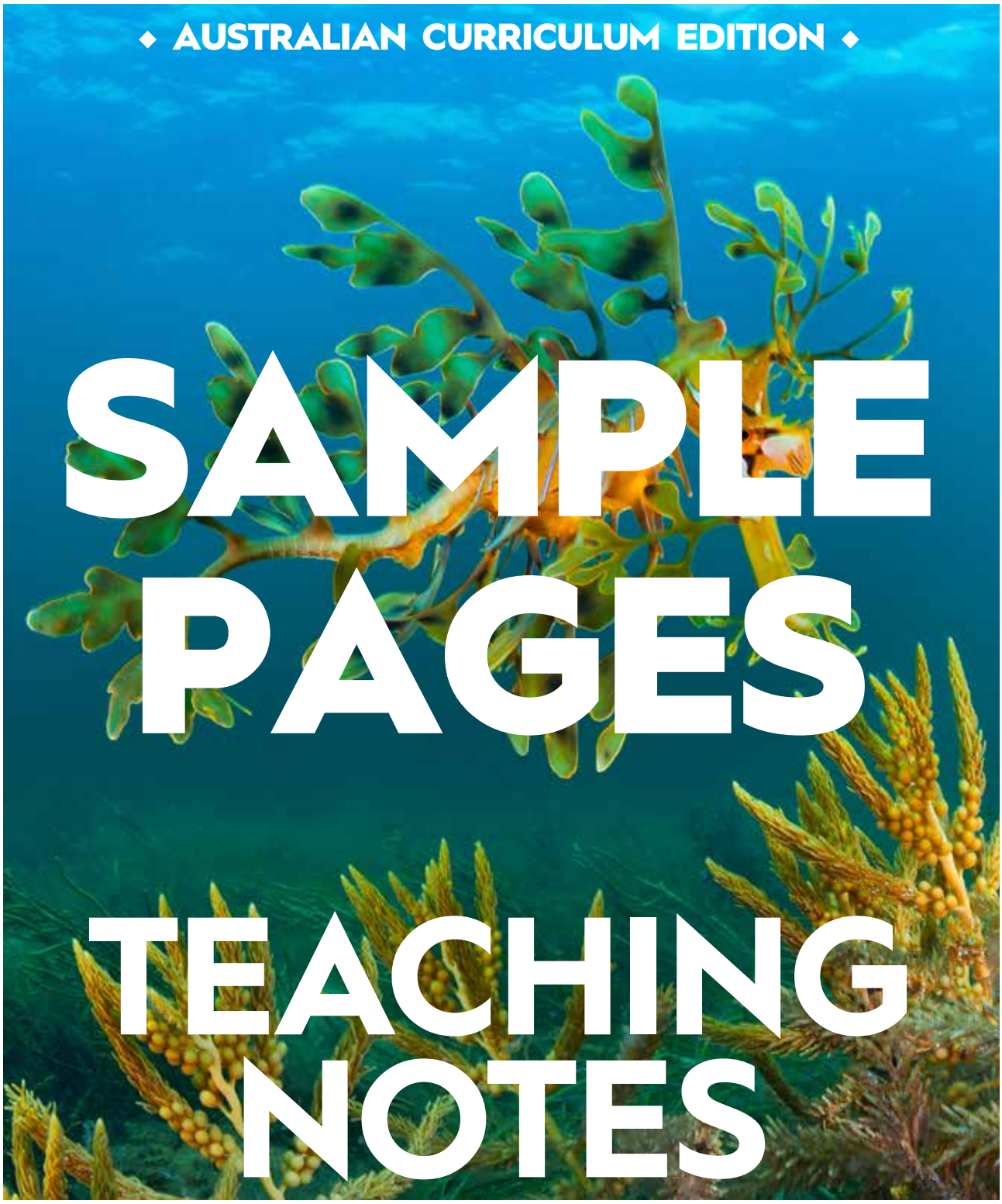
# BIOLOGY

## LEVELS OF LIFE

◆ AUSTRALIAN CURRICULUM EDITION ◆



# SAMPLE PAGES

# TEACHING NOTES

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# 1 Chromosomes and DNA

## The Composition of Living Things

- All matter is made up of **atoms**.
- **Elements** are made up of one kind of atom.
- A **molecule** is made up of two or more atoms joined together with no overall charge.
- **Compounds** are substances made up of two or more different kinds of atoms chemically combined.
- **Organic compounds**: contain carbon
  are complex
  are produced by organisms
- All other compounds are called **inorganic**.

**Four major types of organic compounds:**

| | |
|---|---|
| carbohydrates | sugars, starches |
| lipids | fats, oils |
| proteins | eggs, meat, fish |
| nucleic acids | |

Macromolecules — large molecules made up of smaller subunits.

DNA stores and transmits genetic information; it functions in the same way in all living things.

**Nucleic acids** — macromolecules made up of subunits called *nucleotides*.

**nucleotides** consist of:
- 5-carbon sugar (deoxyribose or ribose)
- phosphate
- a nitrogen base

**nitrogen bases**
- adenine (A), cytosine (C), guanine (G), thymine (T), uracil (U)

There are two types of nucleic acid — DNA and RNA

DNA nucleotides contain deoxyribose sugar
RNA nucleotides contain ribose sugar
Both have a sugar-phosphate backbone

**DNA**
- two complementary strands (double helix)
- made up of four types of nucleotide: A,C,G,T

**RNA**
- single-stranded
- made up of four types of nucleotide: A,C,G,U

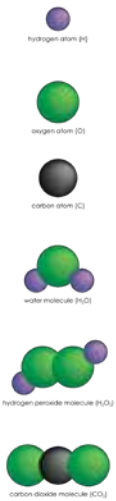


Fig. 1.1

Give examples of elements and compounds — hydrogen, oxygen, water, carbon dioxide

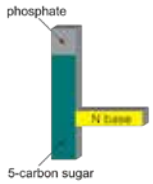



Fig. 1.4
Nucleotide

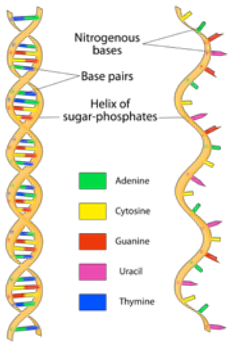



Fig. 1.5

# 2 The Language of Life

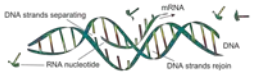
In eukaryotic cells, transcription occurs in the nucleus.

Describe and illustrate the role of DNA, mRNA, transfer RNA (tRNA), ribosomal RNA (rRNA) in transcription and translation.

## Protein Synthesis

Step 1: Transcription (in the nucleus)
DNA → RNA

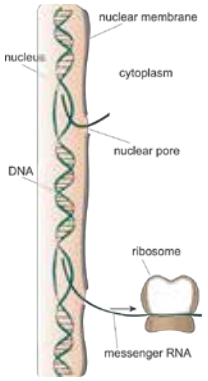
- DNA strands separate at the site of the gene
- one strand of the DNA is used as a template for mRNA synthesis (base pairing rules apply, except that U joins to A)
- mRNA breaks away from DNA and travels through nuclear pores to ribosomes in the cytoplasm
- DNA strands rejoin

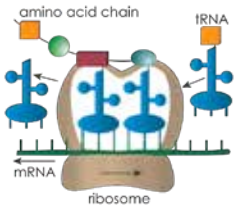



Describe the relationship between DNA codons, RNA codons, anticodons, and amino acids.

Step 2: Translation (in the cytoplasm)
RNA → protein

- mRNA attaches to ribosome
- tRNA molecules bring specific amino acids to the ribosome, according to the codon on the mRNA. (See Fig 2.9 mRNA codons on P16) Complementary base triplets on tRNA are called *anticodons*.
- polypeptide chain grows as the amino acids are joined
- completed polypeptide breaks away from ribosome and folds to form a 3D protein

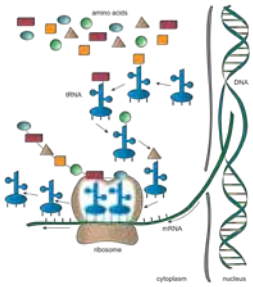



Distinguish between coding (gene) and template strands of DNA.

A **gene** is a segment of DNA on a chromosome that contains the complete sequence of nucleotide bases that codes for a polypeptide or RNA molecule.

Note that it is the complementary strand of DNA, called the **template** strand, that is transcribed to form mRNA. The other strand is called the **gene**.




Recognise that DNA strands are directional and are read 5' to 3'.

By convention, humans read DNA and RNA in the 5' to 3' direction.

Note that the transcribed RNA molecule has the same sequence of bases as the **gene**, with U instead of T.

# 7 Living Things are Made of Cells

The cell theory unifies all living things.

The Cell Theory

1. All living things are made up of cells and cell products (structure)
2. Cells carry out the life processes of organisms (function)
3. Cells arise from pre-existing cells
4. Cells contain hereditary material

Cells are the smallest independent units of life

Characteristics of living things

- complex, organised
- take in energy
- maintain identity
- respond to stimuli
- able to reproduce
- grow and develop

The cell is the smallest unit of life that can fulfil all of the above requirements.

The cell membrane separates the cell cytoplasm from its surroundings and controls the exchange of materials, including nutrients and wastes, between the cell and its environment.

## Functions of the membrane

- cell boundary
- regulates passage of materials in/out of cell
- cell recognition (e.g. other cells and hormones)
- attachment of cytoskeleton

Describe and represent the fluid mosaic model of the cell membrane.

## The structure of the cell membrane

- very thin (8nm, a page is 100 000 nm thick!!)
- fluid mosaic (latest model)
- bilipid layer of phospholipid
- protein molecules some have CHO attached
- proteins act as transport channels, membrane receptors

Note: Viruses are not considered living as they:

- don't use energy
- don't maintain their structure
- cannot reproduce independently
- don't grow and develop

LIPIDS AND PHOSPHOLIPIDS

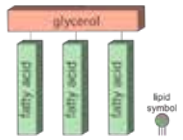



Fig. 7.5
A lipid molecule has three fatty acids joined to a glycerol

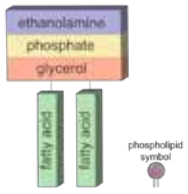



Fig. 7.6
A phospholipid molecule has two fatty acids joined to a glycerol, ethanolamine, and phophate

# 13 Sexual Reproduction and Meiosis

Explain the importance of crossing over and independent assortment in meiosis.

## Behaviour of Chromosomes in Meiosis

- **Meiosis I** (reduction division)
  - homologous chromosomes (four chromatids) pair up — this is called synapsis
  - non-sister chromatids cross over at points called chiasmata
  - they may exchange genetic material by breaking and rejoining at these points — this is called *crossing over*
  - homologous pairs of chromosomes line up at equator of spindle, attached by centromeres
  - maternal and paternal chromosomes of each pair line up independently of other pairs — *independent assortment*

Explain why the products of meiosis are haploid cells and contain a single set of chromosomes.

  - homologous chromosomes separate and move towards opposite poles — centromeres remain intact
  - two new cells formed, each with half the original chromosome number i.e. haploid

- **Meiosis II**
  - new spindle apparatus forms
  - chromosomes line up at equator in a single line
  - centromeres divide and sister chromatids move towards opposite poles
  - each cell divides, resulting in a total of four haploid products
  - each cell formed is genetically unique due to crossing over and independent assortment.

Explain that fertilisation restores the diploid number.

| | | | | |
|---|---|---|---|---|
| sperm | + | egg | → | zygote |
| haploid (n) | | haploid (n) | | diploid (2n) |

In humans n=23 and 2n=46

Crossing over and independent assortment increase the degree of genetic variation.

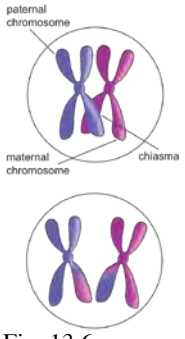


Fig. 13.6


Fig. 13.7

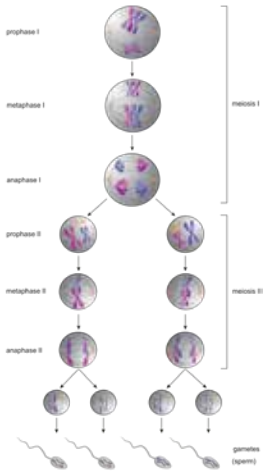


Fig. 13.5

Failure of homologous chromosomes to separate during meiosis I ('non-disjunction') can give rise to conditions such as Down Syndrome, Klinefelter Syndrome, and Turner Syndrome. See textbox on P110

See textbox on P110 (POLYPLOIDY) for effect of non-disjunction in plants. Also see P186.

# 17 The Nervous System

## Motor neurons

Structure: multipolar

Function: transmit signal from CNS to effectors

Describe the structure of a nerve pathway from receptor to effector.

- receptor
- sensory neuron
- CNS (spinal cord or brain – may involve interneuron)
- motor neuron
- effector (muscle or gland)

Note: This shows the structures involved in the stimulus-response model (See Chapter 16)

Describe the role of synapses and neurotransmitters.

Synapses connect neurons in a nerve pathway

Neurotransmitters are chemicals that carry a signal across the synaptic cleft

Describe the role and pathway of reflex responses.

**Reflex Response** — is an automatic response to a stimulus, the brain is not directly involved, a nerve message passes into and out of spinal cord

— results in a rapid response provides protection

STIMULUS → sensory receptor → sensory neuron ↓

RESPONSE ← effector ← motor neuron

Examples: knee jerk reflex
swallowing reflex
removing hand from a hot object
alteration of pupil size in response to light

NOTE: The enteric NS operates independently of the CNS – see Page 138.

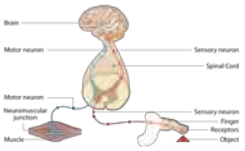


Fig. 17.6

Fig 17.7

Note: Neurotoxins, including Botox, snake venom, and fly spray work at synapses. See textboxes on P139 & 140

Fig 17.8

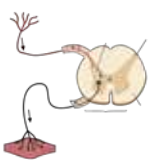


Fig 17.9

# 23 Gene Pools and Natural Selection

A gene pool comprises all the genetic information in a population.

A **gene pool** is the sum of all of the genes of all of the individuals in a population. (See Chapter 21)

## Not all offspring will survive to reproduce

Malthus (1798) — wrote that population sizes do not increase in an uncontrolled way. Even slow reproducers, such as elephants, would overrun the Earth if not kept in check by factors such as disease, food supply, predators, competition, water availability, shelter, and environmental temperature.

In any population with genetic variability, some individuals have a better chance of survival than others. Thus, some individuals will die before they reproduce.

Individuals that have favourable genetically controlled characteristics will have a better chance of surviving and reproducing than those that do not.

These ideas form the basis of **Natural Selection**, the process involved in the evolution of life on Earth.

Natural selection is a process in which organisms that are better adapted to their environment are more likely to survive and produce offspring.

The idea of **natural selection** was put forward in 1859 by Charles Darwin. He had observed differences in populations of finches on separate islands in the Galapagos group.

Darwin proposed that the distinctly different populations of finches had arisen from an original population as follows:

- within a population there is genetic variability between individuals
- some individuals are better suited (adapted) to the environment than others
- these individuals tend to survive longer and produce more offspring
- they tend to pass on the genes for favourable characteristics to the next generation
- over many generations the proportion of individuals in the population with favourable characteristics will increase.

Fig. 23.3 Galapagos Is.

Note: the changes described refer to changes in populations, **not** individuals.