Biology A Level Introduction Work

Most of the topics covered at A level involve revisiting and adding more detail to topics covered in GCSE and assume excellent knowledge at GCSE level.

The topics in the first year of A level form a firm foundation of knowledge that the topics in year 2 heavily rely upon. Therefore, solid knowledge of the GCSE topics that will be extended in A Level year 1 will ensure that extra knowledge is built upon a strong foundation in year 12.

Information about A-level Biology

Year 1 Biology Topics	Year 2 Biology Topics
3.1 Biological Molecules 3.1.1 Monomers and Polymers 3.1.2 Carbohydrates 3.1.3 Lipids 3.1.4 Proteins & Enzymes 3.1.5 Nucleic acids are important information-carrying molecules 3.1.6 ATP 3.1.7 Water 3.1.8 Inorganic ions	**3.5 Energy transfers in and between organisms** 3.5.1 Photosynthesis 3.5.2 Respiration 3.5.3 Energy and Ecosystems 3.5.4 Nutrient cycles
3.2 Cells 3.2.1 Cell structure 3.2.2 All cells arise from other cells 3.2.3 Transport across cell membranes 3.2.4 Cell recognition and the immune system	**3.6 Organisms respond to changes in their internal and external environments** 3.6.1 Stimuli, both internal and external are detected and lead to a response 3.6.2 Nervous coordination 3.6.3 Skeletal muscles are stimulated to contract by nerves and act as effectors 3.6.4 Homeostasis is the maintenance of a stable internal environment
3.3 Organisms exchange substances with their environment 3.3.1 Surface area to volume ratio 3.3.2 Gas exchange 3.3.3 Digestion and absorption 3.3.4 Mass transport	**3.7 Genetics, populations, evolution and ecosystems** 3.7.1 Inheritance 3.7.2 Populations 3.7.3 Evolution may lead to speciation 3.7.4 Populations in ecosystems
3.4 Genetic information, variation and relationships between organisms 3.4.1 DNA, genes and chromosomes 3.4.2 Protein synthesis 3.4.3 Genetic diversity via mutation and meiosis 3.4.4 Genetic diversity and adaptation 3.4.5 Species and taxonomy 3.4.6 Biodiversity within a community	**3.8 The control of gene expression** 3.8.1 Alteration of the sequence of bases in DNA can alter the structure of proteins 3.8.2 Gene expression is controlled by a number of features 3.8.3 Using genome projects 3.8.4 Gene technologies allow the study and alteration of gene function allowing a better understanding of organism function and the design of new industrial and medical processes.

A Level Required Practical Activities

***Some of these activities were also required practical activities at GCSE and so it will be useful if you are familiar with them.**

Year 1

1. **Investigation into the effect of a named variable on the rate of an enzyme-controlled reaction (enzymes)***
2. Preparation of stained squashes of cells from plant root tips; set-up and use of an optical microscope to identify the stages of mitosis in these stained squashes and calculation of a mitotic index (mitosis)
3. **Production of a dilution series of a solution to produce a calibration curve with which to identify the water potential of plant tissue (osmosis)***
4. Investigation into the effect of a named variable on the permeability of cell-surface membranes (diffusion)
5. Dissection of animal or plant gas exchange or mass transport system or of organ within such a system (heart)
6. **Use of aseptic techniques to investigate the effect of antimicrobial substances on microbial growth (bacteria)***

Year 2

7. Use of chromatography to investigate the pigments isolated from leaves of different plants e.g. leaves from shade-tolerant and shade- intolerant plants or leaves of different colours (photosynthesis)
8. Investigation into the effect of a named factor on the rate of dehydrogenase activity in extracts of chloroplasts (photosynthesis)
9. Investigation into the effect of a named variable on the rate of respiration of cultures of single-celled organisms (respiration)
10. Investigation into the effect of an environmental variable on the movement of an animal using either a choice chamber or a maze (response)
11. Production of a dilution series of a glucose solution and use of colorimetric techniques to produce a calibration curve with which to identify the concentration of glucose in an unknown 'urine' sample (diabetes)
12. **Investigation into the effect of a named environmental factor on the distribution of a given species (quadrats)***

Breakdown of Biology A Level Exams

A-level Paper 1	**Paper 2**	**Paper 3**
What's assessed Any content from topics 1-4 Relevant practical skills	**What's assessed** Any content from topics 5-8 Relevant practical skills	**What's assessed** Any content from topics 1-8. All practical skills
How it's assessed • Written exam: 2 hours • 91 marks • 35% of the A-level	**How it's assessed** • Written exam: 2 hours • 91 marks • 35% of the A-level	**How it's assessed** • Written exam: 2 hours • 78 marks • 30% of the A-level.
Questions • 76 marks a mixture of short and long answer questions • 15 marks extended response questions	**Questions** • 76 marks a mixture of short and long answer questions • 15 marks comprehension question	**Questions** • 38 marks structured questions including practical techniques • 15 marks critical analysis of given experimental data • 25 marks one essay from a choice of two titles.

Preparation Tasks for Year 1

The tasks are given in order of the topics in Year 1 of the Biology A-level course and will enable you to get your knowledge to the point required to begin your A-level studies.

First there is a summary (in blue) of the knowledge gained in the topic at GCSE level that is needed at A-level.

For each topic look back at your GCSE notes and summarise the key information that you need to know at A level and learn it.

- **Use your own GCSE Notes and revision materials**
- **Use text books/revision guides**
- **Use your own teacher's resources and revision materials on FROG**
- **And/or you can access power points, questions and revision materials for GCSE on FROG: Science Department → Science Staff → Dr Laval's Resources → Year 9, Year 10, Year 11 Tabs**

Then there are some example questions to test your understanding and introduce you to A-level style questions.

You may need to do a bit of research to answer some questions (especially if you have done combined science).

Use the answers at the end of the document to assess your work and make some targets for improvement in knowledge or exam technique.

You could then look ahead to the topics in Year 2 and firm up your GCSE knowledge.

To get more of an idea of the level of work at A Level and see the resources available, use the Year 12 and Year 13 Tabs in the following staff resources: Dr Laval, Miss Brown, Dr Emery, Mrs Dugdale.

1. Biological Molecules

Key Nutrients

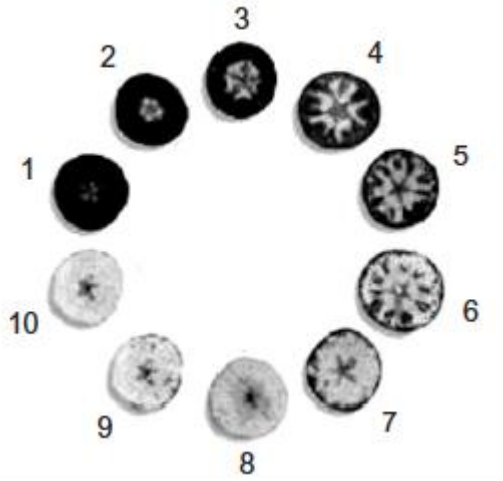
Living things are made from carbon-based (organic) molecules. These large insoluble molecules are made up of smaller soluble molecules

- **Carbohydrates** are polymers (e.g. starch, glycogen) made from sugar monomers e.g. glucose
- **Fats/Lipids** are made up of glycerol and fatty acids
- **Proteins** are polymers (e.g. enzymes) made from amino acid monomers
- There are qualitative tests for each of these nutrients (starch, sugar, lipid, protein) that you are expected to know (Practical: **Food tests**)

A Level style questions

Q1. Apple farmers want to harvest their fruit when it is ripe enough for eating but also when it can be stored to sell later. One method apple farmers use to decide when to harvest their fruit is to determine the starch content. As apples ripen, starch in the apple is converted into soluble sugars that make them taste sweet. Scientists investigated the best time to harvest apples for storage before being sold.

Figure 1

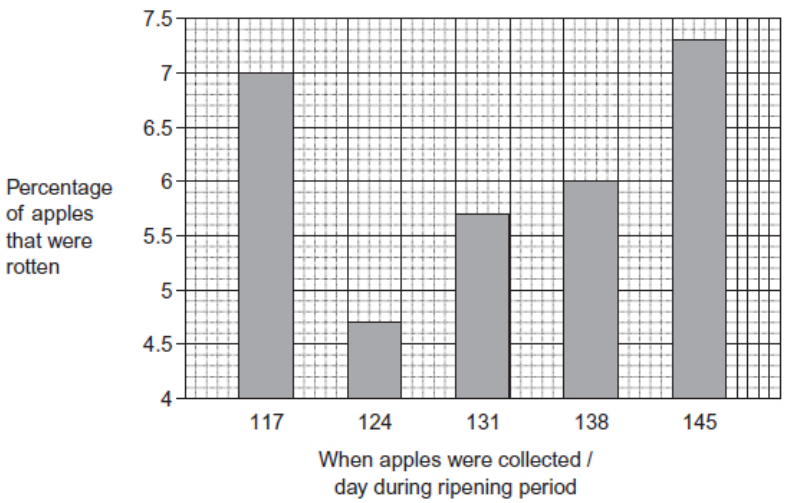


To determine the starch content, they picked samples of apples. They cut each apple in half and covered the cut surface with iodine solution. They left it for 1 minute and then compared it with Figure 1 to give it a starch index score between 1 and 10.
They collected samples of apples at 5 different days during the ripening period and tested them for starch content. These results are shown in the table below.

When apples were collected / day during ripening period	Mean starch index
117	3.7
124	4.4
131	6.3
138	7.7
145	8.2

The scientists stored samples of apples from each collection day for 180 days. They then determined the percentage of apples that were rotten. These results are shown in the graph below.

Figure 2



(a) The cut surface of the apple covered with iodine solution is left for 1 minute before being compared to Figure 1.

Explain why each apple must be left for the same length of time. (2)

(b) Describe and explain the change in appearance of the cut surface of the apple when treated with iodine solution from under-ripe (starch index 1) to overripe (starch index 10). (3)

(Total 5 marks)

Q2. (a) Most blood glucose comes from starch and sugars in the diet. Describe a test you could use to check if food in the diet contained starch.

(2)

(b) Explain how digestion of starch in the gut leads to an increase in the concentration of glucose in the blood.

(3)

(c) Suggest a method you could use to estimate the concentration of glucose in several different solutions that all turned brick red with Benedict's reagent in 3 minutes. (1)

(Total 6 marks)

Q3. (a) Starch and protein are biologically important polymers.

(i) Explain what is meant by a polymer.

(1)

(ii) Give one example of a biologically important polymer other than starch or protein.

(1)

(b) In an investigation, the **enzyme amylase** was mixed in a test tube with a buffer solution and a suspension of starch. The amylase broke down the starch to sugar. When all the starch had been broken down, a sample was removed from the test tube and tested with biuret reagent.

(i) Explain why a buffer solution was added to the amylase-starch mixture.

(2)

(ii) What colour would you expect the sample to go when tested with biuret reagent?

(1)

(iii) Give an explanation for your answer to part (ii) (2)

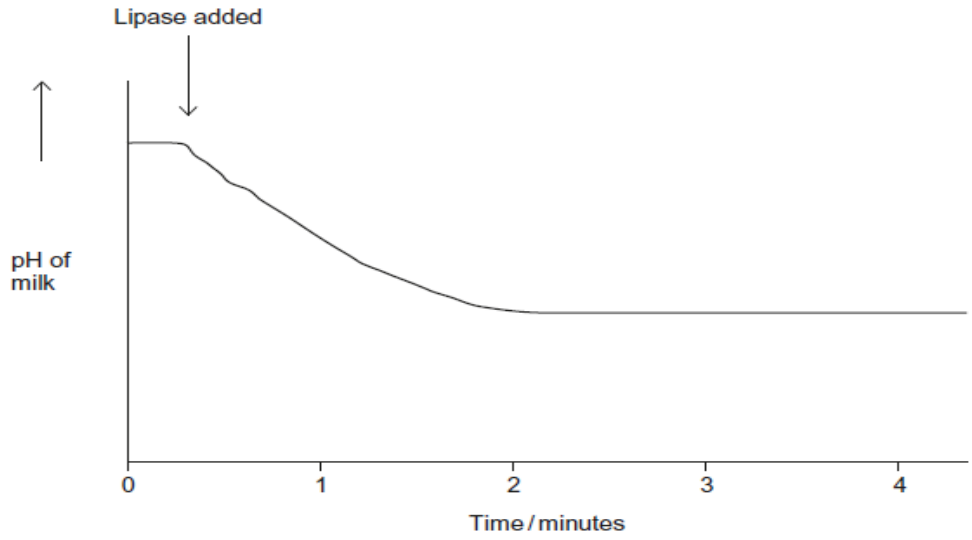
(Total 7 marks)

Digestion and Enzymes

- The **digestive system** is adapted for its function to break down large insoluble food molecules into smaller soluble ones and to allow their **absorption** into the bloodstream.
- Chemicals and enzymes allow digestion of food to take place
- **Enzymes** are specific biological catalysts made from protein that enable all chemical reactions in living things to happen at fairly low temperatures
- Temperature, pH and concentration are **factors that affect the activity of enzymes** (Practical: effect of pH on Amylase)

A Level style question

Q4. Lipase is an enzyme that breaks down lipids. A student investigated the digestion of lipid in milk by human lipase at 20 °C. He used a pH meter and recorded the pH of a sample of milk before and after adding lipase. His results are shown in the graph.



(a) Suggest **one** advantage of using a pH meter rather than a pH indicator in this experiment.

(1)

(b) Explain why the pH decreases when the lipase is added to the milk.

(1)

(c) Suggest why the pH remained constant after 2 minutes.

(2)

(d) The student carried out his experiment at 20 °C. He then repeated the experiment at 15 °C. Draw a line on the graph to show the results you would expect at 15 °C. (2)

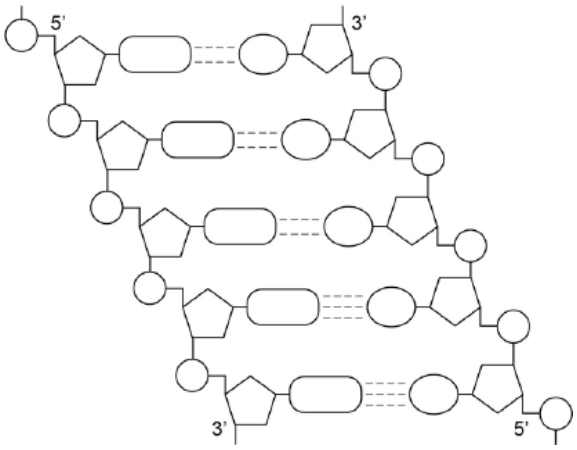
(Total 6 marks)

Nucleic acids are important information-carrying molecules

- **DNA** is found in the nucleus of eukaryotic cells (see cell structure)
- DNA carries the **genes** which are instructions that code for proteins
- DNA is arranged into **chromosomes** in the nucleus
- DNA is a double-stranded polymer of **nucleotides** which contain the **four bases A, G, C and T**
- The DNA of the chromosomes must be copied every time a cell divides (see **mitosis**)
- **RNA** takes the message from the DNA in the nucleus out to the **ribosomes** in the cytoplasm which then make the **protein** using the information.

A Level style questions

Q5. The figure represents part of a DNA molecule.



(a) Draw a box around a single nucleotide.

(1)

In DNA A always pairs with T and C always pairs with G. The table below shows the percentage of bases in each of the strands of a DNA molecule.

DNA strand	**Percentage of each base**			
	A	**C**	**G**	**T**
Strand **1**	16			
Strand **2**		21	34	

(b) Complete the table by adding the missing values.

(2)

(c) Other than being smaller, give **two** ways in which prokaryotic DNA is different from eukaryotic DNA.

1. _____

2. _____

(2)

(d) The table shows the percentage of each base in the DNA from three different organisms.

Organism	**Percentage of each base in DNA**			
	Adenine	Guanine	Thymine	Cytosine
Human	30.9	19.9	29.4	19.8
Grasshopper	29.4	20.5	29.4	20.7
Virus	24.0	23.3	21.5	31.2

(i) Humans and grasshoppers have very similar percentages of each base in their DNA but they are very different organisms.

Use your knowledge of DNA structure and function to explain how this is possible.

(2)

(ii) The DNA of the virus is different from that of other organisms. Use the table above and your knowledge of DNA to suggest what this difference is. Explain your answer.

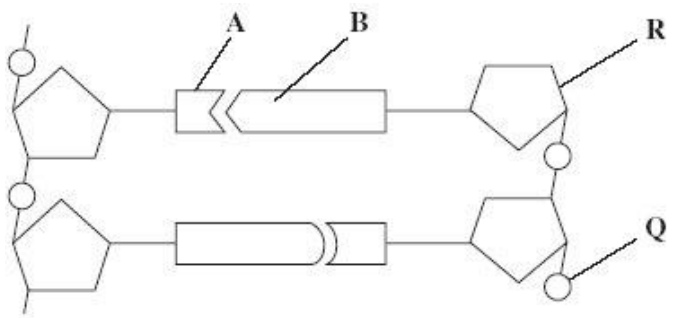
(2)

Figure 2 shows a short section of a DNA molecule.

(e) Name parts **R** and **Q**.

(i) **R** _____

(ii) **Q** _____



(2)

(f) Give an example of what **A** and **B** could be.

(1)

(g) Explain how a change in a sequence of DNA bases could result in a non-functional enzyme.

(3)

(Total 15 marks)

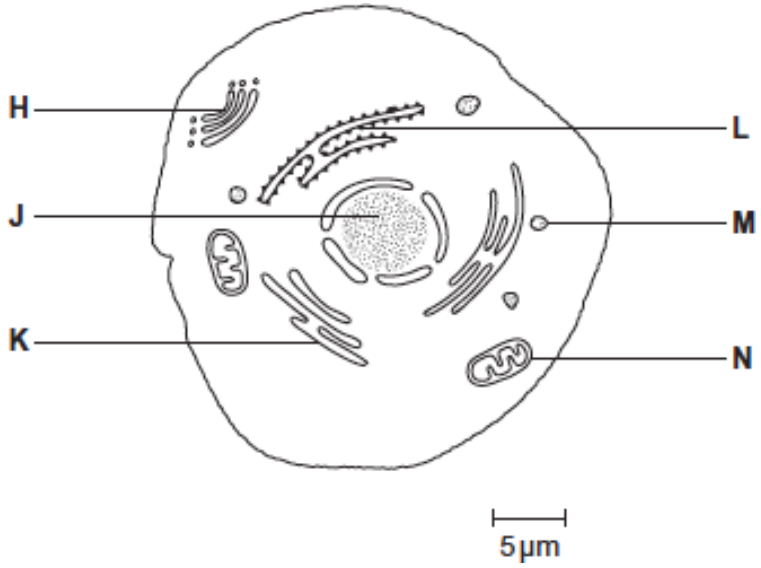
3.2 Cells

Cell Structure

- **Cells** are the smallest unit of life
- **Viruses** are not cells and are not strictly alive
- **Eukaryote** and **Prokaryot**e cells have a different structure
- Eukaryotic cells contain **organelles** that carry out different **functions** within the cell
- Cells **differentiate** to become **specialised** so that they can carry out different functions in an organism
- The structure of cells can be seen using **light microscopes** (Required practical: Use of microscopes to look at cheek and onion cells) or **electron microscopes**
- **Cell Magnification (M)** can be calculated from an image (I) if the actual size (A) of the cell is known (M = I/A)
- **Cell size (A)** can be calculated from an image (I) if the magnification (M) of the cell is known (A = I/M)
- Cells are measured in **micrometres** (1000µm = 1mm)

A Level style questions

Q1. The diagram shows a eukaryotic cell.



(a) Complete the table by giving the letter labelling the organelle that matches the function.

Function of organelle	Letter
Protein synthesis	
Contains the genetic information	
Aerobic respiration	

(3)

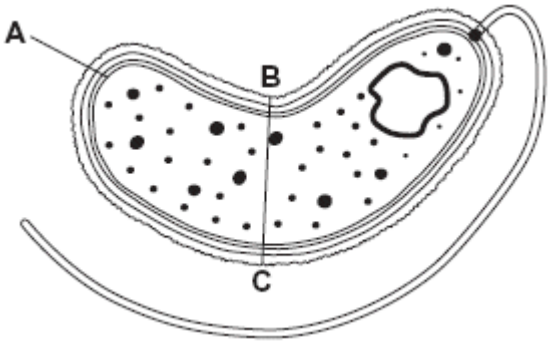
(b) Use the scale bar in the diagram above to calculate the magnification of the drawing. Show your working.

Answer = _____

(2)

(Total 5 marks)

Q2. The diagram shows a cholera bacterium. It has been magnified 50 000 times.



(a) Name **A**.

(1)

(b) Name **two** structures present in an epithelial cell from the small intestine that are **not** present in a cholera bacterium.

(2)

(c) Cholera bacteria can be viewed using an electron microscope (EM) or a light microscope (LM)

(i) Give **one** advantage of using an EM rather than a LM.

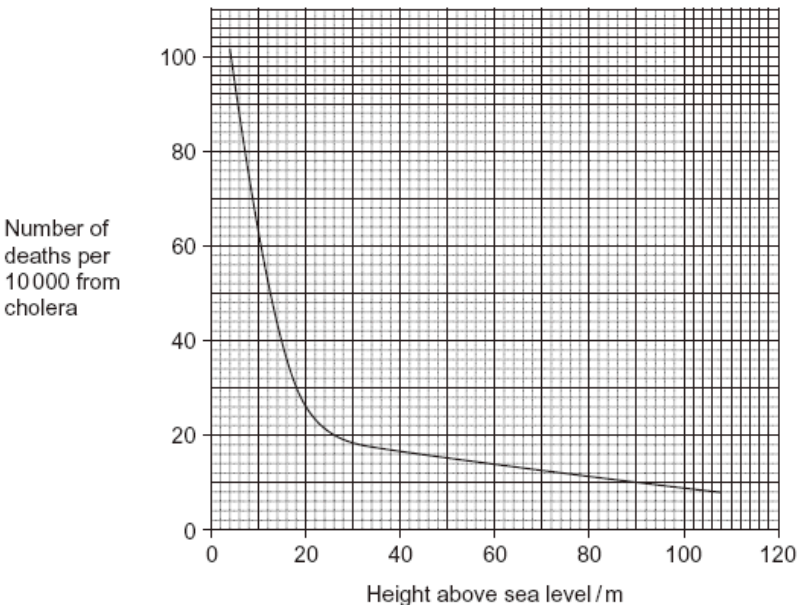
(1)

(ii) Give **one** advantage of using a LM rather than an EM.

(1)

(d) Calculate the actual width of the cholera bacterium between points **B** and **C**. Give your answer in micrometres and show your working.

(2)



(e) An outbreak of cholera occurred in London in 1849. The graph shows the relationship between the number of deaths from cholera and the height at which people lived above sea level.

Describe the relationship between the number of deaths from cholera and the height at which people lived above sea level.

(2)

(Total 9 marks)

Cell Division

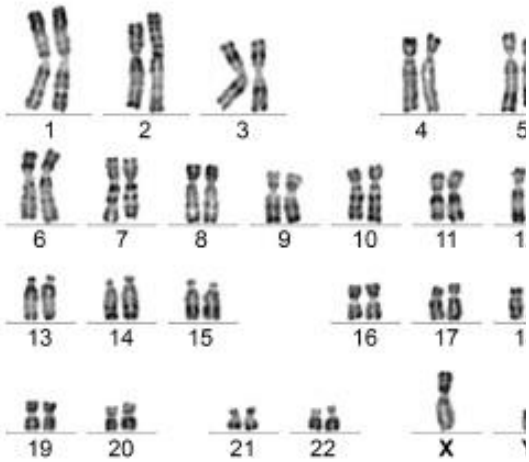
- All cells arise from other cells by **asexual reproduction**
- Prokaryotes reproduce by **binary fission** as they do not have a nucleus
- **Viruses** do not undergo cell division (they are not cells) but replicate by injection of their nucleic acid into host cells.
- The eukaryotic cell cycle involves **DNA replication** followed by **mitosis** which is nuclear division.
- Uncontrolled cell division can lead to the formation of tumours and of **cancers.**
- Many cancer treatments are directed at **controlling the rate of cell division**.

A Level style questions

Q3. Figure 1 shows all the chromosomes present in one human cell during mitosis. A scientist stained and photographed the chromosomes. In **Figure 2**, the scientist has arranged the images of these chromosomes in homologous pairs.

Figure 1

Figure 2



(a) Give **one** pieces of evidence from **Figure 1** that this cell was undergoing mitosis. Explain your answer. (2)

(b) Tick (✓) **one** box that gives the name of the stage of mitosis shown in **Figure 1**.

A Anaphase ☐

B Interphase ☐

C Prophase ☐

D Telophase ☐

(1)

(c) When preparing the cells for observation the scientist placed them in a solution that had a slightly higher water potential (less salt) than the cytoplasm. This did not cause the cells to burst but moved the chromosomes further apart in order to reduce the overlapping of the chromosomes when observed with an optical microscope.

Suggest how this procedure moved the chromosomes apart. (2)

(d) The dark stain used on the chromosomes binds more to some areas of the chromosomes than others, giving the chromosomes a striped appearance. Suggest **one** way the structure of the chromosome could differ along its length to result in the stain binding more in some areas.

(1)

(e) In **Figure 2** the chromosomes are arranged in homologous pairs.
What is a homologous pair of chromosomes?

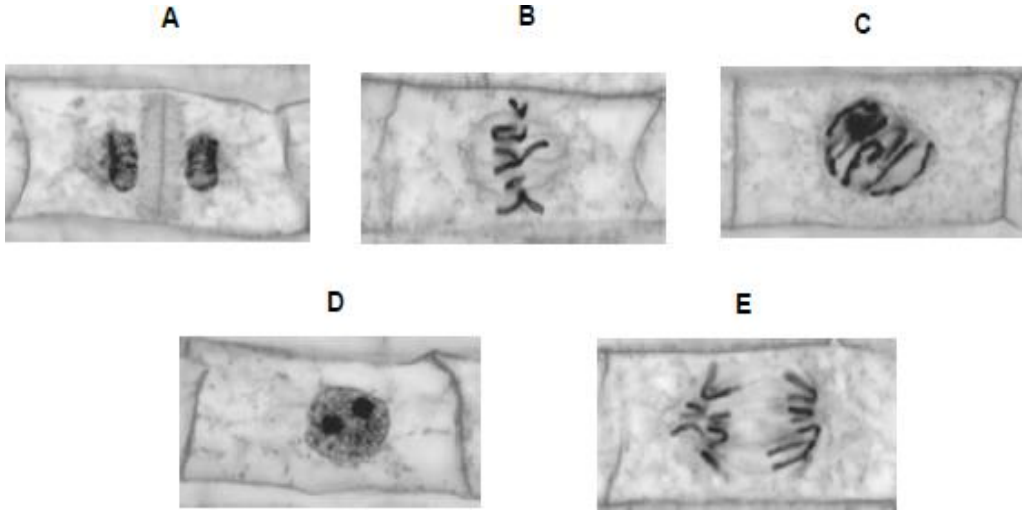
(1)

(f) Give **two** ways in which the arrangement of prokaryotic DNA is different from the arrangement of the human DNA in **Figure 1**.

(2)

(Total 9 marks)

Q4. The figure below shows some cells from an onion root tip at different stages of the cell cycle.



(a) Place stages **A** to **E** in the correct order. Start with stage **D**.

D _____

(1)

To obtain these images, the onion root tip was cut off, stained and put on a microscope slide. A cover slip was placed on top. The root tip was then firmly squashed and viewed under an optical microscope.

(b) Complete the table below to give **one** reason why each of these steps was necessary.

Step Taken	Reason
Taking cells from the onion root tip	
Firmly squashing the root tip	

(2) **(Total 3 marks)**

Q5. (a) Some cancer tumours are benign and some are malignant.

(i) Give **one** way in which a benign tumour differs from a malignant tumour.

(1)

(ii) Describe **two** ways in which both types of tumour may cause harm to the body.

(2)

(b) (i) Explain the link between excessive sunbathing and skin cancer.

(2)

(ii) Suggest why fair-skinned people are at a greater risk of skin cancer than dark-skinned people when sunbathing.

(1)

(Total 6 marks)

Transport across cell membranes

- Many substances can enter cells by **diffusion** and this is affected by **temperature, surface area of membrane, distance and concentration gradient.**
- Water moves across partially permeable membranes by **osmosis**. (Required practical: osmosis in potato)
- Osmosis is dependent on differences in **water potential** (hypotonic, hypertonic and isotonic solutions)
- Movement of molecules and ions **against a concentration gradient** happens by **active transport** and requires energy.
- Some cells have **adaptations** for rapid transport across membranes e.g. small intestine epithelial cells.

A Level style questions

Q6. (a) Give **two** similarities in the movement of substances by diffusion and by osmosis.

(2)

A group of students carried out an investigation to find the water potential of potato tissue. The students were each given a potato and 50 cm^3 of a 1.0 mol dm^{-3} solution of sucrose.

- They used the 1.0 mol dm^{-3} solution of sucrose to make a series of different concentrations.
- They cut and weighed discs of potato tissue and left them in the sucrose solutions for a set time.
- They then removed the discs of potato tissue and reweighed them.

The table below shows how one student presented his processed results.

Concentration of sucrose solution / mol dm^{-3}	Percentage change in mass of potato tissue
0.15	+4.7
0.20	+4.1
0.25	+3.0
0.30	+1.9
0.35	−0.9
0.40	−3.8

(b) Explain why the data in the table above are described as **processed** results.

(1)

(c) Describe how you would use a 1.0 mol dm^{-3} solution of sucrose to produce 30 cm^3 of a 0.15 mol dm^{-3} solution of sucrose.

(2)

(d) Explain the change in mass of potato tissue in the 0.40 mol dm^{-3} solution of sucrose.

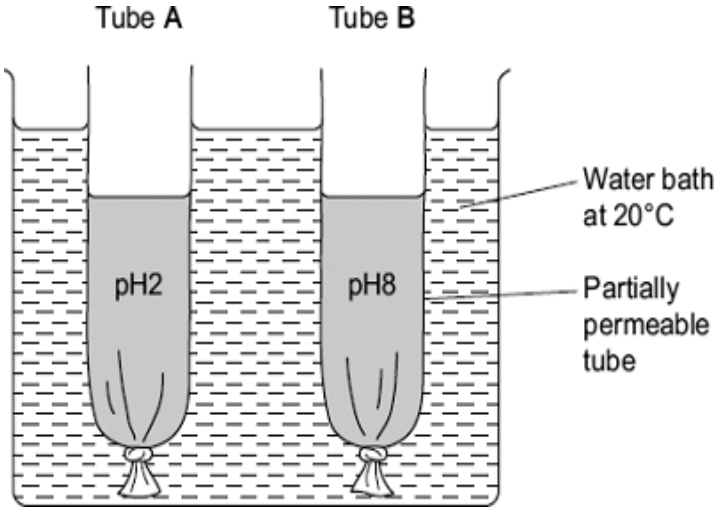
(2)

(e) Describe how you would use the student's results in the table above to find the sucrose concentrationl of the potato tissue.

(3)

(Total 8 marks)

Q7. (a) A student investigated the effect of pH on the activity of the enzyme amylase. She set up the apparatus shown in the diagram.



The tubes were made from Visking tubing which is partially permeable.

She added an equal volume of **amylase solution** and **starch** to each tube.

- She added a buffer solution at pH2 to tube **A**.
- She added an equal volume of buffer solution at pH8 to tube **B**.

After 30 minutes, she measured the height of the solutions in both tubes. She then tested the solutions in tubes **A** and **B** for the presence of sugar.

Describe how the student would show that sugar was present in a solution.

(3)

(b) After 30 minutes, the solution in tube **B** was higher than the solution in tube **A**.

(i) Explain why the solution in tube **B** was higher.

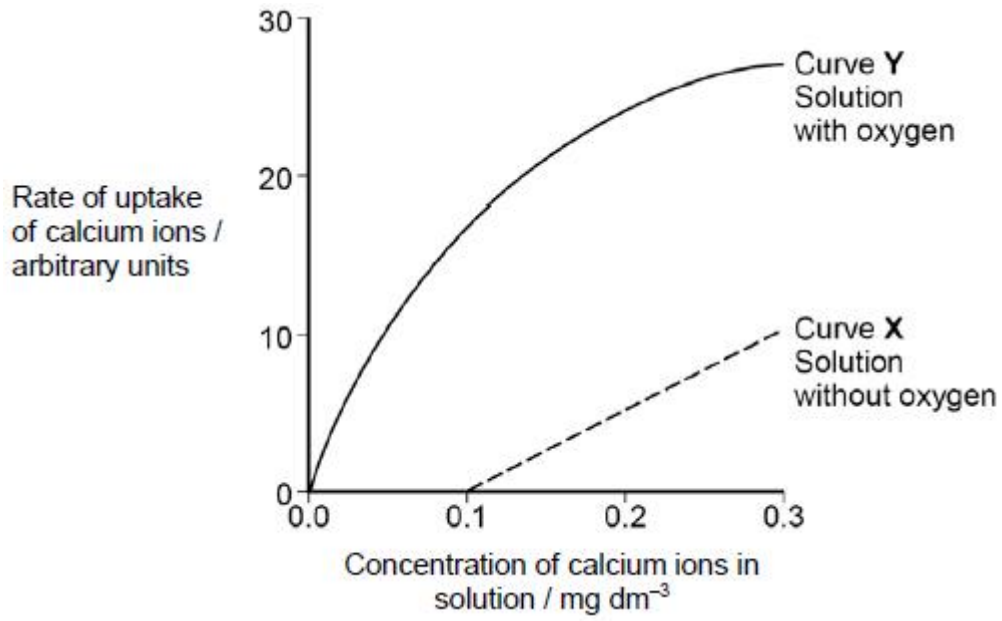
(3)

(ii) The student concluded from her investigation that the optimum pH of amylase was pH8. Is this conclusion valid? Explain your answer.

(1)

(Total 7 marks)

Q8. A scientist placed plant cells in solutions containing different concentrations of calcium ions. She measured the rate of uptake of calcium ions by plant cells. The graph below shows her results.



(a) What can you conclude from the graph about the processes involved in the uptake of calcium ions by these plant cells? Use evidence from the graph to support your answer.

(5)

(b) Suggest **one** way in which the scientist could have ensured the solutions she used for curve **X** contained **no** oxygen.

(1)

(Total 6 marks)

The Immune response

- **White blood cells** help to defend against pathogens by: **ingesting pathogens**; producing **antibodies**; and producing **antitoxins**.
- The **immune system** of the body produces **specific antibodies** to specific **antigens** and can kill a particular **pathogen** leading to immunity from that pathogen.
- People can be **vaccinated** by introducing small quantities of **dead or inactive forms of pathogen** into the body stimulating white blood cells to produce antibodies and forming immunity against future infections.
- The effect of **antigen variability** on disease (particularly viral) and disease prevention.
- MMR is used to vaccinate against measles, mumps and rubella.
- If a large proportion of the population is **immune** to a pathogen, the spread of the pathogen is very much reduced.
- **HIV** and AIDS
- Use of **monoclonal antibodies** for diagnosis (e.g. pregnancy test) and research

A Level style questions

Q9. (a) Give **two** ways in which pathogens can cause disease.

(2)

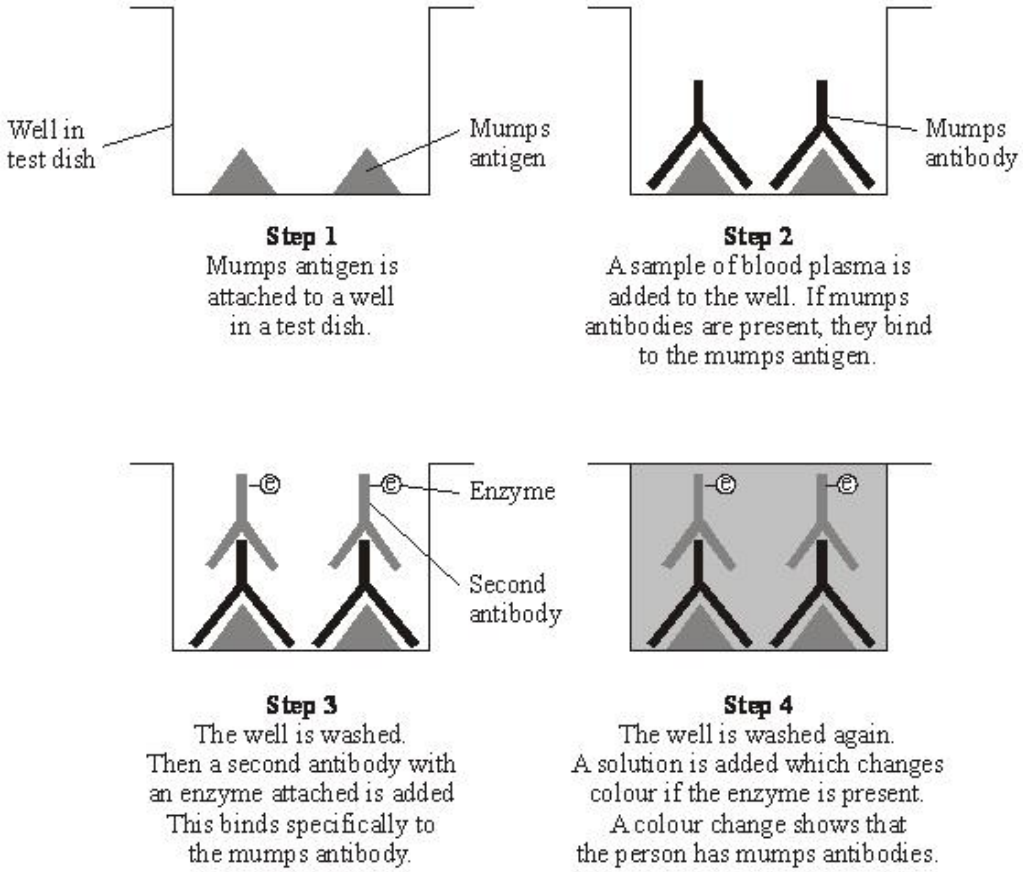
(b) Putting bee honey on a cut kills bacteria. Honey contains a high concentration of sugar. Use your knowledge of water potential to suggest how putting honey on a cut kills bacteria.

(3) **(Total 5 marks)**

Q10. (a) What is vaccination?

(2)

(b) A test has been developed to find out whether a person has antibodies against the mumps virus. The test is shown in the diagram.



(i) Explain why this test will detect mumps antibodies, but not other antibodies in the blood.

(1)

(ii) Explain why it is important to wash the well at the start of **Step 4**.

(2)

(iii) Explain why there will be no colour change if mumps antibodies are not present in the blood.

(2)

(Total 7 marks)

Q11. (a) What is an antigen?

(2)

(b) What is an antibody?

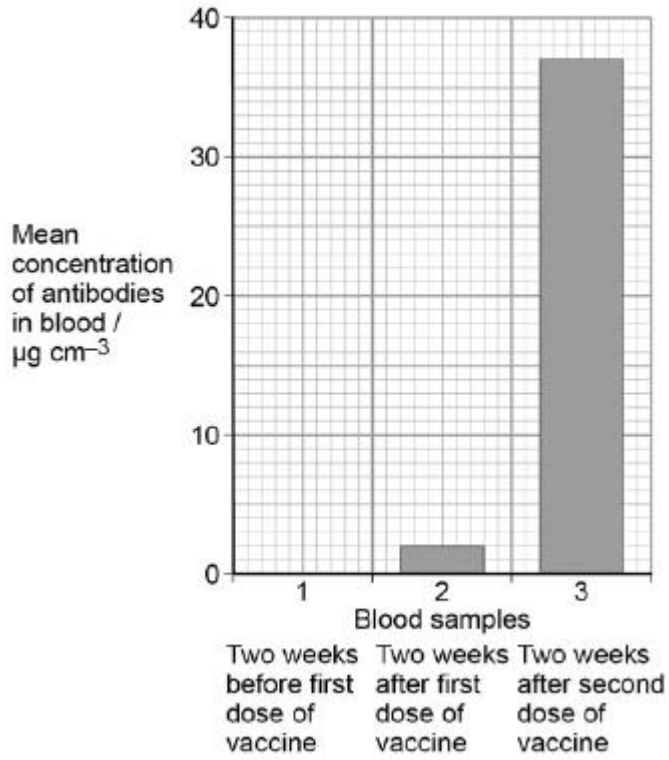
(2)

Poliomyelitis is an infection caused by a virus. A doctor vaccinated a group of patients against poliomyelitis. He gave each patient two doses of vaccine, 3 months apart.

An immunologist tested three samples of blood from each of the patients:

- (sample 1) taken 2 weeks before the first dose of vaccine
- (sample 2) taken 2 weeks after the first dose of vaccine
- (sample 3) taken 2 weeks after the second dose of vaccine.

He measured the concentration of antibodies against the poliomyelitis virus in the patients' blood each time. The results are shown in the graph.



(c) Calculate the percentage increase in the mean concentration of antibodies in blood between samples 2 and 3. Answer = _____ %

(1)

(d) Explain the differences between the mean concentrations of antibodies in blood samples 1, 2 and 3.

(4)

(Total 9 marks)

3.3 Organisms exchange substances with their environment

Surface area to volume ratio

- The relationship between the size or body shape of an organism and its **surface area to volume ratio**.
- **Adaptations that facilitate exchange** as this ratio reduces e.g. heat, oxygen.

A Level style questions

Q1. (a) Describe the relationship between size and surface area to volume ratio of organisms.

(1)

(b) A scientist calculated the surface area of a large number of frog eggs which are spherical.

He found that the mean surface area was 9.73 mm^2.

The surface area of a sphere is calculated using this equation

Surface area = $4\pi r^2$

where **r** is the radius of a sphere and π = 3.14

Use this equation to calculate the mean diameter of a frog egg. Show your working.
Diameter = _____ mm (2)

The scientist calculated the ratio of surface area to mass for eggs, tadpoles and frogs. He also determined the mean rate of oxygen uptake by tadpoles and frogs.

His results are shown in the table.

Stage of frog development	Ratio of surface area to mass	Mean rate of oxygen uptake / µmol g^{-1} h^{-1}
Egg	2904 : 1	no information
Tadpole	336 : 1	5.7
Adult	166 : 1	1.3

(c) The scientist used units of µmol g^{-1} h^{-1} for the rate of oxygen uptake.
Suggest why he used µmol in these units.

(1)

(d) The scientist decided to use the ratio of surface area to mass, rather than the ratio of surface area to volume. He made this decision for practical reasons.
Suggest **one** practical advantage of measuring the masses of frog eggs, tadpoles and adults, compared with measuring their volumes.

(1)

(e) Explain why oxygen uptake is a measure of metabolic rate in organisms.

(1)

(f) A student who looked at these results said that they could not make a conclusion about the relationship between stage of development and metabolic rate.
Use information in the table to explain reasons why they were unable to make a conclusion.

(3)
(Total 9 marks)

Gas exchange

Plants

- Adaptations of gas exchange surfaces in **leaves** of plants (**mesophyll** tissue and **stomata**).
- How plants are **adapted to limit water loss** (transpiration) and still be able to carry out gas exchange

Animals

- Adaptations of **gas exchange surfaces** e.g. lungs and fish gills.
- The structure and function of the **human gas exchange system**.
- The mechanism of **breathing** and the exchange of gases in the lungs.
- The essential features of the **alveoli** for gas exchange.
- **Lung diseases** and the risk factors associated with them e.g. smoking.

A Level style questions

Q2. (a) Describe the gross structure of the human gas exchange system and how we breathe in and out.

(6)

(b) (i) Name the process by which oxygen passes from an alveolus in the lungs into the blood.

(1)

(ii) Describe **two** adaptations of the structure of alveoli for efficient gas exchange.

(2) **(Total 9 marks)**

Q3. A student investigated the distribution of stomata on leaves from two species of plant. She removed small pieces from the lower surface of the leaves of each plant species. She mounted these pieces on separate microscope slides. She then counted the number of stomata in several parts of the epidermis on each piece of leaf tissue using a microscope.

(a) Suggest appropriate units the student should use to compare the distribution of stomata on leaves.

(1)

(b) The pieces of leaf tissue examined were very thin. Explain why this was important.

(2)

(c) Give **two** reasons why it was important that the student counted the number of stomata in several parts of each piece of leaf tissue.

(2)

(d) The student then compared the rate of transpiration (evaporation of water) from the two species of plant. She did this by measuring the rate of water uptake by each plant species. Suggest **two** reasons why the rate of water uptake by a plant might not be the same as the rate of transpiration.

(2)

(Total 7 marks)

Q4. Scientists studied three species of plant. They selected fully grown leaves from five different plants of each species. For each leaf they measured:

- leaf surface area
- leaf thickness
- the number of stomata per mm^2.

The scientists' results are shown in the table below.

Plant species	**Mean leaf surface area / mm^2**	**Mean leaf thickness / µm**	**Mean number of stomata per mm^2**
A	218.0	191.5	380.0
B	17.0	296.3	136.0
C	2.2	354.8	419.0

(a) How did the scientists ensure they could make a valid comparison between leaves from different species?

(1)

(b) Describe a method you could use to find the surface area of a leaf.

(3)

(c) Which species, **A** or **B**, would you predict grew in a drier environment?

Explain **one** feature that caused you to choose this species.

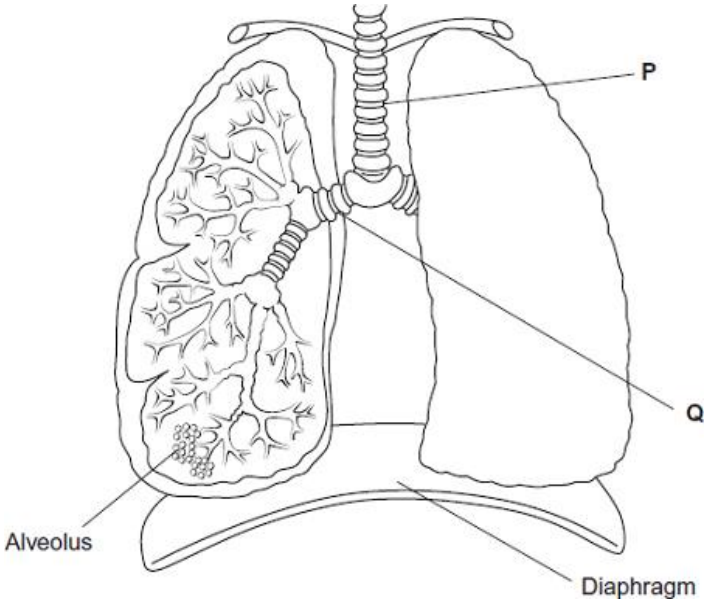
(1)

(d) Species **C** has a high number of stomata per mm^2. Despite this it loses a small amount of water. Use the data to explain why.

(1)

(Total 6 marks)

Q5. (a) The diagram shows the structure of the human gas exchange system.



Name organs

P _____

Q _____

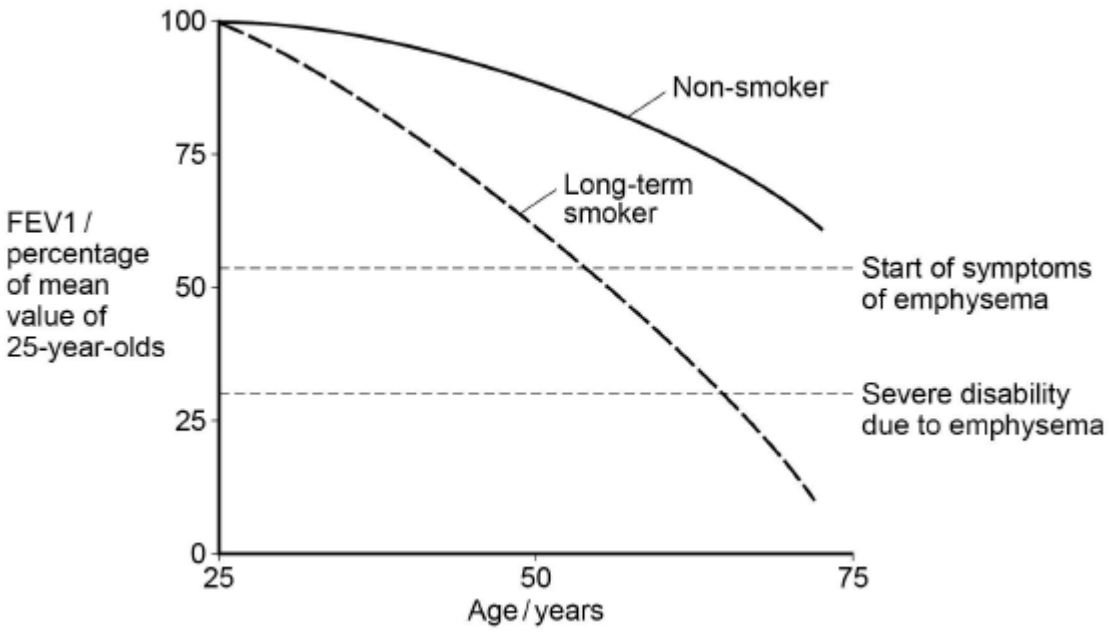
(1)

(b) Explain how downward movement of the diaphragm leads to air entering the lungs.

(2)

Forced expiration volume (FEV1) is the volume of air a person can breathe out in 1 second. Emphysema is a lung disease which results in a reduction in FEV1. Emphysema is mainly caused by long-term cigarette smoking. Scientists investigated the effects of ageing and long-term cigarette smoking on FEV1 and on the development of emphysema.

The graph shows their results.



(c) Scientists determined the mean FEV1 value of 25-year-olds in the population. Suggest **two** precautions that should have been taken to ensure that this mean FEV1 value was reliable.

(2)

(d) Explain the importance of determining a mean FEV1 value of 25-year-olds in this investigation.

(2)

(e) The mean FEV1 value of non-smokers decreases after the age of 30. Use your knowledge of breathing to suggest why.

(1)

(f) One of the severe disabilities that results from emphysema is that walking upstairs becomes difficult. Explain how a low FEV1 value could cause this disability.

(3)

(Total 11 marks)

Mass transport

Animals

- The structure of the **heart** and the general pattern of **blood circulation** in a mammal.
- Control of **heart beat** and the **effect of exercise** on human pulse rate.
- The structure of **arteries** and **veins** in relation to their function.
- The structure of **capillaries** and the importance of capillary beds at **exchange surfaces** e.g. lungs, small intestine, kidney, skin.
- **Cardiovascular disease** (CVD) and associated risk factors.

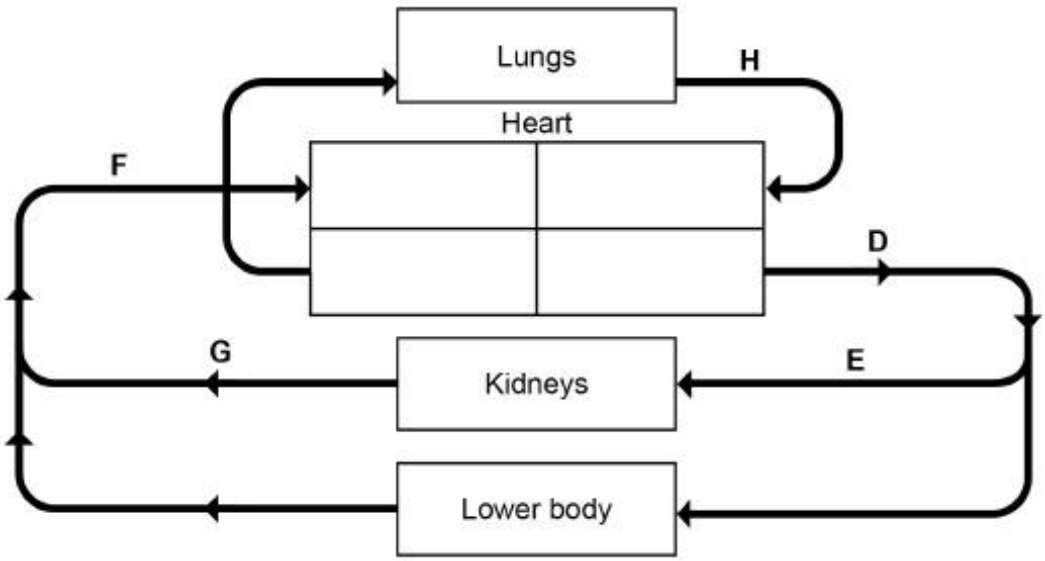
Plants

- **Xylem** as the tissue that transports water in the stem and leaves of plants.
- The importance of the **transpiration** from the leaves and **osmosis** in the roots to enable water transport
- Phloem is the tissue that transports sugars in plants.
- Use of a **potometer** to investigate water uptake in a plant

A Level style questions

Q6. (a) **Figure 1** shows part of the blood circulation in a mammal.

Figure 1



Use **Figure 1** to give the letter that represents each of these blood vessels.

Aorta ☐

Renal vein ☐

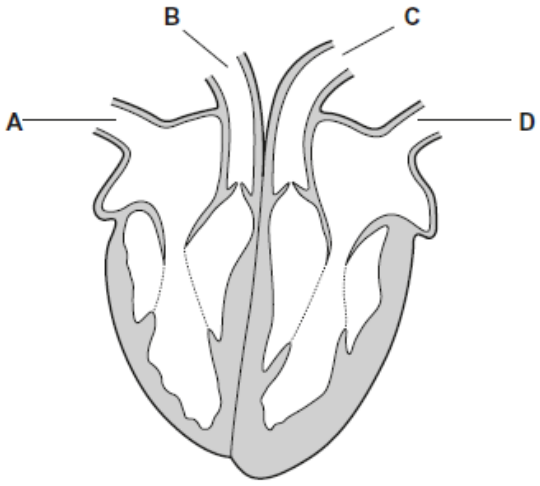
Vena cava ☐

(3)

(b) Name the blood vessels that carry blood to the heart **muscle**.

(1)

The diagram shows a section through the heart. The main blood vessels are labelled **A**, **B**, **C** and **D**.



(c) Write a letter, **A**, **B**, **C** or **D**, to represent the correct blood vessel.

(i) Which blood vessel carries oxygenated blood away from the heart?

(1)

(ii) Which blood vessel carries deoxygenated blood to the heart?

(1)

(d) Explain how the highest blood pressure is produced in the left ventricle. (1)

(e) Some babies are born with a hole between the right and the left ventricles. These babies are unable to get enough oxygen to their tissues. Suggest why.

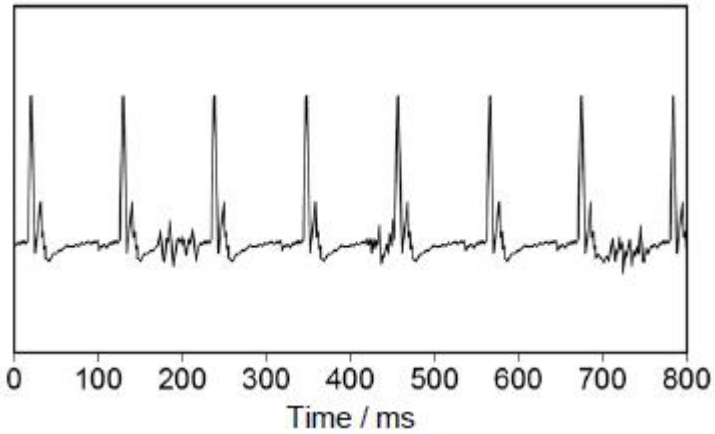
(2) **(Total 9 marks)**

Q7. (a) Explain **three** ways in which the structure of the aorta is related to its function.

(3)

(b) An electrocardiogram (ECG) shows the electrical activity of the heart. **Figure 2** shows an ECG for an animal of species **B** at rest. Each large spike represents a contraction of the ventricles.

Figure 2



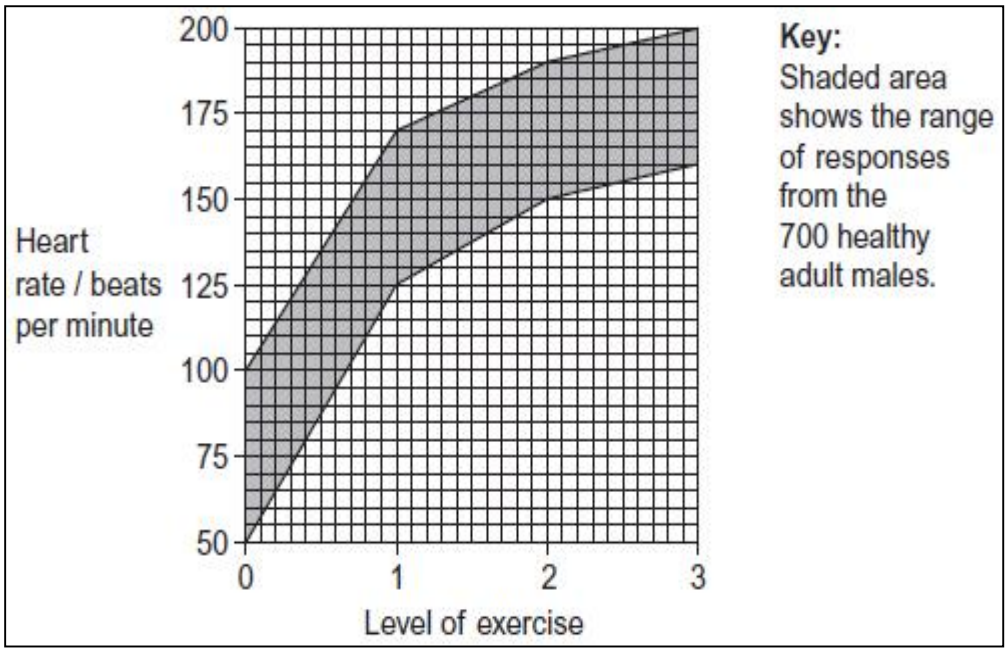
For species **B**, the mean volume of blood leaving the left ventricle during each contraction is 0.03 cm^3.

Calculate the mean volume of blood leaving the left ventricle **per minute**.

Volume of blood = _____ cm^3 $minute^{-1}$

(2)

It is possible to test for signs of heart disease using an exercise test. This involves the patient doing a controlled period of exercise whilst their heart rate is monitored.



Scientists measured the heart rates of 700 healthy adult males aged between 25 and 54 before, during and after an exercise test. The test involved running on a treadmill at different speeds. Their results are shown in the graph in the form in which they were presented.

(c) Suggest **two** variables the scientists would have controlled during the exercise test.

(2)

(d) Calculate the ratio of the range of heart rates at exercise level 3 and exercise level 1. Answer = _____: 1

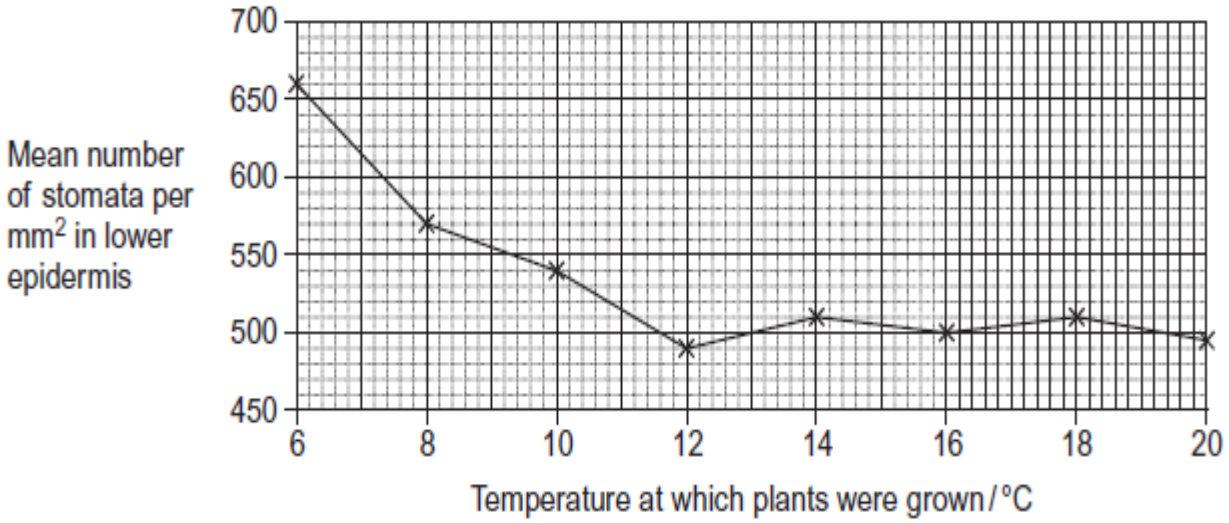
(2)

(Total 9 marks)

Q8. Environmental factors can affect the density of stomata in the lower epidermis of leaves of plants of the same species. Scientists investigated how growing plants at different temperatures affected the density of stomata in the lower epidermis of leaves. They grew plants of the same species from seeds. Their method is outlined below.

- They took 8 trays containing soil and planted 50 seeds in each tray.
- They put each tray in a controlled environment at a different temperature.
- When the plants had grown from the seeds, they selected 20 fully grown leaves from the plants in each tray.
- They determined the mean number of stomata per mm^2 in the lower epidermis for each group of leaves.

Their results are shown in the graph.



(a) Give **three** environmental variables, other than temperature, that the scientists would have controlled when growing the plants.

(3)

(b) The scientists used a range of temperatures from 6 to 20 °C.
Using their data, explain why they did not use temperatures above 20 °C.

(1)

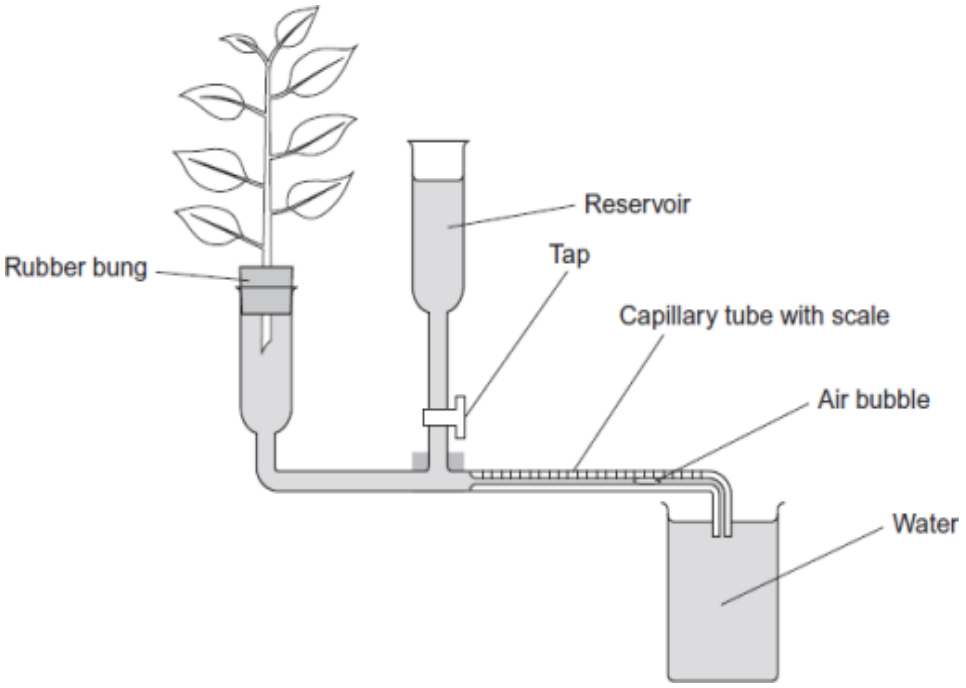
(c) The scientists only selected fully grown leaves from the plants. Suggest why.

(1)

(d) The plants grown at higher temperatures had a lower number of stomata per mm^2.
This would be an advantage to the plant because the transpiration rate increases as the temperature increases. Explain why the transpiration rate increases when the temperature increases.

(2)

(Total 7 marks)



Q9. Students investigated the effect of removing leaves from a plant shoot on the rate of water uptake. Each student set up a potometer with a shoot that had eight leaves. All the shoots came from the same plant. The potometer they used is shown in the diagram.

(a) Describe how the students would have returned the air bubble to the start of the capillary tube in this investigation.

(1)

(b) Give **two** precautions the students should have taken when setting up the potometer to obtain reliable measurements of water uptake by the plant shoot.

(2)

(c) A potometer measures the rate of water uptake rather than the rate of transpiration. Give **two** reasons why the potometer does **not** truly measure the rate of transpiration.

(2)

(d) The students' results are shown in the table.

Number of leaves removed from the plant shoot	Mean rate of water uptake / cm^3 per minute
0	0.10
2	0.08
4	0.04
6	0.02
8	0.01

Explain the relationship between the number of leaves removed from the plant shoot and the mean rate of water uptake.

(3)
(Total 8 marks)

3.4 Genetic information, variation and relationships between organisms

DNA, genes and chromosomes

- A **gene** is a section of **DNA** located at a particular site on a **chromosome**, called its locus.
- DNA is wrapped around proteins to form **chromosomes** which are only visible in the **nucleus** when a cell divides by **mitosis or meiosis**
- Humans have 46 chromosomes in their cells, **23 pairs** where one chromosome came from mum in the **egg** and the other from dad in the **sperm**
- A gene codes for the production of a **protein** and there are two copies of every gene **(alleles)** in our cells

A Level style questions

Q1. The diagram shows a short sequence of DNA bases.

T T T G T A T A C T A G T C T A C T T C G T T A A T A

(a) What is the maximum number of amino acids for which this sequence of DNA bases could code?

(1)

(b) Explain how a change in the DNA base sequence for a protein may result in a change in the structure of the protein.

(3)

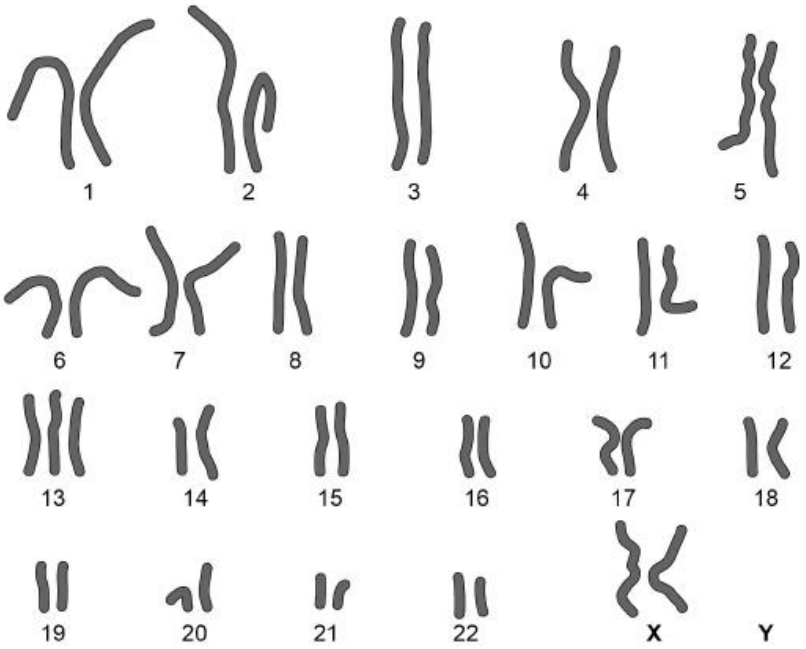
(c) A piece of DNA consisted of 74 base pairs. The two strands of the DNA, strands **A** and **B**, were analysed to find the **number** of bases of each type that were present. Some of the results are shown in the table. Complete the table by writing in the missing values.

(2)
(Total 6 marks)

	Number of bases			
	C	G	A	T
Strand **A**	26			
Strand **B**	19		9	

Q2. Patau syndrome is a condition caused by a mutation affecting chromosome number. All the cells of the body will have this mutation. **Figure 1** shows the chromosomes from one of the cells of a female who has Patau syndrome.

Figure 1



(a) What is the effect of Patau syndrome on the chromosomes of this female?

(1)

(b) Most children born with Patau syndrome die in the first 12 months, often due to defects of circulation of blood. One of these defects is patent ductus arteriosus (PDA). This can result in some of the blood flowing between the aorta and the pulmonary artery.

Figure 2

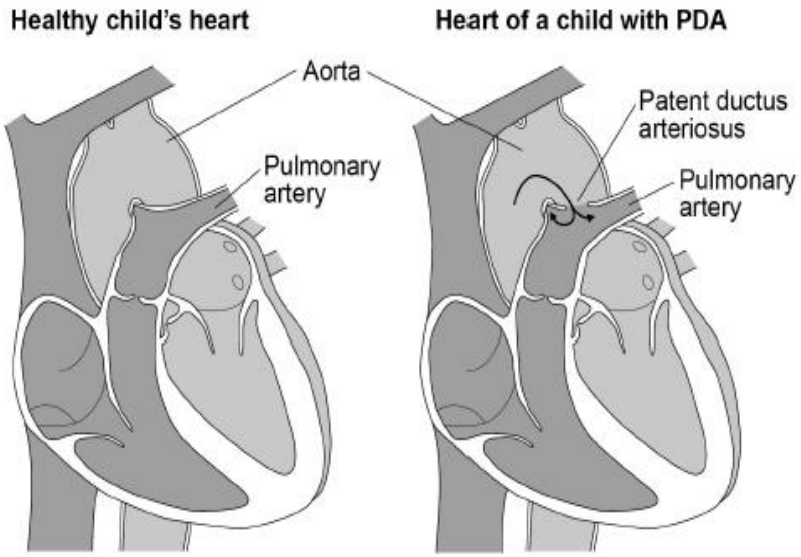


Figure 2 shows a healthy child's heart and the heart of a child with PDA.

Suggest how the flow of some of the blood between the aorta and pulmonary artery could cause children to die in the first 12 months.

(3)

(Total 4 marks)

Protein synthesis

- The base sequence of each gene carries the **genetic code** that determines the sequence of amino acids during **protein synthesis**.
- The genetic code is **a triplet code** and is the same in all organisms, providing indirect evidence for **evolution.**
- Much of eukaryotic DNA does not code for proteins and there are **non-coding regions** between genes.
- The process of **transcription** in the nucleus copies the DNA sequence of a gene into a molecule of **RNA**
- The process of **translation** is when the **ribosome** in the cytoplasm uses the RNA sequence to join **amino acids** together in the coded order to make a **protein**

A Level style questions

Q3. (a) The genetic code is **universal** and **non-overlapping**

Explain the meaning of:

(i) Universal

(ii) Non-overlapping

(2)

The table shows a short section of an RNA molecule and the section of a polypeptide for which it codes (NOTE: RNA uses the base U instead of T)

mRNA	G G G	G C U	U C A	C C G	G C A	A C G
Polypeptide	glycine	alanine	serine	proline	alanine	threonine

(b) Name the bases represented in the table by:

A _____

C _____

G _____

U _____

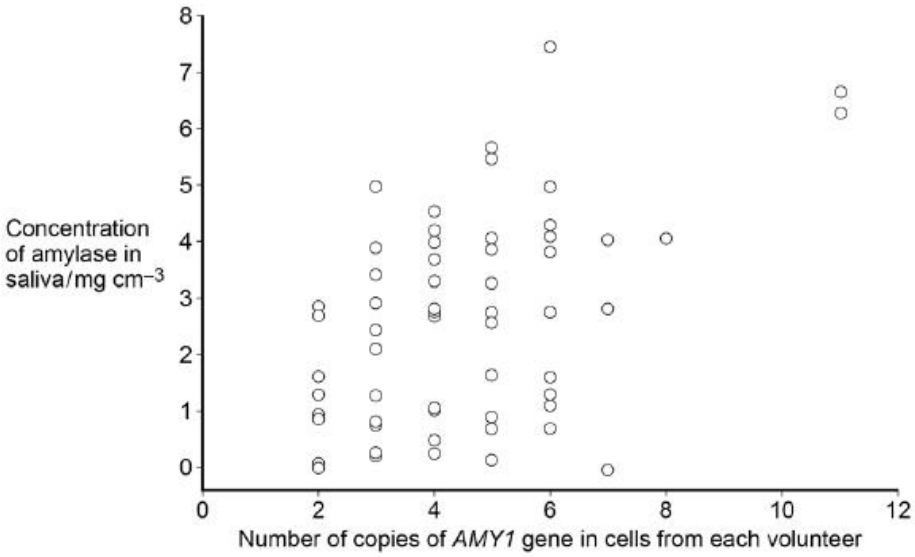
(2)

(c) Use information in the table to give the sequence of bases in **DNA** that codes for serine.

(1)

(Total 5 marks)

Q4. The saliva of most humans contains the enzyme amylase. The gene encoding the amylase protein is called *AMY1;* it is located on chromosome 1.



As a result of mutation, humans might have more than one copy of the *AMY1* gene on one, or both, of their copies of chromosome 1. A team of scientists investigated whether the number of copies of the *AMY1* gene was associated with the concentration of amylase in the saliva of 58 human volunteers.

The graph shows their results. Each circle represents one volunteer.

(a) What was the range in the number of copies of the *AMY1* gene?

(1)

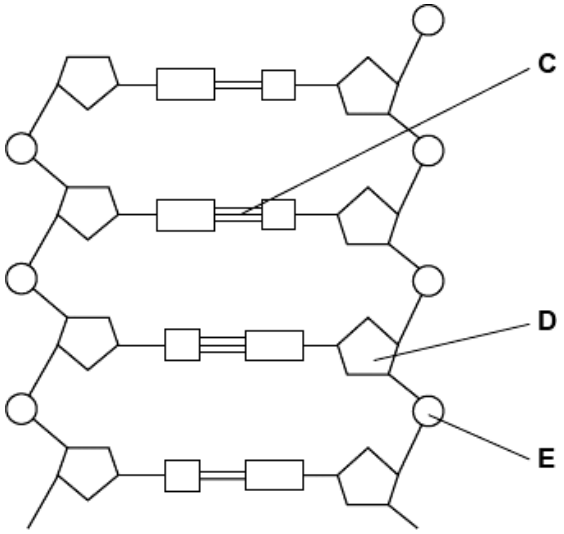
(b) The number of copies of the *AMY1* gene is unlikely to affect people's ability to digest starch.

Explain why.

(3)

(Total 4 marks)

Q5. The diagram shows part of a DNA molecule.



(a) (i) DNA is a polymer. What is the evidence from the diagram that DNA is a polymer?

(1)

(ii) Name the parts of the diagram labelled **C**, **D** and **E**.

Bond **C** _____
Part **D** _____
Part **E** _____

(3)

(iii) In a piece of DNA, 34% of the bases were thymine. Complete the table to show the names and percentages of the other bases.

Name of base	Percentage
Thymine	34
	34

(2)

(b) A protein has 51 amino acids in its sequence.

(i) What is the minimum number of DNA bases required to code for the amino acids in this polypeptide?

(1)

(ii) The gene for this polypeptide contains more than this number of bases. Explain why

(1)

(Total 8 marks)

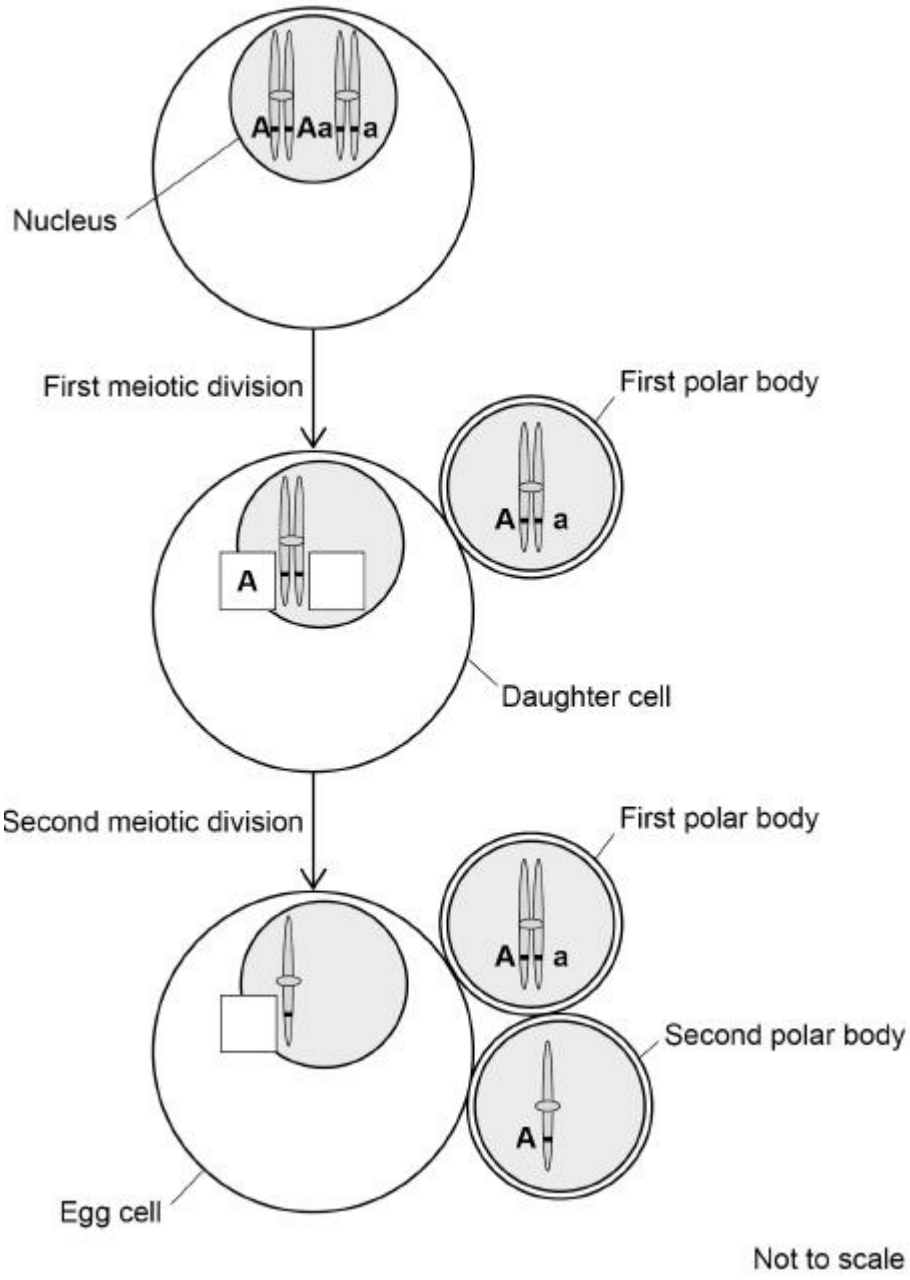
Genetic diversity via mutation and meiosis

- The production of **gametes by meiosis** introduces **variety** by shuffling alleles
- Sexual reproduction leads to variation as **fertilisation** is a random process
- Where new forms of a gene result from **mutation** there may be relatively rapid change in a species if the environment changes.
- Individual organisms within a particular **species** may show a wide range of **variation** because of differences in their **alleles**.

A Level style questions

Q6. In women, the first division of meiosis produces one daughter cell that has almost all of the cytoplasm. The other daughter cell consists of a nucleus surrounded by a very small amount of cytoplasm and a cell-surface membrane. This very small daughter cell is called a polar body. Polar bodies do not usually divide. The same process occurs in the second division of meiosis, resulting in one egg cell and two polar bodies.

The diagram shows the formation of an egg cell and two polar bodies during meiosis. It also shows what happens to one pair of homologous chromosomes. This pair carries two alleles of gene A.



(a) Complete the diagram by putting **A** or **a** in the boxes. One box has been completed for you with **A**.

(1)

(b) Put a tick (✓) in the box next to the name of the process that produced the combination of alleles on the chromosome in the first polar body in the diagram.

Anaphase ☐

Crossing over ☐

Independent assortment ☐

Semi-conservative replication ☐

(1)

(c) A scientist measured the diameter of a polar body and the nucleus inside it:

- The diameter of the **polar body was 10.4 µm**
- The diameter of the **nucleus was 7.0 µm.**
-

The density of mitochondria in the cytoplasm of the polar body (outside of the nucleus):

0.08 mitochondria per µm^3.

Calculate the number of mitochondria in the polar body. You should assume polar bodies and nuclei are spherical.

The formula for the volume of a sphere $= \frac{4}{3}\pi r^3$ $\pi = 3.14$

Show your working.

Number of mitochondria =_____

(2)

(d) Mitochondrial diseases are caused by faulty mitochondria.

All of a person's mitochondria are inherited from their mother via the egg cell.

An egg cell contains approximately 3×10^5 mitochondria.

One proposed treatment to prevent passing on faulty mitochondria involves

- removing the nucleus from an egg cell donated by a woman with healthy mitochondria
- replacing this nucleus with the contents of the polar body from a woman whose egg cells are affected by mitochondrial disease.

Suggest how this treatment prevents inheritance of mitochondrial diseases.

(2)

(e) If most of the mitochondria in a cell are faulty, this prevents many important enzyme-catalysed reactions taking place or slows them down.
Suggest and explain **one** reason why.

(2)

(f) A mutation can lead to the production of a non-functional enzyme. Explain how.

(4)

(Total 12 marks)

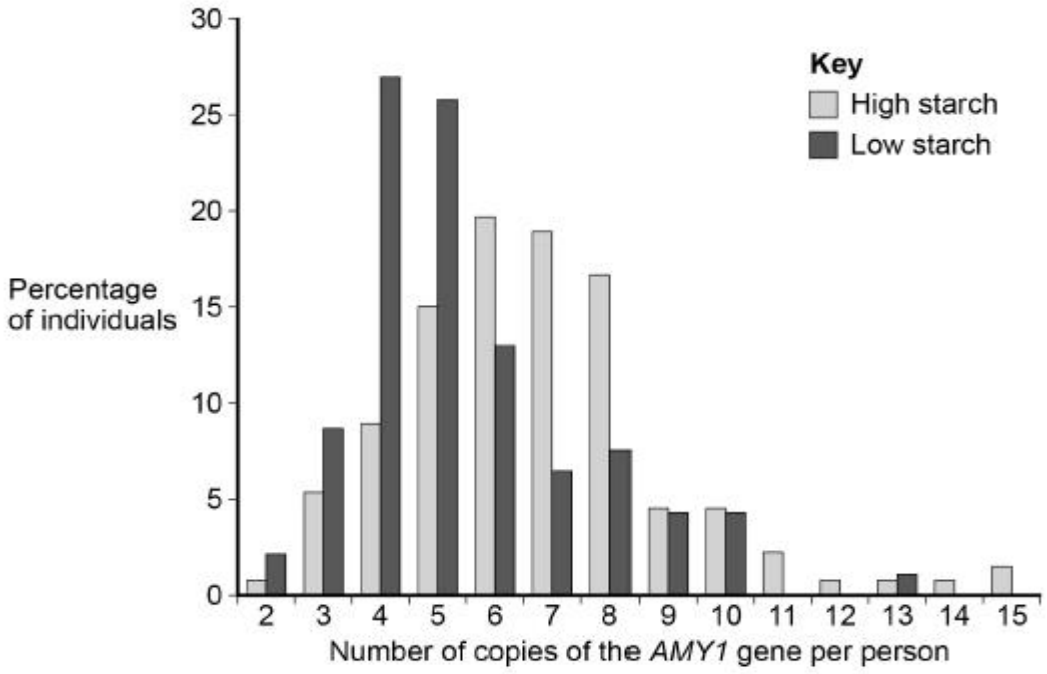
Genetic diversity and adaptation

- Darwin's theory of **evolution by natural selection** states that all species of living things have **evolved** from simple life forms that first developed more than three billion years ago.
- Individuals with characteristics **most suited** to the environment are more likely to **survive to breed** successfully.
- The genes that have enabled these individuals to survive are then **passed on** to the **next generation**.
- **New species** arise as a result of:
  - **isolation** – two populations of a species become separated.
  - **genetic variation** – each population has a wide range of alleles that control their characteristics
  - **natural selection** – in each population, the alleles that control the characteristics which help the organism to survive are selected
  - **speciation** – the populations become so different that successful interbreeding is no longer possible.

A Level style questions

Q7. (a) Most human cells contain two copies of each gene. However, there might be up to 15 copies of the gene for amylase enzyme (*AMY1*). Scientists investigated the number of copies of the *AMY1* gene in individual people in two populations. One population had a high-starch diet and the other population had a low-starch diet.

The graph below shows their results.



Describe what their results show.

(3)

(b) Multiple copies of the *AMY1* gene is an adaptation to a high-starch diet. Use your knowledge of protein synthesis and enzyme action to explain the advantage of this adaptation.

(3)

(c) Multiple copies of the *AMY1* gene is an adaptation to a high-starch diet. Suggest how this evolved through natural selection.

(3)

(Total 9 marks)

Species and taxonomy

- A **species** is a group of similar organisms that are able to mate and produce fertile offspring.
- Those members of a species that have the best **characteristics** are more likely to breed and pass on their genes
- **Classification** of organisms is based on evolutionary origins and **relationships**.
- Classification is hierarchical and places organisms into **taxonomic ranks** (KPCOFGS)
- A **binomial system** (two names) is used in the identification of species
- Genome **sequencing** help to clarify evolutionary relationships between organisms.
- **Variation** within a species can be measured using differences in the base **sequence of DNA** or in the **amino acid sequence** of proteins.

A Level style questions

Q8. (a) There are many different species of field mouse in Europe. Using a phylogenetic classification, all of these species have names that start with *Apodemus*.

What information does this give about field mice?

(2)

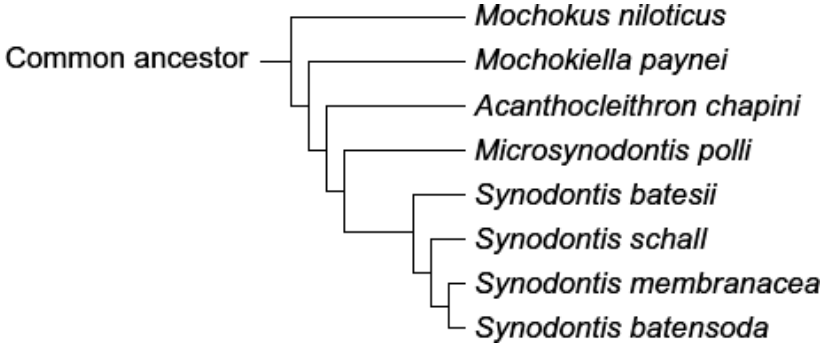
(b) The long-tailed field mouse, *Apodemus sylvaticus*, is a small mammal common in mainland Britain. Complete **Table 1** to show the classification of the long-tailed field mouse.

Table 1

Taxon	Name of Taxon
	Eukarya
Kingdom	Animalia
	Chordata
	Mammalia
Order	Rodentia
Family	Muridae

(2)

There are over 200 species of catfish. All catfish evolved from a common ancestor.
The diagram shows how some species of catfish are classified. This diagram is based on the evolutionary links between these species.



(c) (i) Which species of catfish is most closely related to *Synodontis membranacea*?

(1)

(ii) Which species of catfish is most distantly related to *Synodontis membranacea*?

(1)

(d) How many different genera are shown in this diagram?

(1)

(e) A scientist carried out breeding experiments with catfish from different populations.
Describe how the results could show that the catfish belong to the same species.

(1)

(Total 8 marks)

Q9. The table shows the taxons and the names of the taxons used to classify one species of otter. They are **not** in the correct order.

	Taxon	Name of taxon
J	Family	Mustelidae
K	Kingdom	Animalia
L	Genus	Lutra
M	Class	Mammalia
N	Order	Carnivora
O	Phylum	Chordata
P	Domain	Eukarya
Q	Species	lutra

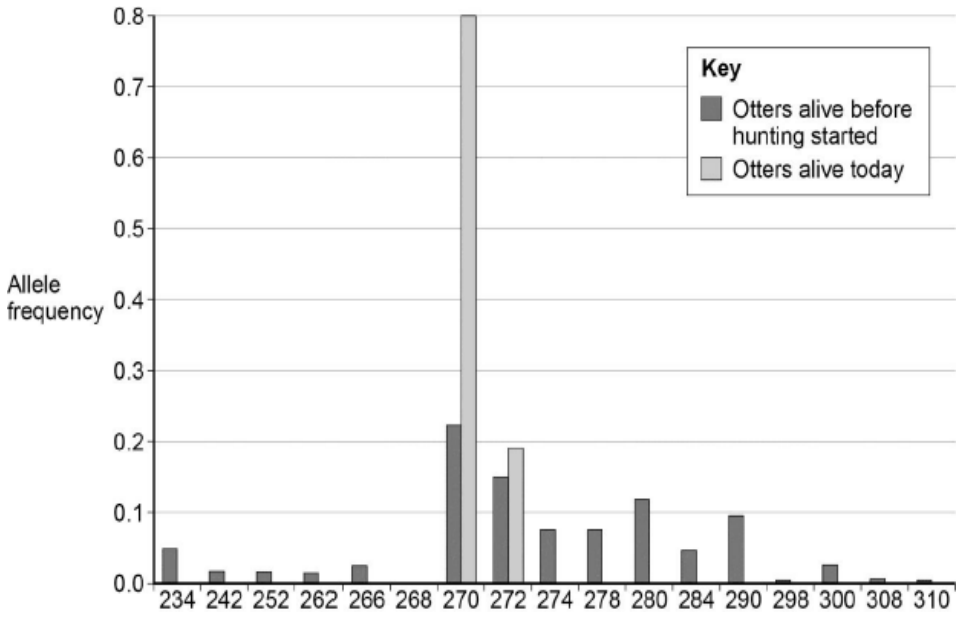
(a) Put letters from the table above into the boxes in the correct order. Some boxes have been completed for you.

		O	**M**			**L**	**Q**

(1)

(b) Give the scientific (binomial) name of this otter.

(1)



Scientists investigated the effect of hunting on the genetic diversity of otters. Otters are animals that were killed in very large numbers for their fur in the past. The scientists obtained DNA from otters alive today and otters that were alive before hunting started. For each sample of DNA, they recorded the number of base pairs in alleles of the same gene. Mutations change the numbers of base pairs over time. The figure shows the scientists' results.

(c) The scientists obtained DNA from otters that were alive before hunting started.

Suggest **one** source of this DNA.

(1)

(d) What can you conclude about the effect of hunting on genetic diversity in otters?

Use data from the figure above to support your answer.

(2)

(e) Some populations of animals that have never been hunted show very low levels of genetic diversity. Other than hunting, suggest **two** reasons why populations might show very low levels of genetic diversity.

(2)

(Total 7 marks)

Biodiversity within a community

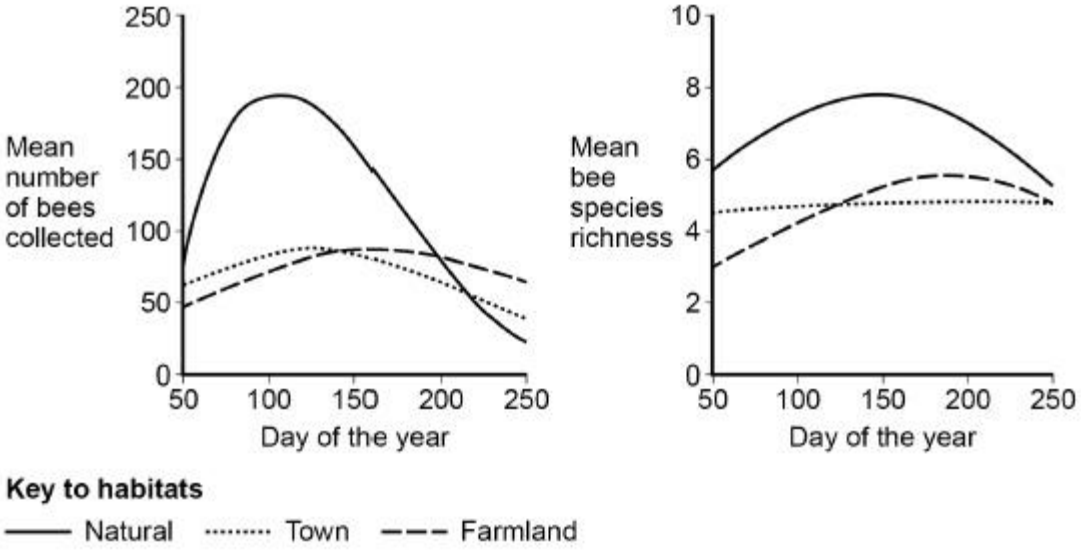
- **Biodiversity** or biological diversity is reflected in the vast **number of species** of organisms
- Biodiversity is also reflected in the **variation** of individual characteristics within a single species and in the **variation of cell types** within a single multicellular organism.
- The most biodiverse **ecosystems** are forests and particularly **rainforests** which have many **habitats**
- Large scale **farming** techniques reduce biodiversity and there should be a balance between **conservation** and farming.

A Level style questions

Q10.

Bees are flying insects that feed on nectar made in flowers. There are many different species of bee. Scientists investigated how biodiversity (species richness) of bees varied in three different habitats during a year. They collected bees from eight sites of each habitat four times per year for three years.

The scientists' results are shown below in the graphs in the form they presented them.



(a) What is meant by biodiversity?

(1)

(b) From the data in the graphs, a student made the following conclusions.

1. The natural habitat is most favourable for bees.
2. The town is the least favourable for bees.

Do the data in the graphs support these conclusions? Explain your answer.

(i) The natural habitat is most favourable for bees.

(ii) The town is the least favourable for bees.

(4)

(c) The scientists collected bees using a method that was ethical and allowed them to identify accurately the species to which each belonged. In each case, suggest **one** consideration the scientists had taken into account to make sure their method

(i) was ethical.

(ii) allowed them to identify accurately the species to which each belonged.

(2)

(d) Suggest and explain **two** ways in which the scientists could have improved the method used for data collection in this investigation.

(2)

(e) Three of the bee species collected in the farmland areas were *Peponapis pruinosa*, *Andrena chlorogaster* and *Andrena piperi*.
What do these names suggest about the evolutionary relationships between these bee species? Explain your answer.

(2)

(Total 11 marks)

Assess your work: Mark Schemes

1.Biological molecules Answers to questions

Q1. (a) 1. Allow equal (time for) diffusion of iodine into apple cells or for reaction/colour change to happen
2. For comparison between apples / between harvest dates;

2

(b) 1. Starch lost from the centre first / area with no starch gets bigger as it ripens;
2. (Less starch / blue / black as the) starch is converted to sugars.
3. By amylase enzyme;

3

[5]

Q2. (a) 1. Add iodine / potassium iodide solution;
2. Blue-black colour (with starch);

2

(b) 1. Starch is broken down/digested by enzyme / amylase
2. Produces glucose (in the gut);
3. Small enough to cross the gut wall (diffuse into the blood) / monomers (can) cross the gut wall (into the blood);

3

(c) 1. Time how long it takes to go brick red;
2. Weigh red precipitate;
3. Dilute glucose samples / use smaller volume of glucose samples / use greater volume of Benedict's reagent;

1 max

[6]

Q3. (a) (i) (Molecule) made up of many identical / similar molecules / monomers / subunits;

1

(ii) Cellulose / glycogen / nucleic acid / DNA / RNA;

1

(b) (i) 1. To keep pH constant;
2. A change in pH will slow the rate of the reaction / denature the amylase / optimum for reaction;

2

(ii) Purple / lilac / mauve / violet;

1

(iii) Protein present / the enzyme / amylase is a protein;
Not used up in the reaction / still present at the end of the reaction;

2

[7]

Q4. (a) Any **one** from:
1. Numerical readings / not subjective / colour change subjective / gives quantitative data / not qualitative / gives continuous data;
2. Greater accuracy or precision

1 max

(b) Fatty acids produced;

1

(c) 1. No more (fatty) acids produced;
2. All fat//lipids/substrate used up / enzyme denatured;

2

(d) 1. Line starting at same point and falling above original line;
2. Levels off at <u>same</u> pH, but later;

2

[6]

Q5. (a) Box around single nucleotide.

1

(b)

DNA strand	Percentage of each base			
	A	**C**	**G**	**T**
Strand **1**	(16)	**34**	**21**	**29**
Strand **2**	**29**	(21)	(34)	**16**

2 rows correct = 2 marks;
1 row correct = 1 mark.

2

(c) Prokaryotic DNA *(Accept converse for eukaryotic DNA)*

1. Circular / non-linear (DNA);
2. Not (associated) with proteins/ does not form chromosomes
3. No non-coding DNA.

2 max

(d) (i) 1. Have different genes;
2. (So bases / triplets) are in a different sequence / order;
3. (So) different amino acid (sequence / coded for) / different protein / different polypeptide / different enzyme.

2 max

(ii) (Virus DNA)
1. A ≠ T / G ≠ C / virus has more C than G / has more A than T
2. (So) <u>no</u> base pairing / DNA is not double stranded / is single stranded.

2

(e) (i) Deoxyribose/sugar

1

(ii) Phosphate /*phosphorus*

1

(f) Pair of bases :C&G/G&C/A&T/T&A

1

(g) Change in (sequence of) DNA causes a change in sequence of amino acids in the protein;
Changes structure / active site (of enzyme);
Substrate cannot bind / no enzyme-substrate complexes form;

3

[15]

2.Cells Answers to questions

Q1. (a)

Protein synthesis	**L;**
Genetic info	**J;**
Aerobic respiration	**N;**

3

(b) **Magnification = (Measured length of line in mm x 1000) ÷ 5**

<u>For example, if line measured 8mm:</u> (this will vary depending on how you view/print image
8000 ÷ 5 = 1600 times magnification

1 mark for an incorrect answer in which student clearly divides measured length by actual length (of scale).

2 [5]

Q2. (a) (Plasma / cell) membrane;

1

(b) Nucleus
Mitochondrion;
(Smooth / rough) ER/ ribosomes on a membrane/ larger ribosomes
Lysosome;
Microvillus / brush border;
Golgi;
Linear / non-circular DNA / chromosome;

2 max

(c) (i) Higher resolution / higher (maximum) magnification / higher detail (of image);
OR
Allows internal details / structures within (cells) to be seen / cross section to be taken;

1

(ii) Can be used on living specimens/ easier to carry out

1

(d) **Actual size in µm = (measured line size in mm x 1000) ÷ magnification**

For example, if line measured 22mm: (this will vary depending on how you view/print image
22,000 ÷ 50,000 = 0.44µm
One mark for incorrect answers in which candidate clearly divides measured width by magnification;

2

(e) As height increases, the number of deaths decrease / inversely proportional / negative correlation;
Correct reference to increase / decrease at 14-30m;

2

[9]

Q3. (a) 1. The (individual) chromosomes are visible
2. because *'chromosomes/ DNA'* they have condensed/become *'tightly coiled' or 'short and*

2

(b) ✓ prophase

1

(c) 1. Water moves into the cells/cytoplasm by osmosis;
2. Cell/cytoplasm gets bigger/ has greater volume/swells/expands.

2

(d) Differences in base sequences/genes **OR** Differences in condensation/(super)coiling;

1

(e) (Two chromosomes that) carry the same genes;

1

(f) (Prokaryotic DNA) is
1. Circular (as opposed to linear);
2. Only one molecule/piece of DNA **OR** present as plasmids;

2 [9]

Q4. (a) (D)CBEA.

1

(b) **Step**	**Reason**
(Taking cells from the root tip)	Region where growth happens so more mitosis / cell division is happening
(Firmly squashing the root tip)	To allow light through / make tissue layer thin/so you can see cells clearly

2 [3]

Q5. (a) (i) benign does not cause cancer / does not invade other tissues causing damage / with benign cancer, pieces which break off do not start new tumours elsewhere in body / metastasis;

1

(ii) may damage organ concerned; may cause blockages / obstructions; may damage / exert pressure on other organs;

2

(b) (i) because sun's radiation contains ultra violet radiation; this causes mutation of genes which control division;

2

(ii) because fair skin has little melanin which protects against UV radiation;

1

[6]

Q6. (a) 1. (Movement) down a gradient / from high concentration to low concentration;
2. Passive / not active processes; **OR** Do not use energy **from** respiration

2

(b) Calculations of percentage change made (from raw data) / raw data would have recorded initial and final masses.

1

(b) Add 4.5 cm^3 of (1.0 mol dm^{-3}) solution to 25.5 cm^3 (distilled) water (*water in a proportion of 0.15:0.85)*

2

(c) 1. Water potential of solution is less than / more concentrated/sugary than that of potato tissue;
2. Therefore, potato tissue loses water by osmosis.

2

(d) 1. Plot a graph of results with concentration on the *x*-axis and percentage change in mass on the *y*-axis;
2. Find concentration where curve crosses the *x*-axis / where percentage change is zero;
3. This is the concentration of sugar in the potato cells/ represents the same water potential as the cells

3

[8]

Q7. (a) 1. Add Benedict's solution
2. Heat to 95°C in *a water bath*
3. Red / orange / yellow / green (shows sugar present);

3

(b) (i) 1. Starch broken down / glucose / maltose/ sugar produced;
2. Lower water potential/ more concentrated (more sugar)
3. Therefore water enters the tube by osmosis, increasing water level

3

(ii) Only 2 pHs studied / more pHs need to be tested;

1

[7]

Q8. (a) 1. Between 0 and 0.1 calcium (ions) cannot enter by diffusion **OR**
Between 0 and 0.1 there is no diffusion gradient for entry into the cell.
2. Between 0.1 and 0.3 calcium (ions) do enter by diffusion;
3. As calcium (ions) enter without oxygen **OR** Oxygen is not required for diffusion;

4. Between 0 and 0.1 calcium (ions) enter by active transport / movement is against the concentration gradient;
5. As calcium (ions) only enter in presence of oxygen / oxygen is required for active transport. **5**

(b) (She could have used) boiled (and cooled) water **OR** Layer of oil in top of solution; **1 [6]**

Q9. (a) 1. Bacteria- (Releases) toxins;
2. Virus- Kills cells / tissues. **2**

(b) 1. Water potential in (bacterial) cells higher (than in honey) / sugar concentration in bacterial cells lower (than in honey); or opposite
2. Water leaves bacteria / cells by osmosis;
3. (Loss of water) stops (metabolic) reactions in bacterial cell. **3**

[5]

Q10. (a) Injection of antigens isolated from pathogen OR an altered/non-virulent/dead pathogen Stimulates an immune response/ the formation of memory cells; **2**

(b) (i) Antibodies are specific to mumps antigen /2nd antibodies are specific to mumps antibody; **1**

(ii) Removes unbound 2nd antibodies;
Otherwise enzyme may be present / may get colour change anyway / false positive; **2**

(iii) No antibodies to bind (to antigen);

Therefore 2nd antibody (with the enzyme) won't bind / no enzyme / enzyme-carrying antibody present (after washing in step 4); **2**

[7]

Q11. (a) 1. Foreign protein;
2. (that) stimulates an immune response / production of antibody; **2**

(b) 1. A protein / immunoglobulin specific to an antigen;
2. Produced by white blood cells / B cells / Secreted by plasma cells; **2**

(c) $\frac{(37 - 2)}{2} \times 100$ = **1750%** **1**

(d) 1. Sample 1 / before vaccination no antibody released/ produced because patients not yet encountered vaccine / antigen / virus;
2. (Sample 2 / primary response / after first dose) activation / expansion of white blood cells / B cells into plasma cells;
3. White blood cells / Plasma cells release antibodies;
4. (Sample 3 / secondary response / after second dose) white blood cells / memory cells produce more antibodies / produce antibodies more quickly; **4**

[9]

3.3 Organisms exchange substances with their environment Answers to questions

Q1. (a) As size increases, ratio (of surface area to volume) decreases; or *converse.*
e.g., smaller organisms have a larger ratio, larger animals have a smaller ratio

1

(b)

Radius = $\sqrt{(\text{surface area} \div 4\pi)}$ = $\sqrt{9.73 \div 12.56}$ = *0.88*

OR

r^2 = *surface area ÷ 4 π = 9.73 ÷ 12.56 = 0.775*

Radius = √0.775 = 0.88

*Diameter = 2 x radius = 2 x 0.88 = 1.76 (***1.75 to 1.76 depending on rounding)**

2

(c) (Measures) small uptake / amount / quantity / volume / concentration / rate (of oxygen uptake) **OR** Avoids use of powers of ten / standard form / many decimal places;

1

(d) More accurate / less error (in measuring mass) **OR** Causes less distress / damage to animal (to measure mass) **OR** Easier / quicker (to find mass) **because** irregular shapes;

1

(e) (Oxygen used in) respiration, **which** provides energy **OR** (Oxygen is used in) respiration, **which** is a metabolic process / chemical reaction;

1

(f) 1. No information about egg;
2. So cannot compare all stages (in Table 2) / cannot compare all three stages
3. No statistical information / test / t-test / comparison of standard deviations;
OR No measure of significant differences/ don't know if difference is significant

3

[9]

Q2. (a) 1. Named structures – trachea, bronchi, bronchioles, alveoli;
2. Above structures named in correct order **OR** Above structures labelled in correct positions on a diagram;
3. Breathing in – diaphragm contracts/moves down **and** external intercostal muscles contract/ribs move up and outwards
4. (Causes) volume increase and pressure decrease in thoracic cavity/thorax/ lungs (to below atmospheric, resulting in air moving in);
5. Breathing out - Diaphragm relaxes/moves up **and** internal intercostal muscles contract/ ribs move down and inwards
6. (Causes) volume decrease and pressure increase in thoracic cavity/thorax/ lungs (to above atmospheric, resulting in air moving out);

6

[6]

Q3. (a) Number of Stomata per mm^2 or cm^2 **OR** Number per mm^2 or cm^2;

1

(b) 1. Single/few layer(s) of cells;
2. So light can pass through;

2

(c) 1. Distribution may not be uniform (*more/fewer stomata in different areas)* **OR** So it is a representative sample
2. To obtain a (reliable) mean/ *average*

2

(d) 1. Some water might be used for support/turgidity;
2. Some water will be used in photosynthesis;
3. Water used in chemical reactions
4. Water produced during respiration;

2

[7]

Q4.

(a) (Scientists) used fully grown leaves / used five plants of each (species).

1

(b) **Either**

1. Draw around leaf on graph paper.
2. Count squares (however described);
3. Multiply by 2 (for upper and lower leaf surface);

OR

4. Draw around a leaf on paper of known mass (per unit area);
5. Cut out *and* weigh;
6. Multiply by 2 (for upper and lower leaf surface).

3

(c) Species **B** (no mark)

1. Smaller surface area *so l*ess evaporation/ transpiration / less heat absorbed;
2. Thicker leaves s*o* greater diffusion distance (for water) / *more water storage'.*
3. Fewer stomata / lower stomatal density *so* less transpiration / evaporation (of water);
4. Smaller surface area to volume ratio *so* less evaporation.

1 max

(d) Small leaves / surface area *so* (total) number of stomata is low.

1

[6]

Q5. (a) (**P**) Trachea / windpipe <u>and</u> (**Q**) bronchus /bronchi

1

(b) 1. Increases volume in lungs / thorax
2. Lowers pressure (in lungs / thorax) / chest expands
3. Air (pushed) in by higher outside pressure / down pressure gradient;

2 max

(c) 1. Large sample size;
2. Individuals chosen at random;
3. Are healthy;
4. Equal number of males and females;
5. Repeat readings;

2 max

(d) 1. (For) comparison / *provides a benchmark/standard.*
2. To see effect of age/emphysema/smoking

2

(e) <u>Intercostal muscle(s)</u> less effective due to loss of muscle tone with age

OR

Less elasticity (of lung tissue) due to age

1

(f) 1. Less carbon dioxide removed;
2. Less oxygen inhaled (uptake/in blood);
3. Less (aerobic) respiration **OR** (More) anaerobic respiration/*(more) lactic acid.*

3

[11]

Q6. (a) D;
G;
F;

3

(b) <u>Coronary arteries;</u>

1

(c) (i) C;

1

(ii) A;

1

(d) Strongest/stronger contractions/ *most muscle in wall / thickest/thicker muscular wall*

1

(e) 1. Blood flows from left ventricle to right ventricle/ mixing of oxygenated and deoxygenated blood;
2. Lower volume/pressure of (oxygenated) blood leaves left ventricle/flows into aorta/C OR Less oxygen in blood leaving left ventricle/aorta/C;

2

[9]

Q7. (a) 1. Elastic tissue to allow stretching / recoil / smoothes out flow of blood / maintains pressure;
2. Muscle for contraction / vasoconstriction;
3. Thick wall withstands pressure **OR** stop bursting;
4. Smooth endothelium reduces friction;
5. Aortic valve / semi-lunar valve prevents backflow.

3 max

(b) **18 (cm^3 $minute^{-1}$);**
heart rate is 5 beats in 500 ms^{-1}
so 10 beat per second (as 1000ms^{-1} in one second)
Therefore 10 x 60 per minute = 600
600 multiplied by 0.03 = 18

2

(c) 1. Length of time of exercise;
2. Difficulty of exercise, e.*g. speed of treadmill / running, incline on treadmill.*
3. An environmental factor, e.*g. temperature / humidity / clothing worn.*

2 max

(b) level 3 range of 40 (200-160) level 1 range of 45 (170-125)
40/45 = 0.89 **Ratio = 0.89:1**

2

[9]

Q8. (a) Any **three** from:
1. Light;
2. Carbon dioxide;
3. Type of soil;
4. Minerals / nutrients;
5. Water (in soil);
6. Humidity (of air);
7. pH (of soil)
8. Planting density/ *equally spaced*

3 max

(b) Already levelled out (before 20 °C);

1

(c) Young leaves (may) have different number of stomata (per mm^2) / number of stomata (per mm^2) changes during development (of leaf);

1

(d) Any **two** from:
1. Molecules have more kinetic energy;
2. Faster diffusion of water / more evaporation/transpiration of water (as temperature increases in leaf);

2

[7]

Q9. (a) Open / use tap / add water from reservoir;

1

(b) 1. Seal joints / ensure airtight / ensure watertight;
2. Cut shoot under water;
3. Cut shoot at a slant;
4. Dry off leaves;
5. Insert into apparatus under water;

6. Ensure no air bubbles are present;
7. Shut tap;
8. Note where bubble is at start / move bubble to the start position;

2 max

(c) 1. Water used for support / turgidity;
2. Water used in photosynthesis;
3. Water produced in respiration;
4. Apparatus not sealed / 'leaks';

2 max

(d) As number of leaves are reduced (no mark),
1. Less surface area / fewer stomata;
3. Less evaporation / transpiration;
4. Less water pulled up the plant in stem/xylem

3

[8]

3.4 Genetic information, variation and relationships between organisms Answers to questions

Q1. (a) 9;

1

(b) Change in the sequence of DNA leads to a change in the sequence of RNA
Leads to a change in amino acid sequence
Alters protein structure/shape so it doesn't function properly

3

(c) Number of bases

	Number of bases			
	C	G	A	T
Strand A	26	**19**	**20**	**9**
Strand B	19	**26**	9	**20**

;

2

[6]

Q2. (a) Three of chromosome 13 / an extra chromosome 13/ trisomy13

1

(b) 1. (Some) oxygenated blood (from the aorta) flows into pulmonary artery;
OR Less oxygenated blood flows out through aorta **OR** Lower blood pressure in aorta;
2. Less oxygen delivered to cells / tissues / organs / named organ / via named blood vessel;
3. So less / not enough oxygen for <u>aerobic</u> respiration (in cell / tissue / organ);
4. Tissue / organ doesn't grow / develop properly (causing death);
OR Tissue dies / organ stops working (causing death);

3 max

[4]

Q3. (a) 1. Universal: all living organisms use the same codons/sequence of three bases to code for amino acids;
2. Non-overlapping: each base is part of only one triplet/codon and is only read once by the ribosome.

2

(b) A = adenine
C = cytosine
G = guanine
U = uracil

2

(c) AGT;

1

[5]

Q4.

(a) 2 to 11;

1

(b) 1. Only part of the starch in food is digested by salivary amylase **OR** starch only in mouth for a short period **OR** salivary amylase inactivated by stomach acid;
2. Amylase also secreted by pancreas;
3. So (most) starch digestion occurs in small intestine.

3

[4]

Q5. (a) (i) Repeating units / nucleotides / monomer / molecules;

1

(ii) 1. C = hydrogen bonds;
2. D = (deoxyribose) sugar
3. E = phosphate;

3

(iii)

Name of base	Percentage
Thymine	34
Cytosine / Guanine	16
Adenine	34
Cytosine / Guanine	16

2

(b) (i) 51 x 3 = **153;**

1

(ii) Some of the codons could be a start / stop code

1

[8]

Q6. (a) Lowercase **a** in both boxes

1

(b) Tick in box next to 'Crossing over';

1

(c) Polar body:
Radius = 11.4 / 2 = 5.2µm
Volume = 4/3 x 3.14 x 5.2^3 = 588.68 μm^3
Nucleus:
Radius = 7 / 2 = 3.5µm
Volume = 4/3 x 3.14 x 3.5^3 = 179.5 μm^3

Difference in volume = 588.68 – 179.5 = 409.18 μm^3 (409.2)
Number of mitochondria = 409.18 x 0.08 = **32.73 / 32.7 / 32 / 33**

2

(d) 1. Egg (created) has nucleus / DNA / genes of (affected) woman / mother;
2. It has mostly / many / lots of normal mitochondria (of unaffected woman) **OR** There are few faulty mitochondria;

2

(e) 1. Not enough / little ATP/energy produced;
2. ATP/ **energy** needed for (enzyme) reactions in a cell such as protein synthesis

2

(f) 1. Change / mutation in base / nucleotide sequence (of DNA / gene);
2. Change in amino acid sequence / primary structure (of enzyme)/ different amino acid(s) coded for
3. Change in the tertiary structure / shape of protein
4. Change in active site;
5. Substrate not complementary / cannot bind (to enzyme / active site) / no enzyme-substrate complexes form.

4

[12]

Q7. (a)

1. Low starch diet has fewer copies;
2. Ranges overlap almost completely; **OR** Ranges overlap from 2 − 13 copies;
3. (surprisingly) very few / 2 or 3% have only 2 copies
4. the mode / highest percentage for low starch is 4 copies and for high starch is 6;
5. the range / spread is greater with high starch;

3 max

(b) 1. More RNA is made from more copies of the gene / more transcription;
2. More translation / more enzyme is made by the ribosomes from the RNA
3. So enzyme reaction is faster as the concentration of enzyme is higher

3

(c) 1. Mutation(s) produce extra copies of (*AMY1*) gene;
2. Those with more copies / this adaptation/mutation reproduce / survive better on high starch diet;
2. And pass on multiple copies / this adaptation/mutation (to offspring);

3

[9]

Q8. (a) 1. Same genus;
2. Same evolutionary origin / common ancestor.

2

(b)

Taxon	**Name of Taxon**
Domain	Eukarya
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Rodentia
Family	Muridae

2

(c) (i) *Synodontis batensoda / S. batensoda;*

1

(ii) *Mochokus niloticus;*

1

(d) 5;

1

(e) Fertile offspring produced;

1

[8]

Q9. (a) PKNJ.

1

(b) *Lutra lutra.*

1

(c) Bone / skin / preserved remains / museums.

1

(d) 1. (Hunting) reduced population size(s), so (much) only few alleles left;
2. Otters today from one / few surviving population(s);
3. Inbreeding.

2 max

(e) 1. Population might have been very small / genetic bottleneck;
2. Population might have started with small number of individuals / by one pregnant female / founder effect;
3. Inbreeding.

2 max

[7]

Q10. (a) the number of (different) species in a community;

1

(b) **Yes, natural best, because**
1. Peak of /highest (mean) bee numbers in natural habitat is highest;
2. The (mean) number of bees was higher in the natural habitat until day 200 (*190 – 210).*
3. (Mean) species richness in natural habitat higher at all times;

No, natural not best, because
4. Lowest (mean) number of bees after day 220 (*210 - 230)*

Yes, town worst, because
5. Peak of/ highest species richness higher in <u>both</u> natural and farmland

OR Species richness lowest in town from day 125 (*115 - 135.)*

No, town not worst, because
6. (Mean) species richness is lower in farmland until day 125 *(115 - 135)*
7. Similar (mean) number of bees to farmland **OR** (Mean) number of bees lower in farmland until day 140 *(130 – 150).*

4 max

(c) 1. Must not harm the bees **OR** Must allow the bee to be released unchanged;
2. Must allow close examination **OR** Use a key/photographs (to identify the species);

2

(d) 1. Collect at more times of the year **so** more points on graph/better line (of best fit) on graph;
2. Collected from more sites/more years **to** increase accuracy of (mean) data/ make data more representative;

.

2

(e) 1. *A. chlorogaster* and *A. piperi* are more closely related (to each other than to *P. pruinosa*) / *A. chlorogaster and A. piperi share a more recent/closer common ancestor (than they do with P. pruinosa);*
2. Because they are in the same genus;

2

[11]