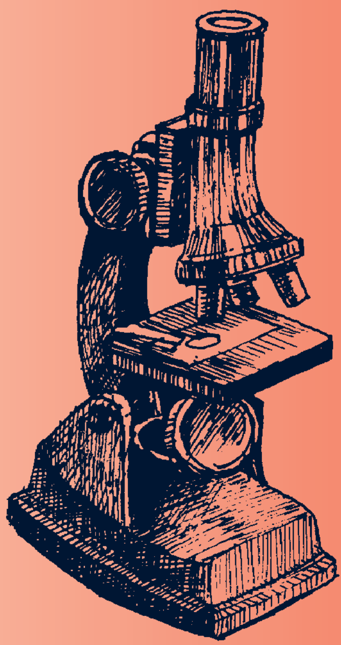
BIOLOGY



Year 13 Learning Guide

BIOLOGY

LEARNING GUIDE
Year 13

GOVERNMENT OF SĀMOA
MINISTRY OF EDUCATION, SPORTS AND CULTURE

Acknowledgements

The Ministry of Education, Sport and Culture would like to thank the following for their vision, patience and hard work in putting together this valuable book:

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Designed, edited and typeset by Egan-Reid Ltd, Auckland, as part of the Sāmoa Secondary Education Curriculum and Resources Project for:

Government of Sāmoa Ministry of Education, Sports and Culture, 2004.

Funded by the New Zealand Agency for International Development, Nga Hoe Tuputupu-mai-tawhiti.

Printed through Egan-Reid Ltd.

Managing Contractor: Auckland UniServices Limited.

ISBN 982-517-084-0

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How To Use This Learning Guide

This learning guide covers all the achievement objectives in the year 13 biology curriculum. Each chapter relates to one strand of the curriculum and is divided into three parts:

- The **achievement objectives**. These are from the year 13 biology curriculum and state what is to be learnt.
- **Key learning points**. The information in the key learning points is a starting point for learning relating to each achievement objective. A reference to where further information and activities can be found is given at the end of the key learning points for each achievement objective.
- **Additional information**. This part provides information and activities that are not in the LifeScience or Ministry of Education textbooks.

It is intended that students and teachers will use this learning guide as a starting point. By reading the achievement objective, students and teachers will know what is to be learnt. By reading the Key Learning Points, the student will gain information about the achievement objective and where further information can be found. The Additional Information provides information not given in the text books.

It is expected that teachers will manage student learning by planning and providing learning experiences that incorporate the opportunities for students to think deeply about and to discuss the biology concepts and processes they are learning about.

Texts That Are Referred To In This Learning Guide

References and their abbreviations (in bold)

Government of Samoa Department of Education, (2003) *Book 1 Year 11 Science*. Egan Reid: Auckland. **(Book 1 Year 11 Science)**

Government of Samoa Ministry of Education, (2004) *Year 12 Biology*. Egan Reid: Auckland. **(Year 12 Biology)**

Randall S., (1997) *Environmental Science The Natural World Around Us Year 11 Students' Booklet*. Education Department of Samoa: Apia. **(Natural World)**

Relph D., Pedder R., DeLacey L., (1986) *A textbook for Senior Biology LifeScience*. Heinemann: Auckland. **(LifeScience)**

Unit 1

Variety Of Life

Achievement objectives

From their study of the *Variety Of Life* students will understand biological organisation and classification:

- ❑ **describe** different levels of organisation, e.g. organism level, organ system, organ, tissue, cell, organelle level
- ❑ **describe** the diversity of organisms.

Classification

- ❑ **investigate** typical examples of the following kingdoms, phyla/ divisions and classes:

Kingdom	**Phyla/divisions and classes** (classes are in brackets)
Monera	Bacteria, Blue green algae
Protista	Unicellular organisms, Algae
Fungi	Fungi
Plantae	Mosses, Ferns, Gymnosperms, Angiosperms (monocotyledons, dicotyledons)
Animalia	Coelenterates, Annelids, Molluscs, Arthropods (Crustaceans, Insects, Arachnids, Myriapods), Echinoderms, Chordates (Fish, Amphibians, Reptiles, Birds, Mammals)

- ❑ **use** the binomial system to name local organisms
- ❑ **use** and **design** dichotomous keys.

Key Learning Points

- ❑ **Levels of organisation** – The study of biology can occur at one or more of several different levels such as cells, individuals or communities. More information can be found in the additional information below and in the CDU book *The Natural World Around Us* (**Natural World**) page 13.

- **Diversity of organisms –** All living things are made up of cells and must carry out the **same** seven life processes (MRS C GREN) yet the different species have a wide diversity (difference) in their structure and function. Chapter 1 in **LifeScience** shows examples of the diversity of living things.
- **Kingdoms, phyla/divisions and classes –** biologists place organisms in groups. The largest groups are called kingdoms. Each kingdom has similar types of organisms in it. The organisms in each kingdom can be divided into smaller groups. Each group contains the organisms that biologists think are the most closely related to each other. See the **additional information** on classification, chapter 1 of **LifeScience** and chapter 1 of **Year 12 Biology**.
- **Binomial naming system –** each organism has at least two scientific names that are used throughout the world. Scientific names are used to identify living things because the same organism could have a different common name on a different island. See the additional information below and chapter 1 of **LifeScience**.
- **Dichotomous keys –** The features of organisms can be used to identify them. Keys have information about the features of living things that is used to identify different organisms. Keys that have the features listed in paired statements are called dichotomous keys. See **LifeScience** pages 14–15 for dichotomous keys. Use the pictures and general information on each organism in the **Natural World** book pages 75–93 to develop a dichotomous key.

Additional Information

In year 13 biology, the study of the variety of different organisms focuses on grouping and classification. The large numbers of different plants and animals on Earth means that Biology is a large and ever-growing 'body of knowledge'. Biologists use two different ways of organising this body of knowledge so that it is easier for people to understand and to use. The first system of organisation is called 'levels of organisation'. The second system is called the 'classification system'.

Levels of organisation

This system divides the body of knowledge into levels. The levels are based upon living things and their environment. The highest level is the **biosphere**, which includes all the living things and the environment as high into the atmosphere and as far down into the soil as living things are found.

Other levels include:

Ecosystem – living things in an area and their environment, e.g. coral reef, ocean, rain forest. The study of biology at ecosystem level involves investigating food chains and webs, energy flow and nutrient cycles.

Community – all the living things in an area. Study at community level involves investigating relationships between organisms, patterns of organisms such as zonation and stratification, and changes such as succession.

Population – one type of living thing in an area, e.g. groups of coral, tamala, uu. Study at population level involves investigating density, distribution, age structures, population growth and regulation and competition.

Individual organism – e.g. vea, pili. Study at organism level involves investigating feeding methods, habitat, ecological niche, environment and adaptation.

Organ systems – e.g. circulatory system, digestive system. Study at organ system level involves investigating how organs work together to carry out a specific body function.

Organs – e.g. heart, lungs, kidneys, eyes. Study at organ level involves investigating the structure and function of organs.

Tissues – e.g. muscle tissue, connective tissue, bone tissue. The investigation of the structure and function of tissues.

Cells – e.g. bone cell, nerve cell. The investigation of the structure and function of cells.

Cell organelles – e.g. mitochondria, nucleus. The investigation of the structure and function of cell organelles.

Molecules – e.g. proteins, carbohydrates. The investigation of the structure and function of the molecules that make up living things.

Activity 1 Levels of Organisation

Purpose: To develop knowledge about levels of organisation.

1 Work in pairs or threes.

2 Match the terms (list A) with their meanings (List B) and an example (List C). Write out the matched terms, meanings and examples in your notes.

3 Work with another group to discuss further examples of each term.

List A	List B	List C
Biosphere	All the living things in an area and their environment	All the togo plants in an area
Ecosystem	All the individuals of one species in an area	A togo plant
Community	One organism	All the togo plants, ferns and mud crabs in an area
Population	All the living things and the environment – sky, sea, soil	A togo forest
Individual	All the living things in an area	The planet Earth
Organ system	A group of cells working together to carry out a specific function	The heart
Organ	A part of a cell	A skin cell
Tissue	A group of cells and tissues working together to carry out a function	The digestive system
Cell	An individual unit that can be the smallest free living 'unit of life'	Ribosome
Organelle	A group of organs working together to carry out a specific function	Muscle

Classification

There are millions of different types of living things. In order to manage all the knowledge related to all these organisms, biologists list similar organisms together in groups. For example, one group is called mammals. This is called **classification**. The classification system makes Biology easier for people because it allows them to list the main features common to all the organisms in that group. The classification system also allows newly discovered organisms to be grouped with organisms that have similar characteristics.

The classification system begins with very broad groups called **Kingdoms**. For example, the 'plant' kingdom. The organisms in each of the kingdoms are divided into smaller groups, **Phyla**. These groups are divided again and again until each living organism is in a group of its own.

For example:

Kingdom

Animalia

Some examples of animal Phyla

Porifera – sponges
Coelenterata – jelly fish
Platyhelminthes – flatworms
Mollusca – snails
Annelida – worms

(Singular – phylum, plural – phyla)

The main groups in the classification system are:

- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species.

There are other groups between these main groups. For example, 'subfamily' is a group between family and genus.

Scientific names

The scientific name of an organism is always at least two words. These are the genus name and its own individual species name. For example, laumei sami, the green turtle, is called *Chelonia mydas*. *Chelonia* is the genus name and *mydas* is the species name.

Activity 2 Classification

Purpose: To develop knowledge about classification and naming of organisms.

Sea turtle classification:

1. Work in groups of two or three.
2. Read the information below on the scientific classification of sea turtles.
3. Compare the features of the different types of organisms that are listed in each of phylum chordata, subphylum vertebrata, class reptilia, order testudine and suborder crytodira.
4. Discuss how the classification system shows relationships between different groups of organisms.
5. Discuss how the classification system helps with the study of biology.
6. Which two species of turtle are the most closely related? How does the classification system show that these two are the most closely related?
7. Choose one of the species of sea turtle. Use the classification information to list as many features as possible of the chosen species of turtle.

Scientific Classification of Sea Turtles

KINGDOM – **Animalia**

PHYLUM – **Chordata** includes animals that have a stiffening rod called a notochord and a pair of gill slits at some stage of their development. Chordates also have a skull, a single hollow dorsal nerve cord and two sets of paired limbs.

SUBPHYLUM – **Vertebrata** includes animals that have cartilage or bone vertebrae surrounding and usually replacing the notochord.

CLASS – **Reptilia** includes snakes, lizards, crocodiles, and turtles. Reptiles are ectothermic (cold-blooded). All reptiles have scaly skin, breath air with lungs, and have a three-chambered heart. Most reptiles lay eggs.

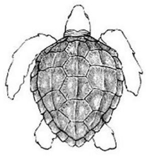
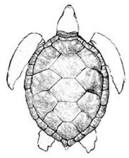
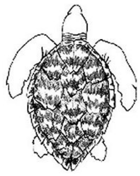
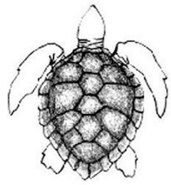
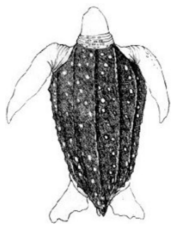
ORDER – **Testudines** includes all turtles and tortoises. It is divided into three suborders. Pleurodira includes side-necked turtles, Cryptodira includes all other living species of turtles and tortoises, and Amphichelydia includes all extinct species.

SUBORDER – **Cryptodira** includes freshwater turtles, snapping turtles, tortoises, soft-shelled turtles and sea turtles.

FAMILY – **Cheloniidae** or **Dermochelyidae**

Sea turtles fall into one of two families. Family Cheloniidae includes sea turtles which have shells covered with scutes (horny plates). Family Dermochelyidae includes only one modern species of sea turtle, the leatherback turtle. Rather than a shell covered with scutes, leatherbacks have leathery skin.

GENUS and SPECIES – Scientists currently recognize seven living species of sea turtles grouped into six genera.

Genus	Species	Common Name	Carapace Pattern
Caretta	*caretta*	loggerhead	
Chelonia	*mydas*	green turtle	
Eretmochelys	*imbricata*	hawksbill	
Lepidochelys	*kempii*	Kemp's ridley	
Lepidochelys	*olivaceaf*	olive ridley	
Natator	*depressus*	flatback	
Dermochelys	*coriacea*	leatherback	

Activity 3 Grouping organisms

1 Work in groups of two or three.

2 Research information to produce a poster that shows information about the features of the organisms in a kingdom, phylum or class. Include as many examples as you can of organisms in the kingdom, phylum or class.

Unit 2

Cell Biology

Achievement objectives

From their study of *Cell Biology* students will understand cell structure:

- ❑ **identify** and **state** the functions of: nucleus, chromosomes, mitochondrion, chloroplast, ribosome, Golgi apparatus, vacuole, cell membrane, cell wall, lysosome, rough and smooth endoplasmic reticulum, and centrioles
- ❑ **discuss** the differences between plant and animal cells
- ❑ **investigate** how surface area to volume ratio limits substances entering and leaving cells.

The Microscope

- ❑ **describe** the advantages and disadvantages of light and electron microscopes
- ❑ **use** a light microscope (low and high power) to view cells and tissues
- ❑ **draw** cells and tissues as seen under a light microscope
- ❑ **determine** size of a specimen under a light microscope
- ❑ **prepare** a wet mount of a biological specimen.

Cellular Respiration

- ❑ **write** a balanced equation for aerobic respiration of glucose
- ❑ **explain** how during glycolysis glucose is converted to pyruvic acid
- ❑ **explain** how pyruvic acid is broken down during the Krebs cycle
- ❑ **discuss** how most ATP is produced during the respiratory chain
- ❑ **compare** anaerobic respiration in muscle cells and in yeast cells
- ❑ **investigate** fermentation in yeast cells or respiration in germinating seeds.

Cell Transport

- ❑ **investigate** the processes of diffusion or osmosis
- ❑ **describe** the processes of diffusion and osmosis
- ❑ **explain** the importance of diffusion and osmosis in cell transport.

Enzymes

- ❑ **describe** the structure and function of enzymes
- ❑ **investigate** the effect of temperature on the action of enzymes
- ❑ **discuss** the effect of temperature on the structure and function of enzymes.

Key Learning Points

Cell structure

- ❑ **Functions of organelles** – Each cell organelle has a specific function that helps the cell to live. Each organelle has a special shape and structure that helps it to carry out its function. See **LifeScience** chapter 9, pages 76–83.
- ❑ **Differences between plant and animal cells** – Plant cells are involved in the support of the plant, therefore they have a strong cell wall outside their cell membrane and they often have a large vacuole that fills with a watery solution. Plant cells also have chloroplasts that are not found in animal cells. See **LifeScience** chapter 9, pages 82–83.
- ❑ **Surface area to volume ratio** – The size and shape of cells is important to the way they grow and function. When a cell gets large it no longer has enough surface area, compared to its volume, to allow diffusion of materials to occur quickly enough to keep the cell functioning well. The large cell will divide into two cells. Small cells have a larger surface area to volume ratio. See Investigation 2 **LifeScience** chapter 11, page 91.

Microscopes

- ❑ **Light and electron microscopes** – Different types of microscopes are suitable for looking at different sized objects. See **LifeScience** chapter 8, pages 70–71.
- ❑ **Using a light microscope** – A light microscope is important for viewing the fine detail of plant and animal organs and tissues. For example the shape and arrangement of cells. See Investigations 2, 3, 4, 5, 6, 7, 8, **LifeScience** chapter 8, pages 72–75.
- ❑ **Draw** cells and tissues – Biological drawings are a way of recording the shape and arrangement of cells in organs and tissues. See 'Biological drawings' in the **additional information** below and 'Observing and drawing' **LifeScience** chapter 8, page 73.
- ❑ **Measurement using a microscope** – A light microscope can be used to find out the size of objects smaller than 1 mm. See Activity 'Making Measurements using a microscope' in the **additional information** below.
- ❑ **Wet mount** – Material for viewing under a microscope is placed on a glass slide, a drop of water or stain is added and a coverslip is placed on top. Stains are used to colour parts of the biological material so that they are easier to see under the microscope. See Investigation 3, **LifeScience** chapter 8, page 73.

Cellular respiration

- ❑ **Aerobic respiration** – Respiration is a series of chemical reactions that most living things use to release energy from molecules such as glucose. In aerobic respiration, oxygen is needed during the chemical reactions. The energy released during respiration is held in a chemical called ATP. The energy in ATP can be used by the cell in other chemical reactions and life processes the cell is carrying out. See **LifeScience** chapter 12, page 96.
- ❑ **Glycolysis** – The process of respiration can be divided into parts. The first part is called glycolysis. During glycolysis glucose is changed into two pyruvate molecules (called pyruvic acid in some textbooks). See **Year 12 Biology** page 65 and the **additional information** below.
- ❑ **Krebs cycle** – This is the second part of respiration in which pyruvate is broken down to release carbon dioxide and energy. See **Year 12 Biology** page 65 and the **additional information** below.
- ❑ **Respiratory chain** – This is the last part of respiration but is the one in which oxygen is used and most ATP is produced. See the **Year 12 Biology** page 65 and **additional information** below.
- ❑ **Anaerobic respiration** – When there is not enough oxygen available for aerobic respiration human muscle cells carry out anaerobic respiration. In anaerobic respiration the pyruvate doesn't go into the Krebs cycle and instead is changed to lactic acid. Plant cells can also carry out anaerobic respiration but they make alcohol and carbon dioxide. See **LifeScience** chapter 12, pages 98–99.
- ❑ **Fermentation** in yeast cells or respiration in germinating seeds. Fermentation is another name for the process of anaerobic respiration. See Investigation 3, page 99 **LifeScience** and the **Year 12 biology** pages 66–67.

Cell transport

- ❑ **Investigate diffusion or osmosis** – See chapter 11 **LifeScience**.
- ❑ **Diffusion and osmosis** – Diffusion is the movement of any chemical from an area of high concentration to an area of low concentration. Osmosis is the movement of water across a semi-permeable membrane. See **LifeScience** chapter 11, pages 90–94.
- ❑ **Importance of diffusion and osmosis** – Diffusion and osmosis are important to the transportation of materials around a cell, between cells, and between cells and the transport system. Diffusion and osmosis do not use any energy from the cells. See **LifeScience** chapter 11, pages 90–94.

Enzymes

- ❑ **Structure and function of enzymes** – Enzymes are proteins. They have a special shape that allows them to work as a catalyst. Enzymes lower the energy needed before a reaction can occur so they are able to speed up and control reactions occurring in the cell. There are two models for enzyme action – lock and key (see **LifeScience** pages 88–89) and the induced fit model (see **Year 12 Biology** pages 72–73).
- ❑ **Investigate the effect of temperature** – The effect of temperature on the rate of an enzyme controlled reaction can be measured by placing tubes containing the reactants and the enzyme in containers of water at different temperatures. The reactions in the Investigation box on page 89 of

LifeScience and Investigation 7 and 8, **LifeScience** page 135, can be used. Saliva contains the enzyme amylase. A number of different fruits, e.g. pineapple, and vegetables have enzymes that will break down agar jelly – different fruits and vegetables could also be tested and suitable ones used for investigation.

- **Effect of temperature** – Because enzymes are proteins their three dimensional shape can be changed by heat. The changing of shape of an enzyme is called **denaturing** (the enzyme is said to be denatured). An enzyme that has been denatured can no longer catalyse a reaction because its active site is no longer the correct shape to hold the reactants. See structure of proteins, **LifeScience** page 86, and enzymes, **LifeScience** pages 88–89.

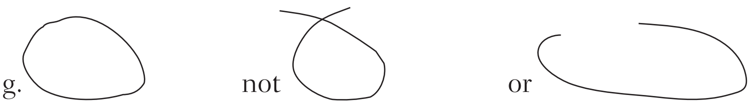
Additional Information

Biological drawings

A good drawing is an accurate record of what you have observed. It has only the amount of detail needed to clearly show the features of the material being observed.

Rules for drawing:

1. Use unlined paper if possible.
2. Always done in pencil.
3. **LARGE** enough to show detail clearly.
4. Parts **labelled** and ruled **arrows**.
5. **Title** included.
6. No shading as the material being viewed is so thin that it is almost two dimensional.
7. Complete outlines

e.g. 

8. Include the **magnification**.
9. Make **two drawings**: one at low power (LP) and one or more at high power (HP). The LP outline shows the relative sizes and positions of the different parts of the material. The HP drawings show details of small areas that are typical of various parts of the slide.

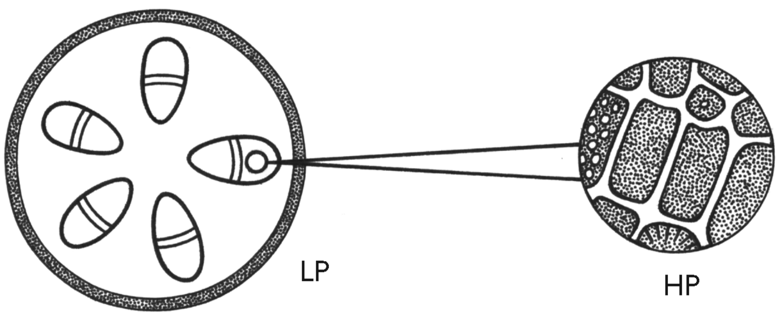


Figure 2.1 Example of LP and HP drawings

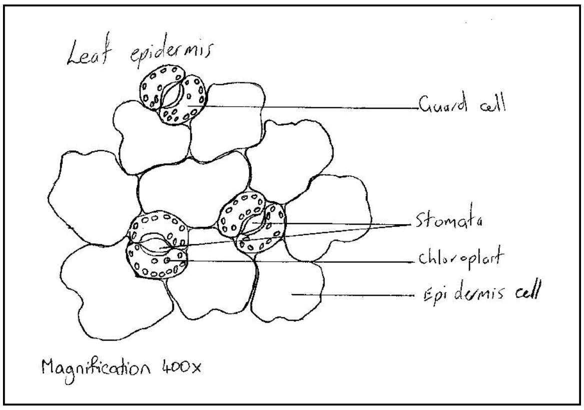


Figure 2.2 An example of a biological drawing

Activity 1 Making measurements with a microscope

Instructions:

Step 1

- **a** Turn to low power (LP).
- **b** Place a clear plastic rule on the stage and bring it into focus.
- **c** Measure and record the width of the LP field of view.

Step 2

Use the width of the LP field and the magnification to calculate the width of the field of view for the other objective lenses.

- **a** Record the magnification of the LP lens.
- **b** Record the magnification of the high power (HP) lens.
- **c** Divide the HP magnification by the LP magnification to get a 'factor'.

Step 3

Divide the width of the LP field of view by the factor to get the width of the HP field of view.

Step 4

Repeat 2 and 3 to get the width of the other fields.

Step 5

Calculation of cell size. This information can be used to calculate the size of objects under the microscope.

e.g. if the LP field is 1.6 mm and 4 cells fit across the field of view then:

1.6 ÷ 4 = 0.4 mm

Each cell is approximately 0.4 mm long.

Working

Step 1

Width of the LP field of view = ___ mm

e.g. 1.5 mm

Step 2

LP magnification = ___ x

e.g. 4x

HP magnification = ___ x

e.g. 40x

HP magnification ÷ LP magn = factor

e.g. 40 ÷ 4 = 10 factor = 10

Step 3

Width LP field of view ÷ factor = Width of HP

Width of HP = ___ mm

e.g. 1.5 ÷ 10 = 0.15

Width of HP field of view = 0.15 mm

Step 4

Calculation of width of other fields of view.

Step 5

Calculate the sizes of cells under LP, medium power (MP) and HP.

Aerobic Respiration

The series of chemical reactions that occur during respiration take a molecule of glucose and join it with oxygen to produce carbon dioxide and water. The chemical reactions in respiration are divided into three phases called:

Glycolysis – occurs in the cytoplasm of the cell.

Krebs cycle – occurs inside the mitochondria.

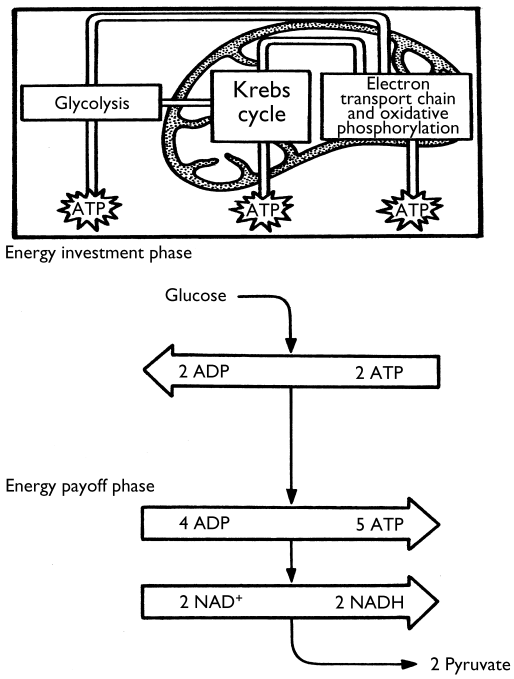
Respiratory chain – occurs on the internal walls of the mitochondria.

(See summary diagram 2.8, page 65, **Year 12 Biology**.)

The overall process of respiration releases 2830 kilojoules (kJ) of energy from each glucose molecule. The energy is not released all at once. It is released in small steps and each step is controlled by an enzyme. As the chemical bonds in the glucose molecule are broken down the energy released is used to join a phosphate group on to a molecule of ADP (adenosine diphosphate) to form ATP (adenosine triphosphate). The energy in ATP can then be used as an energy source by the cell. It can be used to make a protein, contract a muscle, form cell parts such as a cell wall, or actively transport materials across the cell membrane.

Most of the energy needed to change ADP into ATP comes from the energy held by the electrons associated with the 12 hydrogen atoms in the glucose molecule. The hydrogen atoms are split from the rest of the molecule during glycolysis and the Krebs cycle. The cell uses chemicals such as NAD (Nicotinamide Adenine Dinucleotide) to carry the hydrogen atoms to where they are used in the respiratory chain.

Glycolysis



Net
Glucose ⟶ 2 pyruvate + $2H_20$
2ADD + 2P ⟶ 2ATP
$2NAD^+$ ⟶ 2NADH + $2H^+$

Figure 2.3 Glycolysis

Glycolysis is a series of 10 steps controlled by different enzymes. The steps rearrange the atoms in glucose (six carbon atoms) and then split it into two atoms of pyruvate (three carbon atoms each). The steps at the beginning of glycolysis need energy to make them occur so two ATP molecules are used but the reactions at the end of glycolysis release energy to form four ATP. During glycolysis two NAD molecules become $NADH_2$.

Summary of what is formed from the one glucose molecule:

- 2 molecules of pyruvate
- 2 molecules of water
- 2 ATP
- 2 $NADH_2$

Krebs cycle

The pyruvate produced during glycolysis diffuses into a mitochondrion where it undergoes changes and is joined to coenzyme A to form acetyl coenzyme A. These changes split off a molecule of carbon dioxide and produce a molecule of $NADH_2$.

Acetyl coenzyme A joins with oxalocetate (the last chemical produced by the previous set of Krebs cycle reactions) to form citrate. The coenzyme A molecule is released and will join with another pyruvate molecule.

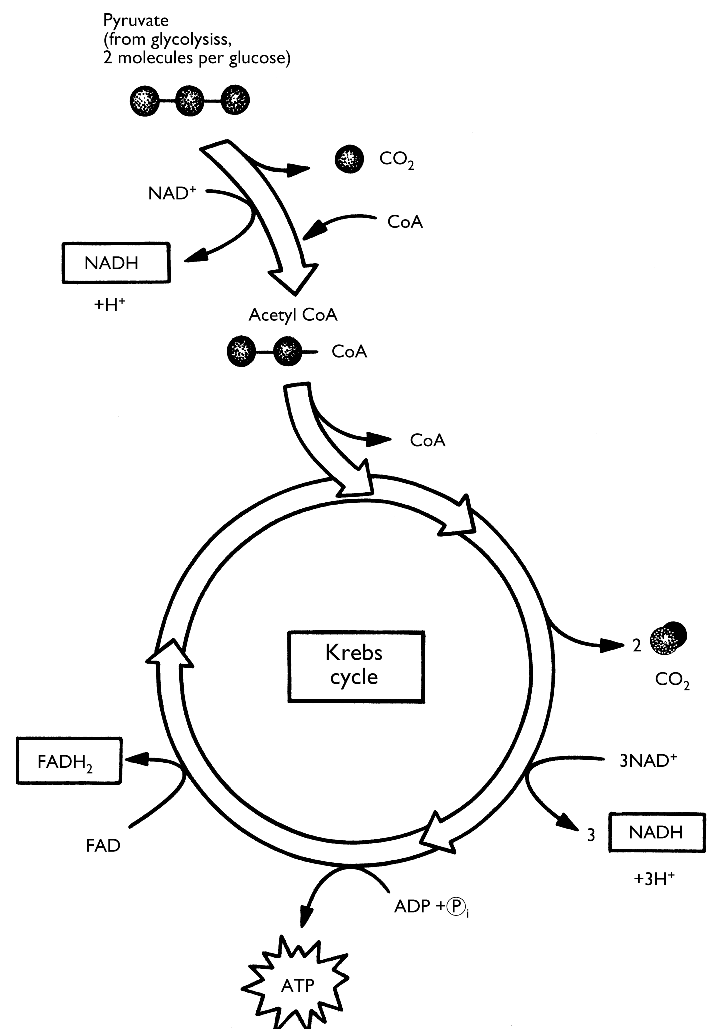


Figure 2.4 Krebs cycle

The citrate molecule then undergoes a series of enzyme-controlled reactions that rearrange the bonds between the oxygen, carbon and hydrogen atoms in order to split off carbon dioxide and hydrogen. This series of reactions is a called a 'cycle' because the chemical reactions are completed when the chemical that starts the cycle, oxalocetate, is produced again.

Summary of what is formed from the two pyruvate molecules (one glucose):

- ❑ six molecules of carbon dioxide
- ❑ eight molecules of $NADH_2$ and two of $FADH_2$
- ❑ two ATP

Two water molecules are used during the Krebs cycle.

Respiratory chain

The molecules used for the respiratory chain or electron transport chain reactions are held in place on the inner membranes of the mitochondria. These membranes are folded to increase the surface area. This means that each mitochondrion can hold thousands of sets of the molecules used in the respiratory chain reactions.

The $NADH_2$ and $FADH_2$ produced during glycolysis and the Krebs cycle are used in the respiratory chain reactions. The NAD and FAD are released to be used again. The last reaction in the respiratory chain uses oxygen to form water. The respiratory chain reactions release energy in small steps. This energy is used to produce a large amount of ATP.

Summary of what is formed as the result of one glucose molecule:

- ❑ 34 ATP molecules

Aerobic respiration summary

$C_6H_{12}O_6$ + 6 O_2 ➜ $6CO_2$ + $6H_20$ + energy held in 38 ATP molecules

Enzymes – induced fit model of enzyme action

The lock and key model of enzyme action suggests that the active site of an enzyme has a fixed shape. The induced fit model suggests that when the substrate molecule or molecules join onto the active site they cause a slight change in the shape of the enzyme. This makes the active site fit the shape of the reactants even more closely and therefore further improves that enzyme's ability to catalyse the reaction.

Genetics

Unit 3

Achievement objectives

From their study of *Genetics* students will understand Genetic material:

- ❑ **describe** the structure and function of chromosomes, DNA and RNA
- ❑ **describe** the process of protein synthesis stating the role of DNA, messenger RNA, transfer RNA, and ribosomes.

Mitosis And Meiosis

- ❑ **distinguish** between mitosis and meiosis
- ❑ **explain** the role of mitosis and meiosis in the life cycle of an organism
- ❑ **investigate** the appearance of chromosomes during mitosis and meiosis
- ❑ **describe** the sequence of events in mitosis and meiosis
- ❑ **discuss** the role of crossing over, recombination and independent assortment in producing variation in species.

Mendelian Inheritance

- ❑ **solve** monohybrid crosses involving complete dominance, co-dominance and incomplete dominance, e.g. Punnett squares, family tree diagrams, resource information
- ❑ **explain** inheritance patterns using the terms: phenotype, genotype, dominant allele, recessive allele, heterozygous, homozygous
- ❑ **explain** how the offspring from a test cross may indicate the genotype of an individual
- ❑ **explain** the effect of multiple alleles on phenotype, e.g. human blood groups
- ❑ **explain** how sex is determined in mammals by X and Y chromosomes
- ❑ **solve** dihybrid crosses involving complete dominance.

Speciation

- ❑ **describe** the causes of mutation
- ❑ **explain** how mutation may produce variation in a population

- ❑ **discuss** natural selection as the process in which better adapted individuals are more likely to survive and reproduce
- ❑ **explain** how speciation results from geographical and reproductive isolation.

Applications Of Genetics

- ❑ **describe** how selective plant and animal breeding can produce different genotypes and different phenotypes
- ❑ **discuss** how humans use genetic engineering to produce organisms and substances of benefit to them
- ❑ **discuss** ethical issues associated with the genetic manipulation of organisms.

Key Learning Points

Genetic material

- ❑ **Chromosomes, DNA and RNA** – Chromosomes are long thin twisted structures that are made up of the chemicals DNA and proteins. The DNA in the chromosomes carries information necessary for the growth and functioning of the cell. RNA is similar to DNA. RNA is formed in the cell nucleus and is a copy of a part of the information carried by the DNA. RNA is used during protein synthesis. Structure and function of chromosomes is described on page 80 of **LifeScience** under the heading 'nucleus' and on pages 107–108. The structure and function of DNA and RNA are described on **LifeScience** pages 104–105.
- ❑ **Protein synthesis** – Much of the structure of cells as well as the enzymes are made up of proteins therefore it is important for cells to be able to make proteins. This process is described on page 105 **LifeScience**.

Mitosis and meiosis

- ❑ **Mitosis and meiosis** – Mitosis is cell division that occurs during growth, repair and replacement of cells. Two cells with the same number of chromosomes as the parent cell are produced each division. Meiosis only occurs in reproduction to form the gametes. Four cells are produced, each with half the number of chromosomes as the original cell. See **LifeScience** pages 110–13. See also http://www.hcs.ohio-state.edu/hcs300/genetic.htm.
- ❑ **Role of cell division** – Meiosis allows gametes to be produced that can combine, during sexual reproduction, to produce a zygote with the same number of chromosomes as in the cells of the original organism. Mitosis allows a new individual to grow into a multicellular organism from the one cell, the zygote, produced at fertilisation. See **LifeScience** pages 110–13.
- ❑ **Appearance of chromosomes** – Chromosomes can only be seen with a light microscope when they are coiled up and ready to divide. See photographs, **LifeScience** page 110–11 and Investigation 2, **LifeScience** page 111.
- ❑ **Sequence of events in cell division** – See **LifeScience** pages 110–13.
- ❑ **Producing variation in species –** During meiosis the pairs of homologous chromosomes line up together. They can line up together in different

combinations each time meiosis occurs. This process is called **independent assortment**.

When the chromatids of the homologous pairs are close together, the ends of the chromatids can sit over each other. This is called **crossing over**. When the ends of one chromatid are crossed over the other, the ends can break off and reattach to the other chromatid of the pair. This produces chromatids with new combinations of alleles. This is called **recombination**. See **LifeScience** pages 112–14.

Mendelian Inheritance

- ❑ **Monohybrid crosses** – Monohybrid crosses consider the inheritance of one gene at a time. The alleles of that gene can show complete dominance, co-dominance and incomplete dominance. See **Year 12 Biology**, 'The study of genetics', pages 92–107 and **additional information** (co-dominance and incomplete dominance) below.
- ❑ **Using genetic terms** – phenotype, genotype, dominant allele, recessive allele, heterozygous, homozygous. See **Year 12 Biology**, 'The study of Genetics', pages 92–107.
- ❑ **Test cross** – A test cross involves the use of a cross to a homozygous recessive individual in an attempt to indicate the genotype of an individual as homozygous dominant or heterozygous. See Game two, **Year 12 Biology**, page 96 and page 101.
- ❑ **Multiple alleles** – Some characteristics have more than two different alleles. This means that more than two different phenotypes occur. Human blood groups are an example of multiple alleles. See **additional information** below.
- ❑ **Sex determination** – In mammals the gender of the individual is determined by the inheritance of the X and Y chromosomes. See **Year 12 Biology**, pages 107–8.
- ❑ **Dihybrid crosses** – Monohybrid crosses consider only one characteristic at a time, e.g. flower colour. Dihybrid crosses consider two characteristics at a time, e.g. flower colour and shape of the seed. See **additional information** below. See also http://www.riverdeep.net/science/biology_gateways/bg_handouts/gen/gend5tni.pdf+Dihybrid+inheritance&hl=en.

Speciation

- ❑ **Mutation** – Mutations are changes in the chromosomes or the DNA. They occur naturally when mistakes are made during DNA replication and meiosis. Mutations do not occur very often but when cells are exposed to mutagens the rate of mutation increases. See **additional information** below.
- ❑ **Mutations produce variation** – Mutations produce new alleles of a gene which produces possible new phenotypes. New alleles mean more variation in the genotypes and phenotypes seen in a population of living things. See **additional information** below and 'Variation' **LifeScience** page 114.
- ❑ **Natural selection** – When the environment a population of organisms is living in changes, the individuals that have genes making them better able to adapt are more likely to survive and reproduce. See **LifeScience** page 114.

- **Geographical and reproductive isolation** – Over long periods of time groups of organisms of the same species can become isolated from each other. This can be because of a geographical barrier such as living on two different islands or it can be a reproductive barrier. A reproductive barrier stops individuals from the two groups from mating and producing fertile offspring. The reproductive barrier can occur at different stages in the reproductive cycle. For example, horses and donkeys can mate and produce offspring, which means that their reproductive structures and behaviour are similar. But the offspring produced, called mules and asses, are infertile and are not able to reproduce. See **LifeScience** page 114.

Applications of Genetics

- **Selective plant and animal breeding** – Over many years humans have selected individual animals and plants with the characteristics they want and then bred them to produce more and more individuals with the desired characteristics. Pigs and esi are examples of organisms that have been developed by selective breeding. See **additional information** below.
- **Genetic engineering** – As scientists have learnt more and more about inheritance they have discovered ways to transfer genetic information from one organism to another. This means that an organism can be given a characteristic it would not normally have. See **additional information** below.
- **Ethical issues** – The ability to change the genetic make up of organisms has raised a number of issues that people are discussing in order to decide if they want genetic manipulation of organisms. This is particularly important in the case of organisms that people use as food. See **additional information** below.

Additional Information

Dominance

Almost all of the examples of inheritance studied in science and year 12 biology are examples of complete dominance of one allele over another. When one allele is completely dominant over another, the phenotype of the homozygous dominant and the heterozygous individuals are the same. Co-dominance and incomplete dominance are examples of alleles where one allele is not completely dominant over the other.

Incomplete dominance occurs when the action of one allele does not completely hide the action of the other. In incomplete dominance the phenotype of the heterozygous individual is somewhere between the phenotypes of the homozygous dominant and the homozygous recessive. An example is the colour of flowers on a plant called a snapdragon. When a red flowered plant is crossed with a white flowered plant the flowers of the offspring are pink. In this case both of the incompletely dominant alleles have worked together to give the pink colour which is an intermediate colour between red and white.
Co-dominance occurs when the action of each of the two alleles shows in the phenotype of the heterozygous individual. Both alleles are equally and independently expressed. For example when a red cattle beast is crossed with a white cattle beast the offspring are roan coloured. Roan colouring is caused by a mix of red and white hairs. The red and the white colour are expressed equally and independently, not mixed to give pink.

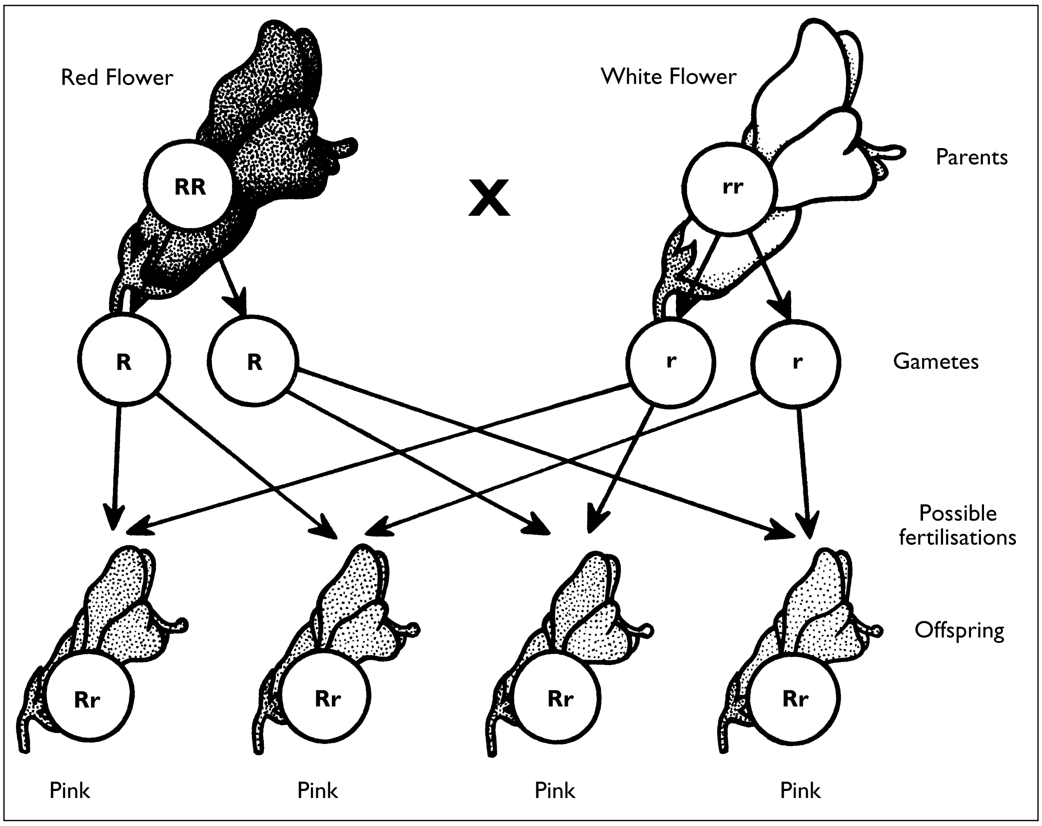


Figure 3.1 Incomplete dominance

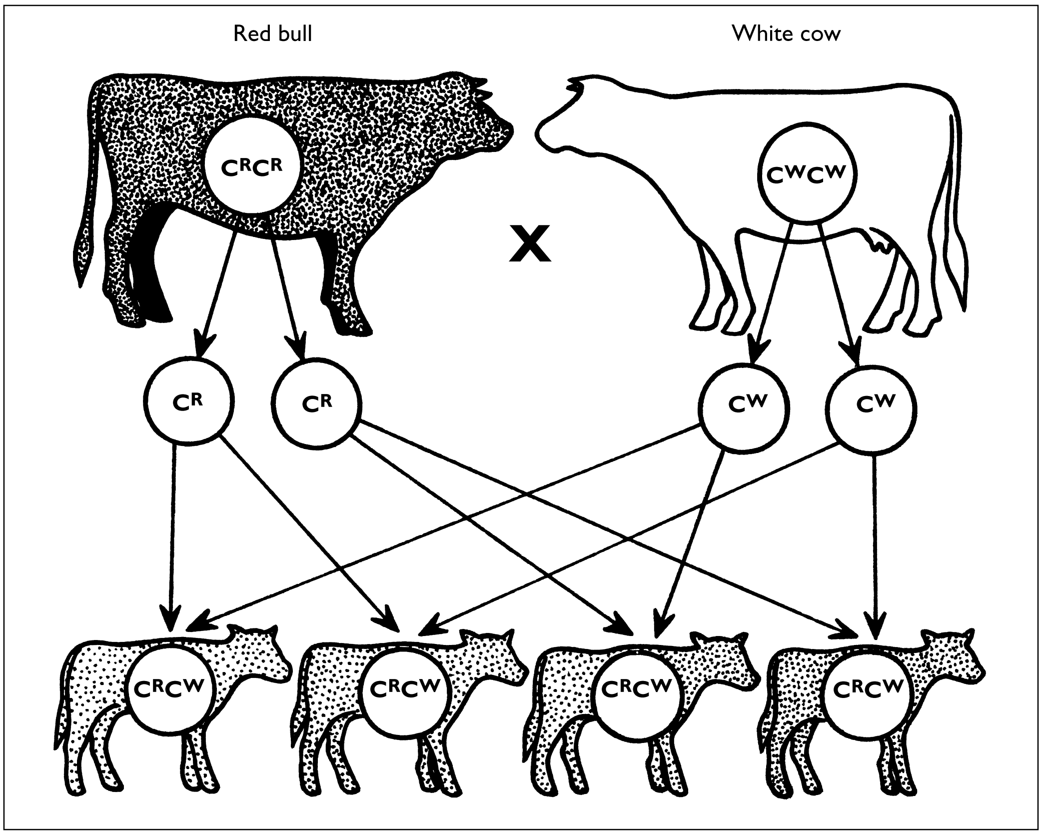


Figure 3.2 Co-dominance

Note how the co-dominance alleles are written.

Activity 1 Incomplete dominance

Aim: To work out the genotype and phenotype ratios for incompletely dominant alleles.

1 What is incomplete dominance of alleles?

2 Work out the genotype and phenotype ratios for each of the following crosses between two snapdragon plants. Rule up punnett squares if needed.

1 RR x RR
2 RR x Rr
3 RR x rr
4 Rr x Rr
5 Rr x rr
6 rr x rr

3 Compare the phenotype ratios gained above with the ratios from the same crosses with a dominant and a recessive allele.

4 Read the following information then explain to a partner how red, white and pink flowers are produced.

> 'For one to fully understand the possibility of pink flowers, remember that the gene for flower colour controls the amount of pigment in the flower petals. Each allele is a code for a specific amount of pigment. When both alleles for pigment are present, the petals have a dark red colour due to the heavy production of pigment. On the other hand, if none of the alleles for pigment exist, the flower is then white. When one of the alleles is present, only half the pigment is produced, creating a pink shade.'
>
> ***http://library.thinkquest.org/20465/genes.html***

5 A plant breeder studied the flowering time of one type of plant growing in the garden. One parent always flowered early and the other parent always flowered late. When given the same conditions 25 % of the offspring flowered early, 25 % flowered late and 50 % flowered somewhere in the middle. Explain these results.

Activity 2 Co-dominance

Aim: To work out the genotype and phenotype ratios for co-dominant alleles.

1 What is co-dominance of alleles?

2 Work out the genotype and phenotype ratios for each of the following crosses between two cattle. Rule up punnett squares if needed.

1 C^RC^R x C^RC^R
2 C^RC^R x C^RC^W
3 C^RC^R x C^WC^W
4 C^RC^W x C^RC^W
5 C^RC^W x C^WC^W
6 C^WC^W x C^WC^W

3 Compare the phenotype ratios gained above with the ratios from the same crosses with a dominant and a recessive allele.

4 Humans have two different proteins on the outside of their red blood cells. The proteins are given the letters N and M. People can have one of three different phenotypes; N, M or NM. An N person has only N protein on their red blood cells and an NM person has both proteins on their red blood cells. Explain how the three phenotypes are produced.

Multiple alleles

Some characteristics have more than two alleles. This is called multiple alleles. Human blood groups are an example of multiple alleles. Three alleles code for blood groups. The alleles are I^A, I^B and i. The I^A, I^B alleles are co-dominant. The following table shows the blood groups and the alleles that produce them.

Blood Group	Genotype
O	ii
A	I^AI^A or I^Ai
B	I^BI^B or I^Bi
AB	I^AI^B

Another example of multiple alleles is hair colour in mice. This characteristic is determined by a single gene with a series of alleles that give different coat colours. There are alleles for black, brown, agouti, grey, albino, and others. The mouse coat colour alleles can be dominant or recessive depending on which alleles are present. Therefore multiple alleles are often written as a series. For example agouti > black > albino. This means that agouti is dominant to black, and black is dominant to albino. (And agouti is necessarily also dominant to albino.) If the black allele is in the presence of an agouti allele, the mouse will be agouti because black is recessive to agouti. If that same black allele is paired with an albino allele, the mouse will be black since black is dominant to albino.

Adapted from http://www.newton.dep.anl.gov/askasci/mole00/mole00087.htm

Activity 3 Multiple alleles

Aim: To work out the genotype and phenotype ratios for multiple alleles.

1 Work out the genotype and phenotype ratios for each of the following crosses. Rule up punnett squares if needed.

1 ii x ii
2 I^AI^A x ii
3 ii x I^Ai
4 I^BI^B x ii
5 I^Bi x ii
6 I^AI^B x ii
7 I^AI^A x I^BI^B
8 I^Bi x I^Ai
9 I^AI^B x I^Ai
10 I^AI^B x I^AI^B
11 I^BI^B x I^Ai
12 I^AI^A x I^Ai

2 Explain how mice with black and albino coat colours occur.

Dihybrid inheritance

Punnett squares can be used to work out dihybrid crosses. The punnett squares can be as large as 4 by 4 because of the number of gametes that can be produced.

Consider two characteristics: height of plant where tall (T) is dominant to short (t) and seed colour where yellow (Y) is dominant to green (y).

a When gametes are formed, each gamete contains one allele for each characteristic.

What gametes will be produced by a plant that is homozygous dominant for both characteristics and one that is homozygous recessive for both?

TTYY x ttyy

The first plant can only produce TY gametes and the second can only produce ty.

Notice that each gamete has one allele for the height characteristic and one for the seed colour characteristic.

b What offspring can be the produced from this cross?

Only TtYy, tall with yellow seeds, can be produced.

Notice that the offspring have two alleles for each characteristic and that the alleles for the first characteristic are written together first, then the alleles for the second characteristic are written next.

A cross between a plant homozygous dominant for both characteristics and a plant that is heterozygous for both characteristics:

TTYY X TtYy

The first plant can only produce TY gametes but the second plant can produce four types of gametes TY, Ty, tY and ty.

A Punnett square can be used to show the possible offspring:

	TY	Ty	tY	ty
TY	TTYY	TTYy	TtYY	TtYy

There are four possible genotypes for the offspring as shown by the Punnett square. All four genotypes give a tall plant with yellow seeds.

If two plants that are heterozygous for both traits are crossed, a 4 x 4 Punnett square must be used:

TtYy x TtYy

Each parent can produce four gametes TY, Ty, tY and ty

	TY	Ty	tY	ty
TY	TTYY	TTYy	TtYY	TtYy
Ty	TTYy	TTyy	TtYy	Ttyy
tY	TtYY	TtYy	ttYY	ttYy
ty	TtYy	Ttyy	ttYy	ttyy

Genotypes	Phenotypes	Phenotype ratio
1 TTYY	Tall yellow	9 tall yellow: 3 tall green: 3 short yellow: 1 short green
2 TTYy	Tall yellow	
2 TtYY	Tall yellow	
1 TTyy	Tall green	
4 TtYy	Tall yellow	
2 Ttyy	Tall green	
1 ttYY	Short yellow	
2 ttYy	Short yellow	
1 ttyy	Short green	

Two heterozygous parents produce offspring with 4 different phenotypes in the ratio of

9 : 3 : 3 : 1

Activity 4 Dihybrid inheritance

Aim: To work out the gametes, genotype and phenotype ratios for dihybrid crosses.

1 Work out the gametes that can be produced from each of the following crosses. Draw up a Punnett square for each and then work out the genotypes of the possible offspring.

1 AaBb x Aabb
2 AaBb x AaBb
3 AaBb x AaBB
4 Aabb x AABB
5 AaBb x aabb
6 AABb x aabb

2 Use the following information to set up a number of dihybrid crosses and use Punnett squares to work out the genotypes and phenotypes of the possible offspring.

Characteristic	Dominant trait	Recessive trait
Flower colour	Purple flower (P)	White (p)
Flower position	Flower on the side of the stem (A)	Flower on top of stem (a)
Seed colour	Yellow seed (Y)	Green seed (y)
Seed shape	Round seed (R)	Wrinkled seed (r)
Pod shape	Full pod (F)	Tight pod (f)
Pod colour	Green pod (G)	Yellow pod (g)
Height	Tall plant (T)	Short plant (t)

3 *Book 1, year 11, Science* pages 55 and 56 have diagrams showing human characteristics. Use the information to develop a set of dihybrid inheritance problems to test yourself and other class members.

4 Type dihybrid inheritance into a web search engine such as Google and investigate the websites found. For example:

http://www.renaissoft.com/april/cgi-bin/wiki.pl?Genetics_-_Dihybrid_Inheritance_(Basic_Biology_Textbook)

http://www.biology.arizona.edu/mendelian_genetics/problem_sets/dihybrid_cross/dihybrid_cross.html

Mutation

A **mutation** is a change in the DNA of an organism. The change is often harmful to the cell in which the mutation occurs. Mutations in body cells can give rise to cancers by promoting uncontrolled cell division. If the mutation occurs in a body cell it will only affect that cell and the cells produced from it. But if the mutation occurs in a gamete (egg or sperm cell), all the cells produced from the gamete will have the mutation. Mutations in a gamete may result in a genetic disorder such as haemophilia.

Mutations do not occur very often but the number increases when cells are exposed to chemicals or physical agents called **mutagens**. Mutagens include:

- high energy radiation such as ultraviolet light, X-rays, atomic radiation
- chemicals – for example nitrous acid, found in cigarette smoke and formaldehyde
- temperature – when the temperature of reproductive cells is increased, the mutation rate increases.

Most mutations are harmful to the cell or organism that they occur in but sometimes a mutation will occur that is either helpful or neutral (not harmful or helpful). A mutation produces a new, different allele for a gene. This increases the variation in the population of living things.

Selective plant and animal breeding

Plant and animal breeders are trying to produce organisms that have desirable characteristics, such as high crop yields, e.g. ufi, ability to run faster, e.g. race horses, resistance to disease, e.g. talo, and high growth rate, e.g. fa'i. This is usually done by crossing two members of the same species which possess the desirable characteristics. When they are crossed they may produce at least some offspring that will show the desirable characteristics. Animal and plant breeders continuously track which characteristics are possessed by each organism so that, when the breeding season comes again, they can selectively breed the organisms to produce more favourable characteristics in the offspring and more offspring with the desirable characteristics.

This process of selecting parents is called artificial selection or selective breeding. Use of selective breeding over thousands of years has allowed people to increase the efficiency of the animals and plants we breed, such as increasing milk yield from cows by continuously selecting and breeding high milk-yielding cows.

Continuous in-breeding and selective breeding for particular alleles usually results from the loss of some of the other alleles from the gene pool altogether. These alleles cannot be replaced and the rate of production of new alleles from mutations is very slow. Usually it is best for organisms to be heterozygous. For example, a wider variety of alleles means the gene pool of a species is prepared for a wide range of possible futures such as food shortage or an epidemic of disease. Some alleles in some organisms may provide the organism with immunity against the disease, or an ability to go long periods of time without food. If continuous selective breeding has occurred in a species, some of these alleles may have been bred out of the population because the breeder was selecting for other alleles considered more desirable in the past.

In the long term, selective breeding reduces genetic diversity. Under natural conditions breeding would be more random, and would produce offspring that are more variable.

Adapted from http://www.biology-online.org/2/12_selective_breeding.htm

Genetic Engineering

Activity 5 Genetic engineering

1 Read the following information from the website: http://www.biology-online.org/2/13_genetic_engineering.htm

During the latter stage of the twentieth century, humans harnessed the power of the atom, and not long after, realised the power of genes. Genetic engineering is going to become a very mainstream part of our lives sooner or later, because there are so many possible advantages (and disadvantages) involved. Here are just some of the advantages:

- ❑ Disease could be prevented by detecting people/plants/animals that are genetically prone to certain hereditary diseases, and preparing for the inevitable. Also, infectious diseases can be treated by implanting genes that are coded for antiviral proteins specific to each antigen.
- ❑ Animals and plants can be 'tailor made' to show desirable characteristics. Genes could also be manipulated in trees, for example, to absorb more CO_2 and reduce the threat of global warming.
- ❑ Genetic engineering could increase genetic diversity, and produce more variant alleles which could also be crossed over and implanted into other species. It is possible to alter the genetics of wheat plants to grow insulin, for example.

Of course there are two sides to the coin. Here are some possible eventualities and disadvantages:

- ❑ Nature is an extremely complex inter-related chain consisting of many species linked in the food chain. Some scientists believe that introducing genetically modified genes may have an irreversible effect with consequences yet unknown.
- ❑ Genetic engineering touches on many moral issues, particularly those involving religion, which question whether humans have the right to manipulate the laws and course of nature.

Genetic engineering may be one of the greatest breakthroughs in recent history, alongside the discovery of the atom and space flight. However, with the above eventualities and facts in hand, governments have produced legislation to control the sort of experiments that are done involving genetic engineering. In Great Britain there are strict laws prohibiting any experiments involving the cloning of humans. However, here are some of the experimental 'breakthroughs' made possible over the years by genetic engineering.

- At the Roslin Institute in Scotland, scientists successfully cloned an exact copy of a sheep, named 'Dolly'. This was the first successful cloning of an animal and most likely the first occurrence of two organisms being genetically identical. Note: Recently the sheep's health has deteriorated.
- Scientists successfully manipulated the genetic sequence of a rat to grow a human ear on its back. (Unusual, but for the purpose of reproducing human organs for medical purposes.)
- Most controversially, and maybe due to more liberal laws, an American scientist is currently conducting tests to clone himself.

Genetic engineering has been impossible until recent times due to the complex and microscopic nature of DNA and its component nucleotides. Through progressive studies, more and more in this area is being made possible, with the above examples only showing some of the potential that genetic engineering has.

To help us understand chromosomes and DNA more clearly, they can be mapped for future reference. Simpler organisms such as the fruit fly (Drosophila) have been chromosome-mapped because their nature means they need less genes to operate. At present, a task named the Human Genome Project is mapping the human genome and should be completed in the next ten years.

The process of genetic engineering involves splicing an area of a chromosome, a gene, that controls a certain characteristic of the body. The enzyme endonuclease is used to split a DNA sequence and split the gene from the rest of the chromosome. For example, this gene may be programmed to produce an antiviral protein. This gene is removed and can be placed into another organism. For example, it can be placed into bacteria, where it is sealed into the DNA chain using ligase. When the chromosome is once again sealed, the bacteria is now effectively re-programmed to replicate this new antiviral protein. The bacteria can continue to live a healthy life, though genetic engineering and human intervention have actively manipulated what the bacteria actually is.

No doubt there are advantages and disadvantages, and this whole subject area will become more prominent over time.

a List the advantages of genetic engineering.

b List the disadvantages of genetic engineering.

c What is your view? Discuss the reasons why different people have different views on genetic engineering.

d Carry out research into the current uses of genetic engineering.

e Discuss how humans use genetic engineering to produce organisms and substances of benefit to them.

Ethical issues

Different people have differing views on the ethical issues relating to the use of genetic engineering. For example, a person with diabetic family members, who have benefited from the use of insulin produced by genetically engineered bacteria, is more likely to agree with the use of genetically modified organisms. The following activity explores differing points of view.

Activity 6 Round table conference

Aim: To develop understanding of differing points of view relating to the use of genetic engineering.

1. Brainstorm examples of groups of people that might hold an opinion or view on genetic engineering. For example a scientist, a diabetic patient.
2. Divide into groups of three or four. If you have five groups of people, select five groups/people from the brainstorm that have differing points of view. Allocate one group/person to each of the groups of people. Each group will represent the group/person they have been allocated and will put forward the point of view of that group/person in a discussion.
3. Each group has 15 minutes to discuss the points of view they think the group/person that they have been allocated would hold and the reasons why they would hold those points of view. The reasons could be biological/environmental, economic, cultural/attitudes/values/beliefs, societal or ethical.
4. Each group develops a two to five minute speech that puts forward the point of view of the group or person they are representing and explains why they hold those points of view. (This could be completed overnight or after a week or more of research.)
5. Each group appoints a speaker to represent the group/person and makes a label for their group/person, e.g. a folded piece of paper that sits in front of the speaker.
6. The speakers from each group sit in a circle around the chairperson controlling the round table conference. The rest of the group members sit behind their speaker.
7. The speakers take turns to deliver the points of view of their group/person. The other group members take notes and begin to think about ideas that they can make for or against the other groups.
8. After each speaker has spoken the groups re-form to discuss further points they wish to make for or against other groups.
9. The speakers form a circle again and the chairperson works out the order in which groups speak. Each speaker can speak more than once as points are raised and debated. The other group members can write notes and hand it to their speaker.
10. When the debate has slowed or time is just about up, the chairperson asks any of the non-speaker members of the groups if they wish to have a say.
11. After any others have spoken the groups reform and plan their concluding statement which summarises their main points and reasons – one to two minutes long.
12. The chairperson finishes by making an overall statement about the opinions of the groups represented.

Unit 4

Plants

Achievement objectives

From their study of *Plants* students will understand leaf structure:

- ❑ **investigate** the internal structure of a leaf
- ❑ **explain** the functions of leaf parts in photosynthesis.

Photosynthesis

- ❑ **write** a balanced chemical equation for photosynthesis
- ❑ **investigate** the extraction and separation of leaf pigments
- ❑ **explain** the structure and function of chloroplasts
- ❑ **describe** the light and dark phase reactions
- ❑ **explain** the link between the light and dark phase reactions.

Factors Affecting The Rate Of Photosynthesis

- ❑ **investigate** the effect of a factor on the rate of photosynthesis
- ❑ **explain** how factors affect the rate of photosynthesis; carbon dioxide concentration, light intensity, water, temperature.

Gas Exchange

- ❑ **describe** the exchange of gases for photosynthesis and respiration
- ❑ **investigate** the external structure of a leaf
- ❑ **explain** how the guard cells control the movement of gases.

The Role Of Stem And Cell Structures

- ❑ **explain** why some plants need a system for support and transport of materials
- ❑ **investigate** the structure of stem tissues
- ❑ **discuss** the structure and function of the stem tissues in support and transport
- ❑ **investigate** a factor affecting cell turgidity
- ❑ **explain** the function of cell turgidity in plant support.

Transpiration

- ❑ **explain** the role of transpiration in support, transport and cooling of the plant
- ❑ **investigate** a factor that affects the rate of transpiration
- ❑ **discuss** how environmental factors affect transpiration rate.

The Role Of Root Structures

- ❑ **investigate** the structure of root tissues
- ❑ **explain** the structure and function of root cells and tissues in transport
- ❑ **describe** the process of translocation
- ❑ **explain** the role of translocation in the transport and storage of materials.

Reproductive Structures And Processes

- ❑ **discuss** the advantages and disadvantages of sexual and asexual reproduction
- ❑ **investigate** the structure of flower parts
- ❑ **explain** the structure and function of flower parts in sexual reproduction
- ❑ **investigate** the processes of pollination, fertilisation, seed development and fruit development
- ❑ **discuss** the processes involved in sexual reproduction of flowering plants
- ❑ **compare** the alternation of sporophyte and gametophyte generations in ferns and angiosperms.

Key Learning Points

Leaf structure

- ❑ **Internal structure** – The internal structure of leaves is adapted to make the carrying out of photosynthesis more efficient. Leaves are also adapted to conserve water. See **LifeScience** pages 214–5.
- ❑ **Functions of leaf parts** – The cells in leaves are arranged in layers. Some cells in a leaf carry out photosynthesis and some do not, they have other functions. See **LifeScience** pages 214–5.

Photosynthesis

- ❑ **Chemical equation** – Photosynthesis produces sugars for the plant. The plant uses light energy and chlorophyll to split water molecules. A series of reactions is used to change carbon dioxide and join it to the hydrogen from the water. See **LifeScience** pages 206–7.
- ❑ **Extraction and separation of leaf pigments** – Leaves have a range of different pigments that are involved in photosynthesis. Chlorophyll is the most common one. See Investigations 1, 2 and 3, **LifeScience** page 102.

- **Structure and function of chloroplasts** – Chloroplasts are organelles containing lots of membranes that hold in place the enzymes used in photosynthesis. See **LifeScience** pages 82 and 100.
- **Light and dark phase reactions** – Photosynthesis begins with two separate sets of reactions. The light phase reactions use light energy and chlorophyll to split water into hydrogen and oxygen. The dark phase reactions 'fix' carbon dioxide gas into the chemical glucose. The term 'carbon dioxide fixation' means to change inorganic carbon dioxide gas into the organic compound glucose. See **LifeScience** pages 100–3.
- **Link between phases** – The light phase and dark phase are linked because the hydrogen produced during the light phase is used in the dark, carbon dioxide fixation phase. See **LifeScience** pages 100–3.

Factors affecting the rate of photosynthesis

- **Investigate the effect of a factor** – The rate of photosynthesis is controlled by a number of factors such as temperature, wavelength of light, intensity of light, carbon dioxide concentration and water. See **LifeScience** pages 209–10.
- **How factors affect the rate of photosynthesis** – The rate of photosynthesis is controlled by the amount of materials or light energy available. For example, if the level of light is low, photosynthesis will be low. If the light intensity is high and the rate of photosynthesis is still low then one of the other factors is limiting the rate. See **LifeScience** pages 209–10.

Gas exchange

- **Exchange of gases** – All plant cells carry out respiration and some plant cells, those containing chloroplasts, also carry out photosynthesis. During the day when photosynthesis is occurring the cells need carbon dioxide. Carbon dioxide enters the leaf through the stomata. Some of the oxygen produced during photosynthesis is used in leaf cell respiration but most of it is released through the stomata. At night only respiration is occurring so oxygen diffuses into the stomata and carbon dioxide is released. See **LifeScience** page 215 section on 'Air spaces'.
- **External structure of a leaf** – The shape and structure of leaves is designed to help them carry out photosynthesis and to control the amount of water the plant is losing. See **LifeScience** pages 211–13.
- **Guard cells** – Guard cells work in pairs. They have a special shape with a thickened wall so that they can change shape to open and close a gap between them. The gap is opened and closed to control the exchange of gases and the movement of water out of the leaf. See **LifeScience** pages 212–13.

The role of stem and cell structures:

- **Need for support and transport**. Plants need a support system to hold their leaves up to reach the light and a transport system to move materials around the plant. See **LifeScience** pages 216 (transport) and 224 (support).
- **Investigate the structure of stem tissues** – The tissues in stems can be investigated by cutting several thin sections of a stem or petiole into water and then using the thinnest section to make a wet mount. See Investigation 1 and 2, **LifeScience** page 216.

- **Structure and function of stem tissues** – The stems of plants are made up of three types of cells, parenchyma, collenchyma and sclerenchyma, as well as two groups of cells called xylem and phloem. These cell types are organised into three types of tissue – epidermis, vascular and ground tissues. See **additional information** below and **LifeScience** pages 216–17.
- **Cell turgidity** – Cells become turgid when they contain enough water in their vacuoles to push the cell contents hard against the cell wall. See **LifeScience** pages 93, 94, 224.
- **Investigate cell turgidity** – Cell turgidity is affected by the amount of water present in the soil, transpiration rate and the concentration of dissolved solutes in the soil or water. Carry out Investigation 5, **LifeScience** page 93 using different types of plant material. Observe differences in the flexibility of the plant material in the different solutions. Plan and carry out your own experiments.

Transpiration:

- **Role of transpiration** – Transpiration is the loss of water from a plant. Water evaporates from around the cells inside a leaf. This allows the gases carbon dioxide and oxygen to dissolve so that they can diffuse into the cells. The water is lost from the leaf because it diffuses down a concentration gradient and out through the stomata. See **LifeScience** page 218.
- **Investigate** a factor that affects the rate of transpiration – The rate of water loss changes in different conditions. The rate of transpiration can be measured with a weight potometer or a bubble potometer. The effect of different environmental conditions on the same plant could be tested, or different plants could be placed in the same conditions and their transpiration rates compared. See **LifeScience** page 219.
- **Effect of environmental factors** – temperature, humidity and wind are examples of environmental factors that affect transpiration rate. Temperature changes the diffusion and evaporation rates while humidity and wind change the concentration gradients for water. See **additional information** below and **LifeScience** pages 226–227 ‘Coping with difficult environments’, and questions 4 and 5 on pohutukawa on page 227.

The role of root structures

- **Investigate structure of root tissues** – most of the tissues found in roots have the same structure as in the stems but root tissues are arranged in a different way. Produce microscope slides of roots and observe the arrangement of cells and tissues. See **additional information** below.
- **Structure and function of root cells and tissues** – root hair cells are adapted to absorb water from the soil. Cells in the epidermis and root cap protect the root and the cortex cells store sugars. See **Year 12 Biology**, pages 116–18 and **LifeScience** pages 220–21.
- **Translocation** – Translocation is the movement of sugars from the leaves to other parts of the plants. See **LifeScience** pages 222–23.
- **Transport and storage of materials** – Translocation is used by the plant to move extra materials to storage areas. See **LifeScience** pages 222–23.

Reproductive structures and processes

- **Sexual and asexual reproduction** – These two methods of reproduction both have advantages and disadvantages. The advantage of sexual reproduction is that it produces offspring that are genetically different to the parents. The disadvantage of sexual reproduction is that it uses a large amount of energy to produce flowers, pollen and seeds. Most of the pollen and many of the seeds end up as food for other organisms instead of new plants. See **Year 12 Biology**, page 121.

- ❑ **Investigate structure of flowers** – Flowers carry out the same function yet they can look very different in size, shape and colour. See Investigations 1, 2 and 3 **LifeScience** page 236.
- ❑ **Structure and function of flower parts** – The sepals (calyx), stamen (filament, anther and pollen), petals (corolla), carpel (stigma, style, ovary and ovule) are important parts of a flower. See **LifeScience** pages 232–33.
- ❑ **Sexual reproduction of flowering plants** – Pollination, fertilisation, seed development, and fruit development are processes that occur as part of sexual reproduction. See **LifeScience** pages 233–36 and **Year 12 Biology**, pages 123–25.
- ❑ **Investigate reproductive processes** – Plan and carry out investigations or research how local plants carry out pollination, fertilisation, seed development, and fruit development. See Investigation 4, **LifeScience** page 236, Investigation 8, **LifeScience** page 239.
- ❑ **Alternation of generations in ferns and angiosperms** – The life history of a plant species shows that it takes two separate generations to complete the life history. 'Alternation of generations' refers to the going from one generation to the other and back again as the plant reproduces and produces new individuals. The two separate generations are called sporophyte and gametophyte. In ferns the sporophyte and gametophyte are separate individuals. In angiosperms the male and female gametophyte generations occur inside the flower. See **LifeScience** page 238–39 and **additional information** below.

Additional Information

Structure and function of stem tissue

Cells and tissues in a stem

Parenchyma cells are simple plant cells. They have thin, flexible cell walls and a large vacuole. They carry out most of the life processes of the plant, for example, photosynthesis, making proteins and storing materials. The fleshy tissue of fruit is mostly parenchyma cells.

Collenchyma cells have thickened cell walls. They are found grouped together in strands that help to support young parts of the plant. The strings in a celery stalk are collenchyma cells.

Sclerenchyma cells are long and very strong because they have an extra thick cell wall that contains the material **lignin**. The lignin in the cell wall allows these cells to provide support for the older parts of the plant. The fibres in fala leaves are sclerenchyma cells.

Xylem is a system of tubes made up of two types of dead cells, tracheids and vessels. These cells carry water and dissolved minerals from the roots to the leaves. Gymnosperms have **tracheids**. These are long narrow cells with pointed ends and walls thickened with lignin. The tracheids are closely packed and have holes in their walls. The holes allow water to move from one cell to the next. Angiosperms have both tracheids and vessels. **Vessels** are wider and shorter than tracheids. Vessels are stacked on top of each other and have gaps in the walls adjoining the next cells so that water can flow from one cell to the next up the stem.

Phloem is a system of tubes that is used to transport sugar and other materials up and down the plant. Phloem is made up of two types of living cell, sieve-tube cells and companion cells. The **sieve-tube** cells form a system of tubes and their end walls, called sieve plates, have gaps so that the sugar can move from one cell to the next. Each sieve-tube cell has at least one **companion cell** beside it. The sieve-tube cells do not have all the organelles found in other living plant cells so the companion cell carries out some of the life processes for the sieve-tube cell.

Organisation of cells and tissues in stems

Young plants are made up of three different tissues: epidermis, vascular and ground tissue. Around the outside of the plant is a layer of 'skin' called the **epidermis**. The epidermis is a single layer of tightly packed cells that protect the plant from micro-organisms. The cells in the epidermis secrete a waxy coating called a cuticle. The cuticle gives the plant a waterproof covering that stops water from being lost through the epidermis.

The **vascular** tissue is made up of phloem and xylem. This tissue is responsible for

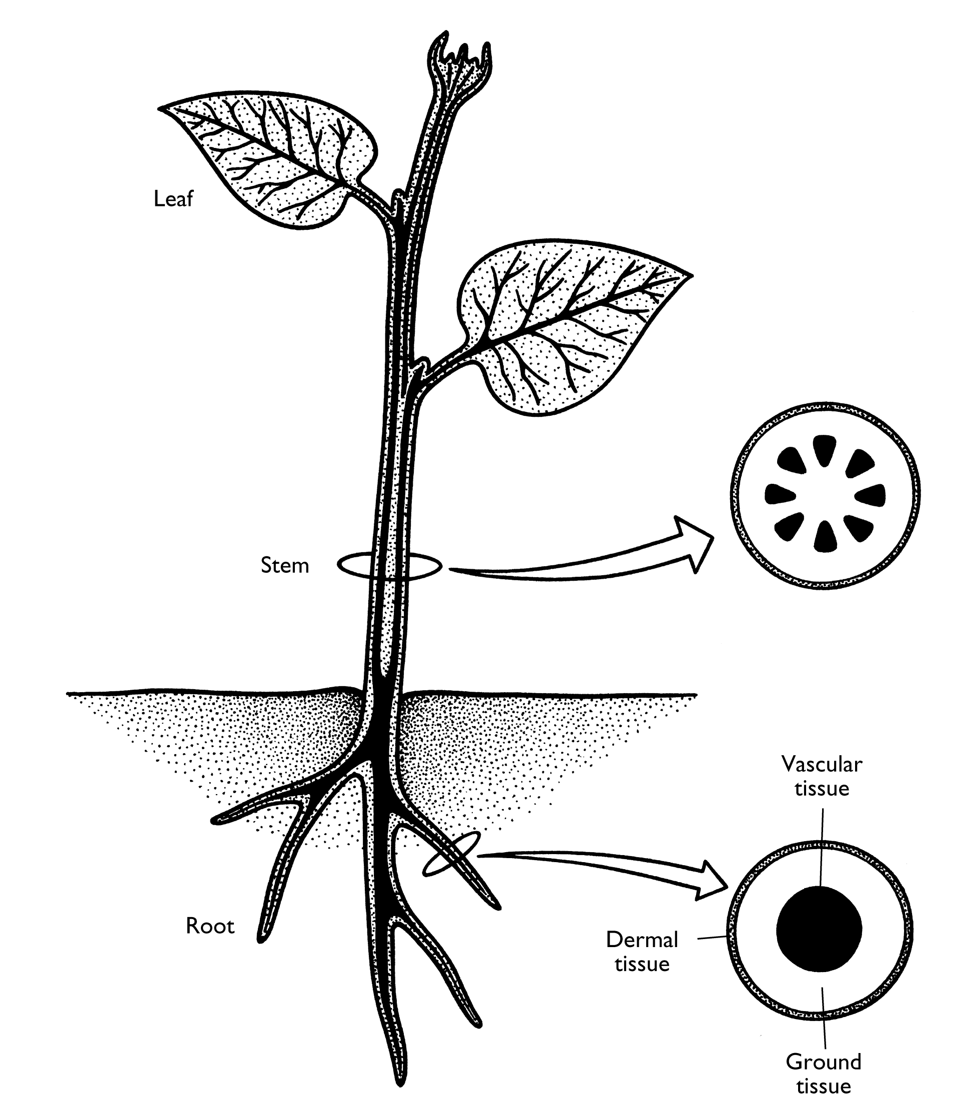


Figure 4.1 Diagram of tissue arrangements in stems and roots

the transport of water, minerals and sugars and other materials produced by the plant.

Ground tissue makes up the rest of the stem. Ground tissue contains many parenchyma cells and can contain collenchyma and sclerenchyma cells. The function of the ground tissues is to carry out photosynthesis and to provide storage and support.

Root tissues

Roots are also made up of the three types of tissue: epidermis, ground and vascular.

The epidermis forms a single layer of cells around the outside of the root. Water and minerals in the soil must travel through the epidermis into the root. Some of the cells in the epidermis have long thin root hairs growing out from them into the soil. This greatly increases the amount of surface area that the roots have in contact with the soil. The higher surface area helps to improve the efficiency of the absorption of water and minerals.

The ground tissue of the root forms an area inside the epidermis called the **cortex**. Monocotyledon plants also have another area of ground tissue called the pith. The pith is found in the middle of the root surrounded by vascular tissue. Ground tissue is made up of parenchyma cells. The function of these cells is to store materials for the plant.

In dicot plants the vascular tissue, containing the phloem and xylem, is located in the centre of the root. Water and dissolved minerals diffuse from the epidermis through the cortex and into the vascular tissue. Sugars made in the photosynthetic parts of the plant travel down the phloem and into the surrounding parenchyma cells for storage.

Effect of environmental factors on transpiration rate

High **humidity** means that there is a lot of water in the atmosphere so the difference in concentration, called the **concentration gradient**, between the atmosphere and the leaf is small and therefore the transpiration rate will be lower. A low humidity rate will mean a larger concentration gradient so more water will be lost from the leaf.

Still air lowers transpiration rate because the water concentration in the air around the leaf stays higher as more water evaporates out of the leaf. If the air is moving the amount of water in the air outside the leaf is lowered, making the concentration gradient higher and therefore the rate of transpiration higher.

On hot days transpiration cools down the leaf because the water removes heat energy from the leaf as it evaporates. The higher the **temperature** the faster the rate of transpiration.

The loss of water by transpiration causes problems for the plant, especially if there is not much water in the soil. Plants have adaptations to reduce the amounts of water lost during transpiration. For example, some plants have their stomata in small pits. This reduces water lost by holding a small amount of moist, still air above the stomata.

See diagram 4.19, Stomata in pits, in **Year 12 Biology**, page 121.

Alternation of generations in plants

Activity 1 Alternation of generations

Purpose: To develop knowledge about the alternation of generations during sexual reproduction of plants.

1 Work in pairs.

2 One person reads the information below and the second person listens and then uses the labels in box 2 to produce a circular life history diagram that shows what is written in box 1. Box 2 has two extra labels to be put on the life history diagram.

General plant life history

Plants have two generations in a complete life cycle. One generation is called the sporophyte generation. Sporophytes have a complete double set of chromosomes so are said to be diploid or 2n. The sporophyte generation uses the process of meiosis to produce spores. Spores have a single set of chromosomes so are said to be haploid or n. In some types of plants these spores can grow into individual plants called gametophytes. Gametophytes use the process of mitosis to produce eggs (n) and sperm (n). Fertilisation occurs when an egg and a sperm join to form a zygote (2n). The zygote grows by mitosis into a mature sporophyte plant (2n).

Sporophyte, Gametophyte, Eggs, Sperm, Zygote, Spores, Fertilization, Mitosis, Mitosis, Mitosis, Meiosis, (2n), (n), (2n), (n), (n), (n)

3 Join the parts of the life history diagram with arrows.

4 Check the accuracy of your diagram against the text and the diagrams produced by other pairs.

5 Read the following information.

Alternation of generations in angiosperms

The dominance of the sporophyte and gametophyte generations is different in different types of plants, such as algae, mosses, ferns, conifers and flowering plants. For example moss plants spend most of the time in their life history as separate male and female gametophytes, but the gametophyte generation in flowering plants is very reduced.

The male gametophyte in flowering plants

Inside a pollen grain there are two haploid or n nuclei – a tube nucleus and a generative nucleus. When the pollen grain germinates, the generative nucleus divides into two sperm cells and the tube nucleus forms into a pollen tube – this represents the mature male gametophyte.

The female gametophyte in flowering plants

The female gametophyte forms inside the ovules. The ovules are protected inside the ovary of the plant. Inside each ovule, specialised cells divide by meiosis to form four haploid cells. One of these haploid cells survives and divides by mitosis to form 8 cells – an egg cell, an endosperm mother cell and six other cells, all of which make up the mature female gametophyte.

Ref: Bailey, A., Bunn, T. (2003) NCEA Level 2 Biology, *Auckland: ESA Publications*

6 Compare the alternation of generations diagrams for a fern (see **LifeScience** pages 238 and 239) and a flowering plant (see below).

7 Copy and complete the following table:

Similarities between fern and flowering plant life histories	Differences between fern and flowering plant life histories	Interesting points

8 Compare your table with the tables produced by other groups.

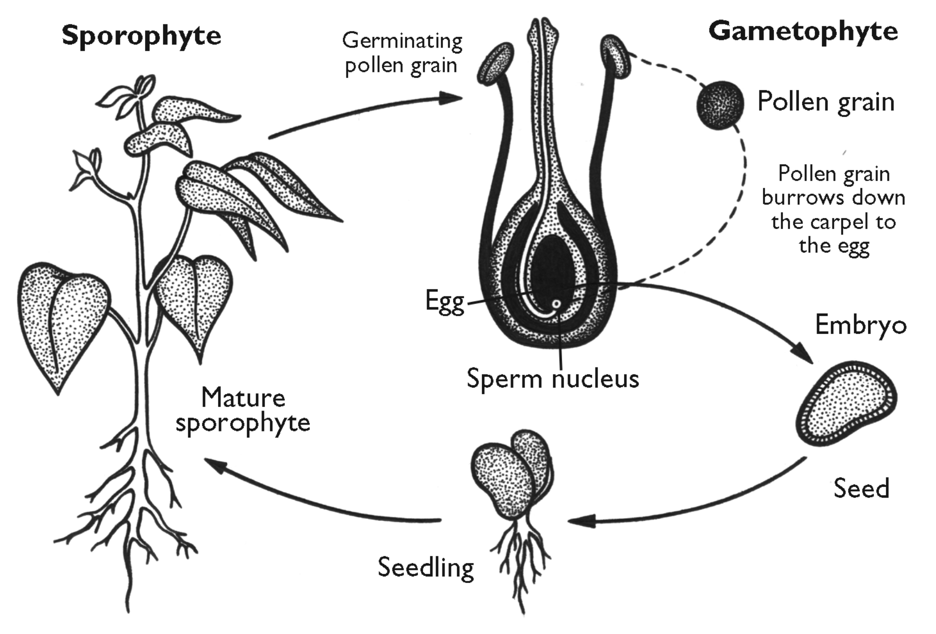


Figure 4.2 Alternation of generations in angiosperms

Unit 5

Animals

Achievement objectives

From their study of *Animals* students will understand nutrition and diet:

- ❑ **describe** the differences between autotrophic and heterotrophic nutrition
- ❑ **explain** the importance of the following classes of food in the human diet; carbohydrate (including fibre), lipid, protein, vitamins (A, B, C, and D), minerals (such as calcium and iron), water
- ❑ **investigate** the presence of glucose, protein, lipids and starch in food
- ❑ **compare** the traditional Pacific diet with more recent diets containing refined and processed food.

The Digestive System

- ❑ **explain** the structure and functions of parts of the digestive system; mouth, oesophagus, stomach, gall bladder, pancreas, small intestine, large intestine, sphincter muscles, hepatic portal vein
- ❑ **discuss** the processes carried out by the digestive system: ingestion, digestion, absorption, assimilation and egestion
- ❑ **investigate** the action of saliva on starch
- ❑ **compare** the gut structures of humans with herbivores and carnivores.

Gas Exchange

- ❑ **explain** the differences between the processes of breathing (ventilation), gas exchange, and cellular respiration
- ❑ **explain** the role of the ribs, intercostal muscles and the diaphragm in inhalation and exhalation
- ❑ **explain** how trachea, mucus, bronchi, alveoli and cilia facilitate gas exchange

The Gas Exchange Systems In Insects And Fish

- ❑ **investigate** the structure and function of the gas exchange systems in insects or fish

- ❑ **compare** the structure and function of the gas exchange systems in mammals, fish and insects.

Support

- ❑ **explain** the advantages and disadvantages of animal endoskeletons, exoskeletons and hydrostatic skeletons
- ❑ **explain** the structure and function of the three types of muscles
- ❑ **explain** how muscles work with the skeleton to allow movement
- ❑ **investigate** the action of antagonistic pairs of muscles in producing movement.

Transport

- ❑ **compare** and **give** examples of an open circulatory system, closed single circulatory system, closed double circulatory system
- ❑ **explain** the structure and function of the human heart, including the atria, ventricles, valves, aorta, vena cava and the pulmonary artery and vein
- ❑ **investigate** the possible effects of smoking, alcohol and obesity in causing coronary heart disease
- ❑ **explain** the structure and function of the red blood cells, platelets and white blood cells
- ❑ **discuss** the structure and function of the three main types of blood vessels; arteries, veins and capillaries.

Homeostasis

- ❑ **define** homeostasis as the keeping of internal body conditions in a stable state
- ❑ **explain** how a constant internal environment helps cells to function efficiently
- ❑ **discuss** the following examples of homeostasis: temperature control in mammals, blood sugar levels in humans.

Excretion

- ❑ **describe** the process involved in the production of carbon dioxide, water and nitrogenous wastes
- ❑ **discuss** the advantages and disadvantages of excreting nitrogen waste in the form of ammonia (aquatic organisms), uric acid (birds, insects and reptiles) or urea (mammals)
- ❑ **explain** the structure and function of the kidney, urethra, ureter and bladder
- ❑ **explain** how the structure of the nephron aids the processes of filtration and reabsorption.

Reproduction

- ❑ **explain** the structure and function of ovary, oviduct (Fallopian tube), uterus (womb), vagina, scrotum, testis, epididymis, sperm duct (vas deferens), prostate gland, seminal vesicle, urethra and penis

- ❑ **discuss** reproductive development from gamete production, fertilisation, implantation to birth
- ❑ **explain** how materials are exchanged between the mother and the foetus via the placenta
- ❑ **discuss** the role of the hormones oestrogen, progesterone and testosterone in the development of secondary sexual characteristics in males and females, and in the menstrual cycle.

Key Learning Points

Nutrition and diet

- ❑ **Autotrophic and heterotrophic nutrition** – Autotrophic organisms make their own food. Heterotrophic organisms must eat. See **LifeScience** pages 5 and 120.
- ❑ **Classes of food in the human diet** – Food contains a variety of nutrients. Each nutrient has an important function. See **LifeScience** pages 121–24.
- ❑ **Food tests** – Simple chemical tests can be used to identify the presence of glucose, protein, lipids and starch in different types of food. See **LifeScience** page 125.
- ❑ **Changes in diet** – The traditional Pacific diet contains a wide range of fresh and cooked foods. The increasing availability of refined and processed food has resulted in dietary changes that are having an impact on the health of local people. Material is available in the home economics textbooks and from local organisations such as the Health Department.

The digestive system

- ❑ **Structure and function of the digestive system** – The role of the digestive system is to process food so that small nutrient molecules from the food are able to be absorbed into the blood stream. See **LifeScience** pages 129–34.
- ❑ **Digestive processes** – The system carries out the processes of ingestion, digestion, absorption, assimilation and egestion. See **LifeScience** page 128.
- ❑ **Action of saliva on starch** – Saliva breaks down starch into smaller molecules. Investigations 7 and 8, **LifeScience** page 135.
- ❑ **Gut structures of animals** – The structure of the digestive systems in different animals is related to their diet. For example, the teeth of humans (omnivores), herbivores and carnivores are different. See **LifeScience** pages 136–37.

Gas exchange

- ❑ **Breathing (ventilation), gas exchange, and cellular respiration** – The processes of breathing, gas exchange and respiration are linked. These processes are often confused with each other because the organs used for breathing and gas exchange are called the respiratory system. See **LifeScience** page 140.

- **Inhalation and exhalation** – These are the two processes involved in breathing. The organs involved in breathing are the ribs, intercostal muscles and the diaphragm. See **LifeScience** page 144.
- **Structure and function of mammal gas exchange organs** – Mucus and cilia help to clean the air being breathed in. The trachea and the bronchi act as pipes through which the gases move. The alveoli in the lungs are moist and have a large surface area to allow gases to be exchanged in the amounts needed by the organism. See **LifeScience** pages 141–43.

The gas exchange systems in insects and fish

- **Investigate gas exchange in insects or fish** – See Investigations 5, 6 and 7, **LifeScience** pages 147–49.
- **Gas exchange systems in animals** – The gas exchange systems of mammals, fish and insects carry out the same processes but have different structures. For gas exchange, insects use a system of tubes throughout their bodies called the tracheal system. Fish have developed a different gas exchange system because of the differences between air and water as a gas exchange medium. See **LifeScience** pages 146–49.

Support

- **Advantages and disadvantages of skeletons** – The three types of skeleton used by animals are endoskeletons, exoskeletons and hydrostatic skeletons. See **LifeScience** pages 160, 168 and 169.
- **Structure and function muscles** – Skeletal, cardiac and involuntary muscles are three types of muscles found in mammals. See **LifeScience** page 164 and **additional information** below.
- **Movement** – Muscles, joints, tendons, ligaments and bones work together to allow mammals to move. See **LifeScience** pages 161–65. Reflexes are covered on page 188 of **LifeScience**.
- **Investigate antagonistic pairs of muscles** – muscles work in pairs to produce movement. See Investigation 4 and Diagram 18.9, **LifeScience** page 164 and page 166.

Transport

- **Types of circulatory system** – The circulatory systems used by animals can be classified as open or closed and single or double. See **LifeScience** page 150.
- **Structure and function of the human heart** – The human heart is a pump made up of two separate pumps sitting side by side. The atria, ventricles, valves, aorta, vena cava, pulmonary artery and pulmonary vein all have special adaptations that help them to carry out and control the pumping of blood around the body. See **LifeScience** pages 152–53.
- **Coronary heart disease** – Smoking, alcohol and obesity are factors important in coronary heart disease. See **additional information** below.
- **Structure and function of blood** – Blood is a liquid medium made up of plasma, red blood cells, white blood cells and platelets. See **LifeScience** pages 154–57.
- **Structure and function of blood vessels** – Arteries, veins and capillaries carry blood. See **LifeScience** page 151.

Homeostasis

- ❑ **Homeostasis –** This means the keeping of internal body conditions, such as temperature and amount of water, as steady as possible. See **LifeScience** page 170.
- ❑ **Purpose of homeostasis –** Body cells cannot function efficiently without systems that keep a constant internal environment inside the body. The skin and liver are two organs important in keeping a constant internal environment so that cells can function effectively. See **LifeScience** pages 172–75.
- ❑ **Examples of homeostasis –** Temperature control in mammals and blood sugar levels in humans are examples of homeostasis. See **LifeScience** pages 170, 171 and 174.

Excretion

- ❑ **Production of wastes –** Carbon dioxide, water and nitrogenous wastes are the main wastes produced in the body that have to be removed by the lungs and excretory system. See **additional information** below.
- ❑ **Advantages and disadvantages of excretory products –** nitrogen waste can be excreted in the form of ammonia (aquatic organisms), uric acid (birds, insects and reptiles) or urea (mammals). Each product has its advantages and disadvantages. See **LifeScience** page 179 and the **additional information** below.
- ❑ **Structure and function of the mammal excretory system –** the kidney, urethra, ureter and bladder are all parts of the mammal excretory system. See **LifeScience** pages 176–77.
- ❑ **Structure of nephrons –** The nephrons in the kidneys are designed to carry out filtration of blood and reabsorption of materials that the body still needs. See **LifeScience** pages 176–77.

Reproduction

- ❑ **Structure and function of the reproductive system –** The ovary, oviduct (Fallopian tube), uterus (womb), vagina, scrotum, testis, epididymis, sperm duct (vas deferens), prostate gland, seminal vesicle, urethra and penis all have important functions in the reproduction of mammals. See **LifeScience** pages 198, 199 and 201 and *Book 1 Year 11 Science* Unit 3.
- ❑ **Reproductive processes –** Reproduction begins with meiosis to produce **gametes**. Once gametes are transferred from the male to the female **fertilisation** can take place. If fertilisation occurs, a zygote is formed. The zygote undergoes cell division many times to become an embryo, which can **implant** in the wall of the uterus. Here the embryo develops into a foetus. The foetus grows and develops until birth. See **LifeScience** pages 192, 195, 196 and 201 and *Book 1 Year 11 Science* Unit 3.
- ❑ **Functioning of the placenta –** Materials are exchanged between the mother and the foetus via the placenta. The placenta is designed so that the blood of the mother and foetus never mix but are close enough to allow diffusion of materials to occur. Diffusion of materials is improved by the use of a 'counter current' system where the blood of the mother flows through the placenta in the opposite direction to the blood of the foetus. See *Book 1 Year 11 Science* Unit 3 pages 33, 38.

- **Role of hormones** – The reproductive hormones oestrogen, progesterone and testosterone are involved in the development of secondary sexual characteristics in males and females. The menstrual cycle is also controlled by hormones. See *Book 1 Year 11 Science* Unit 3 pages 26, 27, 29.

Additional Information

Muscles

The muscle in the heart is called **cardiac muscle**. The cells in cardiac muscle form long branching fibres. When seen under a microscope, cardiac muscle has a striped appearance like the striated skeletal muscle in our skeleton.

Cardiac muscle contracts about 70 times per minute for your whole lifetime and doesn't get tired. Each minute the heart pumps about 5 litres of blood. Cardiac muscle is involuntary muscle which means it contracts without you having to think about it.

Smooth muscle, sometimes called involuntary muscle, is the muscle found in the walls of all hollow organs of the body except the heart. The cells in smooth muscle lack striations, which means it does not have the striped appearance under the microscope seen in skeletal and cardiac muscle. The cells in smooth muscle are oval shaped. Smooth muscle contracts more slowly then skeletal muscle but can stay contracted for longer.

When the smooth muscle contracts it makes the hollow in the organ it surrounds smaller. Smooth muscles are responsible for involuntary body activities such as;

- moving food along the digestive system by peristalsis
- churning of the stomach
- changing the size of the arteries to regulate the flow of blood
- emptying urine from the bladder
- pushing babies from the uterus at birth
- regulating the flow of air to the lungs.

The smooth muscle is involuntary and all these activities are controlled by the brain and are carried out without you having to think about it.

Coronary heart disease

Coronary heart disease (CHD) is the most common form of heart disease. It often results in a heart attack and is the leading cause of death in many countries.

What is CHD?

The heart muscle must work continuously throughout your life. Oxygen and nutrients are needed to keep the heart muscle alive and working well. Coronary arteries branch off the aorta and surround the outside of the heart, supplying the heart muscle with oxygen and nutrients.

In CHD, a process called **atherosclerosis**, in which fat builds up inside the walls of the coronary blood vessels. This reduces the blood flow in the coronary arteries. Over time the fatty build-up makes the arteries narrower and narrower, which results in less blood reaching the heart muscle.

When too little blood reaches a part of the heart, a cardiac ischemia occurs. If the blood flow is cut off a heart attack results and cells in the heart muscle that do not receive enough oxygen begin to die. If a large area of cells dies the heart will no longer be able to pump blood around the body and the person dies.

Who Gets CHD?
Certain risk factors increase the risk that someone will develop CHD. Some risk factors cannot be changed but most can.

Risk factors that cannot be changed are: age (45 or older for men; 55 or older for women) and a family history of early CHD (a father or brother diagnosed before age 55, or a mother or sister diagnosed with heart disease before age 65).

Factors that can be changed are: cigarette smoking, high blood cholesterol, high blood pressure, overweight/obesity, physical inactivity, and diabetes.

Generally, each risk factor alone doubles a person's chance of developing CHD. Someone who has high blood cholesterol and high blood pressure, and smokes cigarettes, is eight times more likely to develop CHD than someone who has no risk factors.

Production of wastes

Our bodies produce chemical wastes as part of the chemical reactions involved in life processes. Respiration produces carbon dioxide and water as wastes. The carbon dioxide diffuses out of the cells, is transported to the lungs in the blood and is excreted during gas exchange.

Water has many uses in the body and is used and produced in a number of different chemical reactions, e.g. digestion of molecules requires water, respiration produces water. Water may or may not be a waste depending on the amount of water the body has. This is called **water balance**. If the body has more water than it needs, the extra water will be excreted. If there is not enough water available, the body has a range of ways to conserve water.

Nitrogenous wastes are produced in the liver as the result of a chemical reaction called **deamination**. Deamination removes the nitrogen-containing parts from amino acids that are not needed by the body and cannot be stored. After deamination the rest of the amino acid is now able to be used for energy production in respiration.

Nitrogenous excretory products
Different organisms produce different types of nitrogenous excretory products depending upon the environment they live in and their adaptations. The deamination of amino acids produces ammonia, which is very toxic to living things. Organisms have to be able to excrete the ammonia very quickly, or they have to use energy to change it into a more harmless form that can be stored and excreted later.

Organisms that live in water environments are able to excrete ammonia. For example, crabs excrete ammonia directly into the surrounding water where it is diluted quickly and does not poison the crab. Fish excrete ammonia through their gills. Crabs and fish do not have to use extra energy to excrete nitrogenous waste.

Mammals excrete urea. Urea is produced by joining ammonia with carbon dioxide. This process uses energy, but the urea produced is not as poisonous as ammonia. Urea still needs to be diluted with water in urine.

Birds, insects and reptiles excrete uric acid. Uric acid is a white paste and it is almost non-toxic. Its non-toxic property is important as the offspring of birds and reptiles develop inside an egg and their wastes must be stored in the egg until hatching time. Uric acid also has the advantage that it can be excreted without the loss of water. This helps insects living in hot dry environments to conserve water.

The conservation of water is also important for organisms that grow inside an egg shell. The disadvantage of producing uric acid as an excretory product is that it requires a lot of energy to make it.

Activity 1 Excretory products

Aim: To compare excretory products.

Use the information above to complete the following table:

Excretory Product	Animal groups that excrete product	Toxicity	Energy required to produce	Advantage to animal
Ammonia				
Urea				
Uric acid				

Unit 6

Environment

Achievement objectives

From their study of *Environment* students will understand adaptations:

- ❑ **explain** the terms: environment, habitat, ecological niche and adaptation, using local examples
- ❑ **investigate** adaptations of any local species
- ❑ **discuss** the four types of adaptations (structural, physiological, behavioural and life history) and give examples of how they help a species to survive
- ❑ **explain** the concepts of tolerance, acclimation, Gause's Principle and Liebig's Law using local examples.

Populations

- ❑ **describe** local populations
- ❑ **investigate** characteristics of a population: size, distribution and density using sampling methods, e.g. quadrants, transects, mark-and-recapture
- ❑ **explain** the effects of natality and mortality on population growth and how these can affect the survivorship curve
- ❑ **explain** why biodiversity is essential for the perpetuation of communities.

Communities

- ❑ **distinguish** between communities and populations
- ❑ **investigate** ecological patterns in local communities, e.g. zonation, stratification, succession
- ❑ **discuss** ecological patterns in local communities, e.g. zonation, stratification, succession
- ❑ **compare** intra-specific and inter-specific competition in terms of competition for living space (territory and breeding grounds), food (animals), reproductive mates, light and nutrients (plants) and how they affect relationships in a community

- ❑ **discuss** the following relationships using local examples for each: predation, parasitism, mutualism, commensalism.

Ecosystems

- ❑ **describe** the living (biotic) and non-living (abiotic) parts of an ecosystem
- ❑ **construct** and **interpret** food chains and food webs in a community
- ❑ **discuss** how energy flows through an ecosystem, e.g. energy flow diagrams, pyramids of numbers, pyramids of biomass
- ❑ **discuss** the importance of recycling of nutrients, using carbon and nitrogen as examples
- ❑ **investigate** a local environmental issue
- ❑ **discuss** the impact of development on the environment, e.g. tourism, logging, commercial fishing, waste management, population increase, sand-mining, reclamation.

Key Learning Points

Adaptations

- ❑ **Ecological terms** – It is important to learn the meanings of a range of ecological terms such as environment, habitat, ecological niche and adaptation. See **additional information** below and **LifeScience** pages 16–21, 22 and 23.
- ❑ **Adaptations** – An organism has many different types of adaptations. They can be structural (e.g. bright-coloured flowers), physiological (e.g. the ability to make a coloured pigment for the flower), behavioural and life history. See **LifeScience** pages 18–19, various pages in **Natural World** and **Year 12 Biology** pages 166–71.
- ❑ **Investigate adaptations of any local species** – Each living thing has adaptations that help it to live. Often local organisms develop specific adaptations that fit with specific features of the local environment. For example, the beak of manumea is adapted to open seeds only found in local forests. See **LifeScience** Investigation 1 page 19 and various pages in **Natural World**.
- ❑ **Ecological concepts** – All living things can **tolerate** day to day changes in their environment such as changes in temperature. But if the change is too large the organism will become close to its **limits of tolerance** and it will suffer physiological stress or death. The organism can undergo **acclimation** which changes its limits of tolerance. This happens at the change of seasons as the result of gradual changes in the abiotic environmental factors. **Liebig's Law** discusses the effect of a single factor on the survival of an organism. See **LifeScience** pages 24–25.
- ❑ **Gause's Principle** states that two species with similar ecological niches cannot live together in the same place for very long. See coexistence in **LifeScience** page 20.

Populations

- **Describing local populations** – Local populations can be described by the type of organism, number of individuals (size), the way individuals are arranged (distribution), e.g. random, in clumps, evenly spaced and how many individuals per area (density). Populations can also be described by **age structure**. Age structure is the number of young, middle-aged and old individuals in the population. You will use sampling methods to investigate and describe local populations.
- **Using sampling methods to investigate a population** – The size, distribution and density of a population are all characteristics that can be investigated. See **LifeScience** pages 36–39.
- **Natality, mortality and survivorship** – The numbers of organisms in a population is linked to the natality (birth rate) and mortality (death rate). If most of the population live to old age (high survivorship), the population has a low mortality rate. If the population has low survivorship, meaning many individuals die young the population has high natality and mortality rates. See **LifeScience** pages 31–35.
- **Biodiversity** – This is related to the number of different populations (species) in a community and the numbers of individuals in each population. See **additional information** below.

Communities

- **Communities** – Communities have a range of different plant and animal populations. The organisms in them are arranged in various patterns such as the vertical layering of plants called stratification. The organisms in the community have various interrelationships with members of the same species, e.g. competition for light, reproduction, and also with members of other species, e.g. feeding, competition for space. You will use sampling methods to investigate patterns and relationships in local communities.
- **Investigate ecological patterns in local communities** – Local communities show patterns of distribution across zones in the environment (zonation), vertical layers (stratification), and changes in the numbers and types of species over time (succession). See **LifeScience** pages 50–53.
- **Ecological patterns in local communities** – The data from sampling can be used to describe the zonation, stratification and succession patterns seen in local communities. See **LifeScience** pages 42–45.
- **Intra-specific and inter-specific competition** – Intra-specific competition is between members of the same species. For example, competition for living space (territory and breeding grounds), food, and mates for reproduction. Intra-specific competition is usually strong because the members of the same species have the same ecological niche. This means that they require the same resources in similar amounts so compete strongly for the resources in the habitat. Inter-specific competition is competition between members of different species. For example, if two species of animal have the same food source they will compete for it. Inter-specific competition between plants of different species for light and nutrients is often strong because many plant species have similar requirements. See **LifeScience** page 41.
- **Feeding relationships** – There are many different types of feeding relationships in a community. Some feeding relationships are examples of **exploitation**, for example predation and parasitism. In these relationships

one organisms benefits and the other is harmed. There are some relationships based around feeding in which two organisms work together for the benefit of one or both of the organisms. For example, **mutualism** where both organisms benefit from the relationship, and **commensalism** where one benefits. See **LifeScience** pages 46–49.

Ecosystems

- ❑ **Ecosystem** – An ecosystem is made up of all the communities and the environment in an area. See **LifeScience** page 54.
- ❑ **Food chains and food webs** – Food chains and webs show the feeding relationships that exist in an ecosystem. See **LifeScience** pages 54–55.
- ❑ **Energy flow** – The transfer of food from one organism to another transfers both nutrients and energy. The energy enters the ecosystem from the sun to plants first and then gets passed on to animals and decomposers. Each group of organisms, plants, animals and decomposers, uses much of the energy in respiration. Respiration releases some of the energy back into the environment as heat energy. Because each trophic level releases some of the energy as heat, there is less and less energy available. This means that there are fewer organisms and less biomass the further along a food chain you go. See **LifeScience** page 56. Trophic pyramids and energy flow.
- ❑ **Recycling of the nutrients** carbon and nitrogen – Nutrients move from one organism to another until they end up in wastes and dead material. The nutrients from this material must be released back into the environment so that they can be used again. See **LifeScience** pages 57–59.
- ❑ **Local environmental issue** – Island environments are sensitive to change and are easily damaged by the activities of humans. Investigate a local environmental issue.
- ❑ **Impact of development on the environment** – Activities such as tourism, logging, commercial fishing, waste management, population increase, sand-mining and land reclamation all have impacts on the island environment. See **LifeScience** pages 60–67.

Additional Information

Ecological niche

The ecological niche of an organism is defined as the sum total of the organism's use of the biotic and abiotic resources in its environment. A famous biologist called Eugene Odum used the following to help his students to understand the term ecological niche. If the organism's habitat is its address, then its ecological niche is its job. This means the role of the organism, its adaptations, its use of resources, the way the organism fits into the ecosystem. The ecological niche has many features, so we are usually only studying a small part of the organism's ecological niche. For example, aspects of the ecological niche of togo that could be studied include use of abiotic resources (light, water, minerals, substrate etc), interaction with biotic resources (browsing animals, other togo, e.g. for reproduction and competition for abiotic resources etc) and adaptations (for living in salty environments, support and holding in a tidal area, pneumatophores etc).

Biodiversity

The importance of biodiversity is becoming better understood and more effort is being made to conserve the biodiversity of the world's natural communities. This is especially important in island communities, as places like Sāmoa have unique plants and animals that are not found on larger areas of land.

The more stable the numbers of individuals in each population, the more likely a community is to be in balance. When ‘in balance’, the natural processes act to maintain the healthy members of the population so that the fittest survive to reproduce and maintain the population.

A high number of individuals of one species also allows for the existence of higher genetic variation in the gene pool of that species and a greater opportunity for helpful mutations to occur. High variation in a population is helpful when the environment changes, as it increases the possibility of existence of an adaptation that is better suited to the changed environment. The individuals with the better adaptation will thrive in the changed environment. They will increase in numbers compared to individuals without the adaptation.

The greater the number of different populations (species) in a community, the greater the chance that the community as a whole will be able to respond to a changing environment.