out of a cell.
- 11 **Glycoproteins:** carbohydrates + proteins; Proteins attached to carbohydrates.
- 12 **Haploid:** single + chromosomes; Containing one set of chromosomes.
- 13 **Hypertonic:** too much + solution; A solution containing a higher solute concentration (than the one it is being compared with).
- 14 **Hypotonic:** not enough + solution; A solution containing a lower solute concentration (than the one it is being compared with).
- 15 **Interphase:** Between (cell division) phases.
- 16 **Isotonic:** equal + solution; A solution containing an equal solute concentration (to the one it is being compared with).
- 17 **Osmoregulation:** Controlling the water potential of a cell/organism.
- 18 **Phospholipid:** A lipid attached to phosphorus.
- 19 **Prokaryote:** Before the evolution of the nucleus.
- 20 **Repolarisation:** Restoring the difference in charges (of the axon's membrane).
- 21 **Xerophyte:** A plant adapted to dry environments.
- 22 **Polyploid:** Containing many sets of chromosomes.
- 23 **Tetraploid:** Containing four sets of chromosomes.
- 24 **Triploid:** Containing three sets of chromosomes.

## 6.2 Evaluating experiments

### Exercise 1: Helpful vocabulary

**Accuracy:** The data collected are close to the true value of data the experiment set out to measure.

**Reliability:** The data collected are the same each time an interval/treatment is repeated.

**Validity:** The experiment measures what it sets out to measure.

- 1 Describe an accurate result: The probe reads pH 7.
- 2 Describe an inaccurate result: The probe reads a value other than pH 7 (e.g. pH 10).
- 3 Describe a reliable set of results: The probe reads the same pH five times in a row.  
(Accept any other valid answer.)
- 4 Describe an unreliable set of results: The probe reads five different pH values when five repeats are carried out. (Accept any other valid answer.)
- 5 Describe an invalid experiment: The temperature of the water is measured.  
(Accept any other valid answer.)

### Exercise 2: Evaluating methods

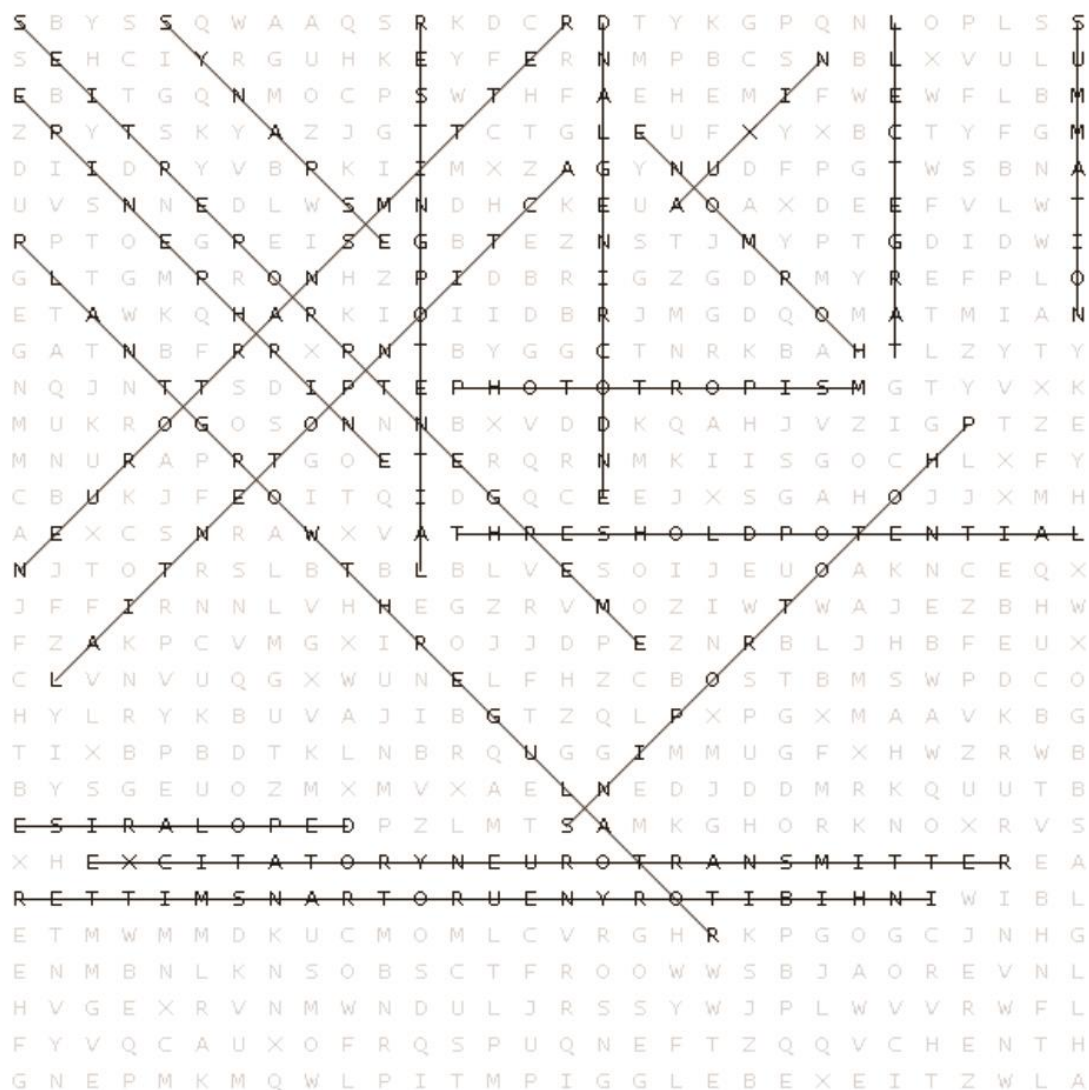
- 1 Description (saying *what* is the weakness): The potato chips were not blotted with tissue paper before being weighed.
- 2 Explanation (saying *why* this is a weakness): This decreases the **accuracy** of the data collected, as the potato chips may have had excess solution on them, resulting in an overestimate of their masses.
- 3 Evaluation (saying how much the conclusion can be trusted): The conclusion is a little **less** trustworthy as the data points plotted on the graph are likely to be inaccurate. However, it is likely that all the potato chips had similar volumes of excess water on them, so the data collected would still be **reliable**. So, the trend of the graph is the trustworthy. However, using the graph to estimate the water potential of the potato chips is likely to be **inaccurate**.



### Exercise 3: Evaluating data

Graph	Statement
A	The data are more reliable on this graph than the other.
A	The highest data point collected for the soil at pH 5 is still lower than the lowest data point collected for the soil at pH 7.
B	Some of the data points are the same regardless of soil pH.
A	There is likely to be a significant difference between the data collected at pH 5 and pH 7. (Can you explain why? Because the error bars do not overlap/The highest data point collected for the soil at pH 5 is still lower than the lowest data point collected for the soil at pH 7.)
B	There may not be a significant difference between the data collected at pH 5 and pH 7. (Can you explain why? What would need to be done to check? Because the error bars overlap/Some of the data points are the same regardless of soil pH. A statistical test would need to be used to check.)

## 7. 1 Definitions wordsearch



- 1 Emergent properties
- 2 Endocrine gland
- 3 Neurotransmitter
- 4 Threshold potential
- 5 Synapse
- 6 Resting potential
- 7 Action potential
- 8 Depolarise
- 9 Hormone
- 10

- 11** Target cell
- 12** Auxin
- 13** Phototropism
- 14** Plant growth regulator
- 15** Summation
- 16** Phototropins
- 17** Inhibitory neurotransmitter
- 18** Excitatory neurotransmitter
- 19** Epinephrine.

## 7.2 Analysing oscilloscope traces

- 1 The neuron at resting potential should have minus (–) symbols along the inside of the axon and plus (+) symbols along the outside of the axon.

The neuron representing an action potential should resemble the axon described here, except that one section of the axon should have a plus symbol on its inside and a minus symbol on its outside.

- 2 a 0–23 ms

b 33 ms

NB There is room for discussion with these answers. For example, students might argue that any time at which the oscilloscope line is below 0 matches their first diagram, and this is not incorrect, although this period does not realistically all fall under the term ‘resting potential’. This could generate a useful discussion to help strengthen students’ understanding.

3	Resting potential	0–23 ms
	Repolarisation	33–37 ms
	Depolarisation	32–33 ms
	Hyperpolarisation	38 ms
	Sodium–potassium pumps move three sodium ions out of the axon for every two potassium ions moved in.	0–23 ms
	Sodium ions move into the axon via facilitated diffusion.	32–33 ms
	Potassium ions move out of the axon via facilitated diffusion.	33–37 ms

- 4 –73 mV

- 5 –30 mV

- 6 There is a rapid increase in membrane voltage;  
depolarisation occurs;  
(voltage-gated) sodium channels open;  
sodium ions diffuse into the axon.

- 7 60 mV

**8** *Either:*

Hyperpolarisation.

Membrane potential should be more negative than the resting potential after repolarisation.

*Or:*

Resting potential after the action potential.

Never reaches the starting point of  $-75$  mV.

*Answers should be accompanied by a linked explanation.*

**9** Summation:

Neuron is receiving EPSPs/excitatory postsynaptic potentials.

Hyperpolarisation prevents further action potential/threshold potential being reached/depolarisation.

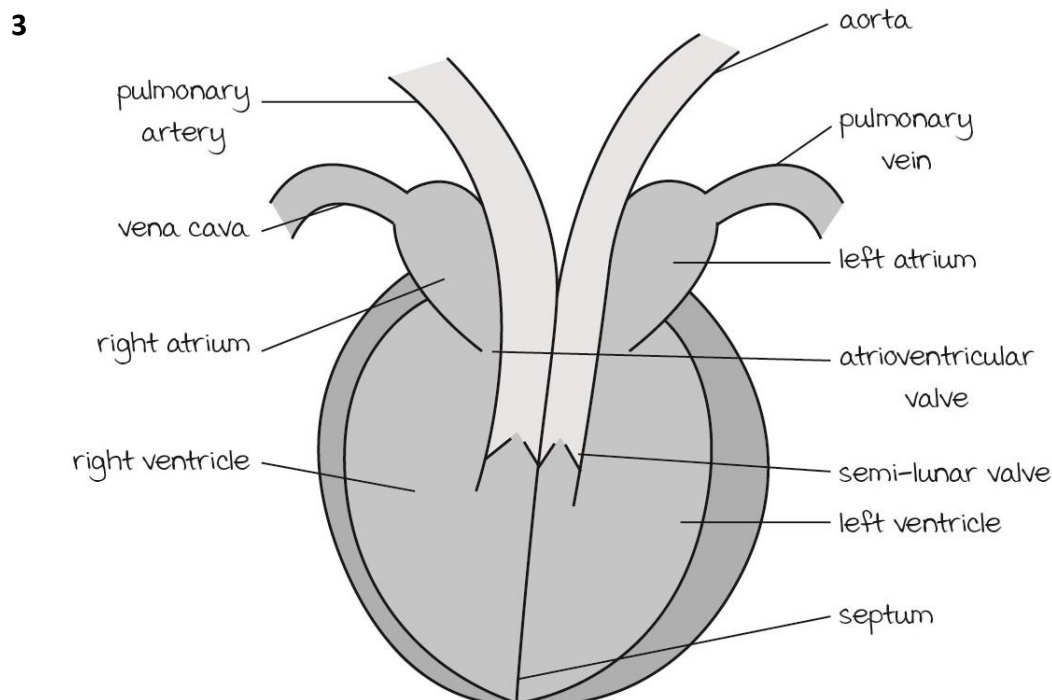
## 8.1 Translating for a scientist

Everyday definition	Key term	Scientific definition
A blue blood vessel.	Vein	A blood vessel which carries blood towards the heart.
A disorder in which the body can't produce insulin.	Diabetes	A condition in which glucose levels in the blood cannot be regulated. Sometimes the body cannot produce insulin whereas sometimes it does not respond to insulin.
A pretty part of a plant that attracts bees.	Flower	The reproductive organ of angiosperm plants.
A repeated beating or throbbing.	Pulse	The rhythmic dilation of an artery.
An exact copy of something.	Clone	An organism or cell which is genetically identical to another.
Breathing.	Respiration	A chemical reaction which releases energy in the form of ATP.
Healthy food that isn't a vegetable.	Fruit	The structure formed from the ovary of a plant, which carries seeds.
Processing food.	Digestion	Chemical breakdown of large insoluble food molecules into small soluble ones which can be absorbed.
Small chemicals that can make you ill.	Spores	A haploid structure used by fungi and non-vascular plants for reproduction.
The movement of air	Ventilation	The process of breathing in (inhalation) and out (exhalation).
Used to blow your nose.	Tissue	A groups of cells which carry out a similar function.
When pollen is picked up and moved somewhere.	Pollination	The transfer of pollen from an anther to a stigma.

## 8.2 Drawing a diagram of a heart in the sagittal plane

- 1
- |   |   |
|---|---|
| a | This ensures lines are clear so that the specimen is accurately portrayed in the diagram. |
| b | This improves clarity, ensuring the reader can see the drawing well.                      |
| c | This ensures lines are clear so that the specimen is accurately portrayed in the diagram. |
| d | This ensures there is no confusion as to what each structure is.                          |
| e | This ensures there is no confusion as to what each structure is.                          |

- 2
- Diagram is quite small.
  - Uses sketchy lines.
  - Pencil is blunt.
  - Labels cross over in places (e.g. chloroplast and cell membrane).
  - Permanent vacuole label not touching the structure it refers to.



**Figure 8.1:** Labelled diagram of a heart

- 4 No answer needed.

## 8.3 Renin–angiotensin–aldosterone system listening comprehension

- 1 Blood vessels in the kidneys
- 2 Renin
- 3 When blood pressure is low.
- 4 In response to major stressors.
- 5 In the distal convoluted tubes of the kidneys.
- 6 Sodium
- 7 It produces angiotensinogen.
- 8 It activates angiotensin from its precursor angiotensinogen.
- 9 Smooth muscle cells, Kidney cells, Pituitary cells, Adrenal gland cells
- 10 Vasoconstriction, Absorption of water by the kidney, Release of antidiuretic hormone (ADH), Release of aldosterone



## 9.1 Definitions – true or false?

Key term	Proposed definition	True or false? Remember to correct the false ones
Chemoreceptor	A specialised sensory receptor cell which transduces a chemical substance to generate a biological signal.	True
Communication	When a sender's action influences the behaviour of a receiver.	True
Endoskeleton	A skeleton found inside the body.	False: An internal framework of bones in the vertebrate body, consisting of both fused and individual bones.
Exoskeleton	A firm external skeleton that supports and protects the bodies of all arthropods.	True
Learned behaviour	Behaviour that is not a result of genes.	False: Behaviour that develops from experiences and which may lead to development of new skills or to changes in existing ones.
Locomotion	The ability to change position, not always resulting in a change of location.	False: The ability of an organism to change location by moving from one place to another.
Movement	The ability of an organism to change location by moving from one place to another.	False: The ability to change position, not always resulting in a change of location.
Transduce	Convert one form of energy into another, e.g. light into an electrical impulse.	True
Tropism	A growth response of plants in which the direction of growth is determined by the direction of a stimulus.	True

## 9.2 Experimental design

### 1 Helpful key terms

Key term	Definition
Independent variable	The factor being changed.
Dependent variable	The factor being measured.
Control variable	Must be kept the same.
Range	The difference between the smallest and largest value of the independent variable.
Interval	The intermediates along the range of your independent variable.
Hypothesis	An explanation of how you think the independent variable will affect the dependent variable.
Prediction	A description of how you think the independent variable will affect the dependent variable.

**a Independent:** Volume of water

**Dependent:** Height of sunflowers

**Control:** Hours of sunlight

**b Independent:** Height of grass

**Dependent:** Number of insects

**Control:** Area sampled

### 2 Developing a focused research question

- To what extent does the colour of sucrose solution food sources (blue, red or grey) affect potential pollination, as shown by the number of Lepidoptera that are present at the food source over a time period of 10 minutes?

### 3 Constructing a detailed prediction and hypothesis

- A statement of which colour will attract the greatest number of insects.
- A statement of which colour will attract the fewest number of insects.
- An explanation of why you think one colour will attract more insects than another, based on biological theories.
- A sketch of what a graph of your results might look like.

4

Control variable	Why does it need to be controlled?	How will it be controlled?
Concentration of sucrose solution	Insects are attracted to sucrose solutions because they provide them with energy. A higher concentration of sucrose may be more attractive to insects so colour will no longer be the only independent variable.	A stock solution of sucrose will be made and used for all trials. 170 g of sucrose will be measured out using electronic scales. This will be added to a 1000 cm <sup>3</sup> measuring cylinder. Then, water will be added to the measuring cylinder until the solution has a volume of 500 cm <sup>3</sup> .
Size and shape of coloured dish	Flower shapes can determine which species of insect can pollinate it. So, it is likely that the shape of the dish could affect the insects entering it. If the dishes were different shapes and sizes, this could affect the number of insects visiting them.	Dishes of the same dimensions will be used for all trials.
Time of day	Different species of insect are active at different times of day. So, if the experiment were conducted at different times of day, this would likely affect the number of insects recorded.	A digital clock will be used to ensure the experiment takes place at the same time of day whenever it is repeated.

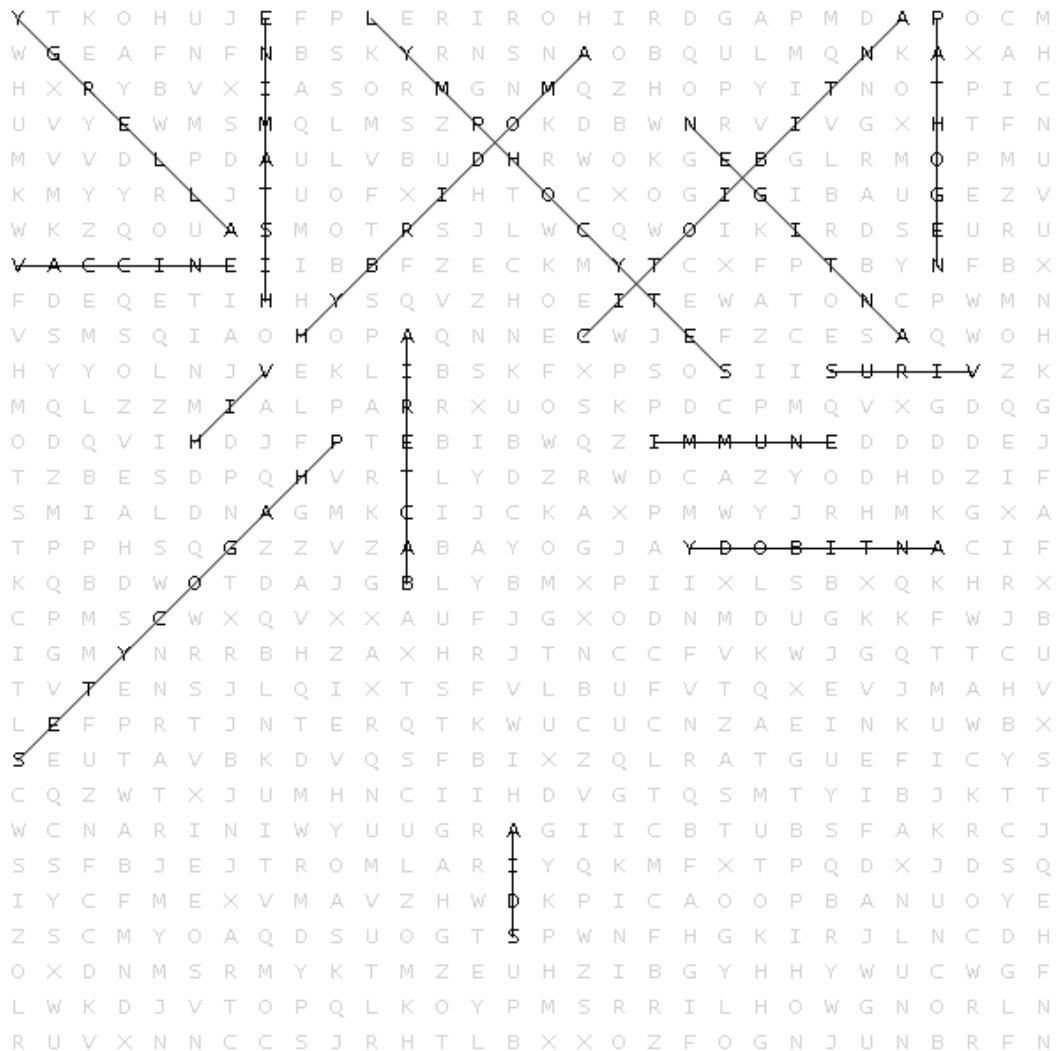
5 Writing a method

Method should match the criteria described on the worksheet.

6

Description of hazard	Steps for prevention	What if it happens?
Using electrical items near liquids can lead to electrocution.	Liquids will be kept on a separate desk to electrical equipment. Any spillages will be cleaned up immediately.	Although the likelihood of this hazard occurring is low, the consequences could be severe. Turn off the source of electricity and seek medical help.
Cuts from sharp equipment such as scalpels.	Always cut away from yourself, on a cutting tile. Use the bridge technique to hold the sample firmly whilst it is being cut.	Apply pressure to the injury to stop the bleeding. If the cut is small/shallow, clean it using soap and water and apply a plaster. If the cut is large/deep, seek medical help.
Burns from the flame of a Bunsen burner.	Tie back long hair and make sure there is no loose clothing. Leave the Bunsen burner on a visible, yellow flame when not in use.	Place the burnt area under cool running water for 20 minutes. If the burn is severe, seek medical attention.

# 10.1 Definitions wordsearch



## Answers

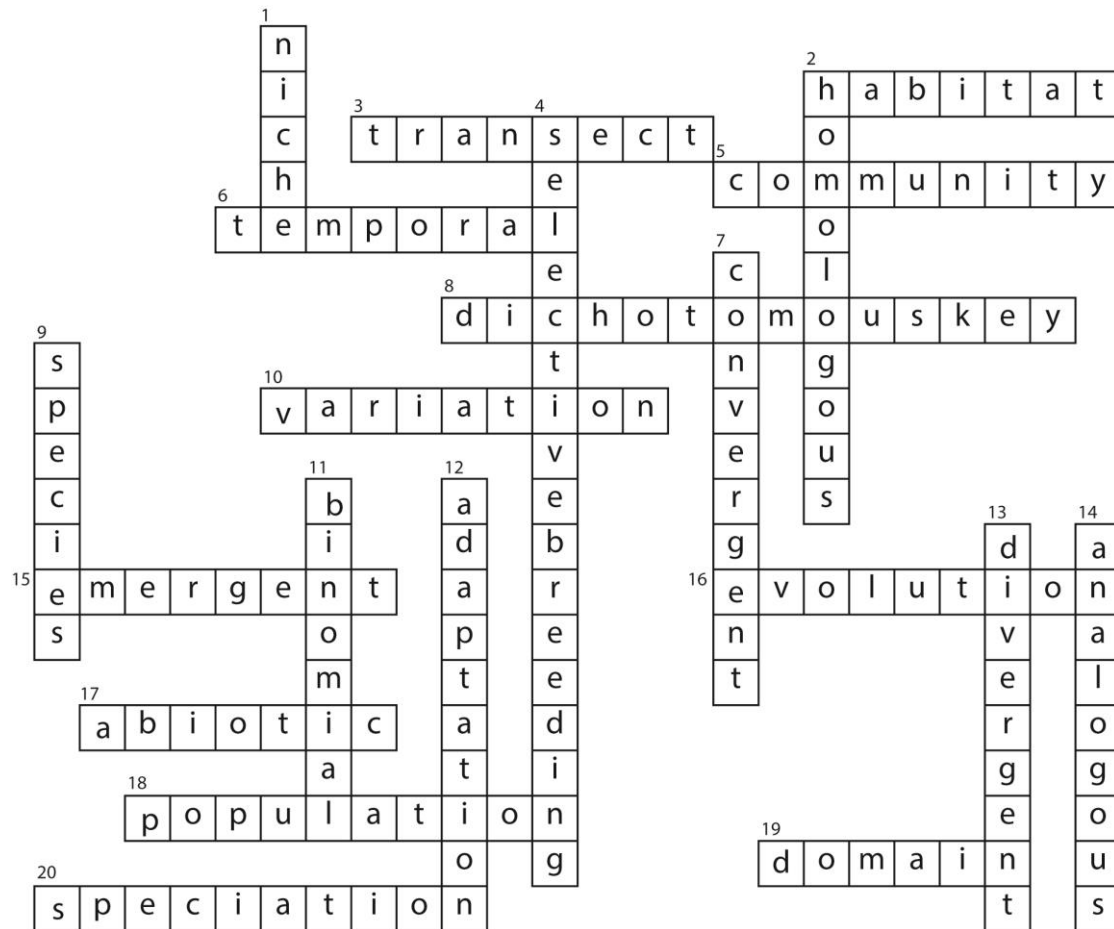
- 1 AIDS: Acquired immune deficiency syndrome. A collection of symptoms caused by infection with HIV.
- 2 Antibiotic: A substance which disrupts metabolic processes in prokaryotes to treat bacterial infections.
- 3 Antibody: A protein produced by B-lymphocytes which helps to destroy pathogens.
- 4 Antigen: A protein or carbohydrate molecular marker which the body detects as non-self and causes the production of specific antibodies.
- 5 Bacteria: Prokaryotes. Some are harmful to humans whereas others are helpful (e.g. in the production of yoghurt).
- 6 HIV: Human immunodeficiency virus.

- 7** Immune: Not displaying symptoms when infected by a particular pathogen due to the presence of memory cells which produce specific antibodies quickly and in large quantities.
- 8** Lymphocytes: A group of white blood cells involved in a specific immune response.
- 9** Pathogen: A virus or living organism which causes a disease.
- 10** Phagocytes: A group of white blood cells that engulfs and digests pathogens as part of the non-specific immune system.
- 11** Virus: A non-living pathogen consisting of a protein coat and genetic material.
- 12** Allergy: An excessive immune response to an antigen.
- 13** Histamine: A chemical produced by some white blood cells that causes inflammation.
- 14** Hybridoma: A cell created from the fusion of a cancer cell with an antibody-producing plasma cell.
- 15** Vaccine: A modified form of a disease-causing pathogen or their antigens that stimulate immunity without causing illness.

## 10.2 Planning for an extended response

- Transmitted through exchange of bodily fluids during unprotected sex.
- Transmitted through blood. (For example) through unscreened transfusions/unsterilised needles.
- Transmitted from mothers to children through the placenta/through breast milk.
- It is a virus.
- HIV infects/damages/reduces the number of T-cells/T-lymphocytes.
- Fewer antibodies are produced.
- The body cannot protect itself against pathogens well.
- HIV leads to AIDS/acquired immune deficiency syndrome.
- The symptoms of AIDS include diseases that are rare in people who have a healthy immune system.

# 11.1 Evolution, speciation and ecosystems



## Across

- 2 The type of environment where an organism usually lives. (**habitat**)
- 3 A line across an area of study along which organisms and abiotic features are counted and recorded. (**transect**)
- 5 A group of organisms of different species. (**community**)
- 6 The type of isolation related to time. (**temporal**)
- 8 A method of identifying organisms using questions with only two possible answers at each step. (**dichotomous key**)
- 10 This results from meiosis, mutation and sexual reproduction. It is needed for evolution to occur. (**variation**)
- 15 An adjective to describe complex properties arising from the interaction of simpler entities. (**emergent**)
- 16 A cumulative change in the heritable characteristics of a population. (**evolution**)
- 17 Non-living factors. (**abiotic**)
- 18 A group of organisms from the same species. (**population**)
- 19 The largest taxon of classification. (**domain**)
- 20 The process which forms new species. (**speciation**)

## Down

- 1 The functional position of an organism in its environment, including its habitat, feeding activities and interactions with other species. (**niche**)
- 2 Features that are structurally similar but functionally different. Arise from divergent evolution. (**homologous**)
- 4 A human driven process which has resulted in domesticated animals. (**selective breeding**)
- 7 A type of evolution in which unrelated organisms develop similar characteristics to occupy similar niches. (**convergent**)
- 9 A group of organisms that share common characteristics and can interbreed to produce fertile offspring. (**species**)
- 11 The type of two-part name given to living things by scientists. (**binomial**)
- 12 A feature that makes an individual better suited to its environment and way of life. (**adaptation**)
- 13 A type of evolution in which there is diversification of new species from a common ancestor to occupy available niches. (**divergent**)
- 14 Features that are functionally similar but structurally different. Arise from convergent evolution. (**analogous**)

# 11.2 Using Simpson's reciprocal index of diversity

1 Both communities contain the same number of organisms/individuals and species.

2 Both communities have the same species richness;  
Community 1 shows more evenness than community 2.

3  $D$  is the diversity index

$N$  is the total number of organisms in the habitat

$n$  is the number of individuals of each species

$\Sigma$  is a Greek letter that means total, or sum of.

4 **Step 1:**

$N$ , the total number of organisms in community 1 is 50.

**Step 2:**

$n$ , the total number of organisms of species A is 10, species B is 10, species C is 10, species D is 10 and species E is 10.

Steps 3: Fill in the equation.

$$D = \frac{50(50-1)}{10(10-1)+10(10-1)+10(10-1)+10(10-1)+10(10-1)}$$

Step 4:

$$D = 5.44$$

5 the index of biodiversity of community 2:

$$D = \frac{50(50-1)}{1(1-1)+1(1-1)+1(1-1)+1(1-1)+46(46-1)}$$

$$D = \frac{2450}{2070}$$

$$D = 1.18$$

6 The biodiversity index for community 1 is higher than the index for community 2;

Suggesting that community 1 has a higher biodiversity than community 2.



## 12.1 Translating for a scientist

Everyday definition	Key term	Scientific definition
Riding a bike.	Cycling	The movement of nutrients through an ecosystem by converting them into different forms.
Waste generated by humans (e.g. bottles and wrappers) that are dropped on the floor.	Litter	A layer of dead organic material (such as fallen leaves and dead wood).
People with common interests living in a particular area.	Community	The total number of individuals from all the populations living in a particular area at a particular time.
Someone who buys a product.	Consumer	A heterotroph that feeds on living organisms by ingestion.
An insect that feeds on blood.	Parasite	An organism that is adapted to live on or inside another organism (its host) and benefits at the host's expense.
Good for the environment.	Sustainable	An ecosystem that can support itself and provide resources without outside influences.
An activity in which people try to show they are the best at something to win a prize.	Competition	An interaction between two species or organisms in which both are harmed.
Good for the environment.	Organic	Derived from living matter.
The process of inheriting a title (e.g. when a princess becomes a queen).	Succession	A process by which increasingly complex communities develop over time.
Large structures build by the ancient Egyptians.	Pyramids	Diagrams which show either the energy, biomass or number of organisms found in each trophic level of a food chain.
Enlarging biological diagrams	Biomagnification	Increasing the amount of a toxin at higher levels of a food chain.
A large brick in the structure of a doorway or arch	Keystone	A species which has a very important effect on the structure of an ecosystem.

## 12.2 Using chi-squared

Students populate the worksheet with their own data.