Ministerial foreword

The Department of Basic Education has pleasure in releasing the series called *Mind the Gap* study guides for Grade 12 learners. The first subjects in the series include Life Sciences, Accounting, Economics and Geography. These study guides are another innovative and committed attempt by the Department of Basic Education to improve the academic performance of Grade 12 candidates in the National Senior Certificate (NSC) examination.

The *Mind the Gap* study guide series is produced in both English and Afrikaans to assist those learners that have been underperforming due to a lack of exposure to the content requirements of the curriculum. The series aims to mind-the-gap between failing and passing, by bridging-the-gap in learners’ understanding of commonly tested concepts so candidates can pass.

The *Mind the Gap* study guide series takes its brief in part from the 2011 National Diagnostic report on learner performance. The marking and moderation process has revealed that candidates consistently perform poorly in certain basic concepts. The *Mind the Gap* study guides also draw on the Grade 12 Examination Guidelines.

Each of the *Mind the Gap* study guides provide explanations of key terminology, simple explanations and examples of the types of questions that learners can expect to be asked in an exam. Model answers are included to assist learners in building their understanding. Learners are also referred to specific questions in past national exam papers and exam memos that are available on the Department’s website – www.education.gov.za

The study guides have been written by subject expert teams comprised of teachers, examiners, moderators, subject advisors and subject coordinators. All that is now required is for our Grade 12 learners to put in the hours studying hard for the examinations. It should be remembered that the support of the teachers and parents is also of utmost importance as they are responsible for supporting the learning process at school and at home.

It is my fervent wish that the *Mind the Gap* study guide series takes us all closer towards ensuring that no learner is left behind.

Learners make us proud - study hard. We wish you all good luck for your Grade 12 examinations.

Matsie Angelina Motshekga, MP
Minister of Basic Education
July 2012

Mr Enver Surty, MP
Deputy Minister of Basic Education
July 2012
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Dear Grade 12 learner

This Mind the Gap study guide helps you to prepare for the end-of-year Life Sciences Grade 12 exam.

The study guide does NOT cover the entire curriculum, but it does focus on core content of each knowledge area and points out where you can earn easy marks.

You must work your way through this study guide to improve your understanding, identify your areas of weakness and correct your own mistakes.

To ensure a high-quality pass, you should also cover the remaining sections of the curriculum using other textbooks and your class notes.

Overview of the exam for Life Sciences Grade 12

The following topics make up each of the TWO Life Sciences exam papers that you write at the end of the year:

<table>
<thead>
<tr>
<th>PAPER 1</th>
<th></th>
<th>PAPER 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleic acids</td>
<td>90 marks</td>
<td>Plant responses</td>
<td>90 marks</td>
</tr>
<tr>
<td>Meiosis</td>
<td></td>
<td>Human nervous system</td>
<td></td>
</tr>
<tr>
<td>Genetics</td>
<td></td>
<td>Human endocrine system</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temperature regulation</td>
<td></td>
</tr>
<tr>
<td>Evolution</td>
<td>60 marks</td>
<td>Reproduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population and community ecology</td>
<td>60 marks</td>
</tr>
<tr>
<td>TOTAL</td>
<td>150 marks</td>
<td>TOTAL</td>
<td>150 marks</td>
</tr>
</tbody>
</table>

Both Paper 1 and Paper 2 will include the following types of questions:

<table>
<thead>
<tr>
<th>Section</th>
<th>Type of question</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Short answer, objective questions such as multiple-choice questions, terminology, columns/statement and items.</td>
<td>50</td>
</tr>
<tr>
<td>B</td>
<td>A variety of longer questions based on graphs, diagrams or text. There will be two questions of 30 marks each. Both of these questions will be divided into three to four subsections.</td>
<td>2 × 30</td>
</tr>
<tr>
<td>C</td>
<td>Consists of two parts:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Data response questions.</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>• A mini-essay (this may address one or more learning outcome).</td>
<td>20</td>
</tr>
</tbody>
</table>
How to use this study guide

This study guide covers selected parts of the different topics of the Grade 12 Life Sciences curriculum in the order they are usually taught during the year. The selected parts of each topic are presented in the following way:

- An explanation of terms and concepts;
- Worked examples to explain and demonstrate;
- Activities with questions for you to answer; and
- Answers for you to use to check your own work.

<table>
<thead>
<tr>
<th>Pay special attention</th>
<th>Hint</th>
<th>Worked examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step-by-step instructions</td>
<td>Exams</td>
<td>Refers you to past exam papers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Activities with questions for you to answer</td>
</tr>
</tbody>
</table>

- A checklist from the exam guidelines for Life Sciences has been provided on page xiv for you to keep track of your progress. Once you have mastered the core concepts and have confidence in your answers to the questions provided, tick the last column of the checklist.
- The activities are based on exam-type questions. Cover the answers provided and do each activity on your own. Then check your answers. Reward yourself for the things you get right. If you get any incorrect answers, make sure you understand where you went wrong before moving on to the next section.
- In Chapter 11, you will find a section on graphing skills which you must master when preparing for both Paper 1 and Paper 2. This chapter also provides guidelines on how to answer essay-type questions in the exam.
- You will be asked to draw a labelled diagram in the exam. On page 95 to 115 are a set of blank diagrams that you can use to practise your drawing and labelling skills. Filling in these blank diagrams is a good way to test yourself and work out what you know well and what you still need more practice in.
- Past exam papers are included in the study guide for you to do. Check your answers by looking back at your notes and the exam memoranda. Past exam papers go a long way in preparing you for what to expect and help reduce exam anxiety. Go to www.education.gov.za to download more past exam papers.

Use this study guide as a workbook. Make notes, draw pictures and highlight important concepts.
Top 10 study tips

1. Have all your materials ready before you begin studying – pencils, pens, highlighters, paper, etc.

2. Be positive. Make sure your brain holds on to the information you are learning by reminding yourself how important it is to remember the work and get the marks.

3. Take a walk outside. A change of scenery will stimulate your learning. You’ll be surprised at how much more you take in after being outside in the fresh air.

4. Break up your learning sections into manageable parts. Trying to learn too much at one time will only result in a tired, unfocused and anxious brain.

5. Keep your study sessions short but effective and reward yourself with short, constructive breaks.

6. Teach your concepts to anyone who will listen. It might feel strange at first, but it is definitely worth reading your revision notes aloud.

7. Your brain learns well with colours and pictures. Try to use them whenever you can.

8. Be confident with the learning areas you know well and focus your brain energy on the sections that you find more difficult to take in.

9. Repetition is the key to retaining information you have to learn. Keep going – don’t give up!

10. Sleeping at least 8 hours every night, eating properly and drinking plenty of water are all important things you need to do for your brain. Studying for exams is like strenuous exercise, so you must be physically prepared.
Question words to help you answer questions

It is important to look for the question words (the words that tell you what to do) to correctly understand what the examiner is asking. Use the words in the table below as a guide when answering questions.

<table>
<thead>
<tr>
<th>Question word</th>
<th>What is required of you</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyse</td>
<td>Separate, examine and interpret</td>
</tr>
<tr>
<td>Calculate</td>
<td>This means a numerical answer is required. In general, you should show your working, especially where two or more steps are involved.</td>
</tr>
<tr>
<td>Classify</td>
<td>Group things based on common characteristics</td>
</tr>
<tr>
<td>Compare</td>
<td>Point out or show both similarities and differences between things, concepts or phenomena</td>
</tr>
<tr>
<td>Define</td>
<td>Give a clear meaning</td>
</tr>
<tr>
<td>Describe</td>
<td>State in words (using diagrams where appropriate) the main points of a structure/process/phenomenon/investigation</td>
</tr>
<tr>
<td>Determine</td>
<td>To calculate something, or to discover the answer by examining evidence</td>
</tr>
<tr>
<td>Differentiate</td>
<td>Use differences to qualify categories</td>
</tr>
<tr>
<td>Discuss</td>
<td>Consider all information and reach a conclusion</td>
</tr>
<tr>
<td>Explain</td>
<td>Make clear; interpret and spell out</td>
</tr>
<tr>
<td>Identify</td>
<td>Name the essential characteristics</td>
</tr>
<tr>
<td>Label</td>
<td>Identify on a diagram or drawing</td>
</tr>
<tr>
<td>List</td>
<td>Write a list of items, with no additional detail</td>
</tr>
<tr>
<td>Mention</td>
<td>Refer to relevant points</td>
</tr>
<tr>
<td>Name</td>
<td>Give the name (proper noun) of something</td>
</tr>
<tr>
<td>State</td>
<td>Write down information without discussion</td>
</tr>
<tr>
<td>Suggest</td>
<td>Offer an explanation or a solution</td>
</tr>
<tr>
<td>Tabulate</td>
<td>Draw a table and indicate the answers as direct pairs</td>
</tr>
</tbody>
</table>

Examples of question words

Questions

1. Figure 6.12 shows a longitudinal section through the human eye. Study the diagram and answer the questions that follow.
   a) Label parts 2, 3, 4 and 5 respectively. (4)
   b) Name and describe the process that causes part 1 to dilate (become wider). (5)

2. Figure 6.13 is a longitudinal section through the human eye. The structures which enable the eye to focus on objects are missing in this diagram. Study the diagram and answer the questions that follow.
   a) Draw a longitudinal section through the missing parts of Figure 6.13 to indicate the appearance of these structures when you are... (6)
   b) reading a book. (6)
   b) looking at an object more than 6 metres away. (6)

In every exam question, put a CIRCLE around the question word and underline any other important key words. These words tell you exactly what is being asked.
Study skills to boost your learning

This guide includes 3 study techniques you can use to help you learn the material:
1. Mobile notes
2. Mnemonics
3. Mind maps

Mobile notes
Mobile notes are excellent tools for learning all the key concepts in the study guide. Mobile notes are easy to make and you can take them with you wherever you go:
1. Fold a blank piece of paper in half. Fold it in half again. Fold it again.
2. Open the paper. It will now be divided into 8 parts.
3. Cut or tear neatly along the folded lines.
4. On one side of each of these 8 bits of paper, write the basic concept.
5. On the other side, write the meaning or the explanation of the basic concept.
6. Use different colours and add pictures to help you remember.
7. Take these mobile notes with you wherever you go and look at them whenever you can.
8. As you learn, place the cards in 3 different piles:
   • I know this information well.
   • I’m getting there.
   • I need more practice.
9. The more you learn them, the better you will remember them.
Mnemonics

A mnemonic code is a useful technique for learning information that is difficult to remember. Below is an example of a word mnemonic using the word SYSTEMS, where each letter of the word stands for something else:

S – Self-discipline means getting it done.
Y – Yes! You can do it.
S – Study hard, this is your chance to give it everything you’ve got.
T – Try and try again, even when the going gets tough.
E – Easy! This study guide will help you.
M – Motivation! Remember, only YOU can motivate yourself.
S – Success comes to those who work for it.

Mnemonics code information and make it easier to remember.

The more creative you are and the more you link your “codes” to familiar things, the more helpful your mnemonics will be.

This guide provides several ideas for using mnemonics. Be sure to make up your own.

*The future depends on what we do in the present.*

Mahatma Gandhi
Mind maps

There are several mind maps included in this guide, summarising some of the sections.

Have a look at the following pictures of a brain cell (neuron) and, below it, a mind map:

Figure 1: Brain cell or neuron

Figure 2: Mind map rules

Mind maps work because they show information that we have to learn in the same way that our brains “see” information.

As you study the mind maps in the guide, add pictures to each of the branches to help you remember the content.

You can make your own mind maps as you finish each section.

How to make your own mind maps:
1. Turn your paper sideways so your brain has space to spread out in all directions.
2. Decide on a name for your mind map that summarises the information you are going to put on it.
3. Write the name in the middle and draw a circle, bubble or picture around it.
4. Write only key words on your branches, not whole sentences. Keep it short and simple.
5. Each branch should show a different idea. Use a different colour for each idea. Connect the information that belongs together. This will help build your understanding of the learning areas.
6. Have fun adding pictures wherever you can. It does not matter if you can’t draw well.
TOP 10 exam tips

1. Make sure you have all the necessary stationery for your exam, i.e. pens, pencils, eraser, protractor, compass, calculator (with new batteries). Make sure you bring your ID document and examination admission letter.

2. Arrive on time, at least one hour before the start of the exam.

3. Go to the toilet before entering the exam room. You don’t want to waste valuable time going to the toilet during the exam.

4. Use the 10 minutes reading time to read the instructions carefully. This helps to ‘open’ the information in your brain. Start with the question you think is the easiest to get the flow going.

5. Break the questions down to make sure you understand what is being asked. If you don’t answer the question properly you won’t get any marks for it. Look for the key words in the question to know how to answer it. A list of these words is on page ix of this study guide.

6. Try all of the questions. Each question has some easy marks in it so make sure that you do all the questions in the exam.

7. Never panic, even if the question seems difficult at first. It will be linked with something you have covered. Find the connection.

8. Manage your time properly. Don’t waste time on questions you are unsure of. Move on and come back if time allows. You have 150 minutes (2½ hours) to answer each of the 150-mark Life Sciences question papers. Spend the following amounts of time on each question:
   - Question 1: 50 marks = 45 minutes
   - Question 2: 30 marks = 25 minutes
   - Question 3: 30 marks = 25 minutes
   - Question 4: 40 marks = 35 minutes
   The remaining 20 minutes can be used to check your answers and attempt to answer any question that you might have left out.

9. Check weighting – how many marks have been allocated for your answer? Take note of the ticks in this study guide as examples of marks allocated. Do not give more or less information than is required.

10. Write big and bold and clearly. You will get more marks if the marker can read your answer clearly.

   If you can dream it, you can do it.
   Walt Disney
Learner’s checklist

Use this checklist to monitor your progress when preparing for the examination. The ticks (✓) tell you which aspects of the curriculum are covered in this study guide. The stars (*) tell you to go to textbooks and class notes.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Aspect</th>
<th>Covered in study guide</th>
<th>I do not understand</th>
<th>I understand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleic acids</td>
<td>Nucleic acids terminology</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Structure of DNA and RNA</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Differences between DNA and RNA</td>
<td>✓</td>
<td></td>
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<tr>
<td></td>
<td>DNA replication</td>
<td>✓</td>
<td></td>
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<td></td>
<td>Protein synthesis</td>
<td>✓</td>
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<tr>
<td></td>
<td>Mutation</td>
<td>*</td>
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<td></td>
<td>DNA profiling</td>
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<tr>
<td>Meiosis</td>
<td>The process of meiosis using diagrams</td>
<td>✓</td>
<td></td>
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<tr>
<td></td>
<td>Significance of meiosis</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Differences between meiosis I and meiosis II</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>Genetics</td>
<td>Genetic terminology</td>
<td>✓</td>
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<tr>
<td></td>
<td>Complete dominance problems</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Incomplete dominance problems</td>
<td>✓</td>
<td></td>
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<tr>
<td></td>
<td>Co-dominance problems</td>
<td>✓</td>
<td></td>
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<tr>
<td></td>
<td>Inheritance of sex</td>
<td>✓</td>
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<td></td>
<td>Sex-linked characteristics</td>
<td>✓</td>
<td></td>
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<tr>
<td></td>
<td>Pedigree diagrams</td>
<td>✓</td>
<td></td>
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<tr>
<td></td>
<td>Genetic engineering</td>
<td>✓</td>
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<td></td>
<td>Genetic counselling</td>
<td>✓</td>
<td></td>
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<td></td>
<td>Genetic mutations</td>
<td>*</td>
<td></td>
<td></td>
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<td></td>
<td>Genetic engineering</td>
<td>*</td>
<td></td>
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<tr>
<td></td>
<td>Genetic disorders</td>
<td>*</td>
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</tr>
<tr>
<td>Evolution</td>
<td>Lamarck and Darwin’s theories</td>
<td>✓</td>
<td></td>
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<tr>
<td></td>
<td>Natural and artificial selection</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Speciation</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Human evolution: Similarities with other primates</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Human evolution: Differences with other primates</td>
<td>✓</td>
<td></td>
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<tr>
<td></td>
<td>Phylogenetic trees</td>
<td>✓</td>
<td></td>
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<tr>
<td></td>
<td>Out of Africa hypothesis</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Evolution in present times</td>
<td>*</td>
<td></td>
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<tr>
<td>Plant responses</td>
<td>Phototropism and geotropism</td>
<td>✓</td>
<td></td>
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<tr>
<td></td>
<td>Plant defence mechanisms</td>
<td>*</td>
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<td></td>
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<tr>
<td>Nervous system</td>
<td>The brain</td>
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<tr>
<td>Neurons, reflex actions and reflex arcs</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autonomic nervous system</td>
<td>*</td>
<td></td>
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<tr>
<td>Peripheral nervous system</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure and functions of parts of the eye</td>
<td>✔</td>
<td></td>
<td></td>
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<tr>
<td>Accommodation</td>
<td>✔</td>
<td></td>
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<tr>
<td>Pupillary mechanism</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure and functions of parts of the ear</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hearing</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disorders of CNS, eye and ear</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Endocrine system | Glands and the hormones they secrete | ✔ |
|                 | Negative feedback – glucose | ✔ |
|                 | Negative feedback – thyroxin | ✔ |
|                 | Endocrine disorders | * |

| Temperature regulation | The role of the skin on hot and cold days | ✔ |

| Reproduction | Reproductive strategies | ✔ |
|              | Sexual and asexual reproduction | * |
|              | Life cycle of plants and insects | * |
|              | Flowers as reproductive structures | ✔ |
|              | Male reproductive organs | ✔ |
|              | Female reproductive organs | ✔ |
|              | Gametogenesis | * |
|              | Menstrual cycle (ovulation and menstruation) | ✔ |
|              | Fertilisation and implantation | ✔ |
|              | Contraception | ✔ |
|              | Sexually transmitted diseases | * |

| Population and community ecology | Population size | ✔ |
|                                  | Population growth forms | ✔ |
|                                  | Age and gender pyramids | ✔ |
|                                  | Methods to determine population size: Mark–recapture method | ✔ |
|                                  | Methods to determine population size: Simple sampling method | ✔ |
|                                  | Interactions in a community: Predation, competition and symbiosis | ✔ |
|                                  | Ecological succession | ✔ |
|                                  | Social organisation | * |
|                                  | Human influence on community structure | * |

| Skills | Draw a line graph | ✔ |
|        | Draw a bar graph | ✔ |
|        | Draw a histogram | ✔ |
|        | Draw a pie chart | ✔ |
|        | Answering essay questions | ✔ |
Nucleic Acids

1.1 The structure of DNA and RNA

- Two kinds of nucleic acids are found in a cell, namely DNA and RNA.
- These two nucleic acids are made of building blocks (or monomers) called nucleotides.
- Figure 1.1 (right) shows what a nucleotide looks like.

Table 1.1 (below) shows the nitrogenous bases of DNA and RNA.

<table>
<thead>
<tr>
<th>DNA has four different nitrogenous bases – adenine, thymine, guanine and cytosine.</th>
<th>RNA has four different nitrogenous bases – adenine, uracil, guanine and cytosine.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{A} )</td>
<td>Adenine</td>
</tr>
<tr>
<td>( \text{T} )</td>
<td>Thymine</td>
</tr>
<tr>
<td>Adenine always joins with thymine.</td>
<td>( \text{A} ) Adenine</td>
</tr>
<tr>
<td>( \text{U} )</td>
<td>Uracil</td>
</tr>
<tr>
<td>RNA contains uracil instead of thymine.</td>
<td>( \text{G} ) Guanine</td>
</tr>
<tr>
<td>( \text{G} )</td>
<td>Guanine</td>
</tr>
<tr>
<td>Cytosine</td>
<td></td>
</tr>
<tr>
<td>Guanine always joins with cytosine.</td>
<td>( \text{C} ) Cytosine</td>
</tr>
</tbody>
</table>

Table 1.1 Nitrogenous bases of DNA and RNA

\[
\begin{array}{c|c|c}
\text{P} & \text{S} & \text{N} \\
\text{Phosphate group} & \text{Deoxyribose or ribose sugar} & \text{Nitrogenous base (adenine, thymine, guanine, cytosine or uracil)} \\
\end{array}
\]

Figure 1.1 A nucleotide

Compare & Contrast

Nucleic acids

DNA

RNA

ALIKE

Nitrogenous bases present: Adenine, cytosine, guanine

DIFFERENT

Nitrogenous base present: Thymine

Contains sugar: Deoxyribose

Double-stranded molecule

Nitrogenous base present: Uracil

Contains sugar: Ribose

Single-stranded molecule

Mind the Gap

Life Sciences

Chapter 1 Nucleic acids (Paper 1) Molecular studies
Figure 1.2 below shows the structure of DNA and RNA. Study the diagrams in Figure 1.2, and then read the information in the boxes below the diagrams to find out how to tell a DNA molecule from an RNA molecule.

**DNA (deoxyribonucleic acid)**
- Phosphate group
- Deoxyribose
- Nitrogenous base
- Weak hydrogen bonds

**RNA (ribonucleic acid)**
- Phosphate group
- Nitrogenous base
- Ribose

### How to recognise a DNA molecule
- Double-stranded molecule
- Contains the nitrogenous base thymine (T) instead of uracil (U)
- A always joins to T
- G always joins to C

### How to recognise an RNA molecule
- Single-stranded molecule
- Contains the nitrogenous base uracil (U) instead of thymine (T)

#### 1.2 Differences between DNA and RNA

Table 1.2 below summarises the differences between a DNA and an RNA molecule.

<table>
<thead>
<tr>
<th>DNA</th>
<th>RNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Double-stranded molecule</td>
<td>1. Single-stranded molecule</td>
</tr>
<tr>
<td>2. Contains deoxyribose (sugar)</td>
<td>2. Contains ribose (sugar)</td>
</tr>
<tr>
<td>3. Contains the nitrogenous base, thymine</td>
<td>3. Contains the nitrogenous base, uracil</td>
</tr>
</tbody>
</table>

*Table 1.2 The differences between DNA and RNA*
1.3 DNA replication

**DNA replication** is the process during which a DNA molecule makes an exact copy (replica) of itself. This is shown in Figure 1.3 below.

1. The double helix unwinds.
2. Weak hydrogen bonds between nitrogenous bases break and two DNA strands unzip (separate).
3. Each original DNA strand serves as a **template** on which its complement is built.
4. Free nucleotides build a DNA strand onto each of the original two DNA strands by attaching to their **complementary** nitrogenous bases (A to T and C to G).
5. This results in two identical DNA molecules. Each molecule consists of one original strand and one new strand.

![Figure 1.3 DNA replication](image)

**Figure 1.3 DNA replication**

1.4 The significance of DNA replication

**DNA replication** is important because it:
- Doubles the genetic material so it can be shared between the resulting daughter cells during cell division.
- Results in the formation of identical daughter cells during mitosis.
1. Figure 1.4 (left) represents part of a nucleic acid molecule. Study the diagram and answer the questions that follow.

1.1 Identify the nucleic acid shown in Figure 1.4. (1)

1.2 Label the following:
   a) Part 1 (1)
   b) Part 2 (1)
   c) The nitrogenous bases 4, 5 and 6 (3)

1.3 What is the collective name for the parts numbered 1, 2 and 3? (1)

2. Questions 2.1 and 2.2 are based on Figure 1.5 (left). This is a diagrammatic representation of a part of two different nucleic acid molecules found in the cells of organisms during a stage in the process of protein synthesis.

2.1 Name the molecules 1 and 2. (2)

2.2 Give a reason for your answer in question 2.1. (2)

[11]

Answers to activity 1

1.1 DNA✓ (1)

1.2 a) Phosphate✓ group (1)
   b) Deoxyribose✓ (1)
   c) 4 – adenine (A)✓
   5 – guanine (G)✓
   6 – thymine✓ (3)

1.3 Nucleotide✓ (1)

2.1 1 – DNA
    2 – mRNA/RNA✓ (2)

2.2 DNA contains the nitrogenous base thymine (T).✓
    RNA contains the nitrogenous base uracil (U).✓ (2)

[11]
1.5 Protein synthesis

Protein synthesis is the process by which proteins are made in each cell of an organism to form enzymes, hormones and new structures for cells.

There are two main processes involved in protein synthesis, namely transcription and translation. They are labelled as A and B in Figure 1.6 above.

Note that the numbers on the diagram correspond with the description below.

**A Transcription (takes place in the nucleus)**

1. DNA unwinds and splits.
2. One DNA strand acts as a template for forming mRNA.
3. Free nucleotides arrange to form mRNA according to the DNA template. This process is called transcription.
4. The mRNA leaves the nucleus. Stage B now takes place when mRNA in the cytoplasm attaches to the ribosome.

**Figure 1.6 The process of protein synthesis**

There are two main processes involved in protein synthesis, namely transcription and translation. They are labelled as A and B in Figure 1.6 above.

Note that the numbers on the diagram correspond with the description below.

**A Transcription (takes place in the nucleus)**

1. DNA unwinds and splits.
2. One DNA strand acts as a template for forming mRNA.
3. Free nucleotides arrange to form mRNA according to the DNA template. This process is called transcription.
4. The mRNA leaves the nucleus. Stage B now takes place when mRNA in the cytoplasm attaches to the ribosome.
**B Translation (takes place in the cytoplasm on the ribosome)**

- **5** Each tRNA brings a specific amino acid to the mRNA. This is called **translation**.
- **6** The amino acids are linked together to form a particular protein.

**Activity 2**

**Question 1**

Study Figure 1.7 (below), which shows the process of protein synthesis, and answer the questions.

---

For two more problems on protein synthesis, refer to these National Life Sciences exam papers:
- Life Sciences Paper 1 November 2010 – Question 1.5 on page 7.

*Figure 1.7 Protein synthesis*
1.1 Label structures A, B and D. (3)

1.2 State ONE function of molecule D. (1)

1.3 Which stage of protein synthesis takes place at F? (1)

1.4 Identify organelle C. (1)

1.5 Name and describe the stage of protein synthesis that takes place at organelle C. (7)

1.6 Write down the codon of anticodon E from top to bottom. (1)

**Answers to question 1**

1.1 A – Nuclear membrane✓
B – mRNA✓
D – DNA✓ (3)

1.2 Carrying hereditary characteristics from parents to their offspring ✓
OR Controls the synthesis (manufacturing) of proteins✓ (1)

1.3 Transcription✓ (1)

1.4 Ribosome✓ (1)

1.5 Translation✓
• The mRNA strand from the nucleus becomes attached✓ to a ribosome with its codons exposed
• each tRNA molecule carrying a specific amino acid✓ according to its anticodon✓
• matches up with/complements the codon of the mRNA✓
• so that the amino acids are placed in the correct sequence✓
• adjacent amino acids are linked✓
• to form a protein✓ (7)

1.6 CAC✓ (the anticodon is GUG, so the complementary codon is CAC) (1)

**Question 2**

Table 1.3 below shows the DNA base triplets that code for different amino acids.

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Base triplet in DNA template</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leu (leucine)</td>
<td>GAA</td>
</tr>
<tr>
<td>His (histidine)</td>
<td>GTA</td>
</tr>
<tr>
<td>Lys (lysine)</td>
<td>TTT</td>
</tr>
<tr>
<td>Pro (proline)</td>
<td>GGG</td>
</tr>
<tr>
<td>Ala (alanine)</td>
<td>CGA</td>
</tr>
<tr>
<td>Trp (tryptophan)</td>
<td>ACC</td>
</tr>
<tr>
<td>Phe (phenylalanine)</td>
<td>AAA</td>
</tr>
<tr>
<td>Gly (glycine)</td>
<td>CCT</td>
</tr>
</tbody>
</table>

**Table 1.3 Different amino acids and their base triplets**

The following is a part of a sequence of amino acids that forms a particular protein molecule:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ala</td>
<td>His</td>
<td>Trp</td>
<td>Leu</td>
<td>Lys</td>
</tr>
</tbody>
</table>
2.1 Name the process by which mRNA is formed from a DNA template. (1)
2.2 How many mRNA codons would be involved in forming the portion of protein shown above? (1)
2.3 Write down the sequence of the first three mRNA codons (from left to right) for this portion of the protein. (3)

Answers to question 2

2.1 Transcription ✓ (1)
2.2 5 ✓ (1)
2.3 GCU - CAU - UGG ✓ (3) [5]

Question 3

Read the song below about protein synthesis and then answer the questions that follow.

The DNA codes protein
The nucleus dissolves when it’s time to replicate
Nitrogenous bases line up side by side
Sugar phosphate backbone goes along for the ride
String them all together to form a nucleotide

A pairs with T and G with C
It works! The codon is complementary
It lets you be you, and me be me.

Transcription takes the bases that are found in one gene
Converts them to mRNA, if you know what I mean
The bases pair up just like before
But U substitutes with T, which isn’t needed anymore
mRNA leaves the nucleus but the job is not done
Ribosome’s turn to join in all the fun
Three bases make a codon — count them 1, 2, 3
An amino acid for each codon in the growing protein.

3.1 Name the four nitrogenous bases of DNA. (4)
3.2 State what substitutes for T in mRNA. (1)
3.3 How many nitrogenous bases are in a codon? (1)
3.4 Name the process that forms mRNA. (1)
3.5 Name the building blocks of proteins. (1)

Answers to question 3

3.1 Adenine ✓; thymine ✓; guanine ✓; cytosine ✓ (4)
3.2 Uracil ✓ (1)
3.3 3 ✓ (1)
3.4 Transcription ✓ (1)
3.5 Amino acids ✓ (1) [8]
2.1 What is meiosis?

**Meiosis** is a type of cell division whereby a diploid cell (somatic cell) divides to form four dissimilar haploid cells (sex cells). Diploid cells have two sets of chromosomes, where each chromosome has a homologous partner. Haploid cells only have one set of chromosomes. Chromosomes in haploid cells have no homologous partners.

Before meiosis begins (during interphase), DNA replication takes place. The result is two sets of chromosomes consisting of two identical chromatids joined together with a centromere. This is shown in Figure 2.1 (right).

2.2 The process of meiosis in animal cells

**Meiosis** is the type of cell division used to produce **gametes or sex cells** (sperm and eggs). A cell undergoing meiosis will divide **twice** – the first division is **meiosis 1** and the second is **meiosis 2**.

In the first meiotic division, the number of cells is doubled, but the number of chromosomes is not. This results in half as many chromosomes per cell.

In the second meiotic division, the number of chromosomes does not get reduced.

The diagram alongside shows how meiosis starts with a diploid cell and divides twice (meiosis 1 and 2), resulting in four haploid cells.

Now turn the page to find out what happens during each stage of meiosis I and II.
### 2.2.1 First meiotic division

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Prophase 1** | • Chromosomes shorten and become visible as two chromatids joined by a centromere.  
• Homologous pairs of chromosomes are now visible.  
• The nuclear membrane and nucleolus disappear.  
• The spindle starts to form.  
• Chromatids from each homologous pair touch.  
The point where they touch is called a chiasma.  
• DNA is crossed over (swopped) at the chiasma.  
• The spindle continues to form. |
| **Metaphase 1** | • The spindle extends across the whole cell.  
• The homologous chromosomes line up along the equator of the spindle in their homologous pairs.  
• One chromosome of each pair lies on either side of the equator.  
• The centromere of each chromosome attaches to the spindle fibres. |
| **Anaphase 1** | • The spindle fibres shorten and pull each chromosome of each chromosome pair to opposite poles of the cell. |
| **Telophase 1** | • The chromosomes reach the poles of the cell.  
• Each pole has half the number of chromosomes present in the original cell.  
• The cell membrane constricts and divides the cytoplasm in half to form two cells. |
# 2.2.2 Second meiotic division

| Prophase 2 | **Prophase 2**  
| --- | ---  
| • Each cell formed during meiosis I now divides again.  
| • A spindle forms in each of the new cells.  
| Figure 2.6 Prophase 2 |

| Metaphase 2 | **Metaphase 2**  
| --- | ---  
| • Individual chromosomes line up at the equator of each cell, with the centromeres attached to the spindle fibres.  
| Figure 2.7 Metaphase 2 |

| Anaphase 2 | **Anaphase 2**  
| --- | ---  
| • The spindle fibres start to contract.  
| • The centromeres split and daughter chromosomes/chromatids are pulled to the opposite poles of each cell.  
| Figure 2.8 Anaphase 2 |

| Telophase 2 | **Telophase 2**  
| --- | ---  
| • The daughter chromosomes/chromatids reach the poles and a new nucleus forms.  
| • The cell membrane of each cell constricts and the cytoplasm divides into two cells.  
| • Four haploid daughter cells are formed.  
| • Each daughter cell has half the number of chromosomes of the original cell.  
| • The daughter cells are genetically different from each other.  
| Figure 2.9 Telophase 2 |
An easy way to remember the events of meiosis is to use the word mnemonic **IPMAT**.

<table>
<thead>
<tr>
<th>Letter</th>
<th>Phase</th>
<th>Meaning</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Interphase</td>
<td>I for in between</td>
<td>The part of the life cycle of the cell that is in between cell divisions.</td>
</tr>
<tr>
<td>P</td>
<td>Prophase</td>
<td>P for preparation</td>
<td>The chromosomes prepare for meiosis by untangling and becoming clearly visible. Crossing over also takes place.</td>
</tr>
<tr>
<td>M</td>
<td>Metaphase</td>
<td>M for middle</td>
<td>The chromosomes move to the ‘middle’ (equator).</td>
</tr>
<tr>
<td>A</td>
<td>Anaphase</td>
<td>A for apart</td>
<td>The chromosomes/chromatids move apart/move to the poles.</td>
</tr>
<tr>
<td>T</td>
<td>Telophase</td>
<td>T for terminal</td>
<td>The final phase of meiosis I/meiosis II.</td>
</tr>
</tbody>
</table>

2.3 The significance of meiosis

There are two reasons why meiosis is important:

1. It reduces the number of chromosomes by half, in other words from diploid to haploid. This ensures that sex cells have half the number of chromosomes of somatic cells (body cells). So, when fertilisation takes place, the zygote that is formed will have the correct number of chromosomes. It therefore balances the doubling effect of fertilisation.

2. Crossing over introduces genetic variation. Genetic variation results in offspring who are better adapted to a particular environment, which gives them a better chance of survival.
2.4 Differences between meiosis I and meiosis II

<table>
<thead>
<tr>
<th>Meiosis I</th>
<th>Meiosis II</th>
</tr>
</thead>
<tbody>
<tr>
<td>The chromosomes arrange at the equator of the cell in homologous pairs.</td>
<td>Chromosomes line up at the equator of the cell individually.</td>
</tr>
<tr>
<td>Whole chromosomes move to opposite poles of the cell.</td>
<td>Daughter chromosomes/chromatids move to opposite poles of the cell.</td>
</tr>
<tr>
<td>Two cells form at the end of this division.</td>
<td>Four cells are formed at the end of this division.</td>
</tr>
<tr>
<td>The chromosome number is halved during meiosis I.</td>
<td>The chromosome number remains the same during meiosis II.</td>
</tr>
<tr>
<td>Crossing over takes place.</td>
<td>Crossing over does not take place.</td>
</tr>
</tbody>
</table>

Table 2.1 The differences between meiosis I and meiosis II

**Worked example**

Figure 2.10 below shows two stages of meiosis. Study the diagrams and then answer the questions that follow.

Figure 2.10 Two stages of meiosis

1. State ONE visible reason in Diagram I which indicates that meiosis is taking place. 
   \(1\)
2. How many chromosomes would be present in each daughter cell at the end of meiosis in this cell? 
   \(1\)
3. Describe what takes place in the cell after the phase shown in Diagram I. 
   \(3\)
4. Tabulate TWO visible differences between the phases of meiosis shown in Diagrams I and II. 
   \(10\)
Answers to worked example

1. The chromosomes are lined up at the equator of the cell in their homologous pairs. ✓
   OR
   The chromosomes show evidence of crossing over. ✓

2. Two ✓ chromosomes.

3. The next phase is Anaphase 1. The spindle fibres contract ✓ (shorten) and pull each chromosome ✓ of each chromosome pair to opposite poles ✓ of the cell.

4. ✓

<table>
<thead>
<tr>
<th>Diagram I (metaphase 1)</th>
<th>Diagram II (metaphase 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chromosomes are lined up at the equator in homologous pairs ✓</td>
<td>1. Chromosomes are lined up at the equator individually ✓</td>
</tr>
<tr>
<td>2. Four chromosomes are present ✓</td>
<td>2. Two chromosomes are present ✓</td>
</tr>
</tbody>
</table>

Activity 1

Question 1

Give the correct word or term for each of the statements or definitions provided below.

<table>
<thead>
<tr>
<th></th>
<th>The structure that joins the two halves of a double-stranded chromosome</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>A pair of chromosomes, one inherited from each parent, that have the same genes at the same locus</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>A single-stranded chromosome formed during Anaphase 2</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>The point of contact between two chromosomes of a homologous pair during crossing over</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>One half of a double-stranded chromosome</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td>(1)</td>
</tr>
</tbody>
</table>

Answers to question 1

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Centromere ✓</td>
</tr>
<tr>
<td>1.2</td>
<td>Homologous chromosomes ✓</td>
</tr>
<tr>
<td>1.3</td>
<td>Daughter chromosome/chromatid ✓</td>
</tr>
<tr>
<td>1.4</td>
<td>Chiasma ✓/chiasmata ✓</td>
</tr>
<tr>
<td>1.5</td>
<td>Chromatid ✓</td>
</tr>
</tbody>
</table>
Question 2
Figure 2.11 (right) represents a process taking place during meiosis. Study the diagram and answer the questions that follow.

2.1 Provide labels for parts A, B, C and D. (4)
2.2 Name the process in meiosis that is illustrated in Figure 2.11. (1)
2.3 State ONE importance of the process you named in question 2.2. (2)
2.4 Draw a diagram of the structure labelled A to show its appearance immediately after the process you named in question 2.2. (2)

Answers to question 2
2.1 A – Chromosome✓
   B – Centromere✓
   C – Chromatid✓
   D – Chiasma✓/chiasmata (4)
2.2 Crossing over✓ (1)
2.3 It introduces genetic✓/variation✓ (2)
2.4 • A double-stranded chromosome with the strands joined by a centromere✓
   • There is evidence of crossing over✓ (2)

Question 3
Figure 2.12 (right) represents an animal cell in a phase of meiosis. Study the diagram and answer the questions that follow.

3.1 State whether the phase of meiosis shown in Figure 2.12 is meiosis I or meiosis II. (1)
3.2 Give ONE visible reason for your answer in question 3.1. (1)
3.3 Identify the parts labelled A and B. (2)
3.4 How many chromosomes:
   a) were present in the parent cell before meiosis began? (1)
   b) will be present in each cell at the end of meiosis? (1)
3.5 State ONE place in a human female where meiosis would take place. (1)
3.6 Could the cell represented in Figure 2.12 be that of a human? (1)
3.7 Explain your answer to question 3.6. (2)
3.8 Give TWO reasons why meiosis is biologically important. (2)
3.9 Give the term for the situation when some of the chromosomes do not separate correctly during the phase shown in Figure 2.12. (1)

[13]
Answers to question 3

3.1 Meiosis II ✓

3.2 Daughter chromosomes/chromatids are being pulled to the poles ✓

3.3 A – Spindle fibre ✓
    B – Cell membrane ✓

3.4 a) 8 ✓
    b) 4 ✓

3.5 Ovaries ✓

3.6 No ✓

3.7 There are only 4 chromosomes present ✓ instead of 23. ✓

3.8 It introduces genetic variation. ✓
    It balances the doubling effect of fertilisation as it halves the number of chromosomes in the sex cells. ✓

3.9 Non-disjunction ✓

For four further problems on meiosis refer to the following National Life Sciences exam papers:

- Life Sciences Paper 1 November 2010 – Question 2.1 on page 10.
- Life Sciences Paper 1 November 2009 – Question 1.5 on page 7.
### 3.1 Key concepts

Make mobile notes (see instructions on page x) to learn these key concepts.

<table>
<thead>
<tr>
<th>Term</th>
<th>Explanation</th>
<th>Diagram/Additional notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gene</td>
<td>A small portion of DNA coding for a particular characteristic.</td>
<td><img src="image" alt="Gene Diagram" /></td>
</tr>
<tr>
<td>Alleles</td>
<td>Different forms of a gene which occur at the same locus (position) on homologous chromosomes.</td>
<td><img src="image" alt="Alleles Diagram" /></td>
</tr>
<tr>
<td>Genotype</td>
<td>Genetic composition (make-up) of an organism.</td>
<td></td>
</tr>
<tr>
<td>Phenotype</td>
<td>The physical appearance of an organism determined by the genotype, e.g. tall, short.</td>
<td><img src="image" alt="Phenotype Diagram" /></td>
</tr>
<tr>
<td>Dominant allele</td>
<td>An allele that is expressed (shown) in the phenotype when found in the heterozygous (Tt) and homozygous (TT) condition.</td>
<td><img src="image" alt="Dominant allele Diagram" /></td>
</tr>
<tr>
<td>Recessive allele</td>
<td>An allele that is masked (not shown) in the phenotype when found in the heterozygous (Tt) condition. It is only expressed in the homozygous (tt) condition.</td>
<td><img src="image" alt="Recessive allele Diagram" /></td>
</tr>
<tr>
<td>Heterozygous</td>
<td>Two different alleles for a particular characteristic, e.g. Tt.</td>
<td><img src="image" alt="Heterozygous Diagram" /></td>
</tr>
<tr>
<td>Homozygous</td>
<td>Two identical alleles for a particular characteristic, e.g. TT or tt.</td>
<td><img src="image" alt="Homozygous Diagram" /></td>
</tr>
<tr>
<td>Term</td>
<td>Explanation</td>
<td>Diagram/Additional notes</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Monohybrid cross</td>
<td>Only one characteristic or trait is being shown in the genetic cross.</td>
<td>Example: Flower colour only, e.g. yellow flower or white flower OR shape of seeds only, e.g. round seeds or wrinkled seeds.</td>
</tr>
<tr>
<td>Complete dominance</td>
<td>A genetic cross where the dominant allele masks (blocks) the expression of a recessive allele in the heterozygous condition.</td>
<td>In this type of cross the allele for tall (T) is dominant over the allele for short (t). The offspring will therefore be tall because the dominant allele (T) masks the expression of the recessive allele (t). Tall (TT) × short (tt) Tall (Tt).</td>
</tr>
<tr>
<td>Incomplete dominance</td>
<td>A genetic cross between two phenotypically different parents produces offspring different from both parents but with an intermediate phenotype.</td>
<td>Example: If a red-flowered plant is crossed with a white-flowered plant there is incomplete dominance – the offspring will have pink flowers (intermediate colour). Red flower – White flower Pink flowers.</td>
</tr>
<tr>
<td>Co-dominance</td>
<td>A genetic cross in which both alleles are expressed equally in the phenotype.</td>
<td>Example: If a red-flowered plant is crossed with a white-flowered plant there is co-dominance when the offspring has flowers with red and white patches. Red flower × White flower Flowers with red and white patches.</td>
</tr>
<tr>
<td>Multiple alleles</td>
<td>More than two alternative forms of a gene at the same locus.</td>
<td>Example: Blood groups are controlled by three alleles, namely I^A, I^B and i.</td>
</tr>
<tr>
<td>Polygenic inheritance</td>
<td>A characteristic that is controlled by two or more genes which may be found on the same or different chromosomes.</td>
<td>Many genes cause intermediate (a range of) expressions of a characteristic, e.g. skin colour or height.</td>
</tr>
<tr>
<td>Sex-linked characteristics</td>
<td>Characteristics or traits that are carried on the sex chromosomes.</td>
<td>Examples: Haemophilia and colour-blindness The alleles for haemophilia (or colour-blindness) are indicated as superscripts on the sex chromosomes, e.g. X^H^H (normal female), X^H^O (normal female), X^O^O (female with haemophilia), X^Y (normal male), X^Y (male with haemophilia).</td>
</tr>
<tr>
<td>Karyotype</td>
<td>The number, shape and arrangement of all the chromosomes in the nucleus of a somatic cell.</td>
<td></td>
</tr>
<tr>
<td>Cloning</td>
<td>Process by which genetically identical organisms are formed using biotechnology.</td>
<td>Example: Dolly the sheep was cloned using a diploid cell from one parent; therefore it had the identical genetic material of that parent.</td>
</tr>
<tr>
<td>Genetic modification</td>
<td>The manipulation of the genetic material of an organism to get desired changes.</td>
<td>Example: The insertion of human insulin gene in plasmid of bacteria so that the bacteria produce human insulin.</td>
</tr>
<tr>
<td>Human genome</td>
<td>The mapping of the exact position of all the genes in all the chromosomes of a human.</td>
<td>Example: Gene number 3 on chromosome number 4 is responsible for a particular characteristic.</td>
</tr>
</tbody>
</table>
Activity 1

Choose an item from COLUMN 2 that matches a description in COLUMN 1. Write only the letter (A to I) next to the question number (1–5), for example 6 J.

<table>
<thead>
<tr>
<th>COLUMN 1</th>
<th>COLUMN 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The allele that is not expressed in the phenotype when found in the</td>
<td>A. Gene</td>
</tr>
<tr>
<td>heterozygous condition</td>
<td></td>
</tr>
<tr>
<td>2. Different forms of a gene which occur at the same locus on homologous</td>
<td>B. Recessive</td>
</tr>
<tr>
<td>chromosomes</td>
<td></td>
</tr>
<tr>
<td>3. A sex-linked condition where blood fails to clot properly</td>
<td>C. Haemophilia</td>
</tr>
<tr>
<td>4. The pair of chromosomes in a diploid organism that have the same</td>
<td>D. Dominant</td>
</tr>
<tr>
<td>size and shape and control the same set of characteristics</td>
<td>E. Homologous</td>
</tr>
<tr>
<td>5. The physical and functional expression of a gene</td>
<td>F. Genotype</td>
</tr>
<tr>
<td></td>
<td>G. Phenotype</td>
</tr>
<tr>
<td></td>
<td>H. Alleles</td>
</tr>
<tr>
<td></td>
<td>I. Karyotype</td>
</tr>
</tbody>
</table>

Answers to activity 1


(5 × 1) [5]

3.2 Genetic crosses

Use the following genetic problem format or template to solve all monohybrid genetic problems:

1. The problem on the next page shows that a cross between a heterozygous parent (Tt) and a homozygous recessive (tt) parent produces F1 offspring that are 50% heterozygous (Tt) and 50% homozygous recessive (tt).
2. A cross between a homozygous dominant (TT) parent and a homozygous recessive (tt) parent produces F1 offspring that are 100% heterozygous (Tt).
3. A cross between a homozygous dominant (TT) and a heterozygous (Tt) parent produces F1 offspring that are 50% homozygous dominant (TT) and 50% heterozygous (Tt).
4. A cross between two heterozygous (Tt) parents produces F1 offspring that are 25% homozygous dominant (TT), 50% heterozygous (Tt) and 25% homozygous recessive (tt).
3.2.1 Complete dominance

This refers to a genetic cross where the dominant allele masks (blocks) the expression of a recessive allele in the heterozygous condition.

The following problem represents a genetic cross which shows complete dominance:

Genetic problem 1

In humans the ability to roll the tongue is due to a dominant allele. A man who is heterozygous for tongue-rolling and a woman who cannot roll her tongue have children. Use the symbols T and t for the alleles of the tongue-rolling character and represent a genetic cross to determine the possible genotypes and phenotypes of the children. (6)

Read the problem carefully and note the following steps:

- Identify the phenotypes of the man and the woman (parents/ P₁), i.e. the man is a tongue-roller and the woman is a non-tongue-roller.........................................................Step 1
- Identify the genotypes of the two parents, i.e. the man is heterozygous (Tt) and the woman can only be a non-tongue-roller if she is homozygous recessive for this characteristic, i.e. she must have the genotype (tt)..................................................................Step 2
- The next step is to show how the alleles are separated through the process of meiosis into separate gametes, i.e. in the man the gametes (sperm) will contain either the ‘T’ allele or the ‘t’ allele. In the woman the egg can only contain the ‘t’ allele..................Step 3
- The next step shows that fertilisation takes place. Indicate all possible combinations of how sperm cells fuse with a possible egg cell to show the possible genotypes of the F₁ generation that could arise.................................................................Step 4
- Interpret the phenotypes of all the possible genotypes from the cross ........................................................................................................Step 5

Solution to genetic problem 1

P₁ Phenotype Tongue-roller × Non-tongue-roller✓ .........Step 1
Genotype Tt × tt✓ ..........................Step 2

Meiosis
Gametes T and t x t✓ ..........................Step 3
Fertilisation
F₁ Genotype Tt tt✓ ..........................Step 4

Phenotype Tongue-roller Non-tongue-roller✓ ....... Step 5
(Max 6 marks)
3.2.2 Incomplete dominance

This refers to a genetic cross between two phenotypically different parents producing an offspring different from both parents but with an intermediate phenotype. The following problem represents a genetic cross that shows incomplete dominance.

Genetic problem 2

A homozygous snapdragon plant with red flowers (R) was cross-pollinated with a homozygous snapdragon plant with white (W) flowers. All the plants that grew from the cross had pink flowers. Represent a genetic cross to show the possible genotypes and phenotypes of the F₁ generation of plants.

Solution to genetic problem 2

\[ \begin{align*}
\text{Step 1} & : \quad \text{Phenotype} \quad \text{Red} \times \text{White} \\
\text{Step 2} & : \quad \text{Genotype} \quad \text{RR} \times \text{WW} \\
\text{Step 3} & : \quad \text{Meiosis} \quad \text{R} \times \text{W} \\
\text{Step 4} & : \quad \text{Fertilisation} \quad \text{RW} \\
\text{Step 5} & : \quad \text{Phenotype} \quad \text{Pink} 
\end{align*} \]

3.2.3 Co-dominance

This refers to a genetic cross in which both alleles are equally expressed in the phenotype.

The following problem represents a genetic cross which shows co-dominance.

Genetic problem 3

A plant with white flowers was cross-pollinated with a plant with red flowers. All the plants that grew from the cross had flowers with equal distribution of red and white colour. Represent a genetic cross to show the possible genotypes and phenotypes of the F₁ generation of plants.

Solution to genetic problem 3

\[ \begin{align*}
\text{Step 1} & : \quad \text{Phenotype} \quad \text{Red} \times \text{White} \\
\text{Step 2} & : \quad \text{Genotype} \quad \text{RR} \times \text{WW} \\
\text{Step 3} & : \quad \text{Meiosis} \quad \text{R} \times \text{W} \\
\text{Step 4} & : \quad \text{Fertilisation} \quad \text{RW} \\
\text{Step 5} & : \quad \text{Phenotype} \quad \text{Flower with equal distribution of red and white colour} 
\end{align*} \]
3.2.4 Inheritance of sex

The following problem represents a genetic cross which shows inheritance of sex.

**Genetic problem 4**

A couple has three sons and the woman is pregnant again. Show diagrammatically by means of a genetic cross what the percentage chance is of the couple having a baby girl.

**Solution to genetic problem 4**

\[\begin{array}{c|c|c|c}
P_1 & Phenotype & Male & Female \checkmark \\
\hline
Genotype & XY & \times & XX \checkmark \\
\hline
Meiosis & X and Y\checkmark & \times & X \checkmark \\
\hline
Gametes & \checkmark \\
\hline
Fertilisation & \times & \checkmark \\
\hline
F_1 & Genotype & XX, & XY \checkmark \\
\hline
Phenotype & Female, & Male \checkmark \\
\hline
\end{array}\]

50% probability √

3.2.5 Inheritance of sex-linked characteristics

**Sex-linked characteristics** are characteristics (traits) that are carried on the sex chromosomes.

The following problem represents a genetic cross which shows the inheritance of sex-linked characteristics.

**Genetic problem 5**

Haemophilia is a sex-linked hereditary disease that occurs as a result of a recessive allele on the X-chromosome (X\(^h\)). A normal father and heterozygous normal mother have children. Represent a genetic cross to determine the possible genotypes and phenotypes of their children.

The alleles for haemophilia are indicated as superscripts on the sex chromosomes, e.g. X\(^H^H\) (normal female), X\(^H^h\) (normal female), X\(^h^h\) (female with haemophilia), X\(^h^Y\) (normal male), X\(^H^Y\) (male with haemophilia).
Solution to genetic problem 5

**P₁**  
Phenotype normal father x normal mother ✓ .......................... Step 1

Genotype     X<sup>y</sup>Y   x    X<sup>h</sup>X<sup>h</sup> ✓ ............................ Step 2

**Meiosis**  
✓ ✓  
**Gametes**  X<sup>y</sup> and Y   x   X<sup>h</sup> and X<sup>h</sup> ✓ ............................ Step 3

**Fertilisation**  
............................ Step 4

**F₁**  
Genotype     X<sup>y</sup>X<sup>y</sup>, X<sup>h</sup>X<sup>h</sup>, X<sup>y</sup>Y, X<sup>h</sup>Y ✓  .......... Step 4

Phenotype 2 normal daughters 1 normal son 1 son with haemophilia ..Step 5

Activity 2

**Question**
Try solving this problem on your own before you look at the solution.

Fur colour in mice is controlled by a gene with two alleles. A homozygous mouse with black fur was crossed with a homozygous mouse with brown fur. All offspring had black fur. Using the symbols B and b to represent the two alleles for fur colour, show diagrammatically a genetic cross between a mouse that is heterozygous for fur colour and a mouse with brown fur. Show the possible genotypes and phenotypes of the offspring.  

**Answer to activity 2**

**P₁**  
Phenotype Black x Brown ✓

Genotype     Bb   x   bb ✓

**Meiosis**  
✓ ✓  
**Gametes**  B and b   x   b ✓

**Fertilisation**  
............................

**F₁**  
Genotype     Bb and bb ✓

Phenotype Black and brown ✓

(Max 6)

The cross between a mouse with black fur and a mouse with brown fur resulted in offspring having black fur. This shows that the allele for black fur (B) is dominant over the allele for brown fur (b).

Exams

For two further problems on genetic crosses, refer to the following National Life Sciences exam papers:

- Life Sciences Paper 1 November 2010 – Question 2.2 on page 11.
3.3 Pedigree diagrams

A *pedigree diagram* is used to study the inheritance of characteristics in a family over a number of generations. A pedigree diagram is also called a *family tree*.

Remember the following steps when interpreting pedigree diagrams:

**Step 1**
Study any key and opening statement/s and look for dominant and recessive characteristics and phenotypes.

**Step 2**
Write in the phenotypes of all the individuals as given in the problem.

**Step 3**
Fill in the genotype of all the individuals with the recessive condition – it must have two recessive alleles (two lower case letters, e.g. ff).

**Step 4**
For every individual in the diagram that has the recessive condition, it means that each allele was obtained from each of the parents. Work backwards and fill in one recessive allele for each parent.

**Step 5**
If the parents showed the dominant characteristic, fill in the second letter which represents the dominant allele (a capital letter, e.g. F).

**Step 6**
Any other individual showing the dominant characteristic will most likely be homozygous dominant (FF) or heterozygous dominant (Ff).

---

### Activity 3

The pedigree diagram in Figure 3.1 shows inheritance of eye colour in humans over three generations of a family. Brown eye colour (B) is dominant over blue eye colour (b). Study the diagram and then answer the questions that follow.

**Figure 3.1 Pedigree diagram showing inheritance of eye colour**
Note the following in the pedigree diagram on page 24:

- Squares represent males and circles represent females.
- The horizontal line between a square (Joshua) and a circle (Ronel) shows that they have mated.
- The vertical line flowing from the horizontal line represents the offspring (Sarah and Peter) of the two parents (Joshua and Ronel).
- Brown eye colour (B) is dominant over blue eye colour (b) – stated in problem............................. Step 4

- Joshua, Jack and John are males with blue eyes.
- Veronica and Marlena are females with blue eyes.
- Peter and Frank are males with brown eyes.
- Ronel, Sarah and Gayle are females with brown eyes.
- Joshua, Veronica, Marlena, Jack and John will have the genotype ‘bb’. The recessive characteristic only shows up in the homozygous condition............................................. Step 3

- Example: The genotype of Peter is ‘Bb’ – working backwards from the offspring Marlena or Jack or John who are homozygous recessive. This means that one of the recessive alleles of Marlena, Jack and John, i.e. ‘b’, must have come from parent Peter and the other one from parent Veronica.................................................. Steps 4 and 5

- Ronel could be homozygous dominant (BB) or heterozygous dominant (Bb) ............................................................. Step 6

Questions

1. How many members of the family have blue eyes? (1)
2. Is Veronica homozygous or heterozygous for eye colour? (1)
3. Write down the genotype of:
   a) Joshua (2)
   b) Ronel (2)
   c) Frank (2)
4. If Frank marries a woman with the same genetic composition as Sarah, what is the percentage probability of them having a child with brown eyes? (1)

Answers to activity 3

1. 5✓ (1)
2. Homozygous✓ (1)
3. a) bb✓ (2)
   b) BB/Bb✓ (2)
   c) Bb✓ (2)
4. 75 (%)✓ (1)
3.4 Genetic engineering

Genetic engineering is the process whereby the genes on the DNA are changed, transferred or manipulated to produce a different organism.

Activity 4

Question

State FOUR disadvantages and FOUR advantages of genetic engineering.

[8]

Answer to activity 4

Four disadvantages of genetic engineering:
• Expensive√/research money could be used for other needs
• Interfering with nature√/immoral
• Potential health impacts√
• Unsure of long-term effects√

Four advantages of genetic engineering:
• Production of medication/resources cheaply√
• Control pests with specific genes inserted into a crop√
• Using specific genes to increase crop yields√/food security
• Selecting genes to increase shelf-life of plant products√

3.5 Genetic counselling

Couples with a risk of a genetic disease can undergo genetic counselling to enable them to make informed decisions on whether they want to have children or not.

Activity 5

Question

A young couple wants to have a child, but they are aware of a serious genetic disorder in one of their families that could be carried through to their offspring. State THREE benefits of genetic counselling in this case.

[3]

Answer to activity 5

Three benefits of genetic counselling:
• To be given advice on the risk of transferring the defective gene√/to find the probability of passing on the defective gene to the offspring
• To be given an explanation of the procedure involved in DNA testing√
• To be given an explanation of the results of DNA testing√
4.1 Theories of Lamarck and Darwin

Jean-Baptiste Lamarck explained evolution using the following two ‘laws’:

1. **The inheritance of acquired characteristics:**
   Characteristics developed during the life of an individual (acquired characteristics) can be passed on to their offspring.

2. **The law of use and disuse:**
   As an organism uses a structure or organ more regularly, it becomes better developed or enlarged. If an organism does not use a structure or organ frequently, it becomes less developed or reduced in size and may disappear altogether.

Charles Darwin and Alfred Wallace had similar ideas about evolution. They explained evolution in terms of **natural selection** which states that:

- There is a great deal of variation among members of the same species.
- Organisms with favourable characteristics, which enable them to cope with challenges in the environment, survive.
- Organisms which do not have favourable characteristics that allow them to cope with challenges in the environment, die.
4.2 Applying the ideas of Lamarck and Darwin

Figure 4.1 below shows a series of changes involving cacti plants over a period of time. Some notes are included on the events at A, B and C.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are many cacti plants. There is variation among the plants. Some have long roots and some have short roots.</td>
<td>Only cacti plants with the longer roots are present. The ones with shorter roots are absent (have died).</td>
<td>Only the plants with longer roots were able to reproduce to form offspring with longer roots.</td>
</tr>
</tbody>
</table>

*Figure 4.1 Changes in cacti plants over time*

We can use Figure 4.1 to describe how Darwin would have explained how modern cacti plants may have developed longer roots as compared to their ancestors with shorter roots.

The second column in Table 4.1 below gives Darwin's explanation for how modern cacti plants may have developed longer roots. The first column contains questions that guide the explanation from one point to the next. You will be able to use the same questions to guide you when answering questions on Darwin's theory using any other example, for example the development of longer necks in modern giraffes.

<table>
<thead>
<tr>
<th>Guiding questions</th>
<th>Darwin's explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the variation in the population.</td>
<td>As a result of genetic variation, in the cacti population, some cacti plants had longer roots than others.</td>
</tr>
<tr>
<td>What was the challenge?</td>
<td>As a result of drought, competition for water occurred.</td>
</tr>
<tr>
<td>What was the result of the challenge?</td>
<td>Plants with shorter roots died, and those with longer roots survived.</td>
</tr>
<tr>
<td>What is this called?</td>
<td>This is called natural selection.</td>
</tr>
<tr>
<td>What happened to the favourable characteristic?</td>
<td>The gene for longer roots was passed on to subsequent generations.</td>
</tr>
<tr>
<td>What was the result of this?</td>
<td>Eventually all the plants had longer roots.</td>
</tr>
</tbody>
</table>

*Table 4.1 Darwin's explanation for changes in cacti plants over time*
The second column in Table 4.2 below states how Lamarck would have explained how modern cacti plants may have developed longer roots when compared to their ancestors with shorter roots. The first column contains guiding questions that will help you answer other questions on Lamarck’s theory using any other example, for example the development of longer necks in modern giraffes.

<table>
<thead>
<tr>
<th>Guiding questions</th>
<th>Lamarck’s explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>What was the original characteristic at the start?</td>
<td>All cacti had short roots originally.</td>
</tr>
<tr>
<td>What did the organism do?</td>
<td>Cacti frequently stretched their roots.</td>
</tr>
<tr>
<td>Why did the organism do this?</td>
<td>They did this to reach deeper for water in the soil.</td>
</tr>
<tr>
<td>What was the result?</td>
<td>As a result, the roots became longer.</td>
</tr>
<tr>
<td>What happened to this new characteristic?</td>
<td>The characteristic of long roots acquired in this way was then passed on to the next generation.</td>
</tr>
<tr>
<td>What was the result of this?</td>
<td>Eventually all the plants had longer roots.</td>
</tr>
</tbody>
</table>

Table 4.2 Lamarck’s explanation for changes in cacti plants over time

Activity 1

Questions

1. Write an account on how Lamarck would have explained the development of longer necks in modern giraffes. (5)
2. Write an account on how Darwin would have explained the development of longer necks in modern giraffes. (7)
3. Explain why Lamarck’s theory was rejected. (2)

Answers to activity 1

1. • All giraffes had short necks originally.
• These giraffes frequently stretched their necks.
• They did this to reach the leaves that were available only higher up on the trees.
• As a result, their necks became longer.
• The characteristic of long necks acquired in this way was then passed on to the next generation.
• Eventually all the giraffes had longer necks. (5)
Answers to activity 1 (continued)

2. • As a result of genetic variation in the giraffe population some giraffe had longer necks than others.
• As a result of leaves being available only higher up on trees giraffes competed for these leaves.
• Giraffes with shorter necks died.
• Giraffes with longer necks survived.
• This is natural selection.
• The gene for longer necks was passed on to subsequent generations.
• Eventually all the giraffes had longer necks. (7)

3. There is no evidence to show that acquired characteristics are inherited. There is no evidence that structures used more frequently become more developed or vice versa (2)

4.3 Differences between natural selection and artificial selection

For a long time, humans have been doing breeding experiments to develop organisms with a selected set of desirable characteristics, for example increased quality and quantity of milk produced by cows, or drought resistance and increased sugar content in sugar cane.

This is achieved by artificial selection, which is a similar process to natural selection. However, artificial selection differs from natural selection in the following ways:

<table>
<thead>
<tr>
<th>Natural selection</th>
<th>Artificial selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>The environment or nature is the selective force.</td>
<td>Humans represent the selective force.</td>
</tr>
<tr>
<td>Selection is in response to suitability to the environment.</td>
<td>Selection is in response to satisfying human needs.</td>
</tr>
<tr>
<td>Occurs within a species.</td>
<td>May involve one or more species (as in cross breeding).</td>
</tr>
</tbody>
</table>

Table 4.3 The differences between natural selection and artificial selection
4.4 Speciation

As a result of natural selection taking place over a period of time, the characteristics of organisms may change to such an extent that they cannot reproduce with the original members of that species to produce fertile offspring. We say that they have become a new species. This is called speciation.

There are two types of speciation:
- **Allopatric speciation**: The population becomes split into two by a geographical barrier, for example a river, lake or mountain range.
- **Sympatric speciation**: The population becomes split into two, not by a geographical barrier (since they occupy the same area), but by other factors that prevent the two parts of the same population from mixing, for example, different feeding times.

We can show the process of speciation as follows:

1. A population of a particular species may become split...
2. by a geographical barrier, e.g. a river.
3. As a result, the two parts of the population cannot interbreed.
4. There is no gene flow between the two populations.
5. Natural selection occurs independently in each population.
6. This is due to different environmental conditions.
7. As a result, the two populations become genotypically and phenotypically different over a period of time.
8. Even if the two populations mixed at a later time, they will not be able to interbreed again.
9. We say that one or both parts of the population have become a new species = speciation.

Exams

For more questions on speciation, refer to these National Life Sciences exam papers:
Activity 2

Question
Use the information in Figure 4.2 below to explain how a new species of rabbit has risen through allopatric speciation. [9]

Answer to activity 2

- A population of rabbits become split by a geographical barrier/river.
- As a result, the two parts of the population cannot interbreed.
- There is no gene flow between the two populations.
- Natural selection occurs independently in each population due to different environmental conditions on either side of the river.
- As a result, the two populations become genotypically and phenotypically different over a period of time.
- Even if the geographical barrier is removed (ie the river returns to its normal course at some later time), the rabbits will not be able to interbreed again.
- We say that one or both parts of the rabbit population have become a new species.
4.5 Human evolution

So far in this chapter you have seen that:

- As a result of **natural selection**, the characteristics of organisms can change over time due to changing environmental conditions.
- **New species** can arise when a group of organisms change so much that they can no longer reproduce with the original species (this is called speciation).

Natural selection and speciation can also be used to explain **how humans have evolved**.

Scientists identify trends in human evolution by comparing humans to other primates in terms of similarities and differences. The differences point to the existence of different species, while the similarities point to a possible common ancestor.

4.5.1 Similarities between humans (**Homo sapiens**) and other primates

Figure 4.3 below shows characteristics of humans that are similar to that of other primates (when compared to all other organisms).

Now try this:

1. Cover the labels on Figure 4.3 and try to list the common features of humans and other primates by looking at the parts that the arrows are pointing to.
2. Write down the EIGHT similarities without looking at the diagram.
### 4.5.2 Differences between humans (*Homo sapiens*) and other primates

Table 4.4 below is a comparison of the skulls of humans and other primates according to the features listed in the first column.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Humans (<em>Homo sapiens</em>)</th>
<th>Other primates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranium</td>
<td>Larger cranium/brain</td>
<td>Smaller cranium/brain</td>
</tr>
<tr>
<td>Forehead</td>
<td>Less sloping forehead</td>
<td>More sloping forehead</td>
</tr>
<tr>
<td>Brow ridges</td>
<td>Brow ridges are not as pronounced</td>
<td>Brow ridges pronounced</td>
</tr>
<tr>
<td>Face</td>
<td>Flat face</td>
<td>Sloping face</td>
</tr>
<tr>
<td>Canines</td>
<td>Smaller canines</td>
<td>Larger canines</td>
</tr>
<tr>
<td>Chin</td>
<td>Lower jaw has a well-developed chin</td>
<td>Lower jaw has poorly developed chin</td>
</tr>
<tr>
<td>Jaws</td>
<td>Less protruding jaws/less prognathous</td>
<td>More protruding jaws/more prognathous</td>
</tr>
<tr>
<td>Spaces between teeth</td>
<td>Smaller spaces between the teeth</td>
<td>Larger spaces between the teeth</td>
</tr>
<tr>
<td>Foramen magnum</td>
<td>Foramen magnum forward/at bottom of skull</td>
<td>Foramen magnum at the back of the skull</td>
</tr>
</tbody>
</table>

*Table 4.4 The differences between the skulls of humans and other primates*

Now try this:

1. Study the differences listed in Table 4.4 above by referring to the features shown in Figure 4.4 below.

   ![Labelled diagram of a primate skull](image)

   - Cranium – size
   - Forehead slope
   - Brow ridges – how developed?
   - Face – slope
   - Foramen magnum – position
   - Canines – size
   - Spaces between teeth
   - Chin – how developed?
   - Jaws – protrusion

2. Now write down the differences using the above diagram but without referring to Table 4.4.
Activity 3

Question 1

Study the two skulls shown in Figure 4.5 below and answer the questions that follow.

![Skull A and Skull B](image)

*Figure 4.5 Skull diagrams of two organisms*

1.1 Which skull (A or B) is that of a non-human primate? (1)

1.2 List FIVE OBSERVABLE reasons (based only on features that are visible in the diagram) for your answer in question 1.1. (5)

<table>
<thead>
<tr>
<th>Answers to question 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Skull B ✓</td>
<td>(1)</td>
</tr>
<tr>
<td>1.2 Sloping forehead ✓</td>
<td></td>
</tr>
<tr>
<td>Pronounced brow ridge ✓</td>
<td></td>
</tr>
<tr>
<td>No chin ✓</td>
<td></td>
</tr>
<tr>
<td>Protruding jaw/prognathous ✓</td>
<td></td>
</tr>
<tr>
<td>Large canine ✓</td>
<td></td>
</tr>
<tr>
<td>Sloping face ✓</td>
<td></td>
</tr>
<tr>
<td>Small cranium ✓</td>
<td></td>
</tr>
<tr>
<td>(any 5) (5)</td>
<td></td>
</tr>
</tbody>
</table>

Question 2

The diagrams in Figure 4.6 below represent the skulls of three organisms: Taung child (*Australopithecus africanus*), a modern human (*Homo sapiens*) and a gorilla (*Gorilla gorilla*). The arrow indicates the position of the foramen magnum (the opening that allows the spinal cord to connect with the brain). Study the diagrams and answer the questions that follow:

![Skull A, Skull B, Skull C](image)

*Figure 4.6 Skull diagrams showing position of foramen magnum*
2.1 Identify the organisms that are represented by each of skulls A, B and C. (3)

2.2 Assuming that the diagrams were drawn to scale, list THREE observable differences between the skulls of organisms A and B. (6)

2.3 Which organism (A, B or C) represents a carnivore? (1)

2.4 Explain your answer in question 2.3 using features observable in the diagram. (2)

2.5 By looking at the position of the foramen magnum (indicated by the arrows), state which TWO organisms are best adapted for walking on two legs rather than four legs. (2)

2.6 Rewrite the letters A, B and C in the order that shows progressive trends (from least developed to most developed) in evolution. (3)

2.7 Explain, using observable features, why the organism to which skull C belongs can be regarded as a transitional species (a species that is in the process of changing). (3)

**Answers to question 2**

2.1 A – *Homo sapiens/human* ✓
    B – *Gorilla gorilla/gorilla* ✓
    C – *Australopithecus africanus* (Taung child) ✓ (3)

2.2

<table>
<thead>
<tr>
<th>Skull A</th>
<th>Skull B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat forehead ✓</td>
<td>Sloping forehead ✓</td>
</tr>
<tr>
<td>Brow ridge reduced/absent ✓</td>
<td>Pronounced brow ridge ✓</td>
</tr>
<tr>
<td>Well-developed chin ✓</td>
<td>No chin ✓</td>
</tr>
<tr>
<td>Non-prognathous/non-protruding jaw ✓</td>
<td>Prognathous/protruding jaw ✓</td>
</tr>
<tr>
<td>Poorly developed canines ✓</td>
<td>Large canines ✓</td>
</tr>
<tr>
<td>Flat face ✓</td>
<td>Sloping face ✓</td>
</tr>
<tr>
<td>Large cranium ✓</td>
<td>Small cranium ✓</td>
</tr>
</tbody>
</table>

(any 3 × 2) (6)

2.3 B ✓ (1)

2.4 Canines ✓ are large ✓ (2)

2.5 *Homo sapiens/human* ✓ AND *Australopithecus africanus* (Taung child) ✓ (2)

2.6 B ✓✓, C ✓✓, A ✓✓ (3)

2.7 It has features of the skull that are intermediate ✓ between that of skulls A and B, e.g. jaw protrudes more than in skull A but less than in skull B ✓ and face slopes less than in skull B but more than in skull A ✓. (3)

[20]
4.5.3 Phylogenetic trees

A phylogenetic tree (or evolutionary tree) represents the evolutionary relationships among a set of organisms or groups of organisms. The tips of the tree represent descendants (often species) and the points where the tree branches represent the common ancestors of those descendants.

**Hint**

Reading a phylogenetic tree is similar to understanding a family tree. The root of the tree represents the ancestor and the tips of the branches represent the descendants of that ancestor. As you move from the root of the tree to its tips, you are moving forward in time.

When speciation occurs, it is represented as branching on the tree. A single ancestral lineage gives rise to two or more daughter lineages.

Each lineage has a part of its history that is unique and parts that are shared with other lineages.

Similarly, each lineage has ancestors that are unique to that lineage and common ancestors that are shared with other lineages.
Look at the phylogenetic tree in Figure 4.7 (left) and read the following information:

- Start in the past (4.5 mya) and read towards the present. This means that the oldest common ancestor of all the hominids on this tree is *A. ramidus*.
- Each branch on the tree represents a point where the common ancestor split into one, two or more groups. In this case, the new species that evolves is shown as a side branch while the original species continues its evolutionary line up the trunk of the tree. For example, *A. aethiopicus* forms a side branch with *A. africanus* evolving from the common ancestor that existed at point X (this took place about 3 mya).
- Progression up the ‘trunk of the tree’ represents a movement in time from the past to the present. This shows the relationships between the hominids through time. Hominids that share a recent common ancestor are the most closely related to each other. For example, *P. robustus* shares a most recent common ancestor with *P. boisei*, namely *A. africanus*.

**Questions**

Let us look at the type of questions that can be asked about this phylogenetic tree:

1. Give the common ancestor of *H. neanderthalensis* and *H. sapiens*. (1)
2. How long ago did *H. rudolfensis* split from its common ancestor? (2)
3. Name the direct ancestor of *H. ergaster*. (1)
4. How long has it taken *H. heidelbergensis* to evolve from *A. afarensis*? (3)
5. Give the common ancestor of all the hominids. (1)

**Answers**

1. *H. heidelbergensis* ✓ (1)
2. 2,4 ✓ million years ago ✓/mya (2)
3. *H. habilis* ✓ (1)
4. 3,8 million years ago – 0,7 million years ago ✓ = 3,1 ✓ million years ✓ (3)
5. *A. ramidus* ✓ (1)
Activity 4

Study the phylogenetic tree in Figure 4.8 below and answer the questions based on it.

Questions

1. How long ago did the ancestral primate live on earth? (2)

2. Name the organism that shares the most distant common ancestor with humans. (1)

3. Name the organism that is most closely related to humans. (1)

4. How many years ago did the New World monkeys split from the common ancestor that gave rise to the Old World monkeys? (2)

5. For how long did the common ancestor that evolved into the gibbons exist? Show your working. (3)

6. Humans and gorillas share many common characteristics with primates. List THREE of these common characteristics. (3)

Figure 4.8 Phylogenetic tree
4.5.4 Out of Africa hypothesis

The ‘Out of Africa’ hypothesis states that modern humans originated in Africa and then migrated out of Africa to the other continents.

The following lines of evidence have been used to support this hypothesis:

- The oldest fossils of australopithecines/Homo habilis/bipedal organisms have been found in Africa.
- The oldest fossils of Homo erectus have been found in Africa.
- Analysis of mutations in mitochondrial DNA shows that the oldest female ancestors of humans are from Africa.
- Analysis of mutations on Y chromosome shows that the oldest male ancestors of humans are from Africa.

Activity 5

Question 1

Give the correct biological term for each of the following descriptions. Write only the term next to the question number (1.1 to 1.18).

1.1 The development of new species from existing species within the same habitat

1.2 A study of the distribution of organisms in different parts of the world

1.3 Similar structures in different organisms indicating common ancestry

1.4 Having a pointed face because of projecting jaws and nose

1.5 A group of similar organisms that can breed to produce fertile offspring

1.6 A group of organisms of the same species that occupy a particular habitat
1.7 The development of new species from existing species
1.8 Only organisms with favourable characteristics survive
1.9 Using parents with particular desirable characteristics to obtain a combination of these desirable characteristics in the offspring
1.10 An opening in the skull through which the spinal cord passes
1.11 Locomotion involving the use of a pair of hind limbs only
1.12 Mechanisms that prevent different species from reproducing with each other
1.13 The study of fossils which provides evidence for evolution
1.14 Sudden change to the genetic composition of an organism
1.15 Branched diagram showing evolutionary relationships among organisms
1.16 Remains of organisms that have existed in the past
1.17 Genus to which Little Foot, Mrs Ples, Karabo and Taung Child belong
1.18 Genotypic and phenotypic differences among organisms of the same species

Answers to question 1

1.1 Sympatric speciation✓
1.2 Biogeography✓
1.3 Homologous✓
1.4 Prognathous✓
1.5 Species✓
1.6 Population✓
1.7 Speciation✓
1.8 Natural selection✓
1.9 Artificial selection✓
1.10 Foramen magnum✓
1.11 Bipedal✓
1.12 Reproductive isolation✓
1.13 Paleontology✓
1.14 Mutation✓
1.15 Phylogenetic tree✓
1.16 Fossil✓
1.17 Australopithecus✓
1.18 Variation✓
Question 2

Indicate whether each of the statements in COLUMN 1 applies to A only, B only, both A and B or none of the items in COLUMN 2. Write A only, B only, Both A and B, or None next to the question number (2.1 to 2.8).

<table>
<thead>
<tr>
<th>COLUMN 1</th>
<th>COLUMN 2</th>
</tr>
</thead>
</table>
| 2.1 A study of the distribution of individual species in different parts of the world | A: Palaeontology  
B: Biogeography |
| 2.2 The evidence used to support the 'Out of Africa' hypothesis by tracing the maternal lineage | A: Mitochondrial DNA  
B: Y chromosome |
| 2.3 First *Homo* species to have migrated out of Africa | A: *Homo habilis*  
B: *Homo sapiens* |
| 2.4 Used natural selection as an explanation for evolution | A: Alfred Wallace  
B: Charles Darwin |
| 2.5 Development of new species after a population is split by a geographical barrier | A: Allopatric speciation  
B: Sympatric speciation |
| 2.6 Desirable characteristics are chosen to satisfy a human need | A: Natural selection  
B: Artificial selection |
| 2.7 Evidence of possible common ancestry | A: Homologous structures  
B: Analogous structures |
| 2.8 Organisms have an inherent (internal) drive to change | A: Lamarck  
B: Wallace |

(8 × 2) [16]

Answers to question 2

2.1 B only
2.2 A only
2.3 None
2.4 Both A and B
2.5 A only
2.6 B only
2.7 A only
2.8 A only

8 × 2 [16]

Keep going!
This short chapter introduces you to plant responses, which are part of the knowledge area *Life processes in plants and animals*, which is examined in Paper 2.

**Tropism** is the growth or turning movement of a plant or part of a plant in response to an environmental stimulus.
- **Phototropism** is the growth of a plant in the direction of a light source.
- **Geotropism** is the growth of a plant in response to gravity.

The growth movement of phototropism and geotropism is due to chemical messengers (hormones) called auxins in a plant.

**Activity 1**

**Questions**

Complete the table:

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Chemical messenger in the plant</td>
</tr>
<tr>
<td>b.</td>
<td>Growth of a plant stem towards light</td>
</tr>
<tr>
<td>Geotropism</td>
<td>c.</td>
</tr>
<tr>
<td>Tropism</td>
<td>d.</td>
</tr>
</tbody>
</table>

**Answers to activity 1**

a) Plant hormone ✓
b) Phototropism ✓
c) Growth of a plant root in response to gravity ✓
d) Growth movement of a part of a plant in response to an environmental stimulus ✓

---

Mind the Gap
Life Sciences

Chapter 5 Plant responses (Paper 2)
Life processes in plants and animals
The nervous system is responsible for processing and transmitting information throughout the body:

- It tells the body how to react to stimuli (changes in the environment to which the body responds). For example, it regulates body temperature on a hot or cold day. It is also responsible for the reflex action, for example, when you step on a pin or touch a hot surface.
- The nervous system also coordinates the various activities of the body, such as walking, hearing, seeing, and so on.

The central nervous system consists of the brain and the spinal cord.

## 6.1 The brain

### 6.1.1 Structure and functions of the brain

Figure 6.1 below shows the different parts of the brain and their functions.

**A. Cerebrum**
- Controls voluntary actions
- Receives and interprets sensations from sense organs
- Higher thought processes

**B. Cerebellum**
- Coordinates all voluntary movements
- Controls muscle tension to maintain balance

**C. Medulla oblongata**
- Transmits nerve impulses between the spinal cord and the brain
- Controls involuntary actions such as heartbeat and breathing

**D. Hypothalamus**
Control centre for hunger, thirst, sleep, body temperature and emotions

*Figure 6.1 The structure and functions of the brain*
Activity 1

Questions
Write down the name of the part which:
1. Controls heartbeat (1)
2. Contains the centres that control balance, muscle tone and equilibrium (1)
3. Has centres that interpret what you see (1)
4. Coordinates voluntary muscle movements (1)
5. Controls body temperature

Answers to activity 1
1. Medulla oblongata (√) (1)
2. Cerebellum (√) (1)
3. Cerebrum (√) (1)
4. Cerebellum (√) (1)
5. Hypothalamus (√) (1)

[5]

6.2 Neurons

Neurons are specialised cells which connect the brain and spinal cord to all other parts of the body.

A note about mind maps:
Look at the information about mind maps on page xii. Information represented in a mind map resembles the way information is stored in our brains. A mind map is an excellent technique for studying.

Figure 6.2 A neuron
There are three types of neurons, namely **sensory** (afferent) neurons, **motor** (efferent) neurons and **interneurons** (or connectors). Table 6.1 below shows the structure and function of these neurons.

<table>
<thead>
<tr>
<th>Type of neuron</th>
<th>Function</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory (afferent) neuron</td>
<td>Transmits impulses from the sense organs or receptors to the spinal cord and brain.</td>
<td><img src="image" alt="Figure 6.3 Sensory neuron" /></td>
</tr>
<tr>
<td>Senses the stimulus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor (efferent) neuron</td>
<td>Transmits impulses from the brain and spinal cord to the effectors (muscles and glands). The effectors bring about the response.</td>
<td><img src="image" alt="Figure 6.4 Motor neuron" /></td>
</tr>
<tr>
<td>Response to the stimulus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interneuron (connector)</td>
<td>Links the sensory neuron to the motor neuron.</td>
<td><img src="image" alt="Figure 6.5 Interneuron" /></td>
</tr>
<tr>
<td>Found in the brain and spinal cord</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6.1 Sensory, motor and interneurons

You must know the structure and function of the different neurons in order to understand the **reflex action**, which will be discussed next.
6.3 Reflex arc

A reflex action is a quick, automatic action that involves the spinal cord and does not involve the brain. It is an important function to protect the body from harm. Examples are blinking the eye, coughing, sneezing, dilation and constriction of the pupil of the eye, and quickly withdrawing your hand when it touches a hot surface.

The reflex arc is the path along which an impulse is transmitted to bring about a response to a stimulus during a reflex action.

Figure 6.6 below shows what happens when you hold your finger close to a flame. The grey arrows represent the reflex arc.

**The path of a reflex arc:**

Receptor (A) → Sensory neuron (B) → Interneuron (C) → Motor neuron (D) → Effector (E)

![Diagram of the reflex arc](image)

**Figure 6.6** The reflex action of withdrawing a finger when placed in a flame
Activity 2

Questions

Use the diagram of the reflex arc in Figure 6.6 on page 48 to answer the following questions.

1. Part B indicates the ...
   A  dendrite of the motor neuron.
   B  axon of the motor neuron.
   C  dendrite of the sensory neuron.
   D  axon of the sensory neuron. (2)

2. The correct sequence in which impulses move from the receptor to the effector in the reflex arc in Figure 6.6 is ...
   A  A → B → C → D → E
   B  C → A → B → E → D
   C  C → B → E → D → A
   D  A → D → E → B → C (2)

3. Give the correct term for the following definitions:
   a)  A structure which receives a stimulus and converts it into a impulse
   b)  A structure which responds to a stimulus, e.g. a muscle or gland
   c)  A neuron that carries impulses from the central nervous system to the effectors
   d)  A neuron that carries impulses from the receptors to the central nervous system
   e)  A neuron that carries impulses from a sensory neuron to a motor neuron in the spinal cord
   f)  A very quick, automatic action that involves the spinal cord and not the brain
   g)  The pathway along which an impulse is transmitted to bring about a response to a stimulus during a reflex action

   7 × 1 = (7) [11]

Answers to activity 2

1. C ✓ ✓ (2)
2. A ✓ ✓ (2)
3. a)  Receptor ✓
   b)  Effector ✓
   c)  Motor/efferent neuron ✓
   d)  Sensory/afferent neuron ✓
   e)  Interneuron ✓ / connector
   f)  Reflex action ✓
   g)  Reflex arc ✓

   7 × 1 = (7) [11]
6.4 The human eye

Figure 6.7 below shows the different parts of the eye and their functions.

- **Retina**: Contains the light-sensitive receptor cells, i.e., the rods and cones.
- **Sclera**: The tough white outer coat, which protects the eye against damage.
- **Choroid**: A dark-coloured layer which:
  - Reduces reflection
  - Is rich in blood vessels which supply the cells of the eye with nutrients and oxygen.
- **Pupil**: A circular opening in the iris which allows light into the eye.
- **Suspensory ligament**: Holds the lens in position.
- **Iris**: The coloured part of the eye.
- **Lens**: Changes shape for near and distant (far) vision.
- **Aqueous humour**: Watery fluid that supports the cornea and the front chamber of the eye.
- **Vitreous humour**: A jelly-like substance which gives shape to the eye.
- **Optic nerve**: Carries nerve impulses from the retina to the brain.
- **Yellow spot**: Has the greatest number of cones; this area offers the clearest image.
- **Blind spot**: This area has no rods and cones; therefore there is no vision at this point.

*Figure 6.7 The structure of the eye*
6.4.1 Accommodation

**Accommodation** is the adjustment of the shape of the lens to see objects clearly whether they are far away or close by. This is shown in Table 6.2 and Figures 6.8 and 6.9 below.

<table>
<thead>
<tr>
<th>Distant vision (objects further than 6 m)</th>
<th>Near vision (objects closer than 6 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ciliary muscles relax</td>
<td>1. Ciliary muscles contract</td>
</tr>
<tr>
<td>2. Suspensory ligaments tighten (become taut)</td>
<td>2. Suspensory ligaments slacken</td>
</tr>
<tr>
<td>3. Tension on lens increases</td>
<td>3. Tension on lens decreases</td>
</tr>
<tr>
<td>4. <strong>Lens</strong> is less convex (flatter)</td>
<td>4. <strong>Lens</strong> becomes more convex (more rounded)</td>
</tr>
<tr>
<td>5. Light rays are refracted (bent) less</td>
<td>5. Light rays are refracted (bent) more</td>
</tr>
<tr>
<td>6. Light rays are focused onto the retina</td>
<td>6. Light rays are focused onto the retina</td>
</tr>
</tbody>
</table>

![Figure 6.8 Distant vision](image)

![Figure 6.9 Near vision](image)

**Table 6.2 Accommodation of the eye for distant and near vision**

6.4.2 Pupillary mechanism

The **pupillary mechanism** (or pupil reflex) regulates the amount of light entering the eye by adjusting the size of the pupil. This is shown in Table 6.3 and Figures 6.10 and 6.11 below.

<table>
<thead>
<tr>
<th>Light is bright</th>
<th>Light is dim</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Radial muscles of the iris relax</td>
<td>1. Radial muscles of the iris contract</td>
</tr>
<tr>
<td>2. Circular muscles of the iris contract</td>
<td>2. Circular muscles of the iris relax</td>
</tr>
<tr>
<td>3. Pupil constricts (gets smaller)</td>
<td>3. Pupil widens (gets bigger)</td>
</tr>
<tr>
<td>4. Less light enters the eye</td>
<td>4. More light enters the eye</td>
</tr>
</tbody>
</table>

![Figure 6.10 The pupil in bright light](image)

![Figure 6.11 The pupil in dim light](image)

**Table 6.3 Pupillary mechanism**
Activity 3

Questions

1. Figure 6.12 (left) shows a longitudinal section through the human eye. Study the diagram and answer the questions that follow.
   a) Label parts 2, 3, 4 and 5 respectively. (4)
   b) Name and describe the process that causes part 1 to dilate (become wider). (5)

2. Figure 6.13 (below left) is a longitudinal section through the human eye. The structures which enable the eye to focus on objects are missing in this diagram. Study the diagram and answer the questions that follow.
   Draw a longitudinal section through the missing parts of Figure 6.13 to indicate the appearance of these structures when you are...
   a) reading a book. (6)
   b) looking at an object more than 6 metres away. (6)

Answers to activity 3

1. a) 2 – Cornea ✓
   3 – Lens ✓
   4 – Suspensory ligaments ✓
   5 – Ciliary muscles ✓/ body (4)
   b) Pupillary mechanism ✓/ pupil reflex
      The radial muscles ✓ of the iris contract ✓ and the circular muscles ✓ relax ✓.
      The pupil dilates and more light enters the eye ✓. (5)

2. a) Ciliary muscle ✓ contracts ✓
       Lens ✓ more convex ✓
       Suspensory ligaments ✓ slacken ✓
   b) Ciliary muscle ✓ relaxes ✓
       Lens ✓ less convex/ flatter ✓
       Suspensory ligaments ✓ tighten/ become taut ✓

Figure 6.12 Longitudinal section through the human eye
Figure 6.13 Longitudinal section through a human eye
6.5 The human ear

6.5.1 Structure of the ear

The human ear consists of three main parts:
- The outer ear
- The middle ear
- The inner ear

<table>
<thead>
<tr>
<th>Outer</th>
<th>Middle</th>
<th>Inner</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Outer Ear Diagram" /></td>
<td><img src="image2.png" alt="Middle Ear Diagram" /></td>
<td><img src="image3.png" alt="Inner Ear Diagram" /></td>
</tr>
</tbody>
</table>

Figure 6.14 below shows the structure and function of each part of the human ear.

Pinna: Directs sound waves to eardrum

Tympanum (eardrum): Transmits sound waves to the middle ear

Ear canal (auditory canal): Transmits sound waves to the eardrum

Ossicles: Transmit vibrations from the eardrum to inner ear

Oval window: Transmits sound waves to the inner ear

Round window: Releases pressure from the inner ear

Eustachian tube: Equalises pressure on either side of the eardrum

Semi circular canals: Balance of the body

Sacculus and utriculus: Balance of the body

Auditory nerve: Transmits impulses to the brain

Cochlea: Contains the organ of Corti which converts sound waves into nerve impulses

Figure 6.14 The structure of the ear
6.5.2 Hearing

Figure 6.15 below shows how the three parts of the ear work together to make it possible for us to hear. The grey arrows show the path of a sound wave.

Look at Figure 6.15 above and read the information in Table 6.4 below to understand how hearing takes place.

<table>
<thead>
<tr>
<th>Part of ear</th>
<th>What it does during the hearing process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinna</td>
<td>Traps the sound waves and directs them into the auditory canal.</td>
</tr>
<tr>
<td>Tympanic membrane</td>
<td>Vibrates and transmits the vibrations to the ossicles in the middle ear.</td>
</tr>
<tr>
<td>Ossicles</td>
<td>The ossicles amplify the vibrations and carry them via the middle ear to the membrane of the oval window.</td>
</tr>
<tr>
<td>Oval window</td>
<td>Vibrates and causes pressure waves in the inner ear.</td>
</tr>
<tr>
<td>Cochlea</td>
<td>These vibrations cause the sensory cells in the organ of Corti to be stimulated in the cochlea and nerve impulses are generated.</td>
</tr>
<tr>
<td>Auditory nerve</td>
<td>Transmits nerve impulses to the cerebrum to be interpreted.</td>
</tr>
</tbody>
</table>

Table 6.4 The hearing process
**Activity 4**

**Questions**

Study Figure 6.16 below and answer the questions that follow.

![Diagram of the ear](image)

**Figure 6.16 Parts of the ear**

1. Identify the parts labelled B, C and F.
   - **B** - Tympanic membrane
   - **C** - Malleus/hammer/an ossicle
   - **F** - Cochlea
   
2. Give the function of the pinna.
   - It directs sound waves into the auditory canal.

3. Write the letter of the part which:
   
   a) contains receptors for balance.
   - **D**
   
   b) equalises the pressure on either side of part B.
   - **G**
   
   c) transmits impulses to the brain.
   - **E**

4. Describe how hearing occurs.
   - Sound waves are directed into the auditory canal by the pinna.
   - The sound waves make the tympanic membrane vibrate and the vibrations are passed on to the ossicles in the middle ear.
   - The ossicles make the oval window vibrate and this causes pressure waves to be set up in the inner ear.
   - These vibrations also cause the organ of Corti to be stimulated and it generates impulses which are sent to the cerebrum along the auditory nerve.
   - The cerebrum interprets the impulses as sound.

**Answers to activity 4**

1. B - Tympanic membrane
   - C - Malleus/hammer/an ossicle
   - F - Cochlea
   
2. It directs sound waves into the auditory canal.

3. a) D
   - b) G
   - c) E

4. • Sound waves are directed into the auditory canal by the pinna.
   • The sound waves make the tympanic membrane vibrate and the vibrations are passed on to the ossicles in the middle ear.
   • The ossicles make the oval window vibrate and this causes pressure waves to be set up in the inner ear.
   • These vibrations also cause the organ of Corti to be stimulated and it generates impulses which are sent to the cerebrum along the auditory nerve.
   • The cerebrum interprets the impulses as sound.
Chapter 7

ENDOCRINE SYSTEM

7.1 The human endocrine system

The endocrine system is responsible for chemical coordination and regulates activities that take place inside the body. The endocrine system consists of glands that produce different hormones, which are the body’s chemical messengers. Figure 7.1 below shows the glands of the endocrine system, the hormones they produce and the function of these hormones in the body.

**Hypothalamus:**
- **ADH (antidiuretic hormone)**
  - Target organ: Kidney
  - Controls the concentration of water in the blood

**Thyroid gland:**
- **Thyroxin**
  - Controls basic metabolic rate

**Adrenal gland:**
- **Adrenalin**
  - Increases:
    - heartbeat
    - blood pressure
    - conversion from glycogen to glucose
    - blood supply to the cardiac and skeletal muscles
    - skeletal muscle tone
    - rate and depth of breathing
    - diameter of pupils
  - Decreases:
    - blood flow to the digestive system and skin

**Aldosterone**
- Target organ: Kidney
- Regulates salt concentration in the blood

**Pituitary gland (hypophysis):**
- **GH (growth hormone)**
  - Controls growth
- **TSH (thyroid stimulating hormone)**
  - Stimulates thyroid gland to secrete thyroxin

Reproductive hormones:
- **FSH, LH and prolactin**
  - Refer to the section on human reproduction in Chapter 9

**Pancreas:**
- **Islets of Langerhans**
  - **Glucagon**
    - Stimulates conversion of glycogen to glucose (increases blood glucose levels)
  - **Insulin**
    - Stimulates conversion of glucose to glycogen (reduces the blood glucose levels)

**Testes (only males):**
- Reproductive hormone:
  - **Testosterone**
    - Refer to the section on human reproduction in Chapter 9

**Ovary (only females):**
- Reproductive hormones:
  - **Oestrogen and progesterone**
    - Refer to Chapter 9

*Figure 7.1 The human endocrine system*
7.2 Negative feedback

Homeostasis maintains a constant internal environment (blood and tissue fluid) within the body. This enables the body to function efficiently, despite changes in the external or internal environment.

Negative feedback mechanisms operate in the human body to detect changes or imbalances in the internal environment and to restore the balance.

7.2.1 General sequence of events in a negative feedback mechanism

Step 1: An imbalance is detected.
Step 2: A control centre is stimulated.
Step 3: Control centre responds.
Step 4: Message sent to target organ/s.
Step 5: The target organ responds.
Step 6: It opposes/reverses the imbalance.
Step 7: Balance is restored.

Create a direction mnemonic, like this example, to remember these steps.

Down the Street
Cross Main Road
OveR the Bridge
7.2.2 Example of negative feedback mechanism

We will look at the regulation of thyroxin in the human body. There are two glands involved in the control of thyroxin levels:

- Gland 1: Thyroid gland (releases thyroxin)
- Gland 2: Pituitary gland (releases TSH)

Let us now look at the sequence of events in this feedback mechanism. When you read the flow diagrams, start with NORMAL THYROXIN LEVELS.

**Situation 1**

<table>
<thead>
<tr>
<th>Step 1: Thyroxin levels increase above normal limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Pituitary gland is stimulated</td>
</tr>
<tr>
<td>Step 3: Pituitary gland produces less TSH</td>
</tr>
<tr>
<td>Step 4: Low TSH level stimulates the thyroid gland</td>
</tr>
<tr>
<td>Step 5: The thyroid gland secretes less thyroxin</td>
</tr>
<tr>
<td>Step 6: The thyroxin level thus decreases</td>
</tr>
<tr>
<td>Step 7: Thyroxin level returns to normal</td>
</tr>
</tbody>
</table>

**Situation 2**

<table>
<thead>
<tr>
<th>Step 1: Thyroxin levels decrease below normal limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Pituitary gland is stimulated</td>
</tr>
<tr>
<td>Step 3: Pituitary gland produces more TSH</td>
</tr>
<tr>
<td>Step 4: High TSH level stimulates the thyroid gland</td>
</tr>
<tr>
<td>Step 5: The thyroid gland secretes more thyroxin</td>
</tr>
<tr>
<td>Step 6: The thyroxin level thus increases</td>
</tr>
<tr>
<td>Step 7: Thyroxin level returns to normal</td>
</tr>
</tbody>
</table>
Activity 1

Question
The flow chart in Figure 7.2 below shows the control of glucose levels. Provide labels for 1 to 6.

Pancreas: Releases 1 .......... → Liver and muscles: Glucose converted to 2 .................

Glucose level increases

Glucose level 3 ..................

NORMAL GLUCOSE LEVEL

Glucose level 4 ..................

Liver and muscles: Glycogen converted to 6 ..............

5 ....................... releases glucagon

Answers to activity 1
1. Insulin ✓
2. Glycogen ✓
3. Decreases ✓
4. Decreases ✓
5. Pancreas ✓
6. Glucose ✓
8.1 The process of temperature regulation

Temperature regulation is the control of body temperature to keep it as close to 37°C as possible to enable the body to function normally.

Body temperature is regulated by the hypothalamus in the brain and the blood vessels and sweat glands in the skin.

Figure 8.1 below shows how the body temperature is regulated by the hypothalamus and the skin.

If the homeostatic mechanism to regulate body temperature as shown in Figure 8.1 does not work, it can lead to hypothermia or hyperthermia. Both of these conditions can lead to death.
8.1.1 Hypothermia (hypo = low)
Hypothermia occurs when the core body temperature drops below 37°C for an extended time. It is caused by extended (for a long time) exposure to cold conditions. More heat is lost than the body is able to produce.

8.1.2 Hyperthermia (hyper = high)
Hyperthermia occurs when the core body temperature increases above 37°C for an extended time. It is caused by prolonged exposure to high temperatures. The body produces and absorbs more heat than it can lose.

Activity 1

Questions
1. Name the heat regulation centre in the brain. (1)
2. What happens to the blood vessels of the skin on a cold day? (1)
3. Describe how the state of the blood vessels mentioned in question 2 decreases heat loss. (4)
4. What happens to blood vessels of the skin on a hot day? (1)
5. Describe how the state of the blood vessels mentioned in question 4 increases heat loss. (4)
6. State the condition that can result if the core body temperature of a person is:
   a) higher than 37°C for an extended period of time. (1)
   b) lower than 37°C for an extended period of time. (1)

Answers to activity 1
1. Hypothalamus ✓ (1)
2. Blood vessels constrict ✓/vasoconstriction (1)
3. • Less blood flows to the surface of the skin. ✓
   • Less heat is lost from the surface of the skin. ✓
   • Less blood flows to the sweat glands. ✓
   • Sweat glands release less sweat. ✓
   • Less evaporation of sweat. ✓
   • Less cooling of the skin on a cold day. ✓ (any 4)(4)
4. Blood vessels dilate ✓/vasodilation (1)
5. • More blood flows to the surface of the skin. ✓
   • More heat is lost from the surface of the skin. ✓
   • More blood flows to the sweat glands. ✓
   • Sweat glands release more sweat. ✓
   • Evaporation of sweat ✓ cools the skin on a hot day. ✓
   (any 4)(4)
6. a) Hyperthermia ✓ (1)
   b) Hypothermia ✓ (1)

[13]
## 9.1 Life cycles in plants and insects, and reproductive strategies in animals

A **life cycle** is a series of developmental steps that organisms go through during their lives. **Reproductive strategies** are methods used by organisms to ensure success in producing offspring under different environmental conditions.

### Activity 1

**Question**

Indicate whether each of the statements in COLUMN 1 applies to A only, B only, both A and B or none of the items in COLUMN 2. There are four possible answers. Choose only one option to answer by writing **A only**, **B only**, **Both A and B** or **None** next to the question number (1 to 9).

<table>
<thead>
<tr>
<th>COLUMN 1</th>
<th>COLUMN 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Oviparous</td>
<td>A. Eggs are produced</td>
</tr>
<tr>
<td></td>
<td>B. Eggs are always incubated by the female</td>
</tr>
<tr>
<td>2. Complete metamorphosis</td>
<td>A. Egg, larva, pupa and adult</td>
</tr>
<tr>
<td></td>
<td>B. Egg and adult</td>
</tr>
<tr>
<td>3. Incomplete metamorphosis</td>
<td>A. Occurs in all insects</td>
</tr>
<tr>
<td></td>
<td>B. No pupa stage</td>
</tr>
<tr>
<td>4. Ovoviviparous</td>
<td>A. Eggs incubated in nests</td>
</tr>
<tr>
<td></td>
<td>B. Eggs incubated in the female’s body</td>
</tr>
<tr>
<td>5. Precocial development</td>
<td>A. Small, helpless offspring born</td>
</tr>
<tr>
<td></td>
<td>B. Intense parental care required</td>
</tr>
<tr>
<td>6. Viviparous</td>
<td>A. Gestation period required</td>
</tr>
<tr>
<td></td>
<td>B. Live offspring born</td>
</tr>
<tr>
<td>7. Altricial development</td>
<td>A. Intense parental care required</td>
</tr>
<tr>
<td></td>
<td>B. Offspring can look after themselves</td>
</tr>
<tr>
<td>8. Wind-pollinated flower</td>
<td>A. Large flower</td>
</tr>
<tr>
<td></td>
<td>B. Colourful petals</td>
</tr>
<tr>
<td>9. Insect-pollinated flower</td>
<td>A. Large flower</td>
</tr>
<tr>
<td></td>
<td>B. Colourful petals</td>
</tr>
</tbody>
</table>
Answers to activity 1

1. A only (B is wrong, because some animals, like insects, simply lay their eggs and do not incubate them. In some birds both the male and female incubate the eggs.)

2. A only (B is wrong, because complete metamorphosis consists of the four stages given in A.)

3. B only (A is wrong, because incomplete metamorphosis only applies to some insects, like grasshoppers. Insects like silk moths have complete metamorphosis.)

4. B only (A is wrong, because the eggs are not released from the female’s body.)

5. None (Precocial animals are born quite well developed, they can live independently from their parents and find their own food, so parental care is not required.)

6. Both A and B

7. A only (B is wrong, because altricial animals are born small and helpless. They cannot look after themselves or find their own food. Their parents must look after them, protect them and feed them.)

8. None (Flowers that are pollinated by the wind are small and without large petals so that the pollen can be released and received easily. They do not need coloured flowers to attract pollinators.)

9. Both A and B

9.1.1 Pollination

Flowers can be pollinated by the wind or by pollinators, for example birds, insects or bats. In Figure 9.1 below, Flower A is wind pollinated and Flower B is insect pollinated.

Flower A: Wind-pollinated flowers are small (X50 means that it is magnified 50 times) and without large petals so that the pollen can be released and received easily. They do not need coloured flowers to attract pollinators. Their anthers are relatively large and hang out of the flower. The stigma is feathery to trap pollen.

Flower B: Insect-pollinated flowers have large, colourful petals. They usually also have nectar to attract insects. The flowers are larger than wind-pollinated flowers. X1 means that the real flower is the same size as the diagram.

Figure 9.1 Wind-pollinated flower (left) and insect-pollinated flower (right)
9.2 Human reproduction

9.2.1 Male reproductive system

Figure 9.2 below shows the different parts of the male reproductive system and their functions.

Functions of testosterone
The testes produce the hormone testosterone, which has the following functions:
1. Development of male secondary sexual characteristics, such as beard, pubic hair, deep voice and a muscular body.
2. Stimulates the maturation of sperm cells.

Structure of a sperm cell
Figure 9.3 below shows the different parts of a sperm cell and their functions.

Figure 9.2 Structure of the male reproductive system

Figure 9.3 Structure of a sperm cell
Activity 2

Questions

1. Name the accessory glands of the male reproductive system and give ONE function of each. (10)

2. Name the organ where testosterone is produced. (1)

3. Give TWO functions of testosterone. (2)

4. Name all the parts of the sperm cell that are responsible for movement. State what the function of each part is. (4)

5. Explain the role of the nucleus of the sperm cell in fertilisation. (3)

Answers to activity 2

1. Seminal vesicle/a produces a fluid that contains nutrients/a for the sperm cells, so that they have energy to swim/a.
   Prostate gland/a produces an alkaline fluid/a that neutralises acids/a produced in the vagina, so that sperm cells are protected.a
   Cowper’s gland/a produces mucus/a that helps with the movement/a of sperm cells. (10)

2. Testes/a (1)

3. Testosterone is responsible for the development of male secondary sexual characteristics/a and it stimulates the maturation of sperm cells.a (2)

4. Mitochondria/a provide energy for swimming/a.
   Tail/a moves in a whip-like fashion to propel the sperm cell forwards/a. (4)

5. The nucleus contains 23 chromosomes (n)/a, and fuses with the nucleus of an egg cell, which also contains 23 chromosomes (n)/a. The result is a zygote with 46 chromosomes (2n)/a. (3)

[20]
9.2.2 Female reproductive system

Figure 9.4 below shows the different parts of the female reproductive system and their functions.

**Activity 3**

**Questions**

Provide the correct biological term for the following definitions.

1. The inner lining of the uterus
2. Tube that connects the ovaries to the uterus
3. The part that produces female hormones
4. The part where the embryo and foetus is kept during pregnancy

**Answers to activity 3**

1. Endometrium✓
2. Fallopian tube✓
3. Ovary/placenta✓
4. Uterus✓
Menstrual cycle
The series of diagrams in Figure 9.5 below shows the events occurring in the ovary (ovarian cycle) and uterus (uterine cycle) during the menstrual cycle. The days are not exact, but are averages.

Day 1–7
Ovaries: New follicles develop and secrete oestrogen
Uterus: Lining breaks down and is released (menstruation)

Day 8–13
Ovaries: Mature Graafian follicle develops:
• The Graafian follicle moves to edge of the ovary
• It secretes oestrogen
Uterus: Oestrogen stimulates the endometrium to become thicker and develop more blood vessels and glands

Day 14
Ovaries: Graafian follicle bursts to release an egg cell. The process is called ovulation

Day 15–22
Ovaries: The Graafian follicle becomes a corpus luteum that secretes progesterone
Uterus: Progesterone stimulates the endometrium to become even thicker and to develop more blood vessels and glands, ready to receive the embryo if an egg cell is fertilised

Day 23–28
Ovaries: If fertilisation does not take place:
• The corpus luteum shrinks and stops secreting progesterone

If fertilisation takes place:
• The corpus luteum remains active in the ovary and continues to secrete progesterone
• No more follicles develop in the ovaries
• No menstruation takes place

Whoever said Life Sciences is hard was ovary-acting!

Figure 9.5 The menstrual cycle
Hormonal control of the menstrual cycle

The graph in Figure 9.6 below shows changes in the ovary, uterus and in the level of hormones during a 28-day menstrual cycle.

Figure 9.6 Hormonal regulation of the female reproductive cycle

The hormonal changes that take place at A, B, C and D in the graph in Figure 9.6 above are explained in Table 9.1 below.

<table>
<thead>
<tr>
<th>Day</th>
<th>A Pituitary/hypophysis hormone levels</th>
<th>B Growth of follicle</th>
<th>C Ovarian hormone levels</th>
<th>D Thickness of uterine lining/endometrium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 0–11</td>
<td>Pituitary gland produces FSH which stimulates development of the follicle.</td>
<td>Follicle is developing to become a Graafian follicle containing an egg cell.</td>
<td>Oestrogen levels increase as the hormone is produced by the follicle.</td>
<td>Thickness of endometrium increases from day 7 (after menstruation has ended) as a result of oestrogen.</td>
</tr>
<tr>
<td>Day 11–17</td>
<td>FSH and LH (produced by the pituitary gland) levels are highest around day 14.</td>
<td>Follicle development is completed as a result of the influence of FSH by day 14. Ovulation is stimulated by high levels of FSH and LH on day 14. LH then stimulates the development of the corpus luteum.</td>
<td>Oestrogen levels reach a maximum towards day 14 until ovulation takes place, but then start to decrease because the Graafian follicle stops functioning.</td>
<td>Endometrium thickens further.</td>
</tr>
<tr>
<td>Day 17–28</td>
<td>LH levels decrease and then remain constant to maintain the corpus luteum.</td>
<td>Corpus luteum produces progesterone. Corpus luteum gradually disintegrates since fertilisation does not take place.</td>
<td>Oestrogen levels increase again and then decrease towards the end of the cycle. Progesterone levels increase towards day 21. Progesterone levels decrease when corpus luteum disintegrates and stops functioning.</td>
<td>Progesterone prepares endometrium fully for pregnancy. Decreased progesterone levels from around day 21 cause endometrium to shed after day 28 by menstruation since no fertilisation took place.</td>
</tr>
</tbody>
</table>

Table 9.1 Hormonal changes during the menstrual cycle
Activity 4

Study Figure 9.7 below and answer the questions that follow.

Figure 9.7 Hormonal changes during the menstrual cycle

1. Name the hormones A and B. (2)
2. Give reasons for your answers in question 1. (2)
3. What event occurs on day 14? (1)
4. Name the other two hormones involved in this cycle. (2)
5. Did fertilisation occur during the cycle shown in Figure 9.7? (1)
6. Explain your answer in question 5. (2)

Answers to activity 4

1. A – Oestrogen✓ B – Progesterone✓ (2)
2. A: The Graafian follicle secretes oestrogen✓/Oestrogen reaches its maximum level before ovulation✓
   B: The corpus luteum produces progesterone✓/Progesterone reaches its maximum level after ovulation✓ (2)
3. Ovulation✓ (1)
4. LH✓ and FSH✓ (2)
5. No✓ (1)
6. Progesterone levels decrease✓ towards the end of the cycle.
   The corpus luteum decreases✓ in size. (2)

[10]

Hint

Here is a hint to help you to remember the names of the two hormones:
- O stands for Oestrogen and when it is high, Ovulation occurs.
- P stands for Progesterone and when it remains high, there is a Pregnancy.
Development of foetus

Figure 9.8 below shows the stages in the development of the foetus.

Explanation of Figure 9.8

1. In the ovary a mature Graafian follicle bursts (usually on day 14 of the menstrual cycle) and releases an egg cell. This process is called **ovulation**.

2. **Fertilisation** takes place high up in the fallopian tube. The egg cell (containing 23 chromosomes) and sperm cell (containing 23 chromosomes) fuse to form a zygote (containing 46 chromosomes).

3. The zygote divides by mitosis to form an **embryo** (a ball of cells) as it moves down the fallopian tube.

4. It takes about 5 to 7 days for the embryo to reach the **uterus**.

5. In the uterus the embryo settles on the endometrium and sinks into it, embedding itself in the endometrium. This process is called **implantation**.

6. After implantation, the embryo produces many finger-like structures called villi from the outer membrane of the embryo, which is known as the **chorion**.

7. The villi grow into the tissue of the uterus to form a **placenta**.

8. The placenta is attached to the embryo by the **umbilical cord**.

9. The embryo is enclosed in a fluid-filled sac called the **amnion**. The fluid is called the amniotic fluid.

10. After about 8 weeks, the embryo develops structures such as limbs and all the organs of the body. Now it is called a **foetus**.

Use this word mnemonic to help you remember the stages in the development of the foetus.

**Activity 5**

**Questions**

1. On which day of the menstrual cycle does ovulation usually take place? (1)

2. What happens to the Graafian follicle after ovulation? (1)

3. Name the TWO hormones that are released by structures in the ovaries. (2)
4. Give THREE functions of the amniotic fluid. 
   (3)

5. Give TWO substances that can move from the mother to the foetus through the placenta. 
   (2)

6. Give TWO substances that can move from the foetus to the mother through the placenta. 
   (2)

Answers to activity 5

1. Day 14✓
   (1)

2. It changes into a corpus luteum✓
   (1)

3. Oestrogen✓ and progesterone✓
   (2)

4. The amniotic fluid protects the foetus against shock✓, drying out✓ and temperature changes✓
   (3)

5. Oxygen✓, nutrients✓ (amino acids, glucose, other sugars), viruses✓ and drugs✓
   (2)

6. Carbon dioxide✓ and waste products✓ (urea).
   (2)

9.2.3 Contraceptive methods and their effect on human reproduction

Contraceptives are used by humans to prevent pregnancy. There are many different methods that can be used to do this. Table 9.2 below lists some contraceptive methods and how they affect human reproduction.

<table>
<thead>
<tr>
<th>Method</th>
<th>Effect on human reproduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condom</td>
<td>Acts as a barrier, stops sperm getting into the vagina</td>
</tr>
<tr>
<td>Loop/IUD</td>
<td>Prevents fertilised eggs/embryos from becoming attached to the uterine wall</td>
</tr>
<tr>
<td>Female condom (femidom)</td>
<td>Acts as a barrier, stops sperm getting into the uterus/fallopian tubes</td>
</tr>
<tr>
<td>Diaphragm</td>
<td>Acts as a barrier as it covers the cervical opening and prevents sperm from entering the uterus</td>
</tr>
<tr>
<td>Contraceptive pill</td>
<td>Contains artificially produced hormones which prevent the production of eggs/ovulation</td>
</tr>
<tr>
<td>Spermicide</td>
<td>Contains a chemical substance that kills sperm and it also acts as a barrier, which prevents sperm from entering through the cervix</td>
</tr>
<tr>
<td>Contraceptive injection</td>
<td>Contains progesterone/combofination of oestrogen and progesterone, which stops ovulation; it works for 2 to 3 months</td>
</tr>
<tr>
<td>Male sterilisation (vasectomy)</td>
<td>The sperm ducts are cut and tied; semen without sperm is produced</td>
</tr>
<tr>
<td>Female sterilisation (tubal ligation)</td>
<td>The fallopian tubes are cut and tied during a small surgical operation preventing the fusion of sperm and egg</td>
</tr>
<tr>
<td>Withdrawal</td>
<td>The penis is taken out of the vagina before ejaculation, but this is not a safe method because many sperms can be released before ejaculation</td>
</tr>
<tr>
<td>Rhythm</td>
<td>Sexual intercourse is avoided three to four days before and after ovulation (between days 10 and 18 of the menstrual cycle)</td>
</tr>
</tbody>
</table>

Table 9.2 Contraceptive methods and their effect on human reproduction
Activity 6

Questions

1. Name TWO:
   a) contraceptives that contain female hormones. (2)
   b) methods of contraception that involve surgery. (2)
   c) barrier methods of contraception. (2)

2. Explain how an IUD prevents pregnancy. (2)

3. Explain the difference between a barrier method of contraception and a contraceptive that uses hormones. (5)

Answers to activity 6

1. a) Contraceptive pill✓ and contraceptive injection✓ (2)
   b) Vasectomy✓ and tubal ligation✓ (2)
   c) Condom✓, female condom✓ and diaphragm✓ (2)

2. It prevents the embryo✓ from becoming attached to the uterine wall.✓ (2)

3. A barrier method blocks the pathway of sperm cells✓ and they are prevented from reaching the egg cell✓. Fertilisation cannot take place. A hormonal contraceptive contains female hormones✓ that prevent ovulation✓. No egg cells are produced✓, therefore fertilisation cannot take place✓. (5)

Keep going!
10.1 Population size

Figure 10.1 below shows how the size of a population changes. The factors indicated by arrows entering the circle will lead to an increase in population size. The factors indicated by arrows leaving the circle will lead to a decrease in population size.

**Migration**
- Periodic movement of organisms into and out of a population

**Natality**
- Births
- Increases population size

**Mortality**
- Deaths
- Decreases population size

**Immigration**
- One-way movement of organisms into a population
- Increases population size

**Emigration**
- One-way movement of organisms out of a population
- Decreases population size

*Figure 10.1 Changes in population size*

Remember the difference between EMIGRATION and IMMIGRATION:
- Emigration is when you EXIT a population (E)
- Immigration is when you come INTO a population (I)
10.2 Population growth forms

10.2.1 Logistic (S-shaped) growth form

The graph in Figure 10.2 below shows a logistic (S-shaped) growth form. Note how the graph is divided into four phases.

1. **Lag phase**: Population grows slowly, because the organisms are becoming acclimatised to (getting used to) the new environment.

2. **Accelerating (geometric) growth phase**: The population size increases rapidly because there is plenty of food and space, and very little competition.

3. **Decelerating growth phase**: The growth rate decreases due to an increase in environmental resistance.

4. **Equilibrium (stationary) phase**: The population size reaches carrying capacity and environmental resistance occurs. In general natality equals mortality.

**Carrying capacity** is the maximum population size that can be supported by a particular environment.

**Environmental resistance** refers to all the factors that prevent a population from increasing, for example, shortage of food and water, limited space, disease, and so on.
10.2.2 Geometric (J-shaped) growth form

The graph in Figure 10.3 below shows a geometric (J-shaped) growth form. Note that this growth form only has two phases: a lag phase and an accelerating (geometric) growth phase. Study the graph and then read the explanations below.

![Figure 10.3 Geometric (J-shaped) growth form](image)

In this growth form the population size increases rapidly with time because of availability of enough food, water and space.

The increase in the human population, in general, follows the same geometric growth form. Possible reasons for this are:

- Decrease in mortality (death rate)
- Increase in natality (birth rate) of a population
- Improved health services
- Improved quality of nutrition
- Little or no environmental resistance
Activity 1

The graph in Figure 10.4 below shows the growth of a population over a period of time. Study the graph and answer the questions that follow.

Figure 10.4 Growth of a population over a period of time

1. Identify the growth form indicated by the graph. (1)
2. Identify the phases labelled A, B and C. (3)
3. Write down the letter (A, B or C) of the phase in the graph which shows rapid growth. (1)
4. Explain why the population size at C stayed constant. (3)
5. Give TWO reasons why the population growth at A was slow. (2)

Answers to activity 1

1. Logistic growth form/S-shaped (1)
2. A – Lag phase
   B – Accelerating/ geometric phase
   C – Equilibrium/ stationary phase (3)
3. B✓ (1)
4. • Environmental resistance increased ✓
   • causing the carrying capacity of the area to be reached ✓
   • leading to increased competition ✓
   • resulting in the death rate increasing to equal the birth rate ✓
   • or resulting in increased emigration that balances with immigration ✓
   (any 3) (3)
5. • Population is acclimatising/adapting to its new environment ✓
   • Few pairing partners ✓
   • Time required to produce offspring is relatively long ✓
   • Not all individuals are sexually mature ✓
   (any 2) (2)
10.3 Age and gender distribution pyramids of developing and developed countries

Study the graphs in Figures 10.5 (top right) and 10.6 (bottom right) and then read the explanations:

Figure 10.5 shows the age and gender pyramid of a developing country:
• This pyramid has a triangular shape with a wide base and a narrow top.
• It shows a small number of old people (older than 50 years). This is an indication that the population has a high birth rate, a high death rate and a short life expectancy.
• Examples of developing countries are South Africa, Brazil and India.

Figure 10.6 shows the age and gender pyramid of a developed country:
• This pyramid has a narrower base.
• It shows a large number of old people. This is an indication that the population has a low birth rate, a low death rate and a long life expectancy.
• Examples of developed countries are Germany and the USA.
10.4 Methods to determine population size

There are two ways of determining population size:

- **Direct technique**: This involves counting all the individuals in a population. It is also known as the census method.
- **Indirect techniques**: We use these techniques to estimate the population size. There are two indirect techniques, namely the mark–recapture method and the quadrant method (also called the simple sampling method).

10.4.1 Mark–recapture method

This method is used to estimate the size of an animal population and it involves two stages:

- A sample of animals (first sample) are captured and marked in some way. The marked animals are then released into the population.
- A second sample is then taken and the number of animals in this sample is recorded. The number of marked animals (from the first sample) in this second sample is also recorded.

We use the following formula to estimate the population size:

\[ P = \frac{F \times S}{M} \]

Where:
- \( P \) = Estimated population
- \( F \) = Total number of animals caught in first sample and marked
- \( S \) = Total number of animals caught in second sample (i.e., recaptured)
- \( M \) = Total number of marked animals in the second sample

**Activity 2**

A group of Grade 12 learners wanted to use the mark–recapture method to determine the population size of a type of fish (*Tilapia sparrmanii*) in a large dam. Their results are shown in the table.

<table>
<thead>
<tr>
<th></th>
<th>October 2010</th>
<th>November 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number marked and released in first sample</td>
<td>Number in recaptured/second sample</td>
</tr>
<tr>
<td><em>Tilapia sparrmanii</em></td>
<td>15</td>
<td>150</td>
</tr>
</tbody>
</table>
Question

Use the formula below to estimate the population size of *Tilapia sparrmanii* in the dam. Show ALL working. [3]

\[
P = \frac{F \times S}{M}
\]

Where:

- \( P \) = Estimated population
- \( F \) = Total number of animals caught in first sample and marked
- \( S \) = Total number of animals caught in second sample (ie recaptured)
- \( M \) = Total number of marked animals in the second sample

**Answer to activity 2**

\[
P = \frac{F \times S}{M} = \frac{(15 \times 150)}{10} = 225 \text{ fish}
\] [3]

10.4.2 Quadrant or simple sampling method

With this method, you make a physical count of all the plants in a small sample area of the habitat and then calculate the total population using the formula:

\[
\text{Estimated total number of plants} = \frac{\text{Number of plants in sample} \times \text{Habitat size}}{\text{Sample size}}
\]

**Activity 3**

**Question**

In an investigation to find the number of African potato plants in a field of area 6 000 m\(^2\), three plots were selected, each with an area of 10 m\(^2\). Plot 1 contained three African potato plants and the other two plots contained seven and two African potato plants, respectively.

1. What indirect method was used to estimate the population size? (1)
2. How should the plots be selected to obtain a reliable estimate? (1)
3. Estimate the total number of African potato plants in the field. Show all working. (3) [5]

**Answer to activity 3**

1. Simple sampling//quadrant method (1)
2. Randomly\(\sqrt{}\) (1)
3. (Average number per plot \(3 + 7 + 2 = \frac{12}{3} = 4\))

\[
\text{Estimated total number of plants} = \frac{\text{Number of plants in sample} \times \text{Habitat size}}{\text{Sample size}} = 4\sqrt{} \times \frac{6000}{10} = 2400\sqrt{}\text{plants}
\] (3) [5]

---

Mind the Gap

Chapter 10 Population and community ecology (Paper 2) 
Environmental studies
10.5 Interactions in a community

10.5.1 Predation

Predation is the feeding interaction between a predator and prey.
- The predator is an animal that hunts, captures and kills other animals (prey) for food.
- The prey is the animal being hunted and killed. As the prey population increases, the predator population will also increase, and vice versa.

In a balanced habitat the number of prey is always greater than the number of predators. In Figure 10.7 (left), A is the prey population and B is the predator population.

10.5.2 Competition

Competition is the interaction between organisms that compete for resources in the environment when these are in short supply. There are three types of competition:
- Intraspecific competition: This is competition between organisms of the same species that depend on the same resources, such as food, space, shelter, water and access to mates. Example: two lions competing for a mating partner.
- Interspecific competition: This is competition between organisms of different species that depend on the same resources, for example light, space, water, shelter or food. Example: a lion and hyena competing for food.
- Competitive exclusion: This is a type of competition where one of the two competing species is much more successful than the other, such that the successful species survives and the other species dies out.

In the graph in Figure 10.8 below, P. aurelia is much more successful and survives, while P. caudatum dies out.
10.5.3 Resource partitioning

This is a type of interaction where different species co-exist in the same habitat since they use the resources slightly differently.

In Figure 10.9 (right), three different species co-exist in the same habitat because they eat leaves of a plant at different heights. In other words, they use the resource slightly differently and this reduces competition.

10.5.4 Symbiosis

Symbiosis is a type of interaction where organisms are either directly or indirectly dependent on each other for survival. The flow diagram in Figure 10.10 below illustrates three types of symbiotic relationships, namely mutualism, commensalism and parasitism.

**Figure 10.9 Resource partitioning**

**Figure 10.10 The three types of symbiosis**

- **Mutualism**: Both species benefit from the relationship.
  - **Example**: Bees get nectar from flowers and flowers get pollinated.

- **Commensalism**: One species benefits and the other species is not harmed.
  - **Example**: Birds nest in trees. Birds benefit and trees are not harmed.

- **Parasitism**: The parasite benefits while the host is harmed.
  - **Example**: Ticks (parasite) suck the blood of a dog (host). The ticks get food while the dog suffers blood loss and runs the risk of infection.
10.6 Ecological succession

Ecological succession refers to a gradual change in the numbers and variety of organisms living in a habitat, leading to a climax community (a relatively stable community). There are two types of succession:

- **Primary succession**: This is a gradual change in the numbers and variety of organisms living in a new habitat, beginning with pioneer plants and ending with a climax community. Example: pioneers occupying a new sand dune.

- **Secondary succession**: A gradual change in the numbers and variety of organisms that occupy a disturbed habitat or when an established community has been disturbed due to a catastrophic event. Example: succession after a veld fire.

### Activity 4

**Question**

Indicate whether each of the statements in COLUMN 1 applies to A only, B only, both A and B or none of the items in COLUMN 2. Write A only, B only, both A and B or None next to the question number (1 to 8).

<table>
<thead>
<tr>
<th>COLUMN 1</th>
<th>COLUMN 2</th>
</tr>
</thead>
</table>
| 1. This would have no effect on the population size | A: Emigration  
B: Immigration |
| 2. A small portion of the population is counted and then used to work out the size of the whole population | A: Census  
B: Simple sampling |
| 3. Competition between cows and goats for grass | A: Interspecific  
B: Intraspecific |
| 4. A relationship between different species in which both benefit | A: Commensalism  
B: Mutualism |
| 5. The periodic movement out of and return to a habitat by living organisms | A: Immigration  
B: Emigration |
| 6. The elimination of one species by another in a habitat as a result of dependence on a common resource | A: Intraspecific competition  
B: Competitive exclusion |
| 7. The maximum size of a population that can be supported by a habitat under the conditions prevailing at any particular time | A: Carrying capacity  
B: Environmental resistance |
| 8. The use of resources in slightly different ways by different species in the same habitat allowing them to co-exist | A: Resource partitioning  
B: Competitive exclusion |

(8 × 2)

[16]

### Answers to activity 4

1. None✓✓  
2. B only✓✓  
3. A only✓✓  
4. B only✓✓  
5. None✓✓  
6. B only✓✓  
7. A only✓✓  
8. A only✓✓  

(8 × 2)

[16]
11.1 Drawing graphs

Graphs and charts condense large amounts of information in a format that is easier to understand, showing important points clearly and effectively.

1. **Line graphs** show the relationship between two types of information where the independent variable is continuous. Line graphs are useful in showing trends over time and are often used for biological data.

2. **Bar graphs** show different categories of data and are used when the independent variable is not a set of continuous numbers or continuous groups (discontinuous data). They are best used to compare values across categories.

3. **Histograms** have connected bars displaying continuous data. They are used when the values of the independent variables are continuous but fit into categories or groups that follow on after the other.

4. **Pie charts** are circular charts used to compare parts of the whole. They are divided into sectors that are equal in size to the quantity represented. They are used for discontinuous data.

### 11.1.1 How to draw a line graph

#### Step 1
Identify the dependent and the independent variables from the information you are given (usually in table format).

- **Dependent**: This is the variable or factor that is being measured, i.e. the temperature in degrees Celsius in this example.

- **Independent**: This is the variable that the investigator can change. The dependent variable changes as the independent variable changes, i.e. the time in hours in this example.

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>9</td>
<td>28</td>
</tr>
<tr>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>24</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 11.1 Air temperature recorded over a 24 hour period
Step 2
Draw a set of axes and label the X and Y axes. The dependent variable goes on the Y-axis and the independent variable on the X-axis. Include the unit in each label, e.g. temperature in °C and time in hours. Do NOT forget to label the axes.

Step 3
Choose a scale for the X and the Y axes. Make sure that the scale includes the highest numbers in the table for each of the variables. Do not use the values for the Y-axis directly from the table unless they have regular intervals.

Step 4
Place a dot at the point where the two values for each result intersect (meet). In the example, the point where 5 hours and 24 °C intersect on the graph is indicated by the second dot on the graph. Plot all the points using the information in the table.

Step 5
Join the dots using a ruler until all the dots have been joined in sequence.

Step 6
Give the graph a heading or caption. The heading or caption should include both variables. In this case both air temperature and the time period of 24 hours must be mentioned in the heading.

If the graph has two lines on it, then you should draw a Key to show what the different lines represent. For example if there was another line on this graph for rainfall, then your Key might look like this:

KEY
---- temperature
------ rainfall

Figure 11.2 Draw the axes and choose a scale

Figure 11.3 Plot the points on the graph and join them

Figure 11.4 Final line graph with heading
11.1.2 How to draw a bar graph

Steps 1 to 3
To draw a bar graph, you follow the same first three steps that you followed to draw a line graph. Use the table to identify the dependent and independent variables. Draw the axes and choose a scale. Note that there will be no units when labelling the X- and the Y-axes in this particular graph.

<table>
<thead>
<tr>
<th>Point number</th>
<th>Number of organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 11.2 Number of organisms found in the water at different points along a river

![Figure 11.5 Draw the axes and choose a scale](image)

Step 4
Draw a bar to show that 10 organisms were found at point number 1 on the river. Then draw bars to represent the number of organisms found at each of the points along the river. Since this is a bar graph, the bars should not touch as the points along the river have no direct relationship with each other.

![Figure 11.6 Draw the first bar](image)

Step 5
Give the graph a heading or caption. See step 6 under the line graph for instruction on how to give your graph a heading or caption.

Note the following:
- The spaces between the bars should all be the same width.
- The bars themselves should all be the same width.

![Figure 11.7 Final bar graph with heading](image)
11.1.3 How to draw a histogram

A histogram is drawn in exactly the same way as a bar graph. The only difference is that a histogram is used when the independent variable is groups of information along a continuous scale. Note that in a histogram, the bars are drawn without any spaces between them. Use the information in Table 11.3 below to draw a histogram. Your graph should look like the one in Figure 11.8 below.

<table>
<thead>
<tr>
<th>Range (%)</th>
<th>Number of pupils</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–19</td>
<td>0</td>
</tr>
<tr>
<td>20–39</td>
<td>5</td>
</tr>
<tr>
<td>40–59</td>
<td>11</td>
</tr>
<tr>
<td>60–79</td>
<td>16</td>
</tr>
<tr>
<td>80–100</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 11.3 Number of learners with a particular percentage (%) score

![Figure 11.8 Final histogram with heading]

NOTE:

When the independent variable is continuous data (an infinite number of values are evenly distributed), we use a line graph or histogram.

When the independent variable is discontinuous data (a fixed number of values that do not form an ordered scale), we use a bar graph or pie chart.
11.1.4 How to draw a pie chart

**Step 1**
Add all the data in the table together. In this case, you will add all the numbers in the 'Number of women' column to find out how many women took part in the investigation.

\[34 + 38 + 22 + 30 + 76 = 200\]

When you do the calculations for the pie chart, then ‘200’ will be the denominator (the number that you divide by).

**Step 2**
Convert your data to angles. Divide each number by 200. Then, since there are 360° in a circle, the angles are worked out by multiplying by 360.

<table>
<thead>
<tr>
<th>Contraceptive</th>
<th>Number of women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterilisation</td>
<td>34</td>
</tr>
<tr>
<td>Pill</td>
<td>38</td>
</tr>
<tr>
<td>Condom</td>
<td>22</td>
</tr>
<tr>
<td>Rhythm method</td>
<td>30</td>
</tr>
<tr>
<td>None</td>
<td>76</td>
</tr>
</tbody>
</table>

*Table 11.4 Table of contraceptive use by a sample group of women*

\[
\begin{align*}
\frac{34}{200} \times 360 &= 61,2° \text{ (round down to 61°)} \\
\frac{38}{200} \times 360 &= 68,4° \text{ (round down to 68°)} \\
\frac{76}{200} \times 360 &= 136,8° \text{ (round up to 137°)} \\
\frac{22}{200} \times 360 &= 39,6° \text{ (round up to 40°)}
\end{align*}
\]

Check that your calculations are correct. All the degrees should add up to 360°. In our example:

\[61° + 68° + 40° + 54° + 137° = 360°\]

If the degrees don’t add up to 360°, you have done something wrong. Go back and check your work.

**Step 3**
Use a mathematical compass to draw a circle.

**Step 4**
Draw in one radius on the circle. Start at the exact middle of the circle and draw a line to the edge of the circle.

*Figure 11.9 Draw a circle and then draw a radius*

**Step 5**
Use a mathematical protractor to measure out the sectors of the pie chart according to the angles you calculated in step 2.

*Figure 11.10 Measure out the sectors*
Step 6
Label each of the sections of the pie chart with the correct information. In this example, each section should be labelled with the correct contraceptive method used by women (OR provide a key for the different sections).

Step 7
Give the pie chart a heading or caption. Remember that both variables should be included in the heading or caption. In this example the two variables are the type of contraceptive and the number of women.

Pie chart to show contraceptive use among a sample group of women

None 76
Sterilised 34
Pill 38
Rhythm method 30
Condom 22

Figure 11.11 Final pie chart with heading

Remember to take a calculator, a compass and a protractor into the exam with you.

Exams
For four more problems on graphs, refer to the following National Life Sciences exam papers:

- Life Sciences Paper 1 March 2012 – Question 4.1 on page 14 – an example of a pie chart.
- Life Sciences Paper 2 March 2012 – Question 3.1 on page 12 – an example of a line graph.
- Life Sciences Paper 1 November 2011: Version 1 – Question 2.3 on page 8 – an example of a histogram.
11.2 Answering essay questions

The essay in the final examination is allocated 20 marks. Answering this question requires planning. Let us look at the planning steps using the following essay question, which appeared in the Life Sciences Paper 2 March 2012: Version 1 exam paper, as an example.

Describe the role of the hypothalamus and the adrenal glands in bringing about changes to the blood vessels of the human skin and explain why these changes take place.

Content (17)
Synthesis (3)
(20)

Step 1
Read the essay question thoroughly to determine the topics that are being covered. Underline the key words in the essay question that provide clues to the different topics:

Nervous system – since the hypothalamus (a part of the brain) is involved
Endocrine system – since adrenal glands are involved
Temperature regulation – since this involves blood vessels of the skin

Step 2
Interpret and analyse the essay question. Identify the aspects or processes that are required from each of the topics identified. You may need to read the question more than once to enable you to do this.

Hypothalamus – What effect does it have on the blood vessels of the skin?
Adrenal glands – What effect do they have on the blood vessels of the skin?

If you cover the above in your essay you will only be answering the ‘describe’ part required by the essay question.

Note that the essay also requires an ‘explanation’ of why these changes take place. For the explanation, you need to elaborate on the functions of the hypothalamus and the adrenal gland that involves the blood vessels of the skin as follows:

Hypothalamus – controls body temperature by stimulating a change in the diameter of the blood vessels of the skin.

Adrenal glands secrete adrenaline into the bloodstream, which decreases the diameter of the blood vessels of the skin so that more blood (with oxygen and glucose) can be directed to other parts of the body to prepare for an emergency.
Step 3

Write the first draft of your essay in a logical and organised manner, linking each aspect that is discussed. This will help you obtain a high mark from the 3 marks allocated for the synthesis of your essay.

Your plan or draft of the essay may take the form of a flow diagram. But note that your final answer to the essay CANNOT be in the form of a flow diagram.

Step 4

Write out the final version of your essay. Put a line across the plan of your essay so that the marker assesses your final answer and not your plan or draft.

Step 5

Now read the question again one more time to check if your answer corresponds to the question.

Proofread your essay carefully. This is your opportunity to pick out any spelling errors or incomplete words, sentences or ideas.
11.3 Line drawings

In the exam, you may be asked to draw a labelled diagram. Keep these tips in mind if you are asked to draw a labelled diagram:

- Draw in pencil and use neat, strong lines.
- Do not use shading in your diagram.
- Your diagram must not be too small. It must be clear and correctly proportioned.
- The label lines must point directly to the structure that is being labelled.
- The label lines should not have arrow points.
- If possible, label lines should all end at the same point so that the labels are neatly aligned.
- Label lines should never cross. If two label lines cross, neither label will be marked.
- Print the labels neatly in pen.
- Finally, give your diagram a descriptive heading that states exactly what it illustrates.

To enable you to practise your drawing and labelling skills, we have included the diagrams from this guide on the following pages.
Appendix 1: Blank drawings

In this section you will find a number of key diagrams from this study guide. These blank diagrams can help you prepare for the exam in two ways:

1. You can use them to practise your drawing and labelling skills. You may be asked to draw a diagram in the exam, so make sure you follow the guidelines set out on page 93 when you redraw and label a diagram.

2. These diagrams are a valuable study aid. They summarise key information and important processes in Life Sciences. If you can label all these diagrams correctly on your own, without looking at them in the text, you'll be well prepared for the exam.

The following diagrams are included:

**Topic 1: Nucleic acids**
- Nucleotide
- DNA
- RNA
- Replication of DNA
- Protein synthesis

**Topic 2: Meiosis**
- Homologous chromosomes
- Stages in meiosis I
- Stages in meiosis II

**Topic 4: Evolution**
- Characteristics we share with primates
- Characteristics that make us different

**Topic 6: Human nervous system**
- Brain
- Neuron
- Reflex arc
- Eye
- Accommodation
- Pupillary mechanism
- Ear

**Topic 7: Endocrine system**
- Name, position and functions of glands

**Topic 8: Temperature regulation**
- Skin regulating temperature on a hot and cold day

**Topic 9: Reproduction**
- Male reproductive system
- Sperm cell
- Female reproductive system
- Hormonal control of the menstrual cycle
- Fertilisation and gestation

**Topic 10: Population and community studies**
- Factors that influence the size of a population
- Logistic (S-shaped) growth form
- Geometric (J-shaped) growth form
- Predator–prey relationship
- Symbiosis relationships

Before you write on the diagrams, photocopy the pages so you can use them to practise, practise, practise!
Topic 1: Nucleic acids

1. Nucleotide

2. DNA

3. RNA
4. Replication of DNA
5. **Protein synthesis**
Topic 2: Meiosis

1. Homologous chromosomes

2. Meiosis I
3. **Meiosis II**

<table>
<thead>
<tr>
<th><img src="image1" alt="Meiosis II Diagram 1" /></th>
<th><img src="image2" alt="Meiosis II Diagram 2" /></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Meiosis II Diagram 3" /></td>
<td><img src="image4" alt="Meiosis II Diagram 4" /></td>
</tr>
<tr>
<td><img src="image5" alt="Meiosis II Diagram 5" /></td>
<td><img src="image6" alt="Meiosis II Diagram 6" /></td>
</tr>
<tr>
<td><img src="image7" alt="Meiosis II Diagram 7" /></td>
<td><img src="image8" alt="Meiosis II Diagram 8" /></td>
</tr>
</tbody>
</table>
Topic 4: Evolution

1. Characteristics we share with primates

2. Characteristics that make us different
Topic 6: Human nervous system

1. Brain
2. Neuron
3. Reflex arc
4. Eye
5. Accommodation

6. Pupillary mechanism
7. Ear
Topic 7: Endocrine system

1. Name, position and functions of glands
1. Skin regulating temperature on a hot and cold day
Topic 9: Reproduction

1. Male reproductive system

2. Sperm cell
3. Female reproductive system
4. Hormonal control of the menstrual cycle
5. Fertilisation and gestation
Topic 10: Population and community studies

1. Factors that influence the size of a population

2. Logistic (S-shaped) growth form
3. Geometric (J-shaped) growth form

4. Predator–prey relationship
5. Symbiosis relationships

Example:

Example:

Example:
Appendix 2: Past Grade 12 exam papers

In this section you will find:

- Grade 12 National Life Sciences Paper 1 from February/March 2012 (pages 117 – 124)
- Grade 12 National Life Sciences Paper 1 marking Memorandum from February/March 2012 (pages 124 – 129)
- Grade 12 National Life Sciences Paper 2 from February/March 2012 (pages 130 – 137)
- Grade 12 National Life Sciences Paper 2 marking Memorandum from February/March 2012 (pages 138 – 142)

Use these exam papers and memoranda to help you prepare for your exams:

1. **Answer the questions** in Life Sciences Paper 1. Make sure you take a break before doing the same with Paper 2. Treat them as “real” exams by preparing yourself as if these were real exams, so have the paper, pens, pencils, eraser and other materials that you need. **Time yourself** so you complete each paper within the 2 ½ hours that is allocated to them. This exercise is meant to test your own knowledge – so **don’t cheat** yourself by looking up the answers in the memo before you’ve finished each exam.

2. **Use the memoranda to check whether or not your answers are correct.** Note where you have got answers wrong – these are the sections of the curriculum that you need to do more work on. Go back to your textbooks and to the relevant sections of this study guide, and **spend time learning** the sections for which you got the lowest marks.
SECTION A

QUESTION 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the question number (1.1.1 to 1.1.10) in your ANSWER BOOK, for example 1.1.1 D.

1.1.1 Genes only code for ....
A starch
B proteins
C glucose
D fats

1.1.2 The wings of a butterfly and the wings of a bird are examples of ...
A homologous structures
B vestigial structures
C analogous structures
D common ancestry

1.1.3 Which ONE of the following is an acceptable explanation based on Darwin's theory of evolution?
A Humans evolved from apes
B A mother who had her appendix removed will give birth to children without an appendix
C An increasing number of TB-causing bacteria are resistant to antibiotics because those that are resistant are able to survive and reproduce
D Giraffes have long necks because the previous generation stretched their necks to reach the leaves in tall trees

1.1.4 As DNA was extracted from cells of E. coli it was analysed for its nitrogenous base composition. It was found that 38% of the bases are cytosine. What percentage of the bases are adenine?
A 12
B 24
C 38
D 62

1.1.5 Below is a list of fossils discovered in South Africa.
1. Mrs Ples
2. Taung child
3. Little foot
4. Karabo

Which of the fossils above are classified in the genus *Australopithecus*?
A 1, 2 and 3 only
B 1, 2, 3 and 4
C 2, 3 and 4 only
D 1, 3 and 4 only

1.1.6 A mother has blood group B and a father blood group O. They have three children and an adopted child. The blood groups of the children are represented in the table below.

<table>
<thead>
<tr>
<th>CHILDREN</th>
<th>BLOOD GROUPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sindy</td>
<td>AB</td>
</tr>
<tr>
<td>Nobubele</td>
<td>B</td>
</tr>
<tr>
<td>Kenny</td>
<td>O</td>
</tr>
<tr>
<td>Gabriele</td>
<td>B</td>
</tr>
</tbody>
</table>

Which child is adopted?
A Sindy
B Nobubele
C Gabriele
D Kenny
QUESTIONS 1.1.7 to 1.1.9 are based on the diagrammatic representation below of a part of two different nucleic acid molecules found in the cells of organisms during a stage in the process of protein synthesis.

![Diagram of nucleic acid molecules](image)

1.1.7 The diagram above illustrates the process of...
A replication.
B transcription.
C translation.
D mutation.

1.1.8 The process illustrated above occurs in the...
A cytoplasm.
B endosome.
C ribosome.
D nucleus.

1.1.9 An observable difference between molecule 1 and molecule 2 is that...
A molecule 1 is double stranded and molecule 2 is single stranded.
B molecule 1 contains deoxyribose sugars and molecule 2 contains ribose sugars.
C molecule 1 has thymine and molecule 2 has uracil.
D molecule 1 is longer than molecule 2.

1.1.10 The mRNA sequence from a portion of a DNA template GATCAA is...
A CTAGTT.
B CUAGUG.
C AGCTGG.
D AGCUUG.

1.2 Give the correct biological term for each of the following descriptions. Write only the term next to the question number (1.2.1 to 1.2.9) in your ANSWER BOOK.

1.2.1 An allele that is not shown/expressed in the phenotype when found in the heterozygous condition

1.2.2 Chromosomes other than the sex chromosomes

1.2.3 The production of genetically identical organisms using biotechnology

1.2.4 More than two haploid sets of chromosomes found in the cells of an organism

1.2.5 The transfer of a selected gene from one organism to another

1.2.6 A variable that is manipulated during an investigation

1.2.7 All the genes of a particular species

1.2.8 The position of a gene on a chromosome

1.2.9 The complete disappearance of a species from Earth
1.3 Indicate whether each of the statements in COLUMN I applies to A ONLY, B ONLY, BOTH A AND B or NONE of the items in COLUMN II. Write A only, B only, both A and B, or none next to the question number (1.3.1 to 1.3.6) in the ANSWER BOOK.

<table>
<thead>
<tr>
<th>COLUMN I</th>
<th>COLUMN II</th>
</tr>
</thead>
</table>
| 1.3.1 The study of the past and present distribution of individual species as evidence for evolution. | A: Palaeontology  
B: Biogeography |
| 1.3.2 The evidence used to support the 'Out of Africa' hypothesis by tracing the maternal lineage.  | A: Y chromosome  
B: Mitochondrial DNA |
| 1.3.3 Inheritance of the disorder linked to a sex chromosome. | A: Colour blindness  
B: Sickle cell anaemia |
| 1.3.4 First Homo species to have migrated out of Africa. | A: Homo habilis  
B: Homo sapiens |
| 1.3.5 Natural selection as an explanation for evolution. | A: Alfred Wallace  
B: Charles Darwin |
| 1.3.6 Organisms have an inherent/innate drive to change. | A: Lamarck  
B: Wallace |

1.4 The diagram below represents a cladogram (phylogenetic tree) showing primate evolution. The letters A to E, indicate the characteristics which are shared by the different species of primates which follow the letter. The point where various species of primates differ from each other is indicated by the branching-off/split into new species.

![Cladogram showing primate evolution](image)

1.4.1 Which LETTER represents a common characteristic of all primates?  

1.4.2 List THREE structural characteristics represented by the LETTER named in QUESTION 1.4.1.  

1.4.3 Which organism is most similar to the chimpanzee?  

1.4.4 Name any TWO structural characteristics of the skull that make the organism named in QUESTION 1.4.3 different from the chimpanzee.  

1.4.5 Write down the names of the organisms that display the characteristic C but not characteristics D and E.  

**TOTAL SECTION A: 50**
2.2 A karyotype is a map of the chromosomes in a cell. It is used to identify genetic disorders. A normal male karyotype is shown below. The chromosomes are arranged in pairs. A karyotype can be used to identify genetic disorders.

2.2.1 State ONE visible difference between the karyotype above and the karyotype of a normal male.

2.2.2 Use your knowledge of meiosis to explain how Klinefelter syndrome could have resulted.

2.3 A lady's mother had a twin of which they called a white foal. This white foal was dead at birth. The father does not have a white foal. The symbol for the recessive allele is h. Represent a genetic cross to determine the possible genotypes and phenotypes of the children.
2.4 Study the pedigree diagram below which shows the inheritance of flower colour in a certain plant over three generations.

Use the following symbols for the contrasting alleles:

- **W** – for white colour
- **R** – for red colour

**Pedigree diagram showing inheritance of flower colour in a certain type of plant over three generations**

**KEY:**

- White flower colour
- Red flower colour
- Flower with equal distribution of white and red colour

2.4.1 Name the type of inheritance shown in the pedigree diagram above. (1)

2.4.2 Explain your answer to QUESTION 2.4.1. (3)

2.4.3 Use the symbols **R** and **W** and write down the genotypes of each of the following flowers:

- (a) A
- (b) B
- (c) C

(3 x 2) [30]

**QUESTION 3**

3.1 A young couple wants to have a child, but they are aware of a serious genetic disorder in one of their families that could be carried through to their offspring.

In this case state:

3.1.1 ONE advantage of DNA testing

3.1.2 THREE benefits of genetic counselling

3.2 State **TWO** ways in which DNA profiling can be used to our advantage.

3.3 Tabulate the structural differences between australopithecines, such as *Australopithecus sediba*, and humans by referring to the size of the skeleton, caninum and the chin.

3.4 Read the passage below and then answer the questions that follow:

All types of domestic dogs are capable of interbreeding to produce puppies, which will eventually be capable of interbreeding with any other domestic dog. The first dog evolved from a population of wolves. It is thought that wolves that were tamer than usual ‘adopted’ humans in order to scavenge food from refuse dumps near human settlements.

Although wolves look very similar to some breeds of domestic dogs, wolves and domestic dogs cannot interbreed.

3.4.1 Explain why all breeds of domestic dogs belong to the same species. (2)

3.4.2 Describe how a population of wolves may have undergone speciation to form the first population of dogs. (6)

3.4.3 Describe how artificial selection led to different breeds of domestic dogs. (2)
PRINCIPLES RELATED TO MARKING LIFE SCIENCES 2012

1. If more information than marks allocated is given
   Stop marking when maximum marks is reached and put a wavy line and 'max' in the right-hand margin.

2. If, for example, three reasons are required and five are given
   Mark the first three irrespective of whether all or some are correct/incorrect.

3. If whole process is given when only part of it is required
   Read all and credit relevant part.

4. If comparisons are asked for and descriptions are given
   Accept if differences/similarities are clear.

5. If tabulation is required but paragraphs are given
   Candidates will lose marks for not tabulating.

6. If diagrams are given with annotations when descriptions are required
   Candidates will lose marks.

7. If flow charts are given instead of descriptions
   Candidates will lose marks.

8. If sequence is muddled and links do not make sense
   Where sequence and links are correct, credit. Where sequence and links is incorrect,
   do not credit. If sequence and links becomes correct again, resume credit.

9. Non-recognised abbreviations
   Accept if first defined in answer. If not defined, do not credit the unrecognized abbreviation but credit the rest of answer if correct.

10. Wrong numbering
    If answer fits into the correct sequence of questions but the wrong number is given, it is acceptable.

11. If language used changes the intended meaning
    Do not accept.

12. Spelling errors
    If recognizable accept provided it does not mean something else in Life Sciences or if it is out of context.

13. If common names given in terminology
    Accept provided it was accepted at the National memo discussion meeting.

14. If only letter is asked for and only name is given (and vice versa)
    No credit.

15. If units are not given in measurements
    Candidates will lose marks. Memorandum will allocate marks for units separately.

16. Be sensitive to the sense of an answer, which may be stated in a different way.

17. Caption
    All illustrations (diagrams, graphs, tables, etc.) must have a caption.

18. Code-switching of official languages (terms and concepts)
    A single word or two that appears in any official language other than the learners' assessment language used to the greatest extent in his/her answers should be credited, if it is correct. A marker that is proficient in the relevant official language should be consulted. This is applicable to all official languages.

19. No changes must be made to the marking memora without consulting the Provincial Internal Moderator who in turn will consult with the National Internal Moderator and the External moderators where necessary.

20. Only memora bearing the signatures of the national Internal Moderator and the UNAL/UN moderator and distributed by the National Department of Education via the Provinces must be used during training and during the marking period.
### Appendix 2

#### Life Sciences

**SECTION A**

**QUESTION 1**

| 1.1 | 1.1.1 | B ✓ ✓ |
|     | 1.1.2 | C ✓ ✓ |
|     | 1.1.3 | C ✓ ✓ |
|     | 1.1.4 | A ✓ ✓ |
|     | 1.1.5 | B ✓ ✓ |
|     | 1.1.6 | A ✓ ✓ |
|     | 1.1.7 | B ✓ ✓ |
|     | 1.1.8 | H ✓ ✓ |
|     | 1.1.9 | C ✓ ✓ |
|     | 1.1.10| B ✓ ✓ | (10 x 2) (20)

| 1.2 | 1.2.1 | Recessive ✓ |
|     | 1.2.2 | Autosomes ✓ |
|     | 1.2.3 | Cloning ✓ |
|     | 1.2.4 | Polyploidy ✓ |
|     | 1.2.5 | Genetic engineering ✓ Genetic modification ✓ Biotechnology |
|     | 1.2.6 | Independent ✓ variable |
|     | 1.2.7 | Genome ✓ |
|     | 1.2.8 | Locus ✓ |
|     | 1.2.9 | Extinction ✓ | (9)

| 1.3 | 1.3.1 | B only ✓ ✓ |
|     | 1.3.2 | B only ✓ ✓ |
|     | 1.3.3 | A only ✓ ✓ |
|     | 1.3.4 | Non ✓ ✓ |
|     | 1.3.5 | Both A and B ✓ ✓ | (6 x 2) (12)

| 1.4 | 1.4.1 | A ✓ |
| 1.4.2 | Opposable thumbs ✓ with power and precision grip |
|     | Bare fingerprints ✓ with nails |
|     | Long arms ✓ |
|     | Freely rotating arms ✓ |
|     | Eyes in front ✓ |
|     | Stereoscopic vision ✓ |
|     | Eyes with cones ✓ |
|     | Large brain size compared to body mass ✓ |
|     | Two mammary glands ✓ |
|     | Sexual dimorphism ✓ |
|     | Olfactory brain centre reduced ✓ | (Mark first THREE only) Any 3 (3)

1.4.3 Humans ✓

1.4.4 Shift in the position of foramen magnum ✓ to a forward position
- Gently curved jaw ✓
- Flat face ✓
- Well developed chin ✓
- Not prognathous ✓
- Forehead less sloping ✓
- No pronounced brow ridges ✓
- Smaller canines ✓
- Spaces between teeth bigger ✓
- Larger brain size ✓ | Any 2 (2)

1.4.5 Rhesus monkey ✓ Gibbon ✓ | (2) (9)

**TOTAL SECTION A: 50**

---

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SECTION B

QUESTION 2

2.1

2.1.1

A = chromatid/ chromosome
B = Spindle fibre

2.1.2

Diagram 3, Diagram 2, Diagram 1 (in correct sequence)

2.1.3

Crossing over in diagram 3
Chromosomes moving to poles in diagram 1
Bivalents (homologous pair of chromosomes lie in equator in diagram 2)

(Any 2)

(2)

2.2

2.2.1

Normal male karyotype has an X and Y chromosome at 23
Klinefelter syndrome karyotype has an extra X chromosome
3 chromosomes at number 23/ two X and one Y chromosome

(2)

2.2.2

During meiosis 1, the homologous chromosome pair 23 of the female parent does not separate (there is no disjunction
OR
During meiosis 2, the chromosome 23 of the female parent does not separate/ non-disjunction of chromosome and both chromatids move to same pole

Any 6

(8)

an ovum with 2 X chromosomes is produced during fertilization this ovum fused with a sperm cell with a Y chromosome to form the zygote with XY/XY

QUESTION 3

3.1

3.1.1

To identify specific defective genes to find out if they are possible carriers

(1)

3.1.2

To be given advice on the risk of transferring the defective gene to offspring
To be able to make decisions on whether they want to have children
To be given explanation of the results of DNA testing

(3)

(Mark first THREE only)

Any 3

(4)

3.2

Identify relationship (biological evidence)
Identify deceased bodies
Identify relatives w/ missing person/ paternity

(Mark first TWO only)

Any 2

(2)

3.3

Australopithecus sediba Homo sapiens

<table>
<thead>
<tr>
<th>Australopithecus sediba</th>
<th>Homo sapiens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smaller skeleton size</td>
<td>Increased skeleton size</td>
</tr>
<tr>
<td>Smaller cranium size</td>
<td>Much larger cranium</td>
</tr>
<tr>
<td>Less developed chin</td>
<td>More developed chin</td>
</tr>
</tbody>
</table>

3.4

3.4.1

They can interbreed and produce fertile offspring (puppies which can interbreed

3 x 2 + 1 table

(7)

3.4.2

There is variation in the wolves in terms of aggressive behaviour/ feeding habits
A population of less aggressive/ tame wolves became scavengers/ around human settlements and were separated from the original wild population
Each group occupying a niche undergoes natural selection
As a result of varying environmental conditions
3.4.3 Humans chose the dogs that had the best desired characteristics and interbred them. Over many generations of careful selection a distinct breed of dog was achieved.

3.5.1 Accepted / not rejected

3.5.2 The bacteria / single-cell organisms appear in the oldest rock layers / strata. Multi-celled / complex organisms appear later in the Palaeozoic era / older era. It is equivalent to older rock strata.

3.5.3 It would indicate that complex organisms did not evolve from simple organisms / therefore the theory will be rejected.

OR

It would mean that first proto-yeasts and dinosaurs co-existed / therefore dinosaurs did not evolve from proto-yeasts.

3.5.4 Invertebrates have soft bodies / which decay easily / do not fossilise.

OR

Some invertebrates may have had an exoskeleton / which decays easily / does not fossilise.

OR

Earlier fossils of invertebrates might not yet have been discovered.

4.1.1 One of

4.1.2 Blood groups are controlled by three alleles / \( I^A, I^B, I^O \) which when in combination provide four phenotypes / A, AB, B, O.

4.1.3 Percentage distribution of blood groups in a province

- Blood group O: 40% / 360 x 100 = 144
- Blood group A: 35% / 360 x 100 = 126
- Blood group B: 15% / 360 x 100 = 54
- Blood group AB: 10% / 360 x 100 = 36

TOTAL SECTION B: 60
Rubric for the mark allocation of the calculations

<table>
<thead>
<tr>
<th>Marks</th>
<th>Calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1–3 correct</td>
</tr>
<tr>
<td>2</td>
<td>4 correct</td>
</tr>
</tbody>
</table>

Rubric for the mark allocation of the pie chart

<table>
<thead>
<tr>
<th>Caption</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct proportion of slices</td>
<td>1: 1–2 correct. 2: 3–4 correct</td>
</tr>
<tr>
<td>Label/key for each slice</td>
<td>1: 1 correct label 2: 2 correct labels 3: 3–4 correct labels</td>
</tr>
</tbody>
</table>

NOTE: If the wrong type of illustration is drawn, marks will be lost for drawing the slices in correct proportions.

4.2 4.2.1 The average height of the plants decreases as the altitude increases OR

The average height of the plants increases as the altitude decreases Max 3

4.2.2 All seeds from different altitudes were planted under the same environmental conditions.

(Same number of seeds for each level was used) Max 2

4.2.3 - There is variation in the height of this plant population:
- Some plants are tall and some are short.
- More short plants survived at high altitude to reproduce the next generation
- Because the short plants are not easily broken by wind at high altitude
- Tall plants did not survive the strong winds/environmental conditions at high altitude
Fewer tall plants survived at high altitude Max 4

ASSESSING THE PRESENTATION OF THE ESSAY

<table>
<thead>
<tr>
<th>Marks</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Well structured — demonstrates insight and understanding of question</td>
</tr>
<tr>
<td>2</td>
<td>Minor gaps in the logic and flow of the answer</td>
</tr>
<tr>
<td>1</td>
<td>Attempted but with significant gaps in the logic and flow of the answer</td>
</tr>
<tr>
<td>0</td>
<td>Not attempted/nothing written other than question number</td>
</tr>
</tbody>
</table>

Synthesis (3) (20)

TOTAL SECTION C: 40
GRAND TOTAL: 150
INSTRUCTIONS AND INFORMATION

Read the following instructions carefully before answering the questions.

1. Answer ALL the questions.
2. Write ALL the answers in your ANSWER BOOK.
3. Start the answers to each question at the top of a NEW page.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Present your answers according to the instructions of each question.
6. ALL drawings should be done in pencil and labelled in blue or black ink.
7. Draw diagrams or flow charts only when asked to do so.
8. The diagrams in this question paper are NOT necessarily drawn to scale.
9. Do NOT use graph paper.
10. You may use a non-programmable calculator, protractor and a compass.
11. Write neatly and legibly.

MARKS: 150

TIME: 2½ hours

This question paper consists of 16 pages.
SECTION A

QUESTION 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the question number (1.1.1 to 1.1.9) in your ANSWER BOOK, for example 1.1.10 D.

1.1.1 All the organisms in a given area as well as the abiotic factors with which they interact are best described as a/an...

A community.
B ecosystem.
C habitat.
D population.

1.1.2 Which of the following is an example of predation?

A Bees visiting a flower
B Ticks on a dog
C A lion catching a zebra
D A bird's nest in a tree

1.1.3 Which ONE of the following refers to development in some birds where the eggs hatch outside the body and the young are born immobile and totally dependent on its parents?

A Vivipary and precocial development
B Ovipary and altricial development
C Vivipary and altricial development
D Ovipary and precocial development

1.1.4 Which ONE of the following is TRUE about seeds?

A Protect the gametes
B Provide the embryo with food from cotyledons
C Develop into a fruit
D Develop from an ovary

1.1.5 Which ONE of the following increases the chances of survival of a species?

A Living individually
B Living in a colony with division of labour
C Having random breeding pairs
D Hunting for prey with different species

QUESTIONS 1.1.6 and 1.1.7 are based on the age-gender pyramid shown below.

Age-gender pyramid of a population (in millions)

Male
Female

1.1.6 The age-gender pyramid shown above is for a developed country since...

A the number of newborn are high
B there are more young people than old people
C there are more females than males in each age group
D the life expectancy of the population is high

1.1.7 Which ONE of the following can be correctly deduced from the age-gender pyramid shown above?

A There are less than 2 million people between 0 and 10 years
B There are more males than females in the age group 11 to 20 years
C The birth and death rates are about the same
D There are more females than males who are 50 years and older
Appendix 2

1.1.8 The statements below refer to the action of different contraceptive methods.

1. Inhibits the secretion of FSH
2. Increases the level of the hormone progesterone
3. Stops the embryo from implanting in the uterus
4. Stops ovulation by inhibiting the development of the follicle

Which combination refers to the action of the oral contraceptive pill only?

A 1, 2 and 3 only
B 1, 2 and 4 only
C 1, 2, 3 and 4
D 2, 3 and 4 only

(9 x 2) (10)

1.1.9 The statements below refer to adaptations of flowers for pollination.

1. Male and female flowers are found on different plants
2. Stigma below anthers
3. Male and female gametes mature at the same time

Which combination of adaptations refers to self-pollination?

A 1 and 2 only
B 1 and 3 only
C 2 and 3 only
D 1, 2 and 3

(9 x 2) (10)

1.2 Give the correct biological term for each of the following descriptions. Write only the term next to the question number (1.2.1 to 1.2.10) in your ANSWER BOOK.

1.2.1 A series of changes that take place during the life cycle of an insect
1.2.2 A fluid containing sperm cells
1.2.3 The maximum size of a population that can be supported by a habitat under the conditions prevailing at any particular time
1.2.4 The relationship between two species in which both benefit from the association
1.2.5 The use of resources in slightly different ways by different species in the same habitat, allowing them to co-exist
1.2.6 The variety of species of living organisms that exist on Earth
1.2.7 The elimination of one species by another in a habitat as a result of dependence on a common resource
1.2.8 The killing of surplus animals by humans to avoid the destruction of the natural environment
1.2.9 The periodic movement out of and return to a habitat by living organisms
1.2.10 A group of organisms, sharing similar characteristics, which are able to interbreed to produce fertile offspring

(9 x 2) (10)
1.3 Indicate whether each of the statements in COLUMN I applies to A ONLY, B ONLY, BOTH A AND B or NONE of the items in COLUMN II. Write A only, B only, both A and B, or none next to the question number (1.3.1 to 1.3.6) in the ANSWER BOOK.

<table>
<thead>
<tr>
<th>COLUMN I</th>
<th>COLUMN II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3.1 This would have no effect on the</td>
<td>A: Emigration</td>
</tr>
<tr>
<td>population size</td>
<td>B: Emigration</td>
</tr>
<tr>
<td>1.3.2 A small portion of the population is</td>
<td>A: Census</td>
</tr>
<tr>
<td>counted and then used to work out the size</td>
<td>B: Simple sampling</td>
</tr>
<tr>
<td>of the whole population</td>
<td></td>
</tr>
<tr>
<td>1.3.3 Competition between cows and goats for</td>
<td>A: Inter-specific</td>
</tr>
<tr>
<td>grass</td>
<td>B: Intra-specific</td>
</tr>
<tr>
<td>1.3.4 A tube that stores sperm cells until</td>
<td>A: Vas deferens</td>
</tr>
<tr>
<td>maturation</td>
<td>B: Seminiferous tubules</td>
</tr>
<tr>
<td>1.3.5 The cell division that takes place in</td>
<td>A: Meiosis</td>
</tr>
<tr>
<td>the gametophyte generation to form gametes</td>
<td>B: Meiosis</td>
</tr>
<tr>
<td>1.3.6 Relationship between two different</td>
<td>A: Parasitism</td>
</tr>
<tr>
<td>species where one species benefits and the</td>
<td>B: Commensalism</td>
</tr>
<tr>
<td>other is harmed</td>
<td></td>
</tr>
<tr>
<td>1.3.7 A change in the composition of species</td>
<td>A: Primary succession</td>
</tr>
<tr>
<td>in a habitat that has never</td>
<td>B: Secondary succession</td>
</tr>
<tr>
<td>been inhabited by organisms before</td>
<td></td>
</tr>
<tr>
<td>1.3.8 The mature community of plants</td>
<td>A: Pioneer</td>
</tr>
<tr>
<td>that remains relatively stable with</td>
<td>B: Climax</td>
</tr>
<tr>
<td>few, if any, changes over time</td>
<td></td>
</tr>
</tbody>
</table>

(8 x 2)  (16)

1.4 The diagram below represents the events leading to the development of the foetus in the human uterus.

Part of the female reproductive system showing various stages in the development of a foetus

Identify the following:

1.4.1 Part labelled 1
1.4.2 Cell labelled 2
1.4.3 Cell labelled 3
1.4.4 Structure labelled 4
1.4.5 Part labelled 5
1.4.6 Fluid labelled 6

TOTAL SECTION A: 50
2.2.1 Identify the neuron labelled A.

2.2.2 Name the type of neuron that is connected to structure B.

2.2.3 Explain the effect on the body if the neuron mentioned in QUESTION 2.2.2 is damaged.

2.2.4 Explain the significance of reflex actions in humans.

2.3.1 Label parts 2, 3, 4, and 5 respectively.

2.3.2 Name and describe the process that causes part 1 to dilate.

2.3.3 State how the following defects can be treated to improve vision:

   (a) Long-sightedness
   (b) Astigmatism
   (c) Short-sightedness
   (d) Cataract

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Appendix 2

Mind the Gap

Life Sciences
2.3 Study the graph below showing the hormonal changes during pregnancy.

![Hormonal Changes Graph]

2.3.1 Identify the following structures:
(a) A  
(b) B

2.3.2 State the following:
(a) Where prolactin is produced  
(b) The function of prolactin

2.3.3 Explain the significance of the levels of oestrogen and progesterone dropping towards the end of pregnancy.

2.3.4 Explain what will happen if structure A breaks down at the end of the first week of pregnancy.

2.3.5 Suggest the role of oxytocin around week 40 of pregnancy.

### QUESTION 3

3.1 The table below shows the changes in population size of a culture of bacteria, grown in a petri dish in a laboratory at 20 °C.

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Number of bacteria in population</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
</tr>
<tr>
<td>4</td>
<td>160</td>
</tr>
<tr>
<td>6</td>
<td>280</td>
</tr>
<tr>
<td>8</td>
<td>450</td>
</tr>
<tr>
<td>10</td>
<td>725</td>
</tr>
<tr>
<td>12</td>
<td>960</td>
</tr>
<tr>
<td>14</td>
<td>975</td>
</tr>
<tr>
<td>16</td>
<td>1,050</td>
</tr>
<tr>
<td>18</td>
<td>1,060</td>
</tr>
</tbody>
</table>

3.1.1 Use these results to plot a line graph.

3.1.2 Explain the shape of the graph between:
(a) 0–12 hours  
(b) 16–18 hours

3.1.3 Describe how the growth may change if the population of bacteria is kept at 30 °C instead of 20 °C.

3.2 A researcher wanted to know how many fish were in a dam. He caught 20 fish and marked them by clipping out a small section of their tail fins. He then released them back into the dam. A few days later he caught 25 fish and found that 8 had been marked.

3.2.1 Estimate the total number of fish in the dam by using the following formula:

$$ P = \frac{F \times S}{M} $$

Where:
- $P$ = Estimated total number of fish in the population
- $F$ = Number caught and marked in the first catch
- $S$ = Number caught in the second catch
- $M$ = Number marked in the second catch

Show ALL working.
### SECTION B

**3.2.2** Give ONE reason why the method used by the researcher to mark the fish could have resulted in an inaccurate estimate of the fish population in the dam.

**3.2.3** Explain ONE way in which the researcher could have increased the reliability of his estimate of the fish population in the dam.

**3.3** The birth rate is the number of births per 1 000 people in the population whilst the death rate is the number of deaths per 1 000 people in the population.

The table below shows the birth and death rates in three countries, A, B and C, between 1960 and 2000.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Birth rate</td>
<td>15.6</td>
<td>16.2</td>
</tr>
<tr>
<td></td>
<td>Death rate</td>
<td>12.3</td>
<td>11.5</td>
</tr>
<tr>
<td>B</td>
<td>Birth rate</td>
<td>34.0</td>
<td>35.4</td>
</tr>
<tr>
<td></td>
<td>Death rate</td>
<td>22.7</td>
<td>21.5</td>
</tr>
<tr>
<td>C</td>
<td>Birth rate</td>
<td>32.9</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>Death rate</td>
<td>17.7</td>
<td>7.4</td>
</tr>
</tbody>
</table>

**3.3.1** Which country (A, B or C) had a decreasing birth rate from 1960 to 2000?

**3.3.2** Which country (A, B or C) is most likely a developing one?

**3.3.3** Give a reason for your answer to QUESTION 3.3.2.

**3.3.4** Explain TWO reasons why the death rate in all three countries had decreased from 1980 to 2000.

**TOTAL SECTION B: 60**

### SECTION C

**QUESTION 4**

4.1 A group of Grade 12 learners carried out an investigation to determine the effect of gibberellic acid on the germination of seeds.

The following procedure was followed:
- A sample of hazelnut seeds was divided into two groups, A and B.
- A gibberellic acid solution was added to the seeds in group A.
- Water was added to the seeds in group B.
- Both groups of seeds were left for 16 days.
- The percentage (%) of seeds germinating in the two groups was recorded.

The results of the investigation are shown in the graph below.

![Graph showing percentage germination over time]

**4.1.1** Formulate a possible hypothesis for this investigation.
4.1.2 Using the information from the graph, determine the percentage germination of Hazelnut seeds on the 10th day with the gibberellin treatment.

4.1.3 Explain the purpose of group B.

4.1.4 State TWO ways in which the validity of this investigation could have been improved.

4.1.5 Give ONE possible reason why seeds of desert plants germinate only after heavy rains.

4.2 Study the diagram below and answer the questions that follow.

4.2.1 Label the parts numbered 1 and 4.

4.2.2 Write down only the NUMBER of the gland that:
   (a) Produces the hormone glucagon
   (b) Produces a hormone that controls the growth of long bones
   (c) Produces an iodine-containing hormone
   (d) Produces a hormone that is involved in the re-absorption of some salts by the kidneys

4.2.3 State TWO similarities between hormones and nerves with regard to their functions.

4.2.4 State ONE functional difference between hormones and motor nerves.
FRUENCES RELATED TO MARKING LIFE SCIENCES 2012

1. If more information than marks allocated is given
   Stop marking when maximum marks is reached and put a wavy line and 'Max' in the right hand margin.

2. If, for example, three reasons are required and five are given
   Mark the first three irrespective of whether all or some are correct/incorrect.

3. If whole process is given when only part of it is required
   Read all and credit relevant part.

4. If comparisons are asked for and descriptions are given
   Accept if differences/similarities are clear.

5. If tabulation is required but paragraphs are given
   Candidates will lose marks for not tabulating.

6. If diagrams are given with annotations when descriptions are required
   Candidates will lose marks.

7. If flow charts are given instead of descriptions
   Candidates will lose marks.

8. If sequence is muddled and links do not make sense
   Where sequence and links are correct, credit. Where sequence and links is incorrect, do not credit. If sequence and links becomes correct again, resume credit.

9. Non-recognized abbreviations
   Accept if first defined in answer. If not defined, do not credit the unrecognized abbreviation but credit the rest of answer if correct.

10. Wrong numbering
    If answer fits into the correct sequence of questions but the wrong number is given, it is acceptable.

11. If language used changes the intended meaning
    Do not accept.

12. Spelling errors
    If recognizable accept provided it does not mean something else in Life Sciences or if it is out of context.

13. If common names given in terminology
    Accept provided it was accepted at the national memo discussion meeting.
14. If only letter is asked for and only name is given (and vice versa) 
No credit

15. If units are not given in measurements 
Candidates will lose marks. Memorandum will allocate marks for units separately.

16. Be sensitive to the sense of an answer, which may be stated in a different way.

17. Caption 
All illustrations (diagrams, graphs, tables, etc.) must have a caption.

18. Code-switching of official languages (terms and concepts) 
A single word or two that appears in any official language other than the learners’ assessment language used to the greatest extent in his/her answers should be credited, if it is correct. A marker that is proficient in the relevant official language should be consulted. This is applicable to all official languages.

19. No changes must be made to the marking memoranda without consulting the Provincial Internal Moderator who in turn will consult with the National Internal Moderator (and the External moderators where necessary).

20. Only memoranda bearing the signatures of the National Internal Moderator and the UMLALUSI moderators and distributed by the National Department of Basic Education via the provinces must be used during training and during the marking period.

SECTION A

QUESTION 1

11. 1.1.1 A ✓ ✓ 
1.1.2 C ✓ ✓ 
1.1.3 B ✓ ✓ 
1.1.4 B ✓ ✓ 
1.1.5 B ✓ ✓ 
1.1.6 D ✓ ✓ 
1.1.7 D ✓ ✓ 
1.1.8 B ✓ ✓ 
1.1.9 C ✓ ✓ 

(9 x 2) (18)

12. 1.2.1 Metamorphosis ✓ 
1.2.2 Semen ✓ 
1.2.3 Carrying capacity ✓ 
1.2.4 Mutualism ✓ 
1.2.5 Resource/niche partitioning ✓ 
1.2.6 Biodiversity ✓ 
1.2.7 Competitive exclusion principle ✓ 
1.2.8 Culling ✓ 
1.2.9 Migration ✓ 
1.2.10 Species ✓ 

(10 x 1) (10)

13. 1.3.1 None ✓ ✓ 
1.3.2 B only ✓ ✓ 
1.3.3 A only ✓ ✓ 
1.3.4 None ✓ ✓ 
1.3.5 B only ✓ ✓ 
1.3.6 A only ✓ ✓ 
1.3.7 A only ✓ ✓ 
1.3.8 B only ✓ ✓ 

(8 x 2) (16)

14. 1.4.1 Ovary ✓ 
1.4.2 Ovum ✓ 
1.4.3 Zygote ✓ 
1.4.4 Sperm cell ✓ 
1.4.5 Umbilical cord ✓ 
1.4.6 Amnion ✓ 

(6)

TOTAL SECTION A: 50
SECTION B

QUESTION 2

2.1 2.1.1 2 - cornea ✓ 
3 - lens ✓ 
4 - suspensory ligaments ✓ 
5 - ciliary muscles ✓ / body

2.1.2 Pupillary mechanism ✓ / Pupil reflex

- The radial muscles ✓ of the iris contract ✓ and the circular muscles ✓ relax ✓
- The pupil ✓ dilates and more light enters the eye ✓ (Any 5)

2.1.3 (a) Wear spectacles with convex ✓ lenses / use contact convex lenses / use laser during surgery to re-shape the cornea
(b) Wear spectacles with lenses which are uneven ground ✓ to compensate for the uneven cornea / lens / surgery
(c) Cataracts surgically ✓ removed / lens replacement
(d) Wear spectacles with concave ✓ lenses / use contact concave lenses / use laser during surgery to re-shape the cornea

2.2 2.2.1 Interneuron ✓ / connector neuron / association neuron

2.2.2 Motor neuron ✓

2.2.3 The person will become aware of the stimulus ✓ but the motor neuron will not be able ✓ to transmit the impulse from the interneuron ✓ to the effector organ ✓ / muscles and movement will not take place ✓ / reaction will not occur (Max 3)

2.2.4 Helps to protect the body ✓ by reacting quickly ✓
The interneuron makes a short cut ✓ / not going to the brain / uses a reflex pathway that is immediately available (Max 2)
QUESTION 3

3.1.1. Changes in population size of bacteria over time

- **Guideline for assessing the graph**
  - Correct type of graph
  - Title of graph
  - Correct label x-axis
  - Correct scale x-axis
  - Correct label y-axis
  - Correct scale y-axis
  - Plotting of points: 1: 1 to 4 points plotted correctly, 2: 5 to 8 points plotted correctly, 3: All 10 points plotted correctly

**NOTE:**
If the wrong type of graph is drawn, marks will be lost for:
- ‘Correct type of graph’
- ‘Plotting’

3.1.2. (a) The population of bacteria shows a rapid increase in numbers because there are very few limiting factors e.g. plenty of food, space available, less competition

(b) Population numbers remains constant because food supply and other resources are limited and environmental resistance began operating.

3.1.3. Growth would be faster in the lag phase and exponential phase and the stationary phase would be reached earlier than 18 hours.

3.2.1. \[ P = \frac{F \times S}{M} \]
\[ = \frac{20 \times 25}{8} \]
\[ = 62.5 \]

3.2.2. Cutting off a portion of tail fin of the fish would prevent movement, thus preventing swimming. Cutting off a portion of tail fin would cause the fish to die.

3.2.3. Do a number of second catches, apply the formula each time, and take an average to get a more reliable estimate of the number of fish in the dam.

3.3.1. Country C
3.3.2. Country B
3.3.3. Shows an increasing birth rate compared to the other two countries. Death rate is still higher than the other two countries.

3.3.4. - Improvement in water supply, sewage treatment, hygienic food handling, and general standards of cleanliness have eradicated many diseases such as typhoid fever, amoebic dysentery resulting in decreased death rates.
- Mass immunizations against polio, measles, small pox, mumps have decreased the incidence of disease.
- Discovery of antibiotics has made it possible to treat most diseases caused by bacteria e.g. TB that used to kill many people in the past.
- Agriculture has become more efficient, production of more food preventing starvation in death in many countries.
- Improved medical care, therefore fewer deaths due to illnesses.
- Focus on lifestyle changes/ exercising/ healthy living therefore fewer deaths due to diabetes, etc.

**Total Section B:** 60
SECTION C

QUESTION 4

4.1 4.1.1 Higher/Lower percentage% of seeds will germinate ✓ in gibberellin solution/water ✓ than in water/gibberellin solution OR
   Same percentage of seeds will germinate ✓ in gibberellin solution and in water ✓
   (3)

4.1.2 Accept any value between 77 to 78% ✓
   (1)

4.1.3 Water serves as a control ✓ to verify that gibberellin does have an effect on germination ✓/to compare results
   (2)

4.1.4 - The number of hazelnut seeds in both sets must be the same ✓
   - Same volume of gibberellin solution and water must be used ✓
   - Use seeds from the same plant ✓
   - Maintain the same environmental conditions ✓
   (Mark first TWO only)
   (2)

4.1.5 Water is available ✓ for the seeds to germinate ✓ and grow after the heavy rain
   (2)
   (10)

4.2 4.2.1 1 = pulillary ✓ gland
   4 = adrenal ✓ gland
   (2)

4.2.2 (a) 3 ✓
   (b) 1 ✓
   (c) 2 ✓
   (d) 4 ✓
   (4)

4.2.3 They respond to internal and/or external stimuli ✓
   They protect organisms ✓
   (Mark first TWO only)
   (2)

4.2.4 Hormones: Responses are slow processes ✓/may affect multiple sites
   Nerves: Responses are quick reactions ✓/affect localized sites
   (2)
   (10)

4.3 Possible answer

Hypothalamus
- The change in temperature is detected ✓ by the thermo-receptors ✓ in the skin
- Stimulus converted to nerve impulse ✓
- Transmitted to the hypothalamus ✓
- Hypothalamus sends impulses to the muscle layer in the arteries ✓ of the skin
   (Max 3) (3)

- On a cold day the arteries close to the surface constrict ✓/vaso-constriction occurs
- Less blood ✓ flows to capillaries close to the surface
- Sweat production decreases ✓/less sweat is lost
- Less heat is radiated from the body ✓/less heat is lost
   (4)

- On a hot day the arteries close to the surface dilate ✓/vaso-dilation occurs
- More blood ✓ flows to the capillaries close to the surface
- Sweat production increases ✓/more sweat is lost
- More heat is radiated ✓ from the body ✓/more heat is lost
   (4)

Adrenal gland
- Secretes adrenalin ✓
- Hormone that prepares the body to cope with emergency ✓/danger/stress situations
- Adrenalin causes the blood vessels of the skin to constrict ✓
- Less blood flows to the surface of the skin ✓
- Because the skin is not an important organ during an emergency ✓
- Redirection of blood to those organs ✓
   (Max 6) (6)
   (17)

ASSESSING THE PRESENTATION OF THE ESSAY

<table>
<thead>
<tr>
<th>Marks</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Well structured - demonstrates insight and understanding of question</td>
</tr>
<tr>
<td>2</td>
<td>Minor gaps in the logic and flow of the answer</td>
</tr>
<tr>
<td>1</td>
<td>Attempted but with significant gaps in the logic and flow of the answer</td>
</tr>
<tr>
<td>0</td>
<td>Not attempted/Nothing written other than question number</td>
</tr>
</tbody>
</table>

Synthesis (3)

(20)

TOTAL SECTION C: 40

GRAND TOTAL: 150
The Mind the Gap study guide series assists you to make the leap by studying hard to achieve success in the Grade 12 exam.

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