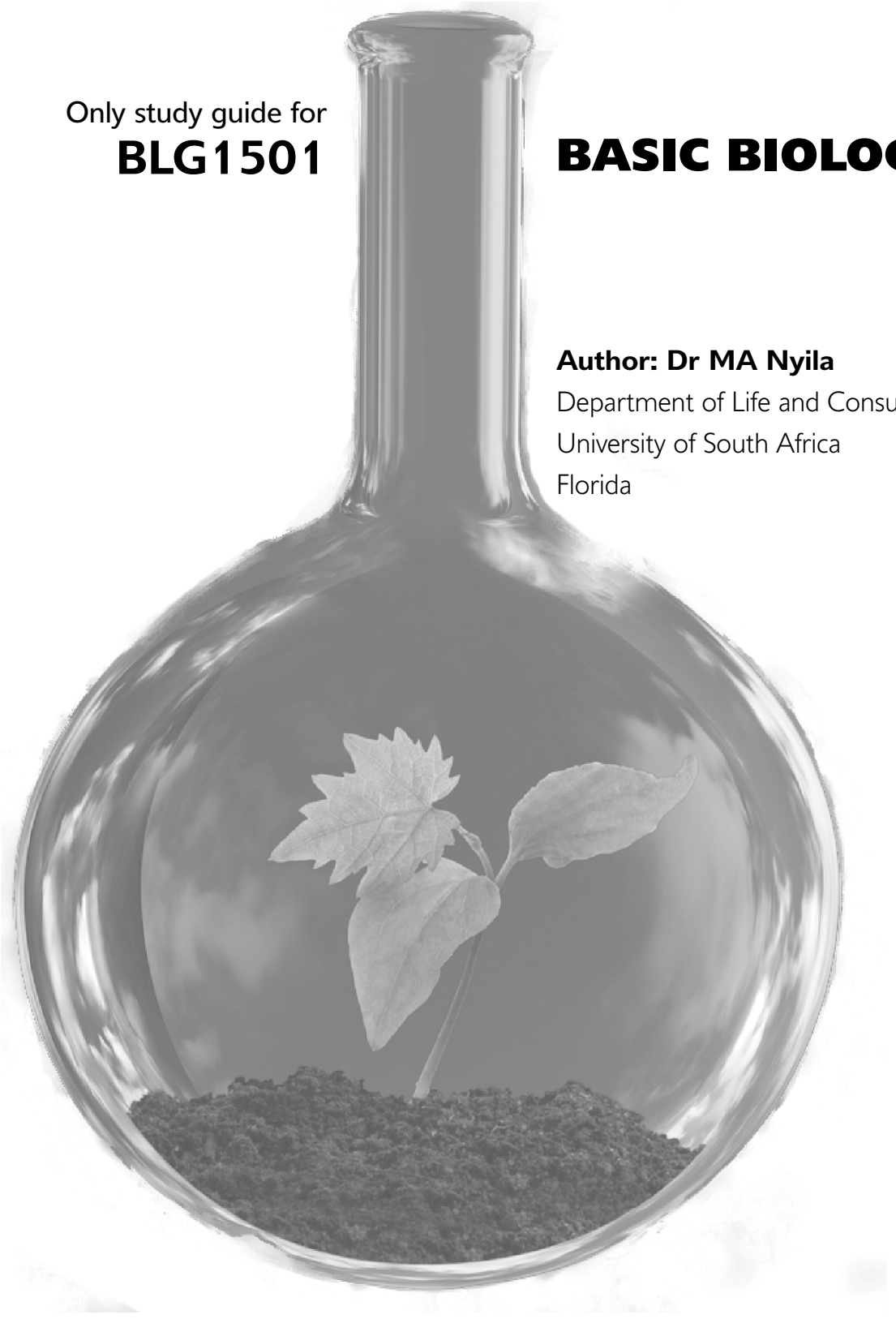
Only study guide for

BLG1501

BASIC BIOLOGY



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ORIENTATION

Dear student

We welcome you to the exciting world of biology! Module BLG1501 deals with the basic concepts of biology that are necessary for understanding how life begins. It is an honour for us to introduce you to this stimulating and dynamic field. This module deals with the theory component of biology. You should also simultaneously be **registered for the practical module,** BLG1603. We hope that you will find this module interesting and stimulating. To ensure that you master this field of study we urge you to read this orientation section in detail. You should use this study guide in conjunction with the tutorial letters (especially TL 101) and the prescribed textbook. For more information on the practical sessions, please consult Tutorial Letter 101 for BLG1603. Should you have any problems or queries about academic matters, feel free to contact us.

1 PURPOSE OF THIS STUDY GUIDE

The purpose of this study guide is to introduce you to biology and its development as a life science. This guide will provide you with insight into the building blocks of biology and the links between these blocks. The role of cells in living organisms will be explored as well as the interrelatedness of all the building blocks of biology.

2 LINK TO OTHER COURSES/MODULES

This module does not stand on its own – it forms an integral part of the life sciences field of study and, more specifically, undergraduate natural science (life sciences streams). It is intended to give you the foundation needed to understand the various branches of life sciences, such as biochemistry, microbiology and physiology.

3 LEARNING OUTCOMES

Unisa's approach to teaching and learning is outcomes-based education. In line with this, this module is based on outcomes-based learning. The learning outcomes for this module are linked to assessment criteria, learning activities, assignments, practicals and the examination.

3.1 Learning outcomes for BLG1501

After working through this study guide, you should be able to

- contextualise the physical and chemical characteristics of life
- demonstrate your knowledge of plant and animal composition
- deal in a knowledgeable way with the molecular basis of inheritance
- explain processes such as protein synthesis and respiration

- use your knowledge of ecology to interpret and understand the biosphere
- discuss/explain the biodiversity and complexity of creation and the methods for its sustainment
- operate ethically using all forms of communication

The assessment criteria for the learning outcomes are included below.

Assessment criteria for BLG1501

1 Contextualise the physical and chemical characteristics of life.

- Categorise living organisms in terms of levels of organisation or structural levels and illustrate the levels with examples.
- Describe the seven properties of life.
- Distinguish between prokaryotic and eukaryotic cells.
- Describe the structure and function of DNA and explain the role of the structure to a lay audience.

2 Demonstrate your knowledge of plant and animal composition.

- Distinguish between an element and a compound.
- Identify the four elements that make up 96% of living matter.
- State what trace elements are.
- Explain why weak bonds are important to living organisms.
- Describe and compare hydrogen bonds and Van der Waals interactions.
- Explain how a molecule's shape influences its biological function.
- Describe the structure of an atom.
- Define and distinguish among atomic number, mass number, atomic weight, and valence.
- Determine the number of an atom's neutrons if the atomic number and mass number of the atom are given.
- Explain why radioactive isotopes are important to biologists.

3 Use your knowledge of ecology to interpret and understand the biosphere.

- Describe how water contributes to the fitness of the environment to support life.
- Describe the structure and geometry of a water molecule and explain what properties emerge as a result of this structure.
- List the four characteristics of water that are emergent properties resulting from hydrogen bonding.
- Describe the biological significance of the cohesiveness of water.
- Explain the basis for the pH scale.
- Explain how acids and bases directly or indirectly affect the hydrogen ion concentration of a solution.
- Use the bicarbonate buffer system as an example and explain how buffers work.
- Describe the causes of acid precipitation and explain how it harms the environment.

4 Explain processes such as the molecular diversity of life, carbon, protein synthesis and respiration.

- Distinguish among the three types of isomers: structural, geometric, and enantiomer.
- Explain how monomers are used to build polymers.
- List the four major classes of macromolecules.
- Compare condensation and hydrolysis.
- Explain how organic polymers contribute to biological diversity.
- Describe the characteristics that distinguish proteins from the other major classes of macromolecules and explain the biologically important functions of this group.
- Distinguish between a polypeptide and a protein.
- Explain what determines protein conformation and why it is important.
- Describe the characteristics that distinguish nucleic acids from other major groups of macromolecules.
- Summarise the functions of nucleic acids.
- Distinguish between prokaryotic and eukaryotic cells.
- Describe the structure and function of the nucleus and briefly explain how the nucleus controls protein synthesis in the cytoplasm.
- Describe the structure and function of a eukaryotic ribosome.
- List the components of the endomembrane system and describe their structure and functions.
- Explain the roles of mitochondria and chloroplasts.
- Describe the structure of a mitochondrion and explain the importance of compartmentalisation in mitochondrial function.

5 Deal in a knowledgeable way with the molecular basis of inheritance.

- Define Mendel's law of segregation.
- Use a Punnett square to predict the results of a monohybrid cross and state the phenotypic and genotypic ratios of the F_2 generation.
- Distinguish between the following pairs of terms: dominant and recessive; heterozygous and homozygous; genotype and phenotype.
- Explain how a testcross can be used to determine if a dominant phenotype is homozygous or heterozygous.
- Use a Punnett square to predict the results of a dihybrid cross and state the phenotypic and genotypic ratios of the F_2 generation.
- Define Mendel's law of independent assortment.

6 Discuss/explain the biodiversity and complexity of creation and the methods for its sustainment.

- Explain the difference between a community and a population.
- List four possible specific interactions and explain how the relationships affect the population densities.
- Explain how interspecific competition may affect community structure.
- Describe the competitive exclusion principle and explain how competitive exclusion may affect community structure.
- Define an ecological niche and restate the competitive exclusion principle using the niche concept.

- Explain how resource partitioning can affect species diversity.
- Define and compare predation, herbivory and parasitism.
- Relate some specific predatory adaptations to the properties of the prey.
- Describe the defence mechanisms that have evolved in plants to reduce predation by herbivores.
- Explain how cryptic coloration and warning coloration aid an animal in avoiding predators.
- Describe the relationship between autotrophs and heterotrophs in an ecosystem.
- Explain how decomposition connects all trophic levels in an ecosystem.
- Explain how the first and second laws of thermodynamics apply to ecosystems.
- Describe the three levels of biodiversity.
- Explain why biodiversity at all levels is vital to human welfare.
- List the four major threats to biodiversity and give an example of each.

7 Operate ethically using all forms of communication.

- Be able to use biology terms correctly in all forms of communication.

4 FRAMEWORK OF BLG1501

Table 1 Framework of BLG1501

Topic 1 Introduction: Themes in the study of life	**Topic: 2** The chemical context of life	**Topic: 3** Water and the fitness of the environment	**Topic 4:** Carbon and the molecular diversity of life
Study unit 1.1: Themes connect the concepts of biology	**Study unit 2.1:** Matter consists of chemical elements in pure form and in combinations called compounds	**Study unit 3.1:** The polarity of water molecules results in hydrogen bonding	**Study unit 4.1:** Organic chemistry is the study of carbon compounds
Study unit 1.2: The core theme: Evolution accounts for the unity and diversity of life.	**Study unit 2.2:** An element's properties depend on the structure of its atoms	**Study unit 3.2:** Four emergent properties of water contribute the earth's fitness for life	**Study unit 4.2:** Carbon atoms can form diverse molecules by bonding to four other atoms

Study unit 1.3: Scientists use two main forms of inquiry in their study of nature	**Study unit 2.3**: The formation and function of molecules depend on chemical bonding between atoms	**Study unit 3.3:** Dissociation of water molecules leads to acidic and basic conditions that affect living organisms	**Study unit 4.3:** Functional groups are the parts of molecule involved in chemical reactions
	STUDY UNIT 2.4: Chemical reactions make and break chemical bonds		

Framework continues

Topic 5: The structure and function of macromolecules	**Topic 6:** A tour of the cell	**Topic 7:** Membrane structure and function	**Topic 8:** An introduction to metabolism
Study unit 5.1: Most macromolecules are polymers, built from monomers	**Study unit 6.1:** To study cells, biologists use microscopes and the tools of biochemistry	**Study unit 7.1:** Cellular membranes are fluid mosaics of lipids and proteins	**STUDY UNIT 8.1:** An organism's metabolism transforms matter and energy, subject to the laws of thermodynamics
Study unit 5.2: Carbohydrates serve as fuel and building material.	**Study unit 6.2:** Eukaryotic cells have internal membranes that compartmentalise their functions.	**Study unit 7.2:** Membrane structure results in selective permeability.	**Study unit 8.2:** The free-energy change of a reaction tells us whether the reaction occurs spontaneously.
Study unit 5.3: Lipids are a diverse group of hydrophobic molecules.	**Study unit 6.3:** The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosome.	**Study unit 7.3:** Passive transport is diffusion of a substance across a membrane with no energy investment.	**Study unit 8.3:** ATP powers cellular work by coupling exergonic reactions to endergonic reactions

Study unit 5.4: Proteins have many structures, resulting in a wide range of functions.	**Study unit 6.4:** The endomembrane system regulates protein traffic and performs metabolic functions in the cell.	**Study unit 7.4:** Active transport uses energy to move solutes against their gradients.	**Study unit 8.4:** Enzymes speed up metabolic reactions by lowering energy barriers.
Study unit 5.5: Nucleic acids store and transmit hereditary information.	**Study unit 6.5:** Mitochondria and chloroplasts change energy from one form to another.	**Study unit 7.5:** Bulk transport across the plasma membrane occurs by means of exocytosis and endocytosis.	**Study unit 8.5:** Regulation of enzyme activity helps control metabolism.
	Study unit 6.6: The cytoskeleton is a network of fibres that organises structures and activities in the cell.		
	Study unit 6.7: Extracellular components and connections between cells help coordinate cellular activities.		
Topic 9: Cellular respiration and fermentation	**Topic 10:** The cell cycle	**Topic 11:** Meiosis and sexual life cycles	**Topic 12:** Mendel and the gene idea
Study unit 9.1: Catabolic pathways yield energy by oxidising organic fuels.	**Study unit 10.1:** Cell division results in genetically identical daughter cells.	**Study unit 11.1:** Offspring acquire genes from parents by inheriting chromosomes.	**Study unit 12.1**: Mendel used the scientific approach to identify two laws of inheritance.
Study unit 9.2: Glycolysis harvests chemical energy by oxidising glucose to pyruvate.	**Study unit 10.2:** The mitotic phase alternates with interphase in the cell cycle.	**Study unit 11.2:** Fertilisation and meiosis alternate in sexual cycles.	**Study unit 12.2:** The laws of probability govern Mendelian inheritance.

Study unit 9.3: The citric acid cycle completes the energy-yielding oxidation of organic molecules.	**Study unit 10.3:** The cell cycle is regulated by a molecular control system.	**Study unit 11.3:** Meiosis reduces the number of chromosome sets from diploid to haploid.	**Study unit 12.3:** Inheritance patterns are often more complex than predicted by simple Mendelian genetics.
Study unit 9.4: During oxidative phosphorylation chemiosmosis couples electron transport to ATP synthesis.		**Study unit 11.4:** Genetic variation produced in sexual life cycles contributes to evolution.	**Study unit 12.4:** Many human traits follow Mendelian patterns of inheritance.
Study unit 9.5: Fermentation enables some cells to produce ATP without the use of oxygen.			
Study unit 9.6: Glycolysis and the citric acid cycle connect to many other metabolic pathways.			
Topic 13: From gene to protein	**Topic 14:** Community ecology	**Topic15:** Ecosystems and restoration ecology	**Topic 16:** Conservation biology and restoration ecology
Topic 13: From gene to protein	**Topic 14:** Community ecology	**Topic15:** Ecosystems and restoration ecology	**Topic 16:** Conservation biology and restoration ecology

Framework continues

Study unit 13.1: Genes specify proteins via transcription and translation.	**Study unit 14.1:** A community's interactions include competition, predation herbivory, symbiosis and disease.	**Study unit 15.1:** Physical laws govern energy flow and chemical cycling.	**STUDY UNIT 16.1:** Human activities threaten earth's biodiversity.
Study unit 13.2: Transcription is the DNA-direct synthesis of RNA: a closer look	**Study unit 14.2:** Diversity and trophic structure characterise biological communities.	**Study unit 15.2:** Energy and other limiting factors control primary production in ecosystems.	**Study unit 16.2:** Population conservation focuses on the population size, genetic diversity and critical habitat
Study unit 13.3: Eukaryotic cells modify RNA after transcription.	**Study unit 14.3:** Disturbance and influences species diversity and composition	**Study unit 15.3:** Energy transfer between trophic levels is typically only 10% efficient.	**Study unit 16.3:** Landscape and regional conservation aim to sustain entire biotas.
Study unit 13.4: Translation is the RNA-directed synthesis of a polypeptide: a closer look.	**Study unit 14.4:** Biogeographic factors affect community biodiversity.	**Study unit 15.4:** Biological and geochemical processes cycle nutrients and water in the ecosystems.	**Study unit 16.4:** Restoration ecology attempts to restore degraded ecosystems to a more natural state.
Study unit 13.5: RNA plays multiple roles in the cell: a review.	**Study unit 14.5:** Contrasting views of community structure are the subject of continuing debate.	**Study unit 15.5:** Restoration ecologists help return degraded ecosystems to a more natural state.	**Study unit 16.5:** Sustainable development can improve human lives while conserving biodiversity.
Study unit 13.6: Comparing gene expression in prokaryotes and eukaryotes reveals key differences.			

Study unit 13.7: Point mutations can affect protein structure and function.			

COMMUNICATION WITH THE DEPARTMENT AND THE UNIVERSITY

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For academic queries please contact the lecturers for the module

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WRITTEN EXAMINATION AND ADMISSION TO THE EXAMINATIONS

Written examination: The exam consists of one two-hour paper written in May/June for Semester 1 and October/November for Semester 2. In order to pass the written examination you need to obtain a minimum of 50% and for a distinction 75%.

Year mark: Both Assignments 01 and 02 contribute towards the year mark.

PRACTICAL WORK AND PRACTICAL EXAMINATION

As stated earlier in this study guide, the module BLG1501 is concerned with theory only. The aspects that need practical exposure are dealt with in the practical module BLG1603L for which you need to register together with the theory module. For other details on the practicals refer to Tutorial Letter 101 for BLG1603.

The practical sessions are presented in September/October at the North-West University.

The practical examination will follow directly after completion of the practical work at the North-West University [Potchefstroom-campus] (for further information refer to Tutorial Letter 101 for module BLG1603).

ACTION VERBS

The action verbs are explained below in order to assist you to understand what is expected of you.

Name: Give a statement only.

Define: Give the essential characteristics of the term.

Tabulate: Compare in a table (tabular form).

Criticise: Give the good and the bad characteristics after scrutinising the statement.

Differentiate: Distinguish between structures, objects or terms.

Substantiate: Give reasons for the statement.

Analyse: Find and give the essence or parts of the matter concerned.

Explain: Make known in detail by using a description, examples or illustrations.

Describe: Give the characteristics of something in a logical and structured way.

Discuss: Examine by argument. Look at the different angles of a statement.

Identify: Give the essential characteristics of a structure or a term.

Compare: Give the similarities and the differences between structures. This is usually done in a table.

Give a line diagram: Give a labelled outline of the different parts of an object. It is not necessary to give a detailed drawing.

Make a drawing: Give a labelled drawing that shows the different parts of the object.

Give a diagrammatic representation: Give a scheme of the different steps or phases of a process.

HOW TO USE THIS STUDY GUIDE

The aim of this study guide is to guide you through certain chapters in your prescribed textbook to attain the desired outcomes. Each study unit is based on a number of chapters in the textbook, which in turn are divided into discussions of various concepts. These concepts are designed to support your learning process and to guide you to achieve the learning outcomes. Follow the sequence of events carefully and complete all learning activities. It is also important to study the learning outcomes in the study guide, as these outcomes define the link between the intentions and the learning results. *In other words: learning outcomes are statements of what is expected of you after studying this section.* Our advice is that you should take these outcomes seriously and that you apply them when you start the section and during all the activities and that you use them as a check list when you complete the section. Relevant and applicable sections from the prescribed book, Campbell *Biology* 9th edition, Reece et all. 2011 are applied in the learning activities. Use these to support your learning process. Make sure you reflect on your learning process and the achievement of the outcomes.

Tutorial Letter 101 will instruct/inform you which questions you must submit to your lecturer for evaluation.

USE OF ICONS

	**LEARNING OUTCOMES.** The learning outcome icon indicates which aspect of the study units of a particular topic you have to master.
	**ACTIVITY.** The activity icon refers to activities that you must complete in order to develop a deeper understanding of the learning material (the study units you have completed).
	**STUDY.** This icon indicates the section that should be studied.

STUDY MATERIAL

The prescribed textbook is:

Reece, JB, Urry, LA, Cain, ML, Wasserman, SA, Minorsky, PV & Jackson, RB. 2011. Campbell *Biology*. 9th edition. San Francisco: Pearson Benjamin Cummings.

ISBN 10: 0321739752; ISBN 13: 9780321739759

www.aw.com/bc

If you already have the following textbook, you can use it instead of the prescribed textbook.

Campbell, NA, Reece, JB, Urry, LA, Cain, ML, Wasserman, SA, Minorsky, PV & Jackson, RB. 2008. *Biology*. 8th edition. San Francisco: Pearson Benjamin Cummings.

www.aw.com/bc

Basic Biology

TOPIC 1

Introduction: Themes in the study of life

STUDY UNIT 1:1

Themes that make connections across different areas of biology

Introduction

In this study unit you will be introduced to the diversity of life. We will focus on biological hierarchy, the interaction of organisms with their environment, biological organisation, the basic units (cells) of an organism, DNA, feedback mechanisms and evolution.

What is life? What is diversity? What is diversity of life? The aim of this study unit is for you to develop an understanding and to acquire knowledge of the properties of life "Themes connect the concept of biology".

Learning outcome 1:
Contextualise the physical and chemical characteristics of life.

You will know that you have achieved this learning outcome if you are able to: do the following:

- categorise living organisms in terms of levels of organisation or structural levels and illustrate the levels with examples
- describe the seven properties of life
- distinguish between prokaryotic and eukaryotic cells

TEXTBOOK READING:

Study the section in your prescribed book, Reece et al (2011) pages 2–6 on biologists who explore life with the microscopic. Read the headings carefully to get an idea of the purpose of the text.

Theme: New properties emerge at each level in the biological hierarchy.

One of the most important things you should know about life is that it extends from the microscopic level of molecules and cells, which constitute organisms, to the global scale of the entire living planet.

Living organisms are divided into different levels of biological organisation. The living world has a hierarchical organisation, extending from molecules to the biosphere. You should be able to draw a diagram depicting the hierarchy of biological organisation (see fig 1.4 on pp 50–51 in Reece et al 2011).

Theme: Organisms interact with other organisms and the physical environment.

Life does not exist in a vacuum. This section gives a brief introduction to ecosystem dynamics and energy conversion. Figure 1.5 (on p 52 of Reece et al 2011) gives a basic scheme for energy flow through an ecosystem.

Global climate change has already caused extreme negative effects on life forms and their habitats all over earth. Can you name any of the consequences of climate change? Your answer may include severe floods, excessive heat waves, and so forth.

Theme: Life requires energy transfer and transformation.

Imagine that you have just eaten lunch. Dou you think your body uses most of this food? Like all animals, the food that you eat provides chemical energy for your body. This energy is in the form of organic molecules, particularly carbohydrates. Originally these organic molecules were produced by plants in the chemical reaction of photosynthesis, a process that requires energy. Where do plants get the energy to make these organic molecules? See fig 1.6 on p 53 of Reece et al (2011) to see how energy flows in an ecosystem. You will learn more about this in the module BLG1502 (photosynthesis).

Theme: Structure and function are correlated at all levels of biological organisation.

Biological structures may give us clues about what they do and how they function. For example, in figure 1.4, the thin, flat shape of the leaf tells us that the leaf receives increased amounts of sunlight, which can be trapped by its chloroplasts.

Theme: Cells are an organism's basic units of structure and function.

What is a cell? Can you give examples of cells found in animals and plants?

All living things consist of cells and all cells originate from other cells. The ability to divide to form new cells is the basis for reproduction, growth, revitalisation and regeneration in organisms.

Prokaryotic and eukaryotic cells can be distinguished by their structural organisation. A eukaryotic cell is subdivided by internal membranes into many different functional compartments membrane enclosed organelles**.** The difference between prokaryotic and eukaryotic cells is that prokaryotic cells lack organelles that is membrane bound.The DNA is contained in a nucleus. Prokaryotic cells lack the cytoplasmic organelles typical of eukaryotic cells and the DNA is not separated by a plasmic membrane from the rest of the cell, thus forming a nucleus. You should be able to tabulate the differences between a prokaryotic and eukaryotic cell.

Theme: The continuity of life is based on heritable information in the form of DNA

The biological information encoded in a molecule is known as deoxyribonucleic acid or DNA. In chapter 17 we will look more closely at the way DNA is expressed as a protein. Study the diagrammatic presentation of DNA (fig 1.10) and make sure that you understand and know what DNA is and what the abbreviation stands for.

Systems biology at the levels of cell and molecules

What do you understand by the word *systems*? How does the word *system* fit into Biology?

Systems biology is necessary to investigate the way in which each part of a system behaves in relation to the others in a working system; however, the ultimate goal of systems biology is to model the dynamic behaviour of whole biological systems.

Theme: Feedback mechanisms regulate biological systems

What do you understand by the feedback mechanism in biological systems? Explain and give examples (where possible from the textbook).

Feedback regulation in biological systems: How does a cell coordinate its various chemical pathways? The key is the ability of many biological processes to self-regulate using a mechanism called feedback. In feedback regulation, the output or product of the process regulates that very process. Figure 1.13 gives you an idea of how negative feedback works.

Evolution, the overarching theme of Biology

We all know that Biology is the study of life. Can you try to answer these two questions?

- What do you know about evolution?
- Can you explain the term *evolution* in your own words?

Evolution is the core theme of biology. Life on earth evolved billions of years ago. You may find that organisms share many features. Look at the penguin, crocodile, hummingbird, sea horse in figure1.3 (Reece et al 2011). You will notice that these organisms look different but their skeletons are similar. The scientific explanation for this phenomenon is known as evolution.

The theory of evolution helps to explain that the organisms found on earth today are modified descendants of common ancestors. What organism do we share our common ancestors with?

STUDY ACTIVITY 1.1

Compare prokaryotic and eukaryotic cells. Draw up a table with two columns headed "Prokaryotic cell" and "Eukaryotic cell", as shown in the example.

Prokaryotic cell	**Eukaryotic cell**
1 Lack membrane-bound nucleus	Membrane-bound nucleus present
2 Characteristic 2	Characteristic 2

Compare the specific characteristics of the two kinds of cells before you write them down. This is what is meant by tabulating differences or similarities.

FEEDBACK

If you are asked to compare two things it is important that you use a table and not to just list the facts. You will find more information about tabulation in the "Overview section" under the heading "Action verbs".

CONCEPT CHECK 1.1

Complete the concept check 1.1 on page 11 of Reece et al (2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook (Reece et al 2011).

STUDY UNIT 1.2

The core theme: Evolution accounts for the unity and diversity of life.

Introduction: In study unit 1.1 you were introduced to evolution**.**

The core theme: Evolution accounts for the unity and diversity of life (pp 12–18 in Reece et al 2011).

Learning outcome 1:
Contextualise the physical and chemical characteristics of life.

You will know that you have achieved this outcome if you can:

- list the three domains of life
- explain Darwin's Theory of Natural Selection

TEXTBOOK READING:

Study the section on evolution on pages 57–63 in Reece et al (2011). Read the headings carefully to get an idea of the purpose of the text.

Classifying diversity

What do you know about the word *diversity*? What do you understand by the concept of "unity in diversity"?

One million species have been named by biologists to date. This diversity of life includes prokaryotes (6 300 species), fungi (100 000 species), plants (290 000 species), vertebrates (52 000 species), and one million insects. Thousands of additional species are identified every year.

Can you give examples of any vertebrate species you know?

Grouping species: the basic idea

Why is grouping necessary? Humans tend to group diverse items according to similarities and their relationships to each other.

How do you group your music collection? You may group your music collection into categories such rock, jazz, rhythm and blues (RMB), soul, and classical. We group species that are similar in the same way.

In BLG1502 you will learn more about taxonomy or the classification of species into groups. Taxonomy is the branch of biology that names and classifies species into groups of increasing breadth, based on the degree to which they share similar characteristics. To get a picture of this see figure 1.14 on page 58 (Reece et al 2011).

It is important that you know the taxonomic levels, that is, the phylum, class, order, family, genus and species, into which an organism can be classified.

The emergent properties of systems: Emergent properties are the result of the arrangement and interactions of the parts of systems. Work through the example in this section to understand the concept of emergent properties better.

The power and limitations of reductionism: Reductionism is to reduce complex systems to simpler components that are more manageable to study. You should know what reductionism is as well as its limitations.

Systems biology is necessary to investigate how each part of a system behaves in relation to others in the working system; however, the ultimate goal of systems biology is to model the dynamic behaviour of entire biological systems.

Feedback regulation in biological systems: How does a cell coordinate its various chemical pathways? The key is the ability of many biological processes to self-regulate by means of a mechanism called feedback. Feedback regulation occurs when the output or product of a process regulates that very process. Figure 1.11 gives you an idea of how negative feedback works.

The three domains of life

Can you name the three domains of life? These are bacteria, Archaea and Eukarya. See figure 1.15 on page 59 (Reece et al 2011).

CONCEPT CHECK 1.2

Complete concept check 1.2 on page 72 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 1.3

Biologists explore life across its great diversity of species.

Learning outcome 1:
Contextualise the physical and chemical characteristics of life.

You will know that you have achieved this learning outcome if you are able to:

- distinguish among the three domains of life
- list and distinguish among the kingdoms of eukaryotic life

TEXTBOOK READING:

Study the section on biologists who explore life across the great diversity of species in Campbell, pages 12–14. Read the headings carefully to get an idea of the purpose of the text.

Organising the diversity of life

Grouping species: In BLG1502 you will learn more about taxonomy or the classification of species into groups. However it is important that you know the taxonomic levels, that is domain, kingdom, phylum, class, order, family, genus and species, on which an organism can be classified.

The three domains of life: Twenty years ago life was divided into five kingdoms namely: Monera (bacteria and cyanobacteria), Fungi, Protists (algae), Plantae and Animalia. A new trend is to assign life to three higher levels of classification called domains. These three domains are Bacteria, Archaea and Eukarya. Eukarya are then divided into four kingdoms: Fungi, Protists, Plantae and Animalia. It is important that you can name the three domains and the four kingdoms of life.

Unity in diversity: Although life is diverse it also displays unity. Unity is evident in the features of the cell structure.

Charles Darwin and the Theory of Natural Selection: Life evolves – that is a fact. However, sometimes people have a problem with the concept of evolution. Nevertheless, evolution is a fact of life and according to which species evolve and adapt to environmental conditions. Read through this paragraph in the prescribed book, but it is not for examination purposes.

STUDY ACTIVITY

Under what domain would you classify the following organisms: humans, a pet (dog or cat), algae and disease-producing bacteria?

FEEDBACK

Figure 1.14 will help you with this classification.

Unity in the diversity of life: Unity at cellular level and diversity to adapt to a specific environment. You should make sure you understand this fascinating concept.

CONCEPT CHECK 1.2

Complete the concept check 1.2 on page 72 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

Basic Biology

TOPIC 2

The chemical context of life

TEXTBOOK READING:

This study unit is based on Reece et al, Chapter 2: The chemical context of life (pp 76–89).

STUDY UNIT 2.1

Matter consists of chemical elements in pure form and in combinations called compounds.

The aim of this study unit is to introduce you to chemical elements that are vital to life. Matter consists of chemical elements in pure form and in combinations called compounds.

Learning outcome 2:
Demonstrate your knowledge of plant and animal composition.

You will know that you have achieved this learning outcome if you are able to:

- distinguish between an element and a compound
- identify the four elements that make up 96% of living matter
- state what trace elements are

TEXTBOOK READING:

Can you define matter? Give examples of matter. For more detailed information on matter, chemical elements and compounds go to Reece et al (2011) pages 31 and 32. You should study the sections under the following headings:

Elements and compounds

As you know from your high school science background, matter is anything that occupies space and has mass, and it can occur in any state (gas, liquid, solid).

Matter is composed of atoms. An atom is the smallest particle of an element that retains its chemical properties. Atoms are much smaller than the smallest particle that is visible under a light microscope.

Can you differentiate between an element and a compound?

The term *element* is used for substances that cannot be broken down into simpler substances by chemical reactions. Each element has been allocated a chemical symbol, usually consisting of the first, or the first and second letters, of the English or Latin name for the element. You should be able to differentiate between matter, elements and compounds.

Essential elements of life: The greater part of the mass of all living organisms is composed of the following six chemical elements (the symbol appears in brackets): oxygen (O), carbon (C), hydrogen (H), nitrogen (N), calcium (Ca) and phosphorus (P).

Other elements occurring in smaller quantities (traces) in living organisms include potassium (K), sulphur (S), sodium (Na), magnesium (Mg), chlorine (Cl), iron (Fe) and iodine (I). See table 2.1 on page 32 (Reece et al 2011).

You know that life on earth is represented by a splendid diversity of organisms, ranging from undetectable viruses to huge pine trees and strange deep-sea fish. This diversity represents a long line of evolution that started when life first appeared on earth and a combination of geological events and biological interactions has produced the life seen on earth today.

Scientists have speculated that there are at least 10 000 solar systems in our Milky Way that have the right conditions to harbour life with the complexity of ours. Indeed, many other planets may contain simple life forms that are not readily recognisable. Astronomers are currently analysing rocks from other planets collected in space and on the earth for probable life. When looking for life, they rely on elemental analyses of the space material. Astronomers are currently analysing rocks from other planets collected in space and on the earth for probable life. When looking for life, they rely on elemental analyses of space material. Planets, no matter which one we are studying, all share the same 92 naturally occurring elements provided by the universe the same particular array and proportion which enable the presence of living organisms.

STUDY ACTIVITY 2.1

Complete the concept check 2.1 on page 32 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook (Reece et al 2011).

STUDY UNIT 2.2

The properties of an element depend on the structure of its atoms.

Learning outcome 2:
Demonstrate your knowledge of plant and animal composition.

You will know that you have achieved this learning outcome if you are able to:

- describe the structure of an atom
- define and distinguish among atomic number, mass number, atomic weight, and valence
- determine the numbers of its neutrons if the atomic number and mass number of an atom are given
- explain why radioactive isotopes are important to biologists

TEXTBOOK READING:

Study the section on that discusses the way an element's properties are dependent on the structure of its atoms (Reece et al 2011, pp 79–83) under the following headings:

Subatomic particles: You should be aware that physicists have formulated theories in connection with the structure of the atom. According to them, atoms consist of the following three particles:

1 electrons, which have a negative electrical charge and an extremely small mass (1/2000 Dalton)
2 protons, which have a positive electrical charge and weigh about 1 Dalton
3 neutrons, which are uncharged and have about the same mass as protons

You should be able to describe the structure of an atom (see fig 2.5 in Reece et al 2011).

Can you remember what an atomic number and a mass number are?

- **Atomic number and atomic mass**: The nucleus of an atom consists of protons and neutrons, while the electrons revolve around the nucleus in orbital paths. Atoms are electrically neutral since the number of protons (+) it has is equal to the number of electrons (-). You should be able to distinguish between atomic number, atomic mass and atomic weight and be able to determine the atomic mass of an element and the number of its neutrons if the atomic number and mass number of an atom are given.

STUDY ACTIVITY 2.2

Calculate the atomic number and atomic mass of the following elements: carbon, nitrogen and oxygen.

Give the electron configuration of a carbon atom, a nitrogen atom and an oxygen atom.

FEEDBACK

Use the periodic table in figure 2.9 to mark your answers.

Isotopes are atoms of the same element containing the same number of protons, but different numbers of neutrons. In nature, elements usually occur as a mixture of isotopes. Radioisotopes are used in the medical world for the diagnosis and treatment of certain diseases such as cancer. You should be able to explain why radioactive isotopes are important to biologists and to determine the number of neutrons in an element if the atomic number and mass number are given.

The energy levels of electrons: Electrons occupy regions of space, called orbitals, around the nucleus. There are no more than two electrons per orbital. Electrons with the same energy form a shell containing all the electrons in the same energy level. An energy level can consist of more than one orbital. For example, the innermost energy level contains a maximum of two electrons (one orbital), while the second energy level contains a maximum of eight electrons (four orbitals), and so forth. The number of electrons in the outermost energy level is very important, since this determines the chemical properties of the specific atom. You should know what an energy level (see fig 2.7 in Reece et al 2011), electron orbitals, valence electrons and valence shells are.

Electron configuration and chemical properties: The chemical behaviour of an atom is determined by its electron configuration. You should be able to give the electron configurations of the first 18 elements as shown in figure 2.9 in Reece et al (2011).

Electron orbitals: The three-dimensional space in which an electron is found 90% of the time is called an orbital. You need not be able to draw the three-dimensional shapes as shown in figure 2.9 (Reece et al 2011).

CONCEPT CHECK 2.2

Complete the concept check 2.2 on page 83 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 2.3

The formation and function of molecules depend on chemical bonding between atoms.

Learning outcome 2:
Demonstrate your knowledge of plant and animal composition.

You will know that you have achieved this learning outcome if you are able to:

- distinguish among non-polar covalent, polar covalent, and ionic bonds
- explain why weak bonds are important to living organisms
- describe and compare hydrogen bonds and Van der Waals interactions
- explain how a molecule's shape influences its biological function

TEXTBOOK READING:

Do you know how molecules are formed? Can you give one of the reasons why molecules are formed?

Study the section on the formation and function of molecules that depend on chemical bonding between atoms (Reece et al 2011, pp 84–88) under the following headings:

Atoms combine by chemical bonding to form molecules: The chemical properties of an element are determined primarily by the number of electrons in the outermost energy level. Elements whose outermost energy level is filled with electrons will not readily combine with other elements. In addition, elements whose outermost energy level is not occupied tend to lose or gain electrons, or to share with other elements, with the result that the outermost energy level of the compound will be occupied. The electrons in the outermost energy level of an atom are called valence electrons. A chemical bond can therefore be regarded as the force that holds atoms together. Each bond represents a certain amount of potential chemical energy.

Do you know why chemical bonds are important in biology? Explain in detail.

The following forms of chemical bonding are of biological importance:

Covalent bonds: When atoms that combine share their electrons on the outermost energy level, a covalent bond is formed, for example chemical formula and structural formula H:H or the molecular formula H_2. Each atom of hydrogen in the example contains only one electron, but two electrons are required to complete the outermost energy level; therefore, the two hydrogen atoms share their two electrons (one pair of electrons). When two pairs of electrons are shared in this way, a double bond occurs, for example: O_2 is O = O. Some atoms even form triple bonds. Study the explanation of covalent bonding in figures 2.11 and 2.12 (Reece et al 2011).

Polar covalent bonds: Electronegativity is the measure of an atom's attraction (pull) for electrons in chemical bonds. Covalent bonds between atoms with different electronegativity are called polar covalent bonds. Although a water molecule is electrically neutral, the two hydrogen atoms have a partial positive charge and the oxygen atom a partial negative

charge, because the electrons are closer to the nucleus of the oxygen atom than to the nucleus of the hydrogen atoms. Study figure 2.13 in Reece et al (2011).

Ionic bonds: When atoms lose or gain electrons, electrically charged particles, called ions, are formed. Atoms with one to three electrons in their outermost energy level may lose the electrons, and therefore become positively charged (because there are more protons than electrons); these are called cations. Atoms with five to seven valence electrons may gain electrons, and become negatively charged anions. Cations and anions play an essential role in processes such as the transmission of nerve impulses and muscle contractions. An ionic bond forms when cations and anions bond as a result of their opposite charges. In ionic bonds, electrons in the outermost energy levels are not shared, but are wholly transferred from one atom to another. Study the explanation of ionic bonding between sodium (Na)and chlorine (Cl) to form sodium chloride (NaCl – table salt) in figures 2.14 and 2.15 (Reece et al 2011).

Weak chemical bonds

Hydrogen bonds: These bonds can form between hydrogen atoms and oxygen atoms (or other electronegative atoms). Hydrogen bonding may occur between hydrogen molecules. Hydrogen bonds are weak and are easily formed and broken, but because of their specific length and orientation, they play an important role in determining the three-dimensional structure of certain large molecules such as proteins and nucleic acids .The large number of hydrogen bonds present in these molecules compensates for their relative weakness. See figure 2.16 in Reece et al (2011).

Van der Waals interactions: Non-polar covalent bonds may have positively and negatively charged regions where very weak bonds can be formed when the atoms and molecules are very close together.

Molecular shape and function: A molecule consisting of two atoms is always linear, but molecules with more than two atoms have different shapes. These shapes are determined by the position of the atom's orbital. Study the shapes of the water molecule and methane molecule. Also refer to figure 2.17 in Reece et al (2011).

STUDY ACTIVITY 2.3

Complete the concept check 2.3 on page 88 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook (Reece et al 2011).

STUDY UNIT 2.4

Chemical reactions make and break chemical bonds.

Learning outcome 2:
Demonstrate your knowledge of plant and animal composition.

You will know that you have achieved this learning outcome if you are able to:

- write the chemical equation that summarises the process of photosynthesis, noting the reactants and products
- describe how the relative concentrations of reactants and products affect a chemical reaction

TEXTBOOK READING:

Study the section on chemical reactions that make and break chemical bonds in Reece et al (2011), pages 88–89:

You should know what a chemical reaction, reactants, products and chemical equilibrium are.

STUDY ACTIVITY 2.4

Complete the concept check 2.4 on page 89 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

INDIVIDUAL EXERCISE

Test your understanding on page 90 in the textbook by doing no. 9.

FEEDBACK

Answers to the self-quiz questions in Reece et al (2011) are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check your answers and mark them.
- Make sure that you have mastered the outcomes.
- Work through the chapter review on page 45 (Reece et al 2011).

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 01.**

2.1 Define a chemical element. List the chemical symbols for ten different chemical elements. Which chemical element(s) make up the bulk of the human organism? (15)

2.2 What is an atom? Show the positions of the nucleus, protons, neutrons and electrons in a hydrogen atom using a diagram. (4)

2.3 Compare the atomic number to the atomic weight and mass number. (2)

2.4 What is an isotope? Discuss this phenomenon with regard to the medical application of radioisotopes. (5)

2.5 Discuss the term *electron configuration* as it applies to atoms. Indicate how the valence of an atom is determined. (3)

2.6 How are chemical bonds formed? Distinguish between an ionic bond and a covalent bond. Give at least one example of each. (5)

2.7 Define a hydrogen bond. (3)

TOPIC 3

Water and the fitness of the environment

STUDY UNIT 3.1

The polarity of water molecules results in hydrogen bonding

Learning outcome 3:
Use your knowledge of ecology to interpret and understand the biosphere.

You will know that you have achieved learning outcome if you are able to:

- discuss the role played by polarity and hydrogen bonding together with neighbouring water molecules

TEXTBOOK READING:

Why do you think water is indispensible to all living organisms? Do you know how the polarity of water functions?

Study the polarity of water molecules, which results in hydrogen bonding on page 92 of Reece et al (2011)

The water molecule is a polar molecule, meaning that opposite ends of the molecule have opposite charges. These opposite charges result in an electrical attraction between the water molecules to form a hydrogen bond. The hydrogen bonding that takes place between water molecules is the basis for water's unusual properties. You should be able to discuss the role played by polarity and hydrogen bonding together with neighbouring water molecules in promoting cohesion and adhesion. Study figure 3.3 in Reece et al (2011).

STUDY ACTIVITY 3.1

Complete concept check 3.1 on page 93 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 3.2

Four emergent properties of water contribute to earth's fitness for life

Learning outcome 3:
Use your knowledge of ecology to interpret and understand the biosphere.

You will know that you have achieved this learning outcome if you are able to:

- describe how water contributes to the fitness of the environment to support life
- describe the structure and geometry of a water molecule
- explain what properties emerge as a result of this structure
- list four characteristics of water that are emergent properties resulting from hydrogen bonding
- describe the biological significance of the cohesiveness of water
- distinguish between heat and temperature
- explain how water's high specific heat, high heat of vaporisation and expansion upon freezing affect both aquatic and terrestrial ecosystems
- distinguish among a solute, a solvent, and a solution
- explain how the polarity of the water molecule makes it a versatile solvent
- distinguish between hydrophilic and hydrophobic substances
- distinguish between a mole and the molecular weight of a substance

TEXTBOOK READING:

Can you explain what cohesion is?

Study the section on the four emergent properties of water that contribute to earth's fitness for life in Reece et al (2011) pages 93–98. Study the sections under the following headings:

Cohesion

Cohesion occurs when water molecules form hydrogen bonds with other water molecules, holding them together. Cohesion contributes to the transport of water against gravity in plants and is, in effect, the clinging of one substance to another. You should be able to explain what characteristic of water enables it to perform a capillary action and the way in which surface tension is exerted in water.

Moderation of temperature: Whenever two objects of different temperature are brought together, heat passes from the warmer to the cooler body until the two are the same temperature.

Heat and temperature

Anything that moves has kinetic energy and heat is a measure of the total amount of kinetic energy that results from molecular motion. You need to understand important concepts such as temperature, the Celsius scale, calories and joules.

Water's high specific heat: The specific heat of a substance is defined as the amount of heat that must be absorbed or lost for 1 g of that substance to change its temperature by 1 °C.

Evaporative cooling: Evaporation takes place when high-energy molecules in a liquid phase escape into the gas phase, taking a lot of energy with them and cooling the surface of the liquid.

Insulation of bodies of water by floating ice: The ability of ice to float because of the expansion of water as it solidifies is an important factor in the fitness of environments. You should be able to explain what is meant by the high specific heat capacity of water and its influence on organisms.

The solvent of life: The polarity of water makes it a versatile solvent because it is attracted to charged substances. Figure 3.6 in Reece et al (2011) shows what happens when a crystal of table salt dissolves in water.

Hydrophilic and hydrophobic substances: Hydrophilic substances have an affinity for water, while hydrophobic substances do not.

Solute concentration in aqueous solutions: Any compound has a molecular mass. The molecular mass of a compound is the sum of the atomic masses of the component atoms of a single molecule. In general this is often referred to as the molecular weight of a compound. Molecular weight, like atomic weight, is dimensionless and is expressed as a number, for example 180. One mole of any element or compound is referred to as the mass in grams, equivalent to its molecular or atomic mass, and is indicated as 1 M. The number of units in an element or compound is usually calculated with Avogadro's number ($6.02\ 6 \times 10^{23}$), which expresses the number of units in a mole of any element or compound. Molecular biologists usually deal with smaller values, such as mill moles (mmole) and micromoles (mole).

STUDY ACTIVITY 3.2

Complete concept check 3.2 on page 93 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 3.3

Acidic and basic conditions affect living organisms.

The purpose of this study unit is to introduce you to concepts such as acidity, alkalinity and pH, and the way these affect living organisms that depend on water for survival.

Learning outcome 3:
Use your knowledge of ecology to interpret and understand the biosphere.

You will know that you have achieved this learning outcome if you are able to:

- write the equation for the dissociation and re-formation of water
- explain the basis for the pH scale
- explain how acids and bases directly or indirectly affect the hydrogen ion concentration of a solution
- use the bicarbonate buffer system as an example and explain how buffers work
- describe the causes of acid precipitation and explain how it harms the environment

TEXTBOOK READING:

We assume that it is not the first time you have heard the words *acid*, *base* and *pH*. Can you define these terms? Can you perhaps also define *acidity* and *alkalinity*.

Study the section on the dissociation of water molecules which leads to acidic and basic conditions that affect living organisms (Reece et al 2011, pp 98–102). You should be able to explain what the dissociation of water molecules means. What is a hydroxide ion? Study the section under the following headings:

Effects of changes in pH

Acids and bases: A base or alkali, for example sodium hydroxide (NaOH) or ammonium hydroxide (NH_4), is a substance that forms many hydroxide ions (OH-) when dissociated from water. Therefore, a base or alkali always has a low concentration of hydrogen ions and, consequently, a high pH (pH of 7,1 to 14). The fewer the hydrogen ions formed, the stronger the base and the higher the pH. On the other hand, an acid, for example hydrochloric acid (HCl) or hydro sulphuric acid (H_2SO_4), is a substance that forms many hydrogen ions (H+) when dissociated (separated) from water. Therefore an acid always has a high concentration of hydrogen ions and, consequently, a low pH (pH of 0 to 6,9). The more hydrogen ions that are formed, the stronger the acid and the lower the pH.

The pH scale: To determine the degree of acidity or alkalinity of a medium, a pH scale is used. The pH of a medium is defined as the logarithm of the reciprocal of the hydrogen ion concentration, and is also expressed as: pH = log $1H^{+.}$ The values of the pH scale range from 0 to 14. Distilled water is a neutral medium with a pH of 7.

Buffers: Changes in the pH can be harmful to cells, as the chemical processes of the cell are very sensitive to the H+ concentration. A buffer minimises changes in the concentrations of the H+ and OH- by accepting hydrogen ions from the solution when they are in excess and donating hydrogen ions to the solution when they have been depleted.

The threat of acid precipitation: Acid precipitation refers to rain, snow or fog that is more acidic than pH 5.6. You should be able to explain what is meant by acid rain. What is the effect of acid precipitation on the environment?

STUDY UNIT 3.3

Complete concept check 3.3 on page 102 in the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

INDIVIDUAL EXERCISE

Complete the self-quiz on page 56 of the textbook (Reece et al 2011).

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

REFLECT ON YOUR LEARNING

- Check your answers and mark them.
- Make sure that you have mastered the outcomes.
- Work through the chapter review on page 56.

EVALUATION QUESTIONS

The evaluation questions will help you to determine if you mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 01.**

3.1 Define a hydrogen bond. Why are hydrogen bonds important? (2)

3.2 What advantage does the high specific heat capacity of water have for aquatic organisms? (2)

3.3 What advantage does the high specific heat capacity of water have for terrestrial organisms? (2)

3.4 Discuss the advantage of the high heat of evaporation of water for humans and plants. (2)

3.5 Define the term *acid* by referring to examples and the pH scale. (3)

3.6 Define the term *base* by referring to examples and the Ph scale. (3)

3.7 Define the term *buffer'*. In the definition refer to suitable examples and also indicate its application in living systems. (3)

3.8 Describe how water contributes to the fitness of the environment to support life. (10)

3.9 List four characteristics of water that are emergent properties resulting from hydrogen bonding. (4)

3.10 Describe the biological significance of the cohesiveness of water. (2)

3.11 Distinguish among a solute, a solvent and a solution. (3)

3.12 Why does sodium chloride dissolve in water? (5)

3.13 Distinguish between hydrophilic and hydrophobic substances. (2)

3.14 Distinguish between a mole and the molecular weight of a substance. (2)

Basic Biology

TOPIC 4

Carbon and the molecular diversity of life

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011), Chapter 4: Carbon and the molecular diversity of life (pp 104–112).

STUDY UNIT 4.1

Organic chemistry is the study of carbon compounds

What do you understand by organic chemistry? Can you give any examples of organic compounds?

Organic chemistry is the branch of chemistry that deals with carbon compounds. As you are aware, people often use the word *organic* without really knowing its meaning. The aim of this study unit is to introduce you to organic chemistry. Read pages 58 and 59 in Campbell (2011) for background information. It is interesting to read about how Stanley Miller created organic compounds in the laboratory in 1953.

In the next study unit you will be introduced to carbon atoms and how they play role in formation of carbon compounds that are essential to life.

STUDY UNIT 4.2

Carbon atoms can form diverse molecules by bonding to four other atoms.

Learning outcome 4:
Explain phenomena such as the molecular diversity of life

You will know that you have achieved this learning outcome if you are able to:

- explain how carbon's electron configuration determines the kinds and numbers of bonds that carbon will form
- describe how carbon skeletons may vary
- explain how the variation in carbon skeletons contributes to the diversity and complexity of organic molecules
- distinguish among the three types of isomers: structural, geometric, and enantiomer

TEXTBOOK READING:

Study the section on carbon atoms which form diverse molecules by bonding with four other atoms (Reece et al 2011 pp 106–109).

What do you know about carbon atoms? Can you explain how organic compounds are formed?

Now let us look at how bonds are formed.

The formation of bonds with carbon: All organic compounds contain carbon atoms (C). The complexity of organic compounds is attributed to the fact that a C atom has a valence of four; in other words this atom may form four bonds with other C atoms, or even with atoms of another type (hydrogen, oxygen, nitrogen, etc). These other atoms are able to bond with the framework of the C atoms in any of four directions. You should be able to give the electron configuration of a carbon atom. Figure 4.3 shows the molecular formula and structural formula and the shape of three simple organic molecules.

What do you know about hydrocarbons? Can you give an example of a hydrocarbon?

Hydrocarbons: The structure of an organic molecule may vary, that is, it may form single (unbranched) chains, branched chains or even rings (figs 4.3 and 4.5). One example of hydrocarbon is methane (CH_4). It is important that you appreciate the diversity of carbon bonding but it is not necessary to learn these figures. Organic molecules consisting only of carbon and hydrogen are called hydrocarbons. What are hydrocarbons and why are they important?

Isomers: It is important that you can differentiate between the different isomers – structural isomers, geometric isomers and enantiomers, as shown in figure 4.7 in Reece et al (2011). Pharmacodynamics is the study of how drug affect the body, including possible side effects. The shape, electrical charge and chemistry of a drug molecule are all factors that determine its pharmacodynamic properties. For example, two drug enantiomer molecules that are mirror images may have quite different effects simply because of their subtle difference in shape.

STUDY ACTIVITY 4.2

Complete concept check 4.2 on page 63 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 4.3

Functional groups are the parts of molecules involved in chemical reaction.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- name the major functional groups and describe the chemical properties of the organic molecules in which they occur

TEXTBOOK READING:

Study the section on the functional groups that form the parts of molecules involved in chemical reactions in Reece et al (2011), page 107.

- The chemical groups that figure most prominently in the processes of life (see fig 4.9) are summarised in this paragraph. Make sure that you know and understand this information.
- Adenosine triphosphate (ATP) is an important source of energy for cellular processes: in addition, it is the primary energy-transferring molecule in the cell.
- Read through the section headed "The chemical elements of life: a review" for background knowledge – you will not be examined on this content.

CONCEPT CHECK 4.3

Complete concept check 4.3 on page 112 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

INDIVIDUAL EXERCISE

Complete the questions in "Test your understanding" on page 113 of the textbook.

FEEDBACK

Answers to the "Test your understanding" questions are provided in Appendix A at the back of the textbook.

SUMMARY

In this topic you learnt about the importance of carbon compounds; in the next topic you will learn about the four major groups of macromolecules. Carbon compounds also form part of these four macromolecules, namely carbohydrates, lipids, proteins and nucleic acids.

REFLECT ON YOUR LEARNING

- Check your answers and mark them.
- Make sure that you have mastered the outcomes.
- Then work through the "Chapter review" on page 112 of Reece et al (2011).

EVALUATION QUESTIONS

The following evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 01.**

4.1 Define the following terms: *organic compound*; *hydrocarbon*; *isomer*; *structural isomer*; *geometrical isomer* and *enatiomers*. (6)

4.2 Give the structural formulae for methane; ethylene and carbon dioxide. (3)

4.3 Give the electron configuration of carbon and nitrogen. (4)

4.4 Give the formulae for and the name of the functional group that occurs in the following compounds: alcohols; aldehydes; ketones; carbolic acids; amines; thiols; organic phosphates. (14)

TOPIC 5

The structure and function of large biological molecules

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011) Chapter 5: The structure and function of large biological molecules (pp 114–135).

STUDY UNIT 5.1

Macromolecules are polymers, built from monomers.

The aim of this study unit is to give an insight into the most important macromolecules.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration

You will know that you have achieved this outcome if you are able to:

- explain how monomers are used to build polymers
- list the four major classes of macromolecules
- compare condensation and hydrolysis
- explain how organic polymers contribute to biological diversity

TEXTBOOK READING:

Do you know how polymers are formed? Study the section that discusses the fact that most macromolecules are polymers and are built from monomers in Reece et al (2011) pages 114–115 under the following headings:

The synthesis and breakdown of polymers: Carbohydrates, lipids, proteins and nucleic acids are the four classes of organic compounds in cells. You should be able to explain how monomers are used to build polymers and to explain concepts such as condensation reaction, dehydration reaction and hydrolysis. Figure 5.2 is helpful for understanding the dehydration reaction and hydrolysis.

The diversity of polymers: All you need to know in this paragraph is that the basis for diversity in life's polymers is attributed to the variety of monomer arrangements.

CONCEPT CHECK 5.1

Complete concept check 5.1 on page 115 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 5.2

Carbohydrates serve as fuel and building material.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- describe the distinguishing characteristics of carbohydrates
- explain how carbohydrates are classified
- distinguish between monosaccharides and disaccharides
- identify a glycosidic linkage and describe how it is formed
- describe the structure and functions of polysaccharides

TEXTBOOK READING:

Can you explain why living organisms need food? What type of food gives us energy? Study the section on carbohydrates, which serve as fuel and building material, in Reece et al (2011), pages 115–120 under the following headings:

Sugars: The smallest carbohydrates serve as fuel and carbon sources. Distinguish between monosaccharides and disaccharides. A disaccharide consists of two monosaccharides joined by a glycosidic linkage. I do not expect you to know any structural formulas but you must know the molecular formula of glucose ($C_6H_{12}O_6$).

Polysaccharides: The polymers of sugars play a both storage role and a structural role. Polysaccharides are polymers with a few hundred to a few thousand monosaccharides joined by glycoside linkages. Storage polysaccharides consist of starch and glycogen, while structural polysaccharides comprise cellulose and chitin. You should be able to describe the structure and functions of these polysaccharides.

STUDY UNIT 5.3

Lipids are a diverse group of hydrophobic molecules.

The purpose of this study unit is to introduce you to macromolecules and lipids.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- explain what distinguishes lipids from other major classes of macromolecules
- describe the unique properties, building-block molecules, and biological importance of the important groups of lipids: fats and phospholipids
- identify an ester linkage and describe how it is formed
- distinguish between a saturated and an unsaturated fat and list some unique emergent properties that are a consequence of these structural differences

TEXTBOOK READING:

Why are fats important? Study the section on lipids, which are a diverse group of hydrophobic molecules, in Reece et al (2011) pages 120–123, under the following headings:

Fats store large amounts of energy. A fat is constructed from two types of smaller molecule: glycerol and fatty acids. You do not need to know the structural formula but consult figure 5.11 to help you to understand the formation of an ester linkage. Make sure that you master all the outcomes.

Phospholipids are major components of cell membranes. What is the difference between a fat and a phospholipid? Why are phospholipids so important in membranes? You do not need to know the structural formulas but figures 5.12 and 5.13 may help you to visualise the information in this paragraph. Steroids are lipids characterised by a carbon skeleton of four fused rings. You should be able to give an example of a steroid.

STUDY ACTIVITY

Describe the differences and similarities between the composition of carbohydrate and lipid molecules.

FEEDBACK

Carbohydrates consist of monomers coupled to form polymers. Lipids do not form polymers. Study figure 5.2 in Reece et al (2011) to help you understand the formation of a polymer and figure 5.11 for the formation of a lipid molecule. Remember, it is not necessary to know any structural formulas.

STUDY ACTIVITY 5.3

Complete concept check 5.3 on page 123 of the textbook.

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 5.4

Proteins have many structures, resulting in a wide range of functions.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- describe the characteristics that distinguish proteins from the other major classes of macromolecules and explain the biologically important functions of this group
- list and describe the four major components of an amino acid
- explain how amino acids may be grouped according to the physical and chemical properties of the side chains
- identify a peptide bond and explain how it is formed
- distinguish between a polypeptide and a protein
- explain what determines protein conformation and why it is important
- define primary structure, secondary, tertiary and quaternary protein structure
- define denaturation and explain how proteins may be denatured

TEXTBOOK READING:

Do you know what role proteins play in our bodies?

Study the section on proteins in Reece et al (2011), pages 123–132, under the following headings. Proteins have many structures, which means that they can perform a wide range of functions,:

- **Polypeptides:** *Amino acids* are organic molecules possessing both carboxyl and amino groups. You do not have to learn figure 5.16 but you must know that amino acids can be grouped according to the properties of their side chains. These side chains can be non-polar, polar and electrically charged.
- **Amino acid polymers:** Figure 5.17 illustrates the making of a polypeptide chain. The section "Determining the amino acid sequence of a polypeptide" makes interesting reading but is does not have to be studied for exam purposes.
- **Protein conformation and function:** Table 5.1 is an important overview of the functions of proteins. Make sure that you understand the difference between a polypeptide and a protein.

- **Four levels of protein structure:** You should be able to define the four levels of protein structure – nothing more – thus you should know the primary, secondary, tertiary and quaternary structure of a protein**.** Figure 5.19 give a visual representation of this.
- **Sickle-cell disease** occurs as a result of a simple change in primary structure of protein. Simply read through this section for background knowledge.
- What determines protein conformation? You have to know what denaturation is and explain how proteins may be denatured. The information on the protein-folding problem makes for interesting reading but is not for exam purposes.

STUDY UNIT 5.4

Complete the concept check 5.4 on page 132 of the textbook (Campbell 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 5.5

Nucleic acids store and transmit hereditary information.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- describe the characteristics that distinguish nucleic acids from other major groups of macromolecules
- summarise the functions of nucleic acids
- list the major components of a nucleotide, and describe how these monomers are linked to form a nucleic acid
- distinguish between a pyrimidine and a purine
- briefly describe the three-dimensional structure of DNA

TEXTBOOK READING:

Do you understand why you resemble your parents? Which macromolecules play a role in heredity? Study the section on nucleic acids, which store and transmit hereditary information, in Reece et al (2011), pages 132–135, under the following headings:

The role of nucleic acids: Nucleic acids store and transmit hereditary information. Genes consist of DNA and are biologically very important because they determine the primary structure of proteins. Why is this so important? There are two types of nucleic acid, deoxyribonucleic acid or DNA and ribonucleic acid or RNA. It is important for you to be able to describe the characteristics that distinguish nucleic acids from the other major

groups of macromolecules and also to be able to state their functions. Make sure that you understand figure 5.25 (Reece et all 2011) because it will help you when you are dealing with Chapter 17 (from gene to protein): The structure of nucleic acids.

Nucleotide monomers: Nucleic acids consist of nucleotides. Each nucleotide is, in turn, composed of three parts: a nitrogenous base, a pentose sugar and a phosphate group. There are two kinds of nitrogenous bases: pyrimidines and purines. The pyrimidines are cytosine, thymine and uracil, while the purines are guanine and adenine.

Nucleotide polymers: You do not need to know the structural formulas of the monomers or nucleotides of nucleic acids, but figure 5.27 will help you understand how things fit together. Figure 5.28 depicts the DNA double helix and will help you to understand the structure of DNA. The section on DNA and proteins as the tape measures of evolution is very interesting — read through it for background knowledge.

STUDY ACTIVITY 5.5

Do question number 1 of concept check 5.5 on page 89 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

A REVIEW: THE THEME OF EMERGENT PROPERTIES IN THE CHEMISTRY OF LIFE 2 (page 135 in Reece et al 2011)

This is a quick overview of the first five chapters. Read through it as it forms a link to the next study unit.

INDIVIDUAL EXERCISE

Complete the "Test your understanding" quiz on page 137 **in Reece et al 2011,** numbers 9 of the exercise in the textbook.

FEEDBACK

The answers to "Test your understanding" are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- check your answers and mark them.
- Make sure that you have mastered the outcomes.
- Work through the "Chapter review" on page 91 of the textbook.

EVALUATION QUESTIONS

The following evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 01.**

5.1 Explain how monomers are used to build polymers. (2)

5.2 List the four major classes of macromolecules. (4)

5.3 Compare condensation to hydrolysis. (2)

5.4 Describe the distinguishing characteristics of carbohydrates and explain how they are classified. (10)

5.5 Distinguish between monosaccharides and disaccharides. (4)

5.6 How are glycosidic linkages formed? (2)

5.7 Describe the structure and functions of four polysaccharides. (8)

5.8 What distinguishes lipids from other major classes of macro-molecules? (1)

5.9 Describe the unique properties, the building-block molecules and the biological importance of fats and phospholipids. (10)

5.10 How are ester linkages formed? (3)

5.11 Distinguish between a saturated and an unsaturated fat and list some unique emergent properties that are a consequence of these structural differences. (5)

5.12 Describe the characteristics that distinguish proteins from the other major classes of macromolecules and explain the biologically important functions of this group (8)

5.13 List and describe the four major components of an amino acid. Explain how amino acids may be grouped according to the physical and chemical properties of the side chains. (10)

5.14 How are peptide bonds formed? (3)

5.15 Distinguish between a polypeptide and a protein. (2)

5.16 Explain what determines protein conformation and why it is important. (4)

5.17 Distinguish between the primary, secondary, tertiary and quaternary protein structure. (4)

5.18 Define denaturation and explain how proteins may be denatured. (4)

5.19 Describe the characteristics that distinguish nucleic acids from the other major groups of macromolecules. (5)

5.20 Summarise the functions of nucleic acids. (4)

5.21 List the major components of a nucleotide, and describe how these monomers are linked to form a nucleic acid. (13)

5.22 Distinguish between a pyrimidine and a purine. (5)

5.23 Briefly describe the three-dimensional structure of DNA. (7)

Basic Biology

TOPIC 6
A tour of the cell

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011) Chapter 6: A tour of the cell (pp 140–168).

The cell is the basic unit of structure and function of the organism.

STUDY UNIT 6.1

To study cells, biologists use microscopes and the tools of biochemistry.

The aim of this study unit is to give you a brief background on cells, microscopy and the organelles of the cell. To study cells, biologist use microscopes and the tools of biochemistry. The section on the study of cells in Reece et al, pages 140 to 143, is not for exam purposes, but it is important that you work through it for the practical part of Biology (BLG1603).

Microscopes provide windows to the world of the cell: Study Appendix C at the back of your book. Make sure that you know where the different parts of the light microscope are. Make sure that you know the difference between magnification and resolution. What is an electron microscope?

For background knowledge read through the section on cell biologists. Such biologists are able to isolate organelles in order to study their functions. The figures in this chapter will help you to understand the structure of the different cells and organelles. It is important for you to be able to explain the structures of the different organelles with aid of drawings.

STUDY UNIT 6.2

Eukaryotic cells have internal membranes that compartmentalise their functions.

Learning outcome 4:
Explain phenomena such as the molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- distinguish between prokaryotic and eukaryotic cells
- explain why there are both upper and lower limits to cell size
- explain why compartmentalisation is important in eukaryotic cells

TEXTBOOK READING:

Study the section on eukaryotic cells, which have internal membranes compartmentalising their functions, in Reece et al (2011) pages 98 and 99 under the following headings:

Comparing prokaryotic and eukaryotic cells: You should be able to compare cells (prokaryotic and eukaryotic cells as well as plant and animal cells) and explain why there are both upper and lower limits to cell size.

STUDY ACTIVITY 6.2

In study unit 1.1 you had to compare prokaryotic and eukaryotic cells. After you worked through this section are you able to add anything to your original comparison?

A panoramic view of the eukaryotic cell: Why is compartmentalisation important in eukaryotic cells? Figure 6.9 compares the various organelles of plant and animal cells.

CONCEPT CHECK

Complete concept check 6.2 on page 102 in the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 6.3

The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes.

Learning outcome 4:
Explain phenomena such as the molecular diversity of life, carbon, protein synthesis and respiration

You will know that you have achieved this learning outcome if you are able to:

- describe the structure and function of the nucleus and briefly explain how the nucleus controls protein synthesis in the cytoplasm
- describe the structure and function of a eukaryotic ribosome

TEXTBOOK READING:

Can you say why ribosomes are important organelles in a cell?

Study the section that discusses the way in which the genetic instructions of the eukaryotic cell are housed in the nucleus and carried out by the ribosomes (Reece et al 2011, pp 148–150, under the following headings:

- **The nucleus:** *genetic library of the cell*: The nucleus houses most of the cell's DNA. (Where would you also find DNA in a cell?) You should be able to describe the structure and function of the nucleus (fig 6.9 Reece et al 2011).
- **Ribosomes:** *protein factories in the cell:* You should be able to describe the structure and function of a eukaryotic ribosome (fig 6.10 in Reece et al 2011)

STUDY ACTIVITY 6.3

Complete concept check 6.3 on page 150 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 6.4

The endomembrane system regulates protein traffic and performs metabolic functions in the cell.

Learning outcome 4:
Explain phenomena such as the molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- list the components of the endomembrane system and describe their structures and functions
- summarise the relationships among the components of the endomembrane system
- explain how impaired lysosomal function can cause the symptoms of storage diseases
- describe the different structures and functions of vacuoles

TEXTBOOK READING:

Do you know which organelle is responsiblefor metabolic processes within the cell? Study the endomembrane system that regulates protein traffic and performs metabolic functions in the cell in Reece et al (2011), pages 150–155, under the following headings:

- **The endoplasmic reticulum:** *biosynthetic factory:* The endomembrane system includes the nuclear envelope, endoplasmic reticulum, Golgi apparatus, lysosome, various kinds of vacuoles and the plasma membrane. You must be able to describe the structure and function of the endoplasmic reticulum (ER) (see fig 6.11 in Reece et al 2011).
- **Functions of smooth ER:** The smooth ER functions in diverse metabolic processes. You must know the functions of the smooth ER.

- **Functions of the rough ER:** Many types of specialised cells secrete proteins produced by ribosomes attached to rough ER. You must know the functions of the rough ER.
- **The Golgi apparatus:** *shipping and receiving centre:* You must be able to describe the structure and function of a Golgi apparatus (fig 6.12).
- **Lysosomes:** *digestive compartments:* You must be able to describe the structure and function of a lysosome (fig 6.13). What is phagocytosis?
- **Vacuoles:** *diverse maintenance:* You must be able to describe the structure and function of different vacuoles (fig 6.14).
- **The endomembrane system: a review:** Figure 6.16 reviews the relationship between the organelles of the endomembrane system.

STUDY ACTIVITY 6.4

Complete concept check 6.4 on page 155 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 6.5

Mitochondria and chloroplasts change energy from one form to another.

Learning outcome 4:
Explain phenomena such as the molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- explain the roles of mitochondria and chloroplasts
- describe the structure of a mitochondrion and explain the importance of compartmentalisation in mitochondrial function
- distinguish among amyloplasts, chromoplasts, and chloroplasts
- identify the three functional compartments of a chloroplast
- explain the importance of compartmentalisation in chloroplast function
- explain the role of peroxisomes in eukaryotic cells

TEXTBOOK READING:

Can you elaborate on the way in which energy is converted in our bodies? Which organelle plays an important role in energy conversion?

Study the section on mitochondria and chloroplasts, which change energy from one form to another, in Reece et al, pages 155–157, under the following headings:

- **Mitochondria:** *Chemical energy conversion:* Mitochondria are found in nearly all eukaryotic cells. You should be able to describe the structure and function of a to-chondrion (fig 6.17).
- **Chloroplasts are the main energy transformers of cells:** You should be able to describe the structure and function of a chloroplast (fig 6.18).
- **Peroxisomes: oxidation:** Explain the role of peroxisomes in eukaryotic cells (fig 6.19).

STUDY ACTIVITY 6.5

The structure of each organelle fits its function. Discuss the form and function of the mitochondrion.

FEEDBACK

To answer this question you need to turn to section 9.2. The function of the mitochondrion is respiration. The mitochondrion consists of a double membrane the inner one of which is folded (cristae). What is the function of the cristae?

CONCEPT CHECK 6.5

Complete concept check 6.5 on page 158 of the textbook Reece et al (2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 6.6

The cytoskeleton is a network of fibres that organises the structures and activities in the cell.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration

You will know that you have achieved this learning outcome if you are able to:

- describe the functions of the cytoskeleton
- describe the structure, monomers and functions of microtubules, microfilaments and intermediate filaments

TEXTBOOK READING:

Can you explain the role played by the skeleton in general? What is the role of cytoskeleton? Study the section on the cytoskeleton, which is a network of fibres organising the structures and activities in the cell (Reece et al 2011, pp 158–164), under the following headings:

- **Roles of the cytoskeleton:** support, motility and regulation: You only have to know table 6.1.

- **Components of the cytoskeleton:** You need to know the three types of fibre that make up the cytoskeleton, that is, microtubules, microfilaments and intermediate filaments.
- **Microtubules, microfilaments and intermediate filaments:** You do not need to know any more details about microtubules, microfilaments and intermediate filaments.

STUDY UNIT 6.7

Extracellular components and connections between cells help coordinate cellular activities.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- describe the development of plant cell walls
- describe the structure and list four functions of the extracellular matrix in animal cells
- describe the structures of the intercellular junctions found in plant and animal cells and relate those structures to their functions

TEXTBOOK READING:

Can you explain how the internal organelles of the cell are protected? Study the section on the extracellular components and connections between cells, which help to coordinate cellular activities (Reece et al 2011, pp 164–167), under the following headings:

- **Cell walls of plants (fig 6.28):** The cell wall is one feature that distinguishes plant cells from animal cells. The primary cell wall is thin and flexible to accommodate growth while the secondary cell wall is thick and strong in order to provide support.
- **The extracellular matrix (ECM) of animal cells (Figure 6.30):** Animals lack cell walls but have an elaborate extracellular matrix (ECM) consisting of collagen embedded in proteoglygcans.
- **Intercellular junctions help integrate cells into higher levels of structure and function:** There are four intercellular junctions: plasmodesmata, which occur in plant cells, tight junctions, desmosomes and gap junctions that occur in animal cells. What is the function of each? (fig 6.32).
- **The cell: a living unit greater than the sum of its parts (p 168):** Read for background knowledge.

STUDY ACTIVITY 6.7

Complete concept check 6.7 on page 168 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook. Read the cell: a living unit greater than the sum of its parts (p 168) for background knowledge.

INDIVIDUAL EXERCISE

Complete the Test your understanding quiz on page 170 in the textbook, number 9.

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check the answers to the questions and mark your attempts.
- Make sure that you have mastered the outcomes.
- Work through the Chapter review on pages 168–170.

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 01.**

6.1 Make labelled drawings of the following organelles:

- 6.1.1 Nucleus (5)
- 6.1.2 Golgi apparatus (4)
- 6.1.3 Mitochondrion (4)
- 6.1.4 Chloroplast (4)

6.2 What is the function of the following?

- 6.2.1 Nucleus
- 6.2.2 Golgi apparatus
- 6.2.3 Mitochondrion
- 6.2.4 Chloroplast
- 6.2.5 Ribosome
- 6.2.6 Lysosome
- 6.2.7 Smooth ER
- 6.2.8 Peroxisomes (8)

6.3 Compare the cells of prokaryotes and eukaryotes in tabular form. (6)

6.4 Compare animal and plant cells in tabular form. (6)

6.5 Name four intercellular junctions and give the function of each. (8)

6.6 Name three different types of vacuole and give their functions. (6)

6.7 Give one function of the following:

6.7.1 Microtubules

6.7.2 Microfilaments

6.7.3 Intermediate filaments (3)

6.8 What are the main ingredients of the ECM? (1)

TOPIC 7

Membrane structure and function

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011), Chapter 7: Membrane structure and function (pp 171–185).

STUDY UNIT 7.1

Cellular membranes are fluid mosaics of lipids and proteins.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- describe the properties of phospholipids and their arrangement in cellular membranes
- describe the fluid properties of the cell membrane and explain how membrane fluidity is influenced by membrane composition
- describe how proteins and carbohydrates are spatially arranged in cell membranes and how they contribute to membrane function

TEXTBOOK READING:

Study the section on cellular membranes, that is, fluid mosaics of lipids and proteins (Reece et al 2011, pp 171–176), under the following headings:

- **Membrane models:** *Scientific inquiry:* The currently accepted model of membranes is the fluid mosaic model, which views the membrane as a fluid structure with various proteins embedded in or attached to a double layer of phospholipids. Figure 7.3 will help you to visualise it. You do not need to know the history of the development of this model of the membranes.
- **The fluidity of membranes:** Figure 7.6 will help you to understand the concept.
- **Membrane proteins and their functions:** A membrane is a collage of different proteins embedded in the fluid matrix of the lipid bilayer. There are two major populations of membrane proteins: integral proteins and peripheral proteins. Figure 7.5 will help you to visualise the concept. Figure 7.10 gives an overview of the functions exhibited by membrane proteins.

The role of membrane carbohydrates in cell–cell recognition:

- Describe the way in which carbohydrates are spatially arranged in cell membranes and the way they contribute to membrane function.
- **Synthesis and sidedness of membranes:** Membranes have distinct inside and outside faces. The two lipid layers may differ in specific lipid composition and each protein has directional orientation in the membrane (see fig 7.12).

STUDY ACTIVITY 7.1

Complete concept check 7.1 on page 176 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 7.2

Membrane structure results in selective permeability.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- describe factors that affect the selective permeability of membranes
- describe the locations and functions of transport proteins

TEXTBOOK READING:

Study the section on membrane structure that results in selective permeability in Reece et al (2011) page 177 under the following headings:

- **The permeability of the lipid bilayer:** Hydrophobic molecules dissolve in the lipid bilayer of the membrane and cross it with ease. Hydrophilic substances avoid contact with the lipid bilayer by passing through transport proteins.
- **Transport proteins:** Specific ions and polar molecules avoid contact with the lipid bilayer and pass through transport proteins that span the membrane.

STUDY ACTIVITY 7.2

Complete concept check 7.2 on page 178 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 7.3

Passive transport refers to the diffusion of a substance across a membrane with no energy investment.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- define diffusion
- explain what causes diffusion and why it is a spontaneous process
- explain what regulates the rate of passive transport
- explain why a concentration gradient across a membrane represents potential energy
- distinguish between hypertonic, hypotonic and isotonic solutions
- define osmosis and predict the direction of water movement based on differences in solute concentrations
- describe how living cells with and without walls regulate the balance of water content
- explain how transport proteins are similar to enzymes
- explain how transport proteins facilitate diffusion

TEXTBOOK READING:

How does water move from the surroundings of the cell into the cell? What process is involved in this?

Study the section on passive transport, that is, the diffusion of a substance across a membrane with no energy investment (in Reece et al 2011, pp 178–181).

Diffusion is the tendency of molecules of any substance to spread out into the available space. A substance will diffuse from where it is more concentrated to where it is less concentrated. This movement is referred to as passive transport because the cell does not have to expend energy to make it happen.

Figure 7.13 will help you to understand the concept passive transport

- **Effect of osmosis on water balance:** It is important to understand the difference between isotonic, hypotonic and hypertonic solutions. Osmosis is the diffusion of water across a selective permeable membrane. The direction of osmosis is determined only by a difference in the total solute concentration. Figure 7.14 will help you to understand the concept.
- **Water balance of cells without walls:** Tonicity is the ability of a solution to cause a cell to gain or lose water. You must be able to explain what is happening in figures 7.15(a) and 7.16.
- **Water balance of cells with walls:** The cells of plants, prokaryotes, fungi and protists have walls. You must be able to explain what is happening in figure 7.15(b).

- **Facilitated diffusion: passive transport aided by proteins:** You must be able to give a definition of facilitated diffusion, the rest is interesting reading.

STUDY ACTIVITY 7.3

Complete concept check 7.3 on page 181 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 7.4

Active transport uses energy to move solutes against their gradients.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- explain how active transport differs from diffusion
- explain what mechanism can generate a membrane potential or electrochemical gradient
- describe the process of co-transport

TEXTBOOK READING:

Do you know how substances are transported in and out of the cell?

Study the section on active transport in Reece et al (2011) pages 181–184 under the following headings:

- **The need for energy in active transport:** You should just be able to give a definition for *active transport*, but this paragraph may help you to understand the proton pump in the thylakoid membranes of the chloroplast during photosynthesis. You will learn more about this in BLG1502. Figure 7.19 gives a summary of passive and active transport.
- **Maintenance of membrane potential by ion pumps:** You only need to be able to explain the concept. Figure 7.20 says it all.
- **Co-transport: coupled transport by a membrane protein:** You only need to be able to explain the concept. Figure 7.21 says it all.

STUDY UNIT 7.5

Bulk transport across the plasma membrane occurs by means of exocytosis and endocytosis.

Learning outcome

You will know that you have achieved this learning outcome if you are able to:

- explain how large molecules are transported across the cell membrane

TEXTBOOK READING:

Can you differentiate between endocytosis and exocytosis?

Study the section on the way bulk transport across the plasma membrane occurs by exocytosis and endocytosis in Reece et al (2011) page 184 under the following headings:

- Exocytosis occurs when the cell secretes macromolecules through the fusion of vesicles with the plasma membrane.
- Endocytosis is the intake of macromolecules and particulate matter by forming vesicles from the plasma membrane. There are three types of endocytosis: phagocytosis, pinocytosis and receptor-mediated endocytosis. These are illustrated in figure 7.22.

STUDY ACTIVITY 7.5

Do number 1 of concept check 7.5 on page 184 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

INDIVIDUAL EXERCISE

Complete the Test your understanding quiz on page 186 of the textbook (Reece et al 2011).

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check the answers to the questions and mark your own attempts.
- Make sure that you have mastered the outcomes.
- Work through the Chapter review on page 186 of Reece et al (2011).

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 01.**

7.1 Explain how membrane fluidity is influenced by membrane composition. (5)

7.2 Describe the way in which proteins and carbohydrates are spatially arranged in cell membranes and how they contribute to membrane function. (8)

7.3 Describe factors that affect the selective permeability of membranes. (4)

7.4 Describe the locations and functions of transport proteins. (4)

7.5 Explain the fluid mosaic model of membranes with the aid of a drawing. (3)

7.6 Define diffusion. (1)

7.7 What regulates the rate of passive transport? (1)

7.8 Distinguish between hypertonic, hypotonic and isotonic solutions. (3)

7.9 Define osmosis. (4)

7.10 What facilitates diffusion? (3)

7.11 What is active transport? (3)

7.12 Describe the process of co-transport. (4)

TOPIC 8

An introduction to metabolism

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011) Chapter 8: An introduction to metabolism (pp 118–206).

We are all aware of the fact that the living cell is a chemical factory in miniature. The process of cellular respiration drives the economy by extracting the energy stored in sugars and other fuels. Cells apply this energy to perform various types of work.

STUDY UNIT 8.1

An organism's metabolism transforms matter and energy, subject to the laws of thermodynamics.

The aim of this study unit is to give you an insight into and understanding of the way an organism's metabolism transforms matter and energy, subject to the laws of thermodynamics.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- explain the role of catabolic and anabolic pathways in the energy exchanges of cellular metabolism
- distinguish between kinetic and potential energy
- distinguish between open and closed systems
- explain, in your own words, the first and second laws of thermodynamics

TEXTBOOK READING:

Why is energy needed by living organisms?

Study the section on the metabolism of the organism, which transforms matter and energy subject to the laws of thermodynamics, in Reece et al (2011) pages 188–191, under the following headings:

- **Organisation of the chemistry of life into metabolic pathways:** Metabolism is the totality of an organism's chemical reaction. It is an emergent property of life that arises from the interactions between molecules within the orderly environment of the cell. Make sure you know what catabolism and anabolism are.
- **Forms of energy:** It is important that you understand the concept of energy. What is energy? You should be able to name and define the various forms of energy.
- **The laws of energy transformation:** What is an open system and what is a closed system? Two laws of thermodynamics govern transformations in organisms and all other collections of matter.
- **The first law of thermodynamics:** Energy can be transferred and transformed but not created or destroyed.
- **The second law of thermodynamics:** Every energy transfer or transformation increases the entropy of the universe.

Biological order and disorder: Read through this section for background knowledge.

STUDY UNIT 8.2

The free-energy change of reaction tells us whether the reaction occurs spontaneously

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- explain the concept of free energy
- explain when a system is in equilibrium
- distinguish between exergonic and endergonic reactions

TEXTBOOK READING:

What do you know about free energy?

Study the section on the free-energy change of a reaction, which tells us whether the reaction occurs spontaneously, subject to the laws of thermodynamics, in Reece et al (2011) pages 192–194, under the following headings:

- **Free energy change, G:** Free energy is energy that can do work under cellular conditions. You do not need to know how to calculate free energy, G.
- **Free energy, stability and equilibrium:** After you've read through this paragraph you only need to know what equilibrium is.
- **Free energy and metabolism**
- **Exergonic and endergonic reactions in metabolism:** All you need to know after you've read through this paragraph is what endergonic and exergonic reactions are.

- **Equilibrium and metabolism:** Reactions in closed systems eventually reach equilibrium and then they do not work. If a cell reaches metabolic equilibrium it is dead. The fact that metabolism as a whole is never in equilibrium is one of the defining features of life. Read through this paragraph and make sure that you understand the concept of equilibrium.

STUDY UNIT 8.3

ATP powers cellular work by coupling exergonic reactions to endergonic reactions.

Learning outcomes

You will know that you have achieved this learning outcome if you are able to:

- describe the three main kinds of cellular work
- describe the function of ATP in a cell
- list the three components of ATP and identify the major class of macromolecules to which ATP belongs
- explain how ATP performs cellular work

TEXTBOOK READING:

Study the section on ATP, which powers cellular work by coupling exergonic reactions to endergonic reactions, subject to the laws of thermodynamics, in Campbell, pages 195–197. ATP provides the power for a cell's mechanical, transport and chemical work.

- **The structure and hydrolysis of ATP:** You do not have to know the structural formula of ATP, but you must be able to give the components of ATP and explain what happens when it is hydrolysed. Figures 8.8 to 8.10 will help you to understand the concept.
- **How ATP performs work:** Figure 8.11 illustrates how ATP drives cellular work.
- **The regeneration of ATP:** Figure 8.12 illustrates the ATP cycle.

STUDY ACTIVITY 8.3

Discuss energy transformation in the biological world.

FEEDBACK

Although this is a very comprehensive question, at this stage of the module I want a more general answer. Your answer should deal with metabolic reactions, the laws of hermodynamics, free energy, ATP, and endergonic and exergonic reactions. In study unit 9.2 we will look at this question again and will use the more specific example of respiration to answer the question.

STUDY UNIT 8.4

Enzymes speed up metabolic reactions by lowering energy barriers.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- describe the function of enzymes in biological systems
- explain the relationship between enzyme structure and enzyme specificity
- explain the induced-fit model of enzyme function and describe the catalytic cycle of an enzyme
- describe several mechanisms by which enzymes lower activation energy
- explain how enzyme activity can be regulated or controlled by environmental factors, substrate concentration co-factors, and enzyme inhibitors

TEXTBOOK READING:

Study the section on enzymes that speed up metabolic reactions by lowering energy barriers in Reece et al (2011) pages 198–203. An enzyme is a catalytic protein that changes the rate of a reaction without being consumed by the reaction.

- **The activation energy barriers:** Figure 8.12 illustrates the energy profile of an exergonic reaction.
- **How enzymes lower the EA barrier:** Figure 8.13 illustrates the effect of enzymes on reaction rate.
- **Enzymes are substrate specific:** An enzyme binds to substrate, then converts the substrate to products without being changed. The region where an enzyme molecule actually binds to the substrate is called the active site. Figure 8.14 will help you to understand the induced fit between an enzyme and its substrate.
- **Catalysis in the enzyme's active site:** Figure 8.15 will help you to understand the catalytic cycle of an enzyme.
- **Effects of local conditions on enzyme activity:** It is important that you can give the factors that influence enzyme activity. Figure 8.16 shows that an enzyme has an optimal temperature and pH.

CONCEPT CHECK 8.4

Complete concept check 8.4 on page 203 in the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 8.5

Regulation of enzyme activity helps control metabolism.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- explain how enzyme activity can be allosterically regulated
- give the location of enzymes in a cell

TEXTBOOK READING:

Can you define an enzyme? Why are enzymes important?

Study the section on the way in which the regulation of enzyme activity helps to control metabolism, in Reece et al (2011) pages 204–206.

- **Allosteric regulation of enzymes:** All you need to know is that enzymes are allosterically regulated. They change shape when regulatory molecules, either activators or inhibitors, bind to specific sites, thus affecting enzymatic function.
- **Specific locations of enzymes within the cell:** All you need to know is that some enzymes are grouped into complexes, some incorporated into membranes and others are contained inside organelles.

INDIVIDUAL EXERCISE

Complete the Test your understanding quiz on page 208 of the textbook, numbers 1–3 and 6–9.

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check the answers up and mark your own attempts.
- Make sure that you have mastered the outcomes.
- Work through the Chapter review on p 207

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 01.**

8.1 Explain the role of catabolic and anabolic pathways in the energy exchanges of cellular metabolism. (2)

8.2 Distinguish between kinetic and potential energy. (2)

8.3 Distinguish between open and closed systems. (2)

8.4 Explain, in your own words, the first and second laws of thermodynamics. (2)

8.5 Distinguish between exergonic and endergonic reactions. (2)

8.6 Describe the three main kinds of cellular work. (6)

8.7 Describe the function of ATP in a cell. (1)

8.8 List the three components of ATP and identify the major class of macro-molecules to which ATP belongs. (4)

8.9 Explain how ATP performs cellular work. (4)

8.10 Describe the function of enzymes in biological systems. (2)

8.11 Explain the relationship between enzyme structure and enzyme specificity. (2)

8.12 Explain the induced-fit model of enzyme function and describe the catalytic cycle of an enzyme. (5)

8.13 Describe several mechanisms by which enzymes lower activation energy. (3)

8.14 Explain how enzyme activity can be regulated or controlled by environmental factors, substrate concentration co-factors, and enzyme inhibitors. (8)

TOPIC 9

Cellular respiration and fermentation

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011), Chapter 9: Cellular respiration: harvesting chemical energy (pp 209–227).

Cells need energy to perform tasks. Figure 9.2 illustrates energy flow and chemical recycling in ecosystems.

STUDY UNIT 9.1

Catabolic pathways yield energy by oxidising organic fuels.

The purpose of this study unit is to introduce you to and give you insight into and knowledge of cellular respiration. Catabolic pathways yield energy by oxidising organic fuels.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- distinguish between fermentation and cellular respiration
- describe the summary equation for cellular respiration. Also note the specific chemical equation for the degradation of glucose.
- explain how ATP is recycled in cells
- define oxidation and reduction
- explain how redox reactions are involved in energy exchanges

TEXTBOOK READING:

Study the section on catabolic pathways that yield energy by oxidising organic fuels, in Campbell, pages 210–214 under the following headings:

- **Catabolic pathways and production of ATP:** Organic molecules are produced during photosynthesis in the chloroplast. This organic material is broken down in the mitochondrion to produce ATP, the fuel of the cell. You will learn more about photo-

synthesis in BLG1502. In this chapter we are going to look at the processes that break down organic materials to produce ATP, namely, respiration and fermentation.

Make sure that you know the difference between respiration and fermentation. You should be able to give an equation to illustrate the breakdown of glucose (respiration).

- **Redox reactions: oxidation and reduction:** The relocation of electrons releases energy stored in organic molecules and this energy is ultimately used to synthesise ATP.

  The principle of redox: It is very important that you know the difference between oxidation and reduction reactions. Figure 9.3 illustrates the redox reaction of methane combustion.

  Oxidation of organic fuel molecules during cellular respiration: Respiration is the oxidation of glucose. You must know what happens during this redox reaction.

- **Stepwise energy harvested via NAD+ and the electron transport chain:** Energy from an explosion cannot be harvested. However, if organic fuels are broken down in a series of steps useful energy can be released. Figure 9.5 illustrates the release of energy for the synthesis in a controlled reaction, while figure 9.4 illustrates the use of nicotinamide adenine dinucleotide (NAD) as an electron shuttle. You do not need to know any structural formulas but you must know what happens during the reaction.
- **The stages of cellular respiration:** This is an important paragraph as it summarises the process of respiration. Respiration is a cumulative function of three metabolic stages, which are illustrated in the diagram in figure 9.6. You do not need to know any structural formulas but you must be able to describe what happens in every stage. You must know how ADP is converted to ATP (fig 9.7).

STUDY UNIT 9.1

Complete concept check 9.1 on page 214 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 9.2

Glycolysis harvests chemical energy by oxidising glucose to pyruvate.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- describe the cellular regions where glycolysis, the Krebs cycle, and the electron transport chain occur
- explain why ATP is required for the preparatory steps of glycolysis

TEXTBOOK READING:

Study the section on the way in which glycolysis harvests chemical energy by oxidising glucose to pyruvate, in Reece et al (2011) page 214. Figure 9.8 will help you to understand the energy output of glycolysis and figure 9.9 looks more closely at glycolysis. You only need to know the different names of the components; no structural formulas are necessary.

STUDY ACTIVITY 9.2

Complete concept check 9.2 on page 215 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 9.3

The citric acid cycle completes the energy-yielding oxidation of organic molecules.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning if you are able to

- give an overview of the citric acid cycle
- describe how pyruvate is oxidised to acetyl CoA, what molecules are produced, and how this process links glycolysis to the Krebs cycle

TEXTBOOK READING:

Study the section on the citric acid cycle that completes the energy-yielding oxidation of organic molecules, in Reece et al (2011) page 216. Figure 9.10 illustrates the conversion of pyruvate to acetyl Coenzyme A and figure 9.11 gives an overview of the citric acid cycle. You need to know the different names of the components.

STUDY ACTIVITY 9.3

Complete concept check 9.3 on page 218 in the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 9.4

During oxidative phosphorylation chemiosmosis couples electron transport to ATP synthesis.

Learning outcome 4:
Explain phenomena such as molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- explain how the exergonic "slide" of electrons down the electron transport chain is coupled to the endergonic production of ATP by chemiosmosis
- summarise the net ATP yield from the oxidation of a glucose molecule during the different stages of glycolysis and cellular respiration

TEXTBOOK READING:

Can you explain what an electron is? What do you know about electron transport?

Study the section on oxidative phosphorylation chemiosmosis, which couples electron transport to ATP synthesis, in Reece et al (2011) pages 218–223 under the following headings:

- **The pathway of electron transport:** The electron transport chain is a collection of molecules embedded in the inner membrane of the mitochondrion and the folding of this membrane to form cristae increases its surface area. Most components of this chain are proteins. You do not need to know the sequence of electron carriers in the electron transport chain shown in figure 9.13; however, you should know that the last cytochrome of the chain passes its electrons to oxygen, which also picks up a pair of hydrogen ions from the aqueous solution to form water.
- **Chemiosmosis:** the energy-coupling mechanism: The electron transport chain makes no ATP directly. Chemiosmosis couples electron transport and energy release to ATP synthesis. You should be able to explain chemiosmosis and explain what happens in figures 9.14 and 9.15.
- **An accounting of ATP production by cellular respiration:** How much ATP does each sugar molecule produce? Figure 9.15 will help you find the answer.

STUDY ACTIVITY 9.4

Complete number 1 of concept check 9.4 on page 223 in the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 9.5

Fermentation enables some cells to produce ATP without the use of oxygen.

Learning outcome 4:
Explain phenomena such as the molecular diversity of life, carbon, protein synthesis and respiration.

You will know that you have achieved this learning outcome if you are able to:

- explain why fermentation is necessary
- compare the fate of pyruvate in alcohol fermentation and lactic acid fermentation
- compare the processes of fermentation and cellular respiration

TEXTBOOK READING:

Study the section on fermentation, which discusses the way in which fermentation enables some cells to produce ATP without the use of oxygen (in Campbell, pp 223–225), under the following headings:

- **Types of fermentation:** You should be able to describe alcoholic and lactic fermentation with the aid of a diagram (fig 9.16).
- **Fermentation and cellular respiration compared:** Compile your own table showing the differences between cellular respiration and fermentation.
- **The evolutionary significance of glycolysis:** Interesting reading but not for exam purposes.

STUDY ACTIVITY 9.5

Complete concept check 9.5 on page 223 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 9.6

Glycolysis and the citric acid cycle connect to many other metabolic pathways.

Read this section for background knowledge.

INDIVIDUAL EXERCISE

Complete the Test your understanding quiz on page 229 of the textbook (Reece et al 2011).

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check the answers and mark your own attempts.
- Make sure that you have mastered the outcomes.
- Work through the Chapter review on p 228 (Reece et al 2011).

SUMMARY

In this topic you learnt about catabolic pathways and cellular respiration. In the next topic you will learn about the cell cycle, that is, the way in which cells divide (mitosis and meiosis).

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 02.**

9.1 Give the summary equation for cellular respiration. (5)

9.2 Make a diagram showing how ATP is recycled in cells. (10)

9.3 Define oxidation and reduction. (2)

9.4 Explain how redox reactions are involved in energy exchanges. (3)

9.5 Name the cellular regions where glycolysis, the Krebs cycle and the electron transport chain occur. (3)

9.6 Explain why ATP is required for the preparatory steps of glycolysis. (2)

9.7 Make a diagram showing how pyruvate is oxidised to acetyl CoA. What molecules are produced? (7)

9.8 Make a diagram showing how many ATP molecules are produced from a glucose molecule during cellular respiration. (10)

9.9 Explain why fermentation is necessary. (2)

9.10 Make a diagram showing the process of alcoholic fermentation. (10)

9.11 Compare in tabulated form the fate of pyruvate in alcohol fermentation and lactic acid fermentation. (6)

9.12 Compare in tabulated form the processes of fermentation and cellular respiration. (6)

TOPIC 10
The cell cycle

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011), Chapter 12: The cell cycle (pp 274–289).

STUDY UNIT 10.1

Cell division results in genetically identical daughter cells.

The aim of this study unit is to give you insight into and knowledge of cell division (mitosis). Cell division results in genetically identical daughter cells.

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- explain how cell division functions in reproduction, growth and repair
- describe the structural organisation of the genome
- describe the major events of cell division that enable the genome of one cell to be passed on to two daughter cells
- describe how the chromosome number changes throughout the human life cycle

TEXTBOOK READING:

Do you know what the word "identical" means?

Study the section on cell division that results in genetically identical daughter cells, in Reece et al (2011), page 275, under the following headings:

- **Cellular organisation of the genetic material:** It is important that you can explain concepts such as genome, chromosome, somatic cells, gametes and chromatin.
- **Distribution of chromosomes during cell division:** It is important that you can explain concepts such as sister chromatids, centromere, mitosis, meiosis and cytokinesis.

STUDY ACTIVITY 10.1

Complete concept check 12.1 on page 276 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 10.2

The mitotic phase alternates with the interphase in the cell cycle.

Learning outcomes

You will know that you have achieved this learning outcome if you are able to:

- list the phases of the cell cycle and describe the sequence of events that occurs during each phase
- list the phases of mitosis and describe the events characteristic of each phase
- recognise the phases of mitosis from diagrams and micrographs
- compare cytokinesis in animals and plants
- explain the process of binary fission

TEXTBOOK READING:

Study the section on the mitotic phase that alternates with the interphase in the cell cycle, in Reece et al (2011), pages 276–283, under the following headings:

- **Phases of the cell cycle:** In the M-phase, mitosis divides the nucleus and distributes its chromosomes to the daughter nuclei. Cytokinesis then divides the cytoplasm to produce two daughter cells. Figure 12.6 illustrates the cell cycle, while figure 12.7 shows light micrographs of mitosis in plant cells.
- **The mitotic spindle:** a closer look: Work through this paragraph with the aid of figures 12.8 and 12.9.
- **Cytokinesis: a closer look:** Figure 12.10 illustrates cytokinesis in plant and animal cells. You should be able to compare these processes. Compile a table showing the differences between them.
- **Binary fission:** This process occurs in prokaryotes such as bacteria and means to divide in half. Figure 12.12 illustrates the process of binary fission.
- **The evolution of mitosis:** very interesting – read for background knowledge.

CONCEPT CHECK 12.2

Complete concept check 12.2 on page 284 in the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 10.3

The cell cycle is regulated by a molecular control system.

This is a very interesting section, especially the paragraph about the loss of cell cycle control in cancer cells. It is interesting to read what goes wrong with the cell cycle when cancer cells are formed. This section is not for exam purposes.

INDIVIDUAL EXERCISE

Complete questions 2, 4, 8, 9, 10, 11 of the Test your understanding quiz on page 290 of the textbook (Reece et al 2011).

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook (Reece et al 2011).

REFLECT ON YOUR LEARNING

- Check the answers and mark your own attempts.
- Make sure that you have mastered the outcomes.
- Work through the Chapter review on p 290 (Reece et al 2011).
- In this chapter you have learnt many new terms. Make sure that you know their definitions. These terms are

anaphase

aster

binary fission

cell division

cell plate

centromere

centrosome

chromatin

chromosome

cleavage

cytokinesis

G0 phase

G1 phase

G2 phase

gamete

genome

growth factor

interphase

kinetochore

M phase

meiosis

metaphase

mitosis

mitotic spindle

prophase

S phase

sister chromatids

somatic cell

telophase

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 02.**

10.1 Define mitosis. (2)

10.2 Make a diagram to illustrate the cell cycle. (8)

10.3 Make labelled drawings to illustrate the different phases of mitosis in an animal cell with two chromososmes. (20)

10.4 Explain the difference between cytokinesis in plant and animal cells. (6)

TOPIC 11

Meiosis and sexual life cycles

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011), Chapter 13: Meiosis and sexual life cycles (pp 294–306).

OVERVIEW: HEREDITARY SIMILARITY AND VARIATION (Reece et al 2011, **p 294)**

Living organisms are distinguished by their ability to reproduce their own kind. You should be able to explain terms such as *heredity*, *variation* and *genetics*.

STUDY UNIT 11.1

Offspring acquire genes from parents by inheriting their chromosomes.

The aim of this study unit is to introduce you to genetics. Offspring acquire genes from their parents by inheriting their chromosomes.

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- explain why offspring more closely resemble their parents than unrelated individuals of the same species
- explain what makes heredity possible
- distinguish between asexual and sexual reproduction

TEXTBOOK READING:

Study the section on offspring acquiring genes from parents by inheriting chromosomes, in Reece et al (2011), pages 294 and 295 under the following headings:

- **Inheritance of genes:** Parents endow their offspring with genes or segments of DNA that programme the specific traits that emerge as we develop into adults. You must know what a gene, gametes and a gene's locus are.
- **Comparison of asexual and sexual reproduction:** In asexual reproduction a single individual is the parent but in sexual reproduction two parents give rise to offspring.

CONCEPT CHECK 13.1

Complete concept check 13.1 on page 295 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 11.2

Fertilisation and meiosis alternate in sexual cycles.

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- draw a diagram showing the human life cycle and indicate where in the human body mitosis and meiosis occur; which cells are the result of meiosis and mitosis; and which cells are haploid
- distinguish among the life cycle patterns of animals, fungi and plants

TEXTBOOK READING:

Study the section on the way fertilisation and meiosis alternate in sexual cycles, in Reece et al (2011), pages 296–298, under the following headings:

- **Sets of chromosomes in human cells:** Make sure that you know what a somatic cell, karyotype, homologous chromosome, sex chromosome, outosome, diploid cell and haploid cell are. Figure 13.3 shows how the human karyotypes are prepared. This is very interesting but is not for exam purposes.
- **Behaviour of chromosome sets in the human life cycle:** Figure 13.5 illustrates the human life cycle. Look at the colour coding for haploid and diploid, as it is used for life cycles later in the book (BLG1502). This section contains very important terms such as *fertilisation* or *syngamy*, *zygote*, *diploid cell* and *meiosis*. Make sure that you can define them.
- **The variety of sexual life cycles:** Figure 13.6 shows general life cycles for animals, plants and some algae, for most fungi and for some protist. You will study these life cycles in more detail in BLG1502. Make sure that you understand terms like *alternation of generations*, *sporophyte*, *spores* and *gametophyte*.

CONCEPT CHECK 13.2

Complete concept check 13.2 on page 299 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 11.3

Meiosis reduces the number of chromosome sets from diploid to haploid

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- list the phases of meiosis I and meiosis II and describe the events characteristic of each phase
- recognise the phases of meiosis from diagrams or micrographs
- describe the process of synapsis during prophase I and explain how genetic recombination occurs
- describe the key differences between mitosis and meiosis
- explain how the end result of meiosis differs from that of mitosis

TEXTBOOK READING:

Study the section that discusses the way in which meiosis reduces the number of chromosome sets from diploid to haploid, in Reece et al (2011) pages 299–302, under the following headings:

- **The stages of meiosis:** This is a very important paragraph. Figure 13.7 gives an overview of meiosis and figure 13.8 describes in detail the stages of the two divisions of meiosis for an animal cell with diploid number 6.
- **A comparison of mitosis and meiosis:** Figure 13.9 says it all.

CONCEPT CHECK 13.3

Complete concept check 13.3 on page 303 in the textbook.

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 11.4

The genetic variation produced in sexual life cycles contributes to evolution.

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- explain how independent assortment, crossing over and random fertilisation contribute to genetic variation in sexually reproducing organisms

TEXTBOOK READING:

Study the section that discusses the way the genetic variation produced in sexual life cycles contributes to evolution, in Reece et al (2011), pages 303–306 under the following headings:

- **Origins of genetic variation among offspring:** Sexual life cycles produce genetic variation among offspring: Figure 13.10 will help you to understand independent assortment and crossing over. The other source of genetic variation is random fertilisation.
- **Evolutionary significance of genetic variation within populations:** Read through this section for background knowledge.

INDIVIDUAL EXERCISE

Complete the Test your understanding quiz on page 307 of the textbook (Reece et al 2011).

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check the answers up and mark your own attempts.
- Make sure that you have mastered the outcomes.
- Work through the Chapter review on p 306 (Reece et al 2011).
- In this chapter you have learnt many new terms. Make sure that you know the definition of each:

alternation of generations

asexual reproduction

autosome

chiasma

clone

crossing over

diploid cell

fertilisation

gametophyte

gene

genetics

haploid cell

heredity

homologous chromosomes

karyotype

life cycle

locus

meiosis

meiosis I

meiosis II

recombinant chromosome

sex chromosome

sexual reproduction

spore

sporophyte

synapsis

tetrad

variation

zygote

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 02.**

11.1 Explain why organisms more closely resemble their parents than unrelated individuals of the same species. (1)

11.2 Distinguish between asexual and sexual reproduction. (2)

11.3 Make a diagram of the human life cycle and indicate where in the human body mitosis and meiosis occur; which cells are the result of meiosis and mitosis; and which cells are haploid. (12)

11.4 Make diagrams to distinguish among the life cycle patterns of animals, fungi and plants. (10)

11.5 List the phases of meiosis I and meiosis II and describe the events characteristic of each phase. (20)

11.6 Tabulate the key differences between mitosis and meiosis. (10)

11.7 Explain how independent assortment, crossing over and random fertilisation contribute to genetic variation in sexually reproducing organisms. (6)

TOPIC 12

Mendel and the gene idea

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011) Chapter 14: Mendel and the gene idea (pp 308–329).

OVERVIEW: DRAWING FROM THE DECK OF GENES (p 308)

What genetic principles account for the transmission of traits from parents to offspring? Mendel is the father of genetics and in this chapter you will learn more about his research.

STUDY UNIT 12.1

Mendel used the scientific approach to identify two laws of inheritance.

The aim of this study unit is give you an insight into and understanding of Mendel's two laws of inheritance. Mendel used the scientific approach to identify two laws of inheritance.

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you area ble to:

- define true breeding, hybridisation, monohybrid cross, P generation, F_1 generation and F_2 generation
- define Mendel's law of segregation
- use a Punnett square to predict the results of a monohybrid cross and state the phenotypic and genotypic ratios of the F_2 generation
- distinguish between the following pairs of terms: dominant and recessive; heterozygous and homozygous; genotype and phenotype
- explain how a testcross can be used to determine if a dominant phenotype is homozygous or heterozygous
- use a Punnett square to predict the results of a dihybrid cross and state the phenotypic and genotypic ratios of the F_2 generation
- define Mendel's law of independent assortment
- explain why Mendel was wise to use large sample sizes in his studies

TEXTBOOK READING:

Study the section on the way in which Mendel used the scientific approach to identify two laws of inheritance, in Reece et al (2011) pages 308 to 315, under the following headings:

- **Mendel's experimental, quantitative approach:** The history of Mendel's life is interesting but you do not need to know it for exam purposes. Figure 14.2 shows what he did with pea plants. It is important that you understand his experiment. You must be able to define terms such as *character* and *trait*, *true breeding*, *hybridisation*, *P-generation*, F_1 and F_2 *generations*.
- **The law of segregation:** The two alleles for a character are packaged into separate gametes. This is a very important section. Figures 14.3 to 14.7 will help you to understand the concepts better. You should be able to define all the terms in the paragraphs on genetic vocabulary and know what a testcross is.
- **The law of independent assortment:** Each pair of alleles segregates into gametes independently. Figure 14.8 will help you to understand this concept.

EXAMPLE

You should be able to use a Punnett square to determine the outcome of a monohybrid or dihybrid crossing. Here is an example of typical exam questions:

Question: In peas, the allele for round seeds (R) is dominant to that for wrinkled seeds (r); and the allele for yellow seeds (Y) is dominant to that for green seeds (y). Plants from a true-breeding line with round, yellow seeds are crossed with plants from a true-breeding line with wrinkled, green seeds. The parents constitute the P generation.

1 What are the genotypes of the P generation? (2)

2 What are the expected genotypes of the F1 hybrids produced by the cross? (2)

3 What kind of gametes can the F1 individuals produce? (4)

4 What is the expected proportion of F2 wrinkled yellow seeds? (2)

5 Why is this a typical Mendelian cross? (1)

SOLUTION

The symbol for the gene for round seeds is R and for yellow, Y. In a cell of a true breeding line with round, yellow seeds, the homologous chromosomes will carry RRYY alleles.

The symbol for the gene for wrinkled seeds is r and for green, y. In a cell of a true breeding line with wrinkled, green seeds, the homologous chromosomes will carry rryy alleles.

Now you can answer the first question: What are the genotypes of the P generations? Answer: RRYY and rryy.

To answer the second question you must first know what gametes are going to be produced. Parent RRYY can only produce one type of gamete and that is RY gametes. Parent rryy also can only produce one type and that is ry. To find out what the F1 generation will look like we use a Punnett square.

	Gametes P1 →	RY	RY
Gametes P2 ↓	Ry	RrYy	RrYy
	Ry	RrYy	RrYy

Therefore, the answer to question 2 is: the expected genotypes of the F1 hybrids produced by the cross are RrYy.

The F1 generation can produce four kinds of gametes: R can be sorted with Y or with y and r can be sorted with Y and y. Therefore the answer to question 3 is: RY, Ry, rY, ry.

To answer the next question you need a Punnett square:

	Gametes P1→	RY	Ry	rY	ry
Gametes P2 ↓	RY	RRYY	RRYy	RrYY	RrYy
	Ry	RRYy	RRyy	RrYy	Rryy
	rY	RrYY	RrYy	rrYY	rrYy
	ry	RrYy	Rryy	rrYy	rryy

Count the different phenotypes:

If the offspring has R- and Y- its seed will be round and yellow: **9** out of **16** are round and yellow.

If the offspring has R- and yy its seed will be round and green: **3** out of **16** are round and green.

If the offspring has rr and Y- its seed will be wrinkled and yellow: **3** out of **16** are wrinkled and yellow.

If the offspring has rr and yy its seed will be wrinkled and green: only **1** out of **16** is wrinkled and green.

So what is the expected proportion of F2 wrinkled yellow seeds? 3/16.

Why is this a typical Mendelian cross? This is a typical dihybrid cross.

The ratios between the different phenotypes are 9 out of 16, 3 out of 16, 3 out of 16 and 1 out of 16, thus 9:3:3:1. That is the ratio for a Mendelian dihybrid cross.

CONCEPT CHECK 14.1

Complete concept check 14.1 on page 315 of the textbook (Reece et al 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 12.2

The laws of probability govern Mendelian inheritance.

Read this section for background knowledge. I will not ask you any probability questions in the examination.

STUDY UNIT 12.3

Inheritance patterns are often more complex than predicted by simple Mendelian genetics.

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- explain how the phenotypic expression of the heterozygote is affected by complete dominance, incomplete dominance and codominance
- explain what multiple alleles, pleiotropy, epistasis and polygenic inheritance are
- give an example of the impact of the environment on the expression of the genotype

TEXTBOOK READING:

Study the section that discusses the fact that inheritance patterns are often more complex than those predicted by simple Mendelian genetics, in Reece et al (2011) pages 317–321 under the following heading:

- **Extending Mendelian genetics for a single gene:** The relationship between genotype and phenotype is rarely simple. In this section you should be able to give a definition and an example of incomplete dominance, complete dominance and codominance.
- **The relation between dominance and phenotype:** Make sure that you understand the concept and can give an example.
- **Frequency of dominant alleles:** Read for background knowledge. What are multiple alleles and pleiotropy? You should be able to explain these concepts using an example.
- **Extending Mendelian genetics for two or more genes:** You should be able to give a definition of epistasis and polygenic inheritance.

- **Nature and nurture: the environmental impact on phenotype:** You should be able to give an example of the impact of the environment on the expression of the genotype.
- **Integrating a Mendelian view of heredity and variation:** Read through for background knowledge.

STUDY ACTIVITY

Explain the principle of multiple alleles in blood groups ABO.

FEEDBACK:

The O-blood group is recessive and will occur in a recessive homozygote. The A and B-blood groups, on the other hand, are dominant. Work through the paragraph on multiple alleles and use a Punnett square to determine the different crossings of the blood group alleles.

STUDY UNIT 12.4

Many human traits follow the Mendelian patterns of inheritance.

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- distinguish between the specific and the broad interpretations of the terms *phenotype* and *genotype*
- explain why studies of human inheritance are not as easily conducted as Mendel's work with peas
- give a simple family pedigree and deduce the genotypes for some of the family members

TEXTBOOK READING:

Study the section that discusses the way in which many human traits follow Mendelian patterns of inheritance in Reece et al (2011), pages 321–327, under the following headings:

- **Pedigree analysis:** Breeding experiments like the ones Mendel performed are unacceptable with humans. However, much can be learnt about human genetics if a specific trait is used to assemble a family tree called a pedigree.
- **Recessive inherited disorders:** Pedigree analysis can help to predict the chances that an offspring will have a disorder. This section is not for exam purposes, but take time to read through it, as it is really interesting.
- **Dominantly inherited disorders:** Read for background knowledge.
- **Multifactorial disorders:** Read for background knowledge.

- **Technology is providing new tools for genetic testing and counselling:** This is a very interesting section. Read for background knowledge.

STUDY ACTIVITY 12.4

Try to compile your own genealogical tree. You can stop at your grandparents. When you look at certain characteristics, such as blue eyes, blond hair, curly hair or maybe a disease such as diabetes, can you see a pattern? Mark persons in the tree who have a certain characteristic to see if a pattern emerges.

FEEDBACK

If you are interested in genealogy you can find out if there is a genealogical society in your area. The library can also be very helpful.

INDIVIDUAL EXERCISE

Complete the Test your understanding quiz on page 330 of the textbook (Reece et al 2011) numbers 1, 4, 5, and 9 to 13.

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check the answers to the questions and mark your own attempts.
- Make sure that you have mastered the outcomes.
- I do not expect you to be able to do a trihybrid crossing.
- Work through the Chapter review on p 328 of Reece et al (2011).
- In this chapter you have learnt many new terms. Make sure that you know the definition of each:

alleles

character

codominance

complete dominance

dihybrid

dominant allele

epistasis

F_1 generation

F_2 generation

genotype

heterozygous

homozygous

hybridisation

incomplete dominance

law of independent assortment

law of segregation

monohybrid

P generation

pedigree

phenotype

pleiotropy

polygenic inheritance

Punnett square

recessive allele

testcross

trait

true-breeding

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 02.**

12.1 Define the terms *true breeding, hybridisation, monohybrid cross, P generation, F_1 generation* and *F_2 generation*. (6)

12.2 Define Mendel's law of segregation. (2)

12.3 A purple flower (P) is dominant and the white flower (p) is recessive. Use a Punnett square to predict the results of this monohybrid cross between a purple homozygote and a white homozygote and state the phenotypic and genotypic ratios of the F_2 generation. (15)

12.4 Distinguish between the following pairs of terms: *dominant* and *recessive;* heterozygous and *homozygous*; *genotype* and *phenotype*. (6)

12.5 A purple flower with an unknown genotype is crossed with a white flower. Determine the genotype of the purple flower if purple (P) is dominant and white (p) is recessive. (20)

12.6 In sesame plants, the one-pod condition (P) is dominant to the three-pod condition (p). Normal leaf (L) is dominant to wrinkled leaf (l). A homozygote with a one-pod condition and normal leaves is crossed with a homozygote with a three-pod condition and wrinkled leaves. Use a Punnett square to predict the phenotypic and genotypic ratios of the F_2 generation. (20)

12.7 Define Mendel's law of independent assortment. (4)

12.8 Explain how the phenotypic expression of the heterozygote is affected by complete dominance, incomplete dominance and codominance. (6)

12.9 What are multiple alleles, pleiotropy, epistasis and polygenic inheritance? (8)

12.10 Give an example of the impact of the environment on the expression of the genotype. (2)

Basic Biology

TOPIC 13

From gene to protein

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011) Chapter 17: from gene to protein (pp 371–394).

OVERVIEW: THE FLOW OF GENETIC INFORMATION (p 371 in Campbell 2011)

DNA takes the form of specific sequences of nucleotides. In this chapter you will find out how the stored information in these nucleotides is used to synthesise a protein.

STUDY UNIT 13.1

Genes specify proteins via transcription and translation.

The purpose of this study unit is to give you background and knowledge on the flow of genetic material. Genes specify proteins via transcription and translation.

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- explain how RNA differs from DNA
- briefly explain how information flows from gene to protein
- distinguish between transcription and translation
- define *codon* and explain the relationship between the linear sequence of codons on mRNA and the linear sequence of amino acids in a polypeptide

TEXTBOOK READING:

Study the section on genes that specify proteins via transcription and translation in Reece et al (2011) pages 371–377 under the following headings:

- **Evidence from the study of metabolic defects:** Read this section for background knowledge.
- **Basic principles of transcription and translation:** You should be able to define concepts such as transcription, translation and messenger RNA (mRNA). Figure 17.3 gives an overview of the roles of transcription and translation in the flow of genetic information.

- The genetic code
- **Codons: triplets of bases:** A codon specifies an amino acid. The genetic instructions for a polypeptide chain are written in the DNA as a series of three-nucleotide words. Make sure that you understand the concept.
- **Cracking the code:** This makes for interesting reading. Explain in what way the genetic code is redundant and unambiguous. You should know the meaning of the term *reading frame*.
- **Evolution of the genetic code:** Read for background knowledge.

STUDY UNIT 13.2

Transcription is the DNA-direct synthesis of RNA: a closer look

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- explain how RNA polymerase recognises where transcription should begin
- describe the promoter, the terminator and the transcription unit
- explain the general process of transcription, including the three major steps of initiation, elongation and termination

TEXTBOOK READING:

Study the section that discusses transcription; that is, the DNA-direct synthesis of RNA, in Reece et al (2011) pages 377–380, under the following headings:

- **Molecular components of transcription:** Study figure 17.7 to familiarise yourself with the stages of transcription. Make sure that you can describe the promoter, the terminator and the transcription unit.
- **Synthesis of an RNA transcript**
- **RNA polymerase binding and initiation of transcription:** Figure 17.8 shows the role of transcription factors and a crucial promoter of DNA sequence called a TATA box in forming the initiation complex in eukaryotes.
- **Elongation of the RNA strand:** RNA polymerase untwists the DNA double helix, exposing DNA bases for paring with RNA nucleotides (see fig 17.7).
- **Termination of transcription:** You should be able to describe how this process differs between prokaryotes and eukaryotes.

CONCEPT CHECK 17.2

Complete concept check 17.2 on page 380 of the textbook (Campbell 2011).

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 13.3

Eukaryotic cells modify RNA after transcription.

Read through this section for background knowledge.

STUDY UNIT 13.4

Translation is the RNA-directed synthesis of a polypeptide: a closer look

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- describe the structure and functions of tRNA
- describe the structure and functions of ribosomes
- describe the process of translation (including initiation, elongation and termination)

TEXTBOOK READING:

Study the section on translation; that is, the RNA-directed synthesis of a Polypeptide in Reece et al (2011) pages 383–389 under the following headings:

- **Molecular components of translation:** Figure 17.14 illustrates the concept of translation.
- **The structure and function of transfer RNA:** Figure 17.15 shows the structure of a transfer RNA (tRNA). Figure 17.16 shows you how an amino acid is joined to a tRNA.
- **Ribosomes:** Figure 17.17 shows a model of the binding sites of a ribosome and how a tRNA fits into it.
- **Building a polypeptide:** The synthesis of a polypeptide can be divided into three stages: initiation, elongation and termination.

  Ribosome association and the initiation of translation: Figure 17.18 illustrates the initiation of translation.

- **Elongation of the polypeptide chain:** Figure 17.19 illustrates the elongation cycle of translation.
- **Termination of translation:** Figure 17.20 illustrates the termination of translation.
- **Polyribosomes:** Figure 17.21 shows strings of ribosomes called polyribosomes.
- **Completing and targeting the functional protein**

- **Protein folding and post-translational modifications:** Read through for background knowledge.
- **Targeting polypeptides to specific locations:** Read through for background knowledge.

CONCEPT CHECK 17.4

Complete concept check 17.4, numbers 1 and 2 on page 390 of the textbook.

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 13.5

RNA plays multiple roles in the cell: a review

Read through this concept for background knowledge. Table 17.1 gives a list of the types of RNA in eukaryotic cells and their functions. You only need to know the functions of mRNA, tRNA and rRNA.

STUDY UNIT 13.6

Comparing gene expression in prokaryotes and eukaryotes reveals key differences.

Read through this section for background knowledge.

STUDY UNIT 13.7

Point mutations can affect protein structure and function

Learning outcome 5:
Deal in a knowledgeable way with the molecular basis of inheritance.

You will know that you have achieved this learning outcome if you are able to:

- define mutation

TEXTBOOK READING:

Study the section on point mutations that can affect protein structure and function, in Reece et al (2011) pages 390–392. Mutations are changes in the genetic material of a cell. You do not need to know the different types of mutation.

- **What is a gene? Revisiting the question:** The definition of a gene has evolved over the past few chapters. Make sure that you understand the concept of a gene.

INDIVIDUAL EXERCISE

Complete number 8 of the Test your understanding quiz on page 396 of the textbook,

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check the answers and mark your own attempts.
- Figure 17.26 is a summary of the transcription and translation processes in the eukaryotic cell. If you understand and know this figure, you have mastered all the outcomes.
- Work through the Chapter review on p 395.

SUMMARY

In this study unit you have learnt about translation and transcription. Now you have a clear picture of how genetic material flows from DNA to messenger RNA → protein. You have also learnt how mutation affects the genes. You should now be in a position to appreciate the role of genes in humans and animals. We inherit our genes from our parents and pass some of our genes on to our children.

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 02.**

13.1	Explain how RNA differs from DNA.	(6)
13.2	Briefly explain how information flows from gene to protein.	(6)
13.3	Distinguish between transcription and translation.	(4)
13.4	What is a codon?	(4)
13.5	Explain in what way the genetic code is redundant and unambiguous.	(2)
13.6	Explain how RNA polymerase recognises where transcription should begin. Describe the promoter, the terminator and the transcription unit.	(8)
13.7	Explain the general process of transcription, including the three major steps of initiation, elongation and termination.	(10)
13.8	What is a reading frame?	(1)
13.9	Describe the structure and functions of tRNA.	(6)
13.10	Describe the structure and functions of ribosomes.	(10)
13.11	Explain the significance of polyribosomes.	(3)

TOPIC 14

Community ecology

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011) Chapter 54: Community ecology (pp 1240–1261).

An organism's environment includes other individuals of the same species as well as populations of other species living in the same area. An assemblage of species living close enough together for potential interaction is called a biological community.

STUDY UNIT 14.1

A community's interactions include competition, predation herbivory, symbiosis and disease.

What is a community? Give three types of symbiosis here.

The purpose of this study material is to give you an insight into and knowledge of the way in which an ecosystem works. A community's interactions include competition, predation, hebivory, symbiosis and disease.

Learning outcome 6:
Discuss/explain the biodiversity and complexity of creation and methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- explain the difference between a community and a population
- list four possible specific interactions and explain how the relationships affect the population densities of the two species
- explain how interspecific competition may affect community structure
- describe the competitive exclusion principle and explain how competitive exclusion may affect community structure
- define an ecological niche and restate the competitive exclusion principle using the niche concept
- define and compare predation, herbivory and parasitism
- relate some specific predatory adaptations to the properties of the prey
- describe the defence mechanisms that have evolved in plants to reduce predation by herbivores
- describe how predators use mimicry to obtain prey

- distinguish among endoparasites, ectoparasites and pathogens
- distinguish among parasitism, mutualism and commensalism
- distinguish between a food chain and a food web
- describe the factors that transform food chains into food webs

TEXTBOOK READING:

Study the section that discusses the way a community's interactions include competition, predation, herbivory, symbiosis and disease, in Reece et al (2011) pages 1240–1246, under the following headings:

- **Competition:** Interspecific competition occurs when species compete for a particular resource that is in short supply. The competitive exclusion principle: One species uses resources more efficiently and thus reproduces more rapidly than the other, which can lead to the elimination of the second species.

Ecological niche: The sum total of a species' use of the biotic and abiotic resources in its environment is called the species' *ecological niche*.

Resource partitioning: When competition between two species having identical niches does not lead to local extinction of either species, it is generally because one species niche becomes modified.

Character displacement. What are allopatric and sympatric populations? Figure 53.4 explains character displacement using an example.

- **Predation:** What is a predator? You should be able to discuss predator adaptation, plant defences against herbivores, animal defences against predators and parasites and pathogens.
- **Herbivory:** The interaction during which a herbivore eats a plant. Can plants avoid being eaten?
- **Parasitism:** Symbiotic interaction in which the parasite derives nourishment from a host, which is harmed in the process. What is an endoparasite and an ectoparasite?
- **Disease:** Pathogens or disease-causing agents, mostly microscopic and usually lethal
- **Mutualism:** You should be able to define mutualism and give an example.
- **Commensalism:** You should be able to define commensalism using an example.
- **Interspecific interactions and adaptations:** A change in one species acts as a selective force on another species. You should be able to discuss co-evolution.

CONCEPT CHECK 54.1

Complete concept check 54.1 on page 1246 in the textbook.

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 14.2

Diversity and trophic structure characterise biological communities.

Learning outcome 6.
Discuss/explain the biodiversity and complexity of creation and the methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- explain what species diversity is
- describe the trophic structure of a community
- explain what dominant and keystone species are
- explain the difference between a bottom-up and a top-down model

TEXTBOOK READING:

Study the section on the diversity and trophic structure that characterise biological communities in Reece et al (2011), pages 1246 –1252 under the following headings:

- **Species diversity:** This is the variety of different organisms that make up a community. It has two components – species richness and relative abundance (see fig 54.10).
- **Diversity and community stability:** Ecologists examine the potential benefits of diversity, including the increased productivity and stability of biological communities. Figure 54.12 shows the site of long-term experiments on manipulating plant diversity.
- **Trophic structure:** The structure and dynamics of a community that depend largely on the feeding relationship between organisms.

Food webs: Figures 54.14 and 54.15 give examples of food webs.

Limits on food chain lengths: Each food chain within a food web is usually only a few links long. Read through the rest of this paragraph for background knowledge.

- **Species with a large impact**

Dominant species are those species in a community that are the most abundant or that collectively have the highest biomass. Do you know what invasive species are?

Keystone species are not necessarily abundant in a community, but exert strong control on community structure (see figs 54.17 and 54.18).

Ecosystem engineers (foundation species) are species that exert their influence not through their trophic interactions but by causing physical changes in the environment that affect the structure of the community.

Bottom-up and top-down controls: You should be able to explain briefly the difference between a bottom-up and a top-down model.

STUDY ACTIVITY 14.2

Complete concept check 54.2, numbers 1 and 2, on page 1252 of the textbook.

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 14.3

Disturbance and influences species diversity and composition

Learning outcome 6:
Discuss/explain the biodiversity and complexity of creation and the methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- explain what species diversity is
- describe how disturbances affect community structure and composition. Illustrate this point with several well-studied examples.
- give examples of humans as widespread agents of disturbance
- describe and distinguish between primary and secondary succession

TEXTBOOK READING:

Study the section on disturbance and the influences on species diversity and composition, in Reece et al (2011), pages 1253–1256, under the following headings:

- **What is a disturbance?** What is a disturbance? Give an example of a disturbance in your own environment? Read through the rest of the paragraph for background knowledge.
- **Human disturbance:** Look at your own environment. Are there any signs of human disturbance?
- **Ecological succession:** What is the sequence of community changes after a disturbance? You should be able to compare primary and secondary succession and give an example of each. Look to your own environment. Can you see any signs of ecological succession? Can you identify such signs as primary or secondary succession?

STUDY UNIT 14.4

Biogeographic factors affect community biodiversity.

Read this section for background knowledge.

STUDY UNIT 14.5

Community ecology is useful for understanding pathogen life cycles and controlling human disease.

Read this section for background knowledge.

INDIVIDUAL EXERCISE

Complete the Test your understanding quiz on page 1263 of the textbook (Campbell 2011), numbers 11 and 12.

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check the answers and mark your own attempts.
- Make sure that you have mastered the outcomes.
- Work through the Chapter review on p 1262.

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 02.**

14.1	Give an example of a community from your own environment.	(2)
14.2	Explain the difference between a community and a population.	(2)
14.3	List four possible specific interactions and explain how each of the relationships affect the population densities of the species.	(8)
14.4	Give an example of interspecific competition in your own environment and explain how it may affect community structure.	(3)
14.5	Describe the competitive exclusion principle and explain how competitive exclusion may affect community structure.	(4)
14.6	Define an ecological niche.	(2)
14.7	Explain how resource partitioning can affect species diversity.	(2)
14.8	Define predation, herbivory and parasitism.	(3)
14.9	Name three defence mechanisms that have evolved in plants to reduce predation by herbivores.	(2)
14.10	Give an example of how predators use mimicry to obtain prey.	(1)
14.11	Distinguish among endoparasites, ectoparasites and pathogens.	(3)
14.12	Distinguish among parasitism, mutualism, and commensalism.	(3)
14.13	Distinguish between a food chain and a food web.	(2)

14.14 Give an example of how disturbances affect community structure and composition in your own environment. (3)

14.15 Give an example of where humans have acted as agents of disturbance in your own community. (1)

14.16 Describe and distinguish between primary and secondary succession. (3)

14.17 Distinguish between species richness and relative abundance. (2)

Basic Biology

TOPIC 15

Ecosystems and restoration ecology

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011), Chapter 55: Ecosystems (pp 1264–1281).

STUDY UNIT 15.1

Ecosystem ecology emphasises energy flow and chemical cycling.

The aim of this study unit is to introduce you to and give you insight into the way energy flows within the ecosystem. Ecosystem ecology emphasises energy flow and chemical cycling.

Learning outcomes:
Discuss/explain the biodiversity and complexity of creation and the methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- describe the relationship between autotrophs and heterotrophs in an ecosystem
- explain how decomposition connects all trophic levels in an ecosystem
- explain how the first and second laws of thermodynamics apply to ecosystems

TEXTBOOK READING:

Can you explain what an ecosystem is?

Study the section on ecosystem ecology that discusses energy flow and chemical cycling, in Reece et al (2011) pages 1265 and 1266, under the following headings:

- **Ecosystems and physical laws:** Can you remember the first and second law of thermodynamics (study unit 8)? Energy flowing through ecosystems is ultimately dissipated into space as heat, but replenished by the sun.
- **Trophic relationships** determine the routes of energy flow and chemical cycling in an ecosystem. Figure 54.4 gives an overview of ecosystem dynamics. It is important that you can distinguish between primary producers, consumers and detritivores.

- **Decomposition:** The organic material that makes up living organisms in an ecosystem gets recycled. Detritivores break down the organic material and recycle the chemical elements in organic forms to abiotic reservoirs such as soil, water and air.

STUDY ACTIVITY 15.1

Complete concept check 55.1 on page 1266 of the textbook.

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 15.2

Energy and other limiting factors control primary production in ecosystems.

You should know what primary production is, but you can read the rest of this section for background knowledge.

STUDY UNIT 15.3

Energy transfer between trophic levels is typically only 10% efficient.

You should know what a pyramid of production, a pyramid of biomass and a pyramid of numbers are, but you can read the rest of this section for background knowledge.

STUDY UNIT 15.4

Biological and geochemical processes cycle nutrients and water in the ecosystem.

The study unit introduces you to the biochemical cycles and their importance in the ecosystem.

Learning outcome 6:
Discuss/explain the biodiversity and complexity of creation and the methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- describe the four nutrient reservoirs and the processes that transfer the elements between reservoirs
- explain why it is difficult to trace elements through biogeochemical cycles
- describe the hydrologic water cycle
- describe the nitrogen cycle and explain the importance of nitrogen fixation to all living organisms
- describe the phosphorus cycle and explain how phosphorus is recycled locally in most ecosystems
- explain how decomposition affects the rate of nutrient cycling in ecosystems

TEXTBOOK READING:

Can you mention three biochemical cycles you know? What role do you think they play in an ecosystem?

Study the section on biological and geochemical processes that move nutrients between organic and inorganic parts of the ecosystem, in Reece et al (2011) pages 1231–1236, under the following headings:

- **A general model of chemical cycling:** Biological and geological processes move nutrients between organic and inorganic compartments. Figure 55.13 gives a general model of nutrient cycling.
- **Biochemical cycles:** You should be able to describe the water cycle, the carbon cycle, the nitrogen cycle and the phosphorus cycle. Figure 55.14 gives diagrams of the different cycles.
- **Decomposition and cycling rates:** Read through for background knowledge.
- **Vegetation and nutrient cycling**: **the Hubbard Brook experimental forest**: Read through for background knowledge.

STUDY UNIT 15.5

Restoration ecologists help return degraded ecosystems to a more natural state.

Human activities now dominate most chemical cycles on earth.

Learning outcome 6 :
Discuss/explain the biodiversity and complexity of creation and the methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- describe the impact of humans on the ecosystems

TEXTBOOK READING:

What is a population? Do you know how the human population impacts on the environment?

Study the section on the way restoration ecologists help return degraded ecosystems to a more natural state in Reece et al (2011) pages 1278 and 1279, under the following headings:

- **Bioremediation:** Bioremediation is the use of organisms, usually prokaryotes, fungi or plants, to detoxify polluted ecosystems. Can you give an example where bioremediation could be applied? Restoration ecologists can introduce organisms to sites polluted by mining and other human activities and then harvest these species to remove the metals from the ecosystem. Figure 55.18 shows the bioremediation of groundwater.

- **Biological augmentation:** This method uses organisms to add essential materials to a degraded ecosystem. How is augmentation performed? Study this in detail in the prescribed book.
- **Restoration projects worldwide:** Because this discipline is new, restoration ecologists generally learn as they progress. Restoration ecologists advocate adaptive management by experimenting with numerous promising kinds of management to learn what functions best.

STUDY ACTIVITY 15.5

Complete concept check 55.5 on page 1279 of the textbook.

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

INDIVIDUAL EXERCISE

Complete numbers 10 and 12 of the Test your understanding quiz on page 1244 of the textbook.

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check the answers and mark your own attempts.
- Make sure that you have mastered the outcomes.
- Work through the Chapter review on p 1282.

SUMMARY

In this study unit you have learnt about energy flow in the ecosystem and the chemical cycling that takes place. In the next study unit you will learn about the way the ecosystem is affected by human actions.

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 02.**

15.1	Distinguish between an autotroph and a heterotroph.	(2)
15.2	Draw a diagram to trace energy flow and material cycling in ecosystems.	(10)
15.3	Draw a diagram to show the movement of carbon in an ecosystem.	(10)
15.4	Draw a diagram to show the net movement of nitrogen in an ecosystem.	(15)
15.5	Draw a diagram to show the net movement of phosphorus in an ecosystem.	(13)
15.6	Draw a diagram to illustrate the processes that transfer the elements between nutrient reservoirs.	(15)
15.7	Write explanatory notes on bioremediation.	(5)
15.8	Write short notes on biological augmentation.	(5)

TOPIC 16

Conservation biology and global change

TEXTBOOK REFERENCE:

This study unit is based on Reece et al (2011) Chapter 56: Conservation biology and restoration ecology (pp 1284–1307).

Conservation biology integrates ecology, physiology, molecular biology, genetics and evolutionary biology to conserve biological diversity at all levels. Restoration ecology applies ecological principles in an effort to return degraded ecosystems to conditions as similar as possible to their natural pre-graded state.

STUDY UNIT 16.1

Human activities threaten earth's biodiversity.

The purpose of this study unit is to give you an insight into and understanding of the way human activities threaten earth's biodiversity.

Learning outcomes: 6
Discuss/explain the biodiversity and complexity of creation and the methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- describe the three levels of biodiversity
- explain why biodiversity at all levels is vital to human welfare
- list the four major threats to biodiversity and give an example of each

TEXTBOOK READING:

Can you explain the three levels of biodiversity?

Study the section on human activities that threaten earth's biodiversity, in Reece et al (2011) pages 1285–1290, under the following headings:

- **The three levels of biodiversity are**

Genetics diversity: Genetic diversity comprises the individual genetic variation in a population and the genetic variation between populations.

Species diversity: Endangered species are in danger of extinction, while threatened species are those that are considered likely to become endangered in the foreseeable future. Read through the statistics, which are hair-raising, but which are not for exam purposes.

Ecosystem diversity: Each ecosystem has characteristic patterns of energy flow and chemical cycling that can affect the whole biosphere. You should be able to write short notes on how the loss of genetic diversity, species diversity and ecosystem diversity influences the ecosystem.

- **Biodiversity and human welfare:** Biophilia – the belief that other species are entitled to life – is a pervasive theme of many religions and the basis of the moral argument that we should protect biodiversity.
- **Benefits of species and genetic diversity:** Many species that are threatened could potentially provide crops, fibres and medicine for human use.
- **Ecosystem services:** We need a functioning ecosystem; just take a look at the section that discusses what would happen if we do not have one that functions.

Threats to biodiversity

There are four major threats to biodiversity:

- **Habitat loss:** Humans caused massive destruction of habitats and loss of habitat can mean extinction.
- **Introduced species:** Some species relocated, either intentionally or accidentally. Can you give a few examples?
- **Overharvesting** refers to the harvesting of wild plants and animals at a rate exceeding the ability to rebound.
- **Global change:** Global change includes change in climate, atmospheric chemistry and broad ecological systems that has a negative effect on the capacity of the earth to sustain life. Can you give any example of global change that is of concern? One example is acid precipitation. For more on this see page 1290 in Reece et al (2011).

STUDY ACTIVITY 16.1

Complete concept check 56.1 on page 1290 of the textbook.

FEEDBACK

For suggested answers see Appendix A at the back of the textbook.

STUDY UNIT 16.2

Population conservation focuses on population size, genetic diversity and critical habitat.

Learning outcome 6:
Discuss/explain the biodiversity and complexity of creation and the methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- explain the small population approach and the declining population approach

TEXTBOOK READING:

Study the section that discusses population conservation which focuses on population size, genetic diversity and critical habitat, in Reece et al (2011) pages 1290–1295, under the following headings:

- **Small-population approach:** Do you know the cause of small populations? Very small populations can drive themselves to extinction.
- **The extinction vortex:** Figure 56.12 gives you the processes that culminate in an extinction vortex.
- **Case study:** The great prairie chicken and the extinction vortex: Read for background knowledge.
- **Minimum viable population size (MVP)** is the minimum size at which a species is able to sustain its numbers and survive.
- **Effective population size** is based on the breeding potential of the population. Read the rest of the paragraph for background knowledge.
- **Case study: analysis of grizzly bear populations:** Read through for background knowledge.
- **Declining-population approach** focuses on threatened and endangered populations.
- **Steps for analysis and intervention:** Read for background knowledge.
- **Case study: decline of the red-cockaded woodpecker:** Read for background knowledge.
- **Weighing conflicting demands:** Declining population approach – read for background knowledge.

STUDY UNIT 16.3

Landscape and regional conservation aim to sustain entire biotas.

Learning outcome 6:
Discuss/explain the biodiversity and complexity of creation and the methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- explain how edges and corridors can strongly influence landscape biodiversity
- define biodiversity hot spots and explain why they are important
- explain why natural reserves must be functional parts of landscapes
- define zoned reserves and explain why they are important

TEXTBOOK READING:

What do you understand by landscape structures, fragments and edges?

Study the section that discusses the way landscape and regional conservation aim to sustain entire biotas, in Reece et al (2011), pages 1295–1299, under the following headings:

- **Landscape structure and biodiversity:** The biodiversity of a given landscape is in large part a function of the structure of the landscape.
- **Fragments and edges:** The boundaries or edges are the defining features of a landscape. You should be able to write short notes on this concept.
- **Corridors that connect habitat fragments:** A movement corridor can be a deciding factor in conserving the biodiversity of fragmented habitats. You should be able to write short notes on this concept.
- **Establishing protected areas**
- **Preserving biodiversity hot spots:** Hot spots are relatively small areas with an exceptional concentration of endemic species and a large number of endangered and threatened species (see fig 56.19).
- **Philosophy of nature reserves:** You should be able to write short notes on this.
- **Zoned reserves:** You should be able to write short notes on this concept.

STUDY UNIT 16.4

Earth is changing rapidly as a result of human action.

Learning outcomes: 6
Discuss/explain the biodiversity and complexity of creation and the methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- define the critical load of greenhouse gases and global warming
- explain the term *greenhouse effect*

TEXTBOOK READING:

Can you make suggestions for ways in which degraded ecosystems in your area could be restored?

Study the section on pages 1300–1305 in Reece et al (2011). After reading through this section you should be able to explain how greenhouse gases affect climate change. The human activities are the result of the climate change. Human activities such as building of roads, heavy industries, nutrient enrichment (agriculture), etc. Humans remove nutrients from one part of the biosphere and add them to another.

- **Critical load:** The amount of added nutrient, usually nitrogen or phosphorus, that can be absorbed by plants without causing harm to the integrity of the ecosystem. If the nutrient level in an ecosystem exceeds the critical load there problems will occur. For example, nitrogenous minerals in the soil that exceed the critical load may eventually seep into groundwater, or run into freshwater and marine ecosystems, thus contaminating water supplies and killing fish.
- **Greenhouse gases and global warming:** You have heard a lot from environmental activists, politicians and people in general about the dangers we are facing from greenhouse gases and global warming. Study this section in the textbook (pp 1302–1305) in detail.

STUDY UNIT 16.5

Sustainable development can improve human lives while conserving biodiversity.

Learning outcome 6:
Discuss/explain the biodiversity and complexity of creation and the methods for sustaining them.

You will know that you have achieved this learning outcome if you are able to:

- describe the process of adaptive management
- describe the concept of sustainable development
- explain the goals of the Sustainable Biosphere Initiative
- define biophilia and explain why the concept gives some biologists hope
- use biology terms correctly in all forms of communication

TEXTBOOK READING:

Study the section on sustainable development that seeks to improve the human condition while conserving biodiversity, in Reece et al (2011) pages 1264 and 1265. After reading through this section you should make sure that you have mastered the outcomes.

STUDY ACTIVITY 16.5

Complete the self-quiz on page 1267 of the textbook, numbers 1, 2, 4 to 6, and10.

FEEDBACK

Answers to the self-quiz questions are provided in Appendix A at the back of the textbook.

REFLECT ON YOUR LEARNING

- Check the answers and mark your own attempts.
- Make sure that you have mastered the outcomes.
- Work through the Chapter review on p 1230 of the textbook.

SUMMARY

In this study unit you have learnt about the challenges presented by the environmental degradation of biodiversity and the ecosystem. Some of these are caused by human factors and some occur naturally. As responsible citizens we should play our part in conserving biodiversity by promoting actions that are friendly to the environment, for example reducing pollution. What you have learnt in this study unit should be applied in everyday life. We should also protect the species that are in danger of extinction.

EVALUATION QUESTIONS

The evaluation questions will help you to determine whether you have mastered all the outcomes. **You should submit some of the questions for evaluation. Please refer to Tutorial Letter 101 for the details of Assignment 02.**

16.1	Describe the three levels of biodiversity.	(3)
16.2	Explain why biodiversity at all levels is vital to human welfare.	(3)
16.3	List the four major threats to biodiversity and give an example of each.	(8)
16.4	Explain how edges and corridors can strongly influence landscape biodiversity.	(5)
16.5	Define biodiversity hot spots.	(1)
16.6	Explain why natural reserves must be functional parts of landscapes.	(2)
16.7	Define zoned reserves and explain why they are important.	(5)
16.8	Define restoration ecology and describe its goals.	(5)
16.9	Explain the goals of the Sustainable Biosphere Initiative.	(4)
16.10	What is biophilia?	(1)

UNIVERSITY EXAMINATIONS

UNIVERSITEITSEKSAMENS

UNISA university of south africa

BLG1501

October/November 2011

BASIC BIOLOGY

Duration : 2 Hours

100 Marks

EXAMINERS :
FIRST : DR MA NYILA
SECOND : DR LS TEFFO

This paper consists of FIVE (5) pages.

ANSWER ALL THE QUESTIONS ON THE EXAMINATION ANSWERBOOK PROVIDED.

[TURN OVER]

QUESTION 1

WRITE ONLY THE CORRECT LETTER NEXT TO THE CORRESPONDING NUMBER IN YOUR ANSWER BOOK, FOR EXAMPLE: 1.1 C.

1.1 An atom is defined as a smallest particle of _____

A. a compound that can take part in chemical reaction.
B. an element that can take part in chemical reaction.
C. a molecule that reacts with other molecules.
D. an isotope that take part in chemical reaction.
E. a compound that react with other compounds.

1.2 The three domains of life are _____

A. eukarya, fungi and bacteria.
B. eukarya, archaea and bacteria.
C. eukarya, fungi and animalia.
D. eukarya, archaea and fungi.
E. eukarya, bacteria and animalia.

1.3 The correct definition of isotopes is _____

A. atoms of the different elements that have the same number of neutrons, but differ in the number of protons.
B. atoms of the same element containing the same number of protons, but differ in the number of electrons.
C. atoms of the same element containing the same number of protons, but differ in the number of neutrons.
D. atoms of the same element containing the same number of electrons, but differ in the number of neutrons.
E. atoms of different elements that have the same number of neutrons, but differ in the number of electrons.

1.4 Van der Waals interaction is a bond formed by _____

A. polar positively charged and polar negatively charged atoms.
B. polar positively charged and non-polar negatively charged atoms.
C. non-polar positively charged and non-polar negatively charged atoms.
D. positively charged and negatively charged atoms.
E. non-polar positively charged and negatively charged atoms.

1.5 Chitin is an example of a _____

A. polypeptide.
B. polysaccharide.
C. fat.
D. nucleic acid.
E. glycerol.

1.6 The electron configuration $1s^2 2s^2 2p^6$, belongs to _____

A. carbon.
B. oxygen.
C. nitrogen.
D. neon.
E. magnesium.

1.7 *Ribosomes are responsible for* _____

A. protein synthesis.
B. digestive compartments.
C. photosynthesis.
D. *controlling the centre of the cell.*
E. the removal of waste from the cell.

1.8 The mass number refers to _____

A. the number of protons in an atom.
B. the combined number of protons and neutrons in an atom.
C. the number of electrons in an atom.
D. the combined number of protons and electrons in an atom.
E. the number of neutrons and electrons in an atom.

1.9 Chloroplasts are responsible for _____

A. the shipping and receiving centre.
B. digestive compartments.
C. photosynthesis.
D. controlling the centre of the cell.
E. protein synthesis.

1.10 In DNA, double helix, adenine pairs with _____, and guanine pairs with _____

A. cytosine, thymine.
B. guanine, adenine.
C. uracil, cytosine.
D. thymine, cytosine.
E. cytosine, uracil.

(10 x 2 = 20)

[20]

QUESTION 2

2. 1 Explain how edges and corridors can strongly influence landscape biodiversity. (6)

2.2 Distinguish between the fate of pyruvate in alcohol fermentation and in lactic acid fermentation. (6)

2.3 Compare in tabular form the process of fermentation and cellular respiration. (10)

2.4 Name three domains of life. (3)

[25]

QUESTION 3

3.1 In sesame plants, the one-pod condition (P) is dominant to the three-pod condition (p).Normal leaf (L) is dominant to wrinkled leaf (l). A homozygote in one-pod condition and normal leaves is crossed with a homozygote in three- pod condition and wrinkled leaves. Use a Punnett square to predict the phenotypic and genotypic ratios of the F_2 generation. (19)

[TURN OVER]

3.2 Distinguish between parasitism, mutualism and commensalism. (6)

3.3 Define the following terms:

3.3.1 diploid

3.3.2 primosome

3.3.3 ecotone

3.3.4 enthalpy

3.3.5 climax community

(1 x 5)

[30]

QUESTION 4

4.1 Compare a prokaryotic cell to a eukaryotic cell. (10)

4.2 List the seven properties of life. (7)

4.3 What is an isotope? Discuss this phenomenon with regard to the medical application of radioisotopes. (5)

4.4 Give the electron configuration of oxygen. (3)

[25]

TOTAL: 100