Living

Biology

TEACHER'S GUIDE

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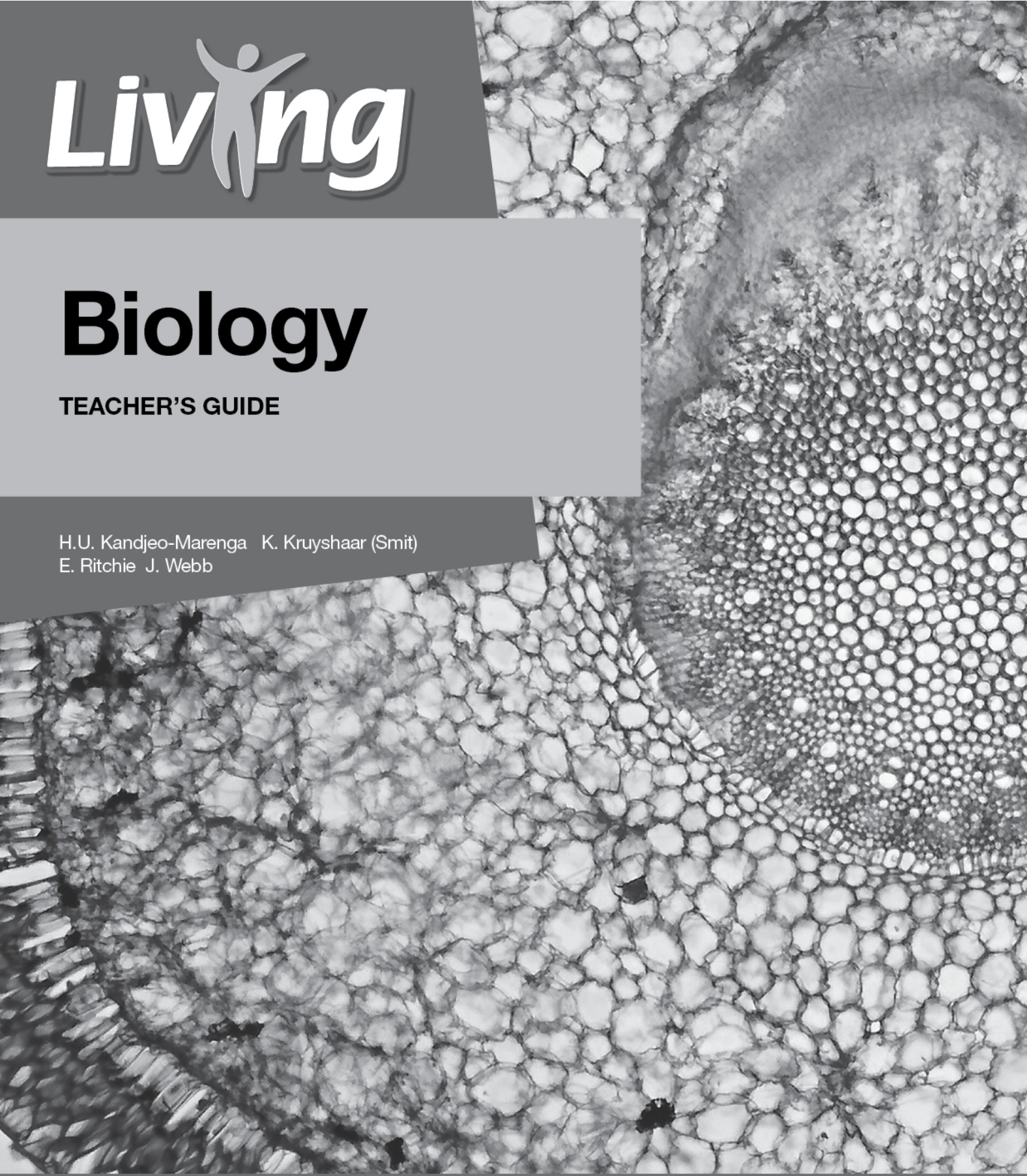

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any omissions or errors to be corrected in subsequent impressions.

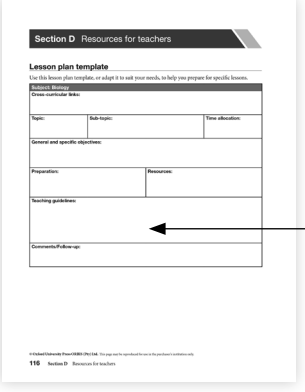
Contents

How to use this Teacher's Guide

This Teacher's Guide supports the *Namibia Biology Grade 12 Learner's Book*. These components follow the Ministry of Education's Senior Secondary Biology syllabus for Grade 12. This means they are up-to-date and relevant to current classroom environments and educational needs.

The Teacher's Guide is divided into three sections:

- **Section B** contains a lesson plan template, a suggested year plan for teaching and guidelines about assessment.
- **Section C** contains teaching guidelines that correspond to each topic and sub-topic of the Learner's Book. These teaching guidelines serve as one possible way of guiding your learners through the content.
- **Section D** contains additional resources you might find useful. You may photocopy these resources to use in your classroom.


Section D Resources for teachers

Lesson plan template

Use this lesson plan template, or adapt it to suit your needs, to help you prepare for specific lessons.

Subject: Biology

Cross-curricular links:

Topic: | Sub-topic: | Time allocation:

General and specific objectives:

Preparation: | Resources:

Teaching guidelines:

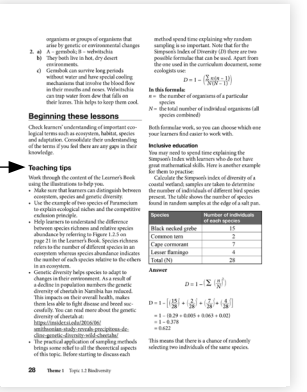
Comments/Follow-up:

Assessment templates for you to photocopy

Teaching Biology in the Senior Secondary Phase

There are many ways of teaching a subject. Each classroom is unique in the composition of its learners, the social and physical environment of the school, and the types of resources it has. As a teacher, you are trained to find the most readily available resources to use while you teach the content covered in these books. Where possible, this guide will help you with ideas on how you can overcome obstacles to deliver the best possible lessons to your learners.

Every subject has its own curriculum and syllabus. Throughout this guide, we have clearly described the competencies that the learners must achieve. All these skills begin with a verb, or doing word, such as use, make, draw, discuss. The skills and requisite knowledge required by the syllabus are listed in this guide, which enables you to check that you are covering the requirements of the subject.


2. a) A – gemsbok; B – welwitschia
b) They both live in hot, dry desert environments.
c) Gemsbok can survive long periods without water and have special cooling mechanisms that involve the blood flow in their mouths and noses. Welwitschia can trap water from dew that falls on their leaves. This helps to keep them cool.

Beginning these lessons

Check learners' understanding of important ecological terms such as ecosystem, habitat, species and adaptation. Consolidate their understanding of the terms if you feel there are any gaps in their knowledge.

Teaching tips

Work through the content of the Learner's Book using the illustrations to help you.
- Make sure that learners can distinguish between ecosystem, species and genetic diversity.
- Use the example of two species of Paramecium to explain ecological niches and the competitive exclusion principle.
- Help learners to understand the difference between species richness and species abundance by referring to Figure 1.2.3 on page 21 in the Learner's Book. Species richness refers to the number of different species in an ecosystem whereas species abundance indicates the number of each species relative to the others in an ecosystem.
- Genetic diversity helps species to adapt to changes in their environment. As a result of a decline in population numbers the genetic diversity of cheetah in Namibia has reduced. This has made it more difficult for them to be there less able to fight disease and breed successfully. You can read more about the genetic diversity of cheetah at: https://insideci.edu/2016/06/smithsonian-study-reveals-precipitous-decline-genetic-diversity-wild-cheetahs/
- The practical application of sampling methods brings some relief to all the theoretical aspects of this topic. Before starting to discuss each method spend time explaining why random sampling is so important. Note that for the Simpson's Index of Diversity (D) there are two possible formulae that can be used. Apart from the one used in the curriculum document, some ecologists use:

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

In this formula:
n = the number of organisms of a particular species
N = the total number of individual organisms (all species combined)

Both formulae work, so you can choose which one your learners find easier to work with.

Inclusive education

You may need to spend time explaining the Simpson's Index with learners who do not have great mathematical skills. Here is another example for them to work on:

Calculate the Simpson's index of diversity of a coastal wetland; samples are taken to determine the number of individuals of different bird species present. The table shows the number of species found in random samples at the edge of a salt pan.

Species	Number of individuals in each hectare
Black-necked grebe	15
Common tern	2
Cape cormorant	7
Lesser flamingo	4
Total (N)	28

Answer

$$D = 1 - \sum \left(\frac{n}{N}\right)^2$$

$$D = 1 - \left[\left(\frac{15}{28}\right)^2 + \left(\frac{2}{28}\right)^2 + \left(\frac{7}{28}\right)^2 + \left(\frac{4}{28}\right)^2\right]$$
$$= 1 - (0.29 + 0.005 + 0.065 + 0.02)$$
$$= 1 - 0.378$$
$$= 0.622$$

This means that there is a chance of randomly selecting two individuals of the same species.

Teaching tips for the teacher

The teaching guidelines

The teaching guidelines for each topic starts with a table that gives you suggested time allocations and relevant cross-curricular links. The overview tables are followed by detailed teaching guidelines, which correspond to the Learner's Book pages. In these notes, you will find:

- tips for introducing and teaching the content
- answers to activities
- applications for suggested resources
- suggestions for continuous assessment.

A dynamic approach

Biology is a science subject. Some schools may have well-equipped laboratories, but if yours does not, remember, in Biology, your laboratory can be outside in nature.

Section A Teaching Biology

The main aim of the Biology syllabus is to instil in our learners a love of science and in particular the science of living things. Most teachers teach a subject out of a genuine love for their discipline and a desire to share the wonder of their chosen field with others. Like all other science subjects, it is a subject that needs to be understood, rather than learnt by rote. This makes it easier to make Biology a popular subject for learners, because it requires less of their time doing tedious rote learning.

Biology starts with understanding, and understanding starts with an interest in the subject. That is where you, the teacher, can make or break a learner's lifelong love or loathing of the subject.

It can be helpful to use the 3-level approach to learning Biology. When teaching, tell the learners what level is being dealt with. When practising questions, rate the questions according to the levels.

- Level 1 – rote learning. These are the names, terms and definitions that need to be memorised.
- Level 2 – pictures and stories. These are the diagrams and processes that require understanding but will need the facts from Level 1.
- Level 3 – application. This is the ability to see the information in the context of life. This requires a deep level of understanding.

All children start with a natural curiosity, which must be curbed for their own safety. Your duty is to re-awaken that curiosity. Here are some strategies to re-awaken a love of science:

- Each day find something science-y that piqued your interest – and read it out loud in class.
- Collect things. This is a human trait. Help the learners to classify and label their collections.
- Grow or care for things. Encourage them to observe and record their findings about plants, insects and birds.
- Visit places. Point out where Biology is used practically: on farms, factories, bakeries and breweries. Encourage learners to observe and record their findings.
- Set up micro ecosystems: aquariums and terrariums.
- Make things together. Remember, cooking and baking is science in action.
- Read books, magazines and newspaper articles that deal with biological issues to keep up to date with the changes and biological issues facing the world now.

Teaching time

The NSSC AS Level syllabuses are designed to be taught over 180 guided learning hours over the duration of one year. However, this is only a guideline number of hours, and the course may be taught in more or fewer hours, depending on the abilities of the learners.

- The National Curriculum for Basic Education (NCBE) indicates that AS Level Biology will be taught for 9 periods of 40 minutes each per 7-day cycle.

(NSSC AS Biology Syllabus, NIED 2019 p. 3)

Links to other subjects and cross-curricular issues

The cross-curricular issues include Environmental Education; HIV and AIDS; Population Education; Education for Human Rights and Democracy (EHRD), Information and Communication Technology (ICT), Road Safety and Special Needs Education.

The links to cross-curricular issues are listed in the tables at the beginning of each topic or subtopic in this Teacher's Guide, and further discussed in each relevant section in the Learner's Book.

This course uses characters to champion each of the cross-curricular issues in the Learner's Book. These characters appear throughout the Learner's Book, highlighting their specific issue.

Methods suited to Biology

In Biology, teachers must encourage, guide and nurture the curiosity of young minds. The practical activities and investigations form an integral part of the Biology curriculum. Encourage learners by providing an atmosphere in which they can ask and answer questions on a practical level. Try to allocate as much time as possible to practical

investigations. When learners put their knowledge into practice by doing activities, real learning takes place. Not only will learners remember the theory better; they will experience the enjoyment of working with nature, and understand how they fit into the cycle of life. The benefit of this child-centred curriculum is that it is linked to the everyday experiences of learners in Namibia. It is essential that learners experience the continuation of everyday life with what happens in the classroom. This will stimulate further inquiry and curiosity.

When learners see and experience the connections between real-life situations and major processes and skills needed in the laboratory, their learning becomes fun and enjoyable. It will also promote creative problem-solving skills. By interacting with the natural world, learners will gain healthy attitudes towards living creatures. Not only will this benefit them in the future, but it may be the spark that starts a career!

It is essential that learners respect and appreciate the natural world and all its inhabitants. They must not waste or mishandle plants, animals and natural resources, such as water and energy sources. Teach at the level of the learners. There is no need for them to be discouraged by language that is not suitable for them. Biology teachers should also be curious about natural processes and lead by example. Young, budding scientists should reflect positive attitudes towards themselves and society.

By creating opportunities for sharing ideas with peers, learners gain valuable communication and listening skills. It is important to remember that the classroom is part of the learners' bigger world. By integrating other subjects, such as Language and Mathematics into Biology, learning is consolidated. This means that learners are actively busy, interacting with the content and each other, and using opportunities to apply their skills in the safety of the classroom.

The National Curriculum

The National Curriculum is based on the democratic principles of an equal opportunity being offered to all. Namibia has a diverse population made up of people of many cultures and languages.

Learners should all receive the same opportunities to learn, develop and prosper in life. The diversity in your class will mean that learners have different learning styles and paces of learning. You may also find that your learners come from very different backgrounds. These factors will affect your planning and lessons. Your teaching challenges lie in your ability to become familiar with:

- issues in learner-centred education
- issues of inclusion in a diverse community
- issues of barriers to learning – their challenges and possible solutions
- managing large classes
- continuous assessment as a positive part of the learning process
- providing or developing resources that meet the requirements of the curriculum.

Inclusive education

Biology, in particular, lends itself towards the extensive promotion of inclusion. We are all humble before the wonders of nature and we are all the same beneath the skin. You can use these opportunities to instil in all learners a sense of inclusivity and caring towards others, as well as building the self-esteem of learners with special needs.

Your learners are all different. Learner-centred education meets the challenge of learning by respecting the individual learning needs and learning styles of every learner. For this model to work, create a positive learning environment that guides learners towards their own achievement and success, both in the classroom and in life. To ensure a match between your teaching style and the needs of the learners, focus your attention on the learners' experiences, backgrounds, interests, talents, capabilities and needs. These will determine the way in which you will present and explore content, and will have a direct impact on the likelihood of successful learning.

Using previous knowledge and experiences

'A learner brings to the school a wealth of knowledge and social experience gained continually from the family, the community, and through interaction with the environment.' Your role is to create opportunities for successful learning by affirming what learners know, giving them opportunities to express themselves, and to use their talents and strengths to direct and inform learning.

More powerful learning is possible when learners can make connections to what they already know and when it builds on their interests. In this way, you can adapt and modify the curriculum to suit the needs of the learners rather than the learners adapting to the demands of the curriculum. 'Learning in school should thus involve, build on, extend and challenge the learner's prior knowledge and experiences.'

Interactive learning

Not all learners learn in the same way. By using a variety of teaching methods and presentation modes, Biology can be fresh and exciting for both teacher and learners. This also accommodates different learning styles. Engage the learners in the learning process by allowing them to carry out investigations and practical tasks. This gives them confidence with basic laboratory equipment and valuable skills for higher learning. The conceptual framework in the Grade 12 curriculum is centred on the learners' abilities. The content is organised in such a way that Grade 12 builds on prior learning. In the learner-centred classroom, you create the opportunities for learner-teacher and learner-learner interactive learning.

In this type of environment, the different approaches to learning become apparent and guide you to identify what learners need to know, the pace at which they can learn and the support each learner requires. Observe, listen and watch the levels of interaction, then use your knowledge and skills to guide learners and build their knowledge, skills, positive attitudes and self-esteem. The better the learners' self-esteem, the more successful they will become in any situation.

Different types of learning

Give opportunities for different types of learning. For example, learners construct knowledge through their senses, such as by:

- hearing and listening, i.e. talking through a problem to find a solution or different solutions and listening to one another
- seeing, i.e. looking at or creating visuals
- touching or feeling, i.e. building or using tactile means to feel their way.

Allow the descriptions given in the syllabus to guide you when choosing your method. Be flexible enough to encourage learners to construct their own meaning and create their own learning. However, always remain the guide, using your year plan and lesson plans as maps with clear objectives, while you develop various ways of achieving them.

Have a planned route that you navigate sensitively so that the learners reach their destinations successfully in their own ways. Constantly make decisions about where to stop and what to experience (content and knowledge), visualise possibilities (methodology and lesson delivery), avoid or deal with misconceptions and make decisions to achieve your goal.

Participation, contribution and production

Participation, contribution and production are key words in the learning process. When they are applied, learning becomes possible. These principles enable each learner to satisfy their needs based on prior experience, knowledge and skills as well as set their pace for learning.

Inclusive education is the right of every learner to participate in, and have access to, all the educational programmes of mainstream schools. Inclusive education supports diversity among all learners, where diversity is regarded as strength rather than a setback. This means that we have to remove all barriers to learning.

In any class, and especially in larger ones, you will deal with many different learners who come from a wide range of backgrounds and abilities. Understanding these learners and their needs enables you to include their needs in their education in a beneficial way. Namibia is a democratic society. 'Democratic' means that decisions are made taking into account each member's contribution. For learners to become well-functioning adults, they should be accepted for who and what they are at this stage of their lives. Their potential should be recognised and developed to the best of their abilities. Democracy also implies that people are individuals with their own strengths and weaknesses, which may be different to other people's strengths and weaknesses.

Classroom organisation

As learners will work alone, in pairs, in groups and as a class, it is useful to have a flexible approach to classroom organisation. Make sure you can move tables and chairs easily and quickly in order to accommodate various teaching and learning strategies. Plan where to stand, sit and move. Your use of classroom space is part of your teaching strategy. For some lessons, you might be up front and clearly visible, while for other lessons, learners might take leadership and you will play a facilitative role in the background.

When learners present or give feedback to the class, make sure they face the whole class and can be seen and heard by all. It is useful to have a small resource corner where learners can help themselves to items such as clean recyclable waste materials, for example, used cardboard, tins and plastic bottles for the various items they need to create. Have enough space in the class for learners to place their posters. If the walls are full, tie a line of wool or string across the classroom as high as possible so the learners can hang their posters on pegs on the line. This creates an interesting visual display.

Group and pair the learners quickly and efficiently. While it is sometimes useful to allow learners to choose their own groups, at other times it is best to place them in groups to ensure inclusivity, so they learn to work in a range of groups, and no learners feel rejected. Quick and fun ways to group learners include the following:

- use scraps of coloured paper to group learners according to the colour they chose
- ask learners to form a line according to their birthdates. The first five learners in a line form a group, the next five learners form another group, and so on.

Depending on the number of groups you may want or the number of learners in each group, you can assign numbers to the learners, such as 1, 2, 3 and then all the 1's go in a group, all the 2's in another and 3's in another.

Managing your class to support inclusive education

This is putting learner-centred education into practice.

Small group work

The advantage of working with a small group of learners is that you can identify learners with similar prior knowledge or skills, who will benefit from this way of teaching. Separate them from the rest of the class for about 15 minutes at a time. Organise the rest of the class in a structured way, so they are positively occupied while you are busy with the group needing your attention. For example, learners could do something they have done before, but can now add new information they have recently learnt. Make sure your instructions are clear and easy to follow, giving you the time and opportunity to work closely with the small group.

Rotating group work

Rotate the types of group work so that learners are not labelled in any way.

- A group that knows more about a topic and can move forward quickly should be able to do so. This gives you the opportunity to attend to the groups needing extra input.
- Create groups with learners of different abilities and needs. Mix the learners from the previous groups, so there is no stigma attached to working in groups. This technique requires you to know each learner's prior knowledge and skills for whatever they are learning. Continuous assessment gives you this knowledge.

Learners guiding learners

Most of the teaching focus is on you as the source of knowledge and skills. Sometimes learners can be the source of knowledge and skills. A learner who has a family member or close friend who has a skill that relates to the content, has a great deal to share with classmates. This builds the learner's confidence and self-esteem, vocabulary and speaking skills. Learners usually enjoy learning from their peers.

Handling barriers to learning

Include learners who have barriers to learning or other individual needs in mainstream schools. The education system addresses the needs of learners with barriers to learning by using different teaching methods and materials where needed. Learning support units, resource units and resource schools provide for learners who are so

severely impaired that they cannot benefit from attending inclusive schools. Once they are ready, they can join inclusive schools.

You might find barriers to learning that you cannot deal with in your class. It is important that you assess learners with barriers carefully, understand their levels of capabilities and whether or not you can help them. If the learners need special education in smaller groups, you should recommend that. Remedial education specialists and psychologists will recommend the best approach to their education.

If learners with fewer barriers to their learning remain in your class, it is better to extend their learning at a different pace so they can reach the same outcomes as the other learners. Their sense of achievement encourages them to reach for further achievements. You might have different groups of learners in your class working at different paces and with different learning methods: this makes your approach and positive attitude important.

General tips to assist learners with learning barriers:

- Learners who have difficulty organising themselves can be paired with learners who are more organised. These learners can support them with writing down homework and completing work on time.
- Keep an ongoing list of new words and terms that will help learners become familiar with words often used in Biology. They can use a picture to assist their recall, as well as a definition.
- Help learners plan their tasks by developing short mind maps that will guide the process and help them feel less overwhelmed. Break down tasks into small portions that will help learners accomplish the task.
- Place learners who battle to concentrate in the front of the class. If you see their minds wandering touch their arms or desks gently as you walk around the class, or involve them in the class by asking them questions.
- It helps learners with learning barriers to have a daily structure that they trust and are familiar with. Always be organised and consistent. Remember to give spoken instructions clearly and simply. As far as possible, involve the learners with practical, hands-on activities during Biology classes.

Achievements and the real world

Remember that school education should equip learners for life as adults. It must develop knowledge, skills and attitudes to help them succeed in the increasingly complex and rapidly changing world of information and communication technology. Use your learners' experience and prior knowledge to build new knowledge and skills.

Learner safety

Learners of Biology will be exposed to various chemicals and equipment that are potentially harmful. It is important that the laboratory is equipped with functional items that are not broken. There should be a clear poster on the wall with the most important laboratory rules preferably using pictures and words.

Spend part of a lesson going through basic laboratory safety rules before learners begin practical lessons.

- No bags or suitcases allowed in the laboratory – only their book/paper and pencil cases.
- No eating or drinking.
- No running or playing.
- A teacher must be present at all times.
- The learners' clothing must not endanger them.
- Hair needs to be tied back.
- Learners need to be alert and watchful of their investigations at all times.
- Any spills need to be cleaned immediately to prevent a fall.

Have a safety plan

- Make sure that the learners know how to call local emergency services.
- Always place a container with basic first aid items in the laboratory where it is easy to access. Ensure that there is a fire extinguisher and fire blanket which are easy to access. Ensure there is an exit plan in the case of fire or dangerous fumes.

Rules for electricity and pesticides

- Pesticides and other chemicals should be stored behind locked doors in childproof containers.
- Containers of poisonous materials should be labelled correctly with warning signs. Poisonous

materials should never be kept in unmarked bottles.
- Electrical boxes should be kept locked and should be far from any source of water.

Animals

It is best not to keep animals in the classroom or laboratory. The animals become stressed by the noise and too much handling. It is best not to do dissections on animals. The internet can be used to show the learners a dissection. Dissections of hearts, lungs and kidneys are of educational value. Ensure that learners wash their hands carefully after a dissection. Ensure the meat is appropriately disposed of. It will not be suitable for human consumption.

Water safety

When learners are near any body of water, there is a danger of drowning. This includes ponds, water troughs and other containers of water. Supervise the learners at all times and remind them to keep away from dams or ponds if you are not around to watch them.

Appreciation

We applaud you for teaching Biology at this level, and for ensuring that your learners can reach their potential. Your work is contributing to the development of our learners, our nation and our beautiful Namibia. Thank you for teaching Biology Grade 12. We hope you and your learners enjoy the lessons.

Section B Teaching guidelines and year plan

This year plan is based on 36 school weeks over one year, and nine periods per seven-day cycle for Biology. Use 32 weeks for teaching to allow sufficient time (four weeks) for formal and summative assessment.

How to use a lesson plan

This Teacher's Guide provides teaching guidelines to suggest a possible way of teaching the content covered in the Learner's Book. The guidelines were developed to meet the requirements set out in the Senior Secondary Syllabus for Biology.

To help you prepare your lessons, each lesson plan includes a guideline of the amount of time that a lesson should take. These times serve only as guidelines and may vary, depending on the strength of your class and your available resources. Note that a lesson does not need to be completed in one 40-minute period, and will probably take more than one period. It is best that you consult the Teaching guidelines well before presenting a lesson. This will help you prepare for lessons, as you may need time to obtain additional resources that will enrich the learning experience. The Teaching guidelines provide ideas on how to teach a given topic, providing you with insights that will assist your approach to a lesson, specifically in terms of how the work is covered in the Learner's Book.

Lesson plan guidelines

Subject: Biology	
Links to cross-curricular issues	This shows the integration of Environmental Education; HIV and AIDS; Population Education; Education for Human Rights and Democracy (EHRD), Information and Communication Technology (ICT), Road Safety or Special Needs Education, where appropriate.
Topic and sub-topic	This is the topic within the given syllabus that is being covered, e.g. Cell membranes and transport. The sub-topic shows the sub-section of that topic, such as Fluid mosaic membranes.
Time for lesson	How many periods or minutes are needed.
Basic competencies	These come from the syllabus and set out the new concepts and skills covered in a topic that learners must master. Check your learners' prior knowledge and ensure that your learners can accomplish these competencies before moving on to the next body of work. Revisit these when you have completed a lesson and ensure learners understand the concepts and skills that were covered.
Preparation	Preparation involves reading through the teaching guidelines provided in the Teacher's Guide. Different lessons may call for different types of preparation, such as field trips or grouping learners for activities.
Resources	The Learner's Book will be your primary resource and the relevant pages are listed here for easy reference. If any other resources or knowledgeable persons are needed for the lesson, these will be mentioned here.
Guidelines	Notes about the structure of the lesson, any difficult concepts that might require additional teaching or explaining, and the keywords that will assist you while you teach.

Beginning these lessons

- **Prior knowledge:** Explains what learners need to know so that they can understand what they will be learning about.
- **New concept/skill:** This refers to the new information that learners will encounter and is linked to their prior knowledge.

Teaching tips

- This will provide notes on how to approach the content, including the new skills and concepts, covered in the lesson.
- The approach will be modelled on how the lesson is covered in the Learner's Book and will follow the same order.

Suggested homework activities

This provides you with options for homework assignments, if needed.

Suggested answers

Answers to activities are provided here.

Informal assessment

This explains how you can use different strategies to continually assess learners.

Extension activities

Extension activities go further into a concept and provide a challenge for faster learners to keep them engaged in the learning experience.

Remedial activities

These are support activities for learners who struggle. These activities help build learners' understanding in areas where they may have experienced difficulties and need extra support and practice.

Summary

Consolidation at the end of each topic helps the learners establish what the key points of the topic were, and where they may need to improve their skills or knowledge.

Self-assessment

Learners should reflect on what they have learnt and ensure they have met the basic competencies. You as the teacher should also reflect on your teaching of the lesson

Assessment

Types and methods of assessment

Informal assessment

There is a distinct difference between informal and formal assessment. Informal assessment is noting, with criteria, how each learner deals with learning and social issues, such as cooperation and negotiation, and then doing something about your findings. You can observe every stage of the process as long as you know what you are looking for. During the process, there is time and opportunity for questions, answers and discussion. There is also opportunity for the learners to self-assess or for you to encourage peer assessment. Be alert when asking for peer assessment, because learners must learn from you how to give feedback that is positive. You can assist the learner-assessors by asking them questions. This takes away the negative possibilities and focuses on positive feedback and assessment. Informal assessment helps improve the process. You should informally assess at every stage of the process, noting the learners' experimentation, their learning, their growing confidence and competence. In this Teacher's Guide, the informal assessment notes that follow each topic or sub-topic are intended as basic guidelines for both continuous and informal assessment – purely for you to be able to monitor the learners' progress as they complete this Biology course.

Formal assessment.

In formal assessment, you need criteria to help you to plan well and for the learners to understand exactly what is required of them. There are three compulsory papers that will constitute the learners' formal assessment.

Paper	Description of paper and types of questions	Duration of paper	Marks
Paper 1: Theory: Multiple choice questions	This paper will consist of forty multiple-choice items of the four-choice type. The questions will be based on content described as specific objectives and will test abilities in Assessment Objectives A and B. Candidates will answer all questions. Candidates will answer on an answer sheet.	1 hour	40
Paper 2: Theory: Structured questions	This paper consists of compulsory short-answer, structured and free-response questions. The questions will test skills and abilities in Assessment Objectives A and B. Learners will answer all questions on the question paper [booklet].	1 hour 15 minutes	60
Paper 3: Advanced practical skills	This paper requires learners to carry out practical work in timed conditions. Learners will be expected to collect, record and analyse data so that they can answer questions related to the activity. The paper will consist of two experiments drawn from different areas of Biology. Learners will answer all questions. Learners will answer on the question paper. These questions may be based on the practical work in this syllabus with which learners are familiar. They may also include practical exercises unfamiliar to learners, but if this is the case then sufficient explanation and instruction will be given to enable learners to use knowledge of practical work in other areas to complete the task satisfactorily. Centres are expected to have standard laboratory facilities available for all of their learners.	2 hours	40
TOTAL			140

NSSCAS Biology Syllabus, NIED 2019

Weighting of papers

All learners will be entered for Papers 1, 2 and 3 specified below.

Learners will be graded from A–E depending on their abilities and achievements. **Paper 1 and 2 will constitute 77% of the final assessment while Paper 3 will constitute 23%.**

Weighting of papers	
Paper 1	29%
Paper 2	42%
Paper 3 (Applied Practical Skills Paper)	29%

The approximate weightings allocated to each of the Assessment Objectives across the papers are summarised in the following table:

Assessment Objective	Weighting across all components	Paper 1	Paper 2	Paper 3
A Knowledge with understanding	40% (not more than 20% recall)	20 marks	30 marks	0 marks
B Handling information, application and solving problems	40%	20 marks	30 marks	0 marks
C Practical (experimental and investigative) skills and abilities	20%	0 marks	0 marks	40 marks
		40 marks	60 marks	40 marks
		140 marks		

NSSCAS Biology Syllabus, NIED 2019

Assessment Objectives

The assessment will include, wherever appropriate, personal, social, environmental, economic and technological applications of Biology in modern society. Learners are required to demonstrate the Assessment Objectives in the context of the content and skills prescribed. Within each of the Assessment Objectives, the assessment must take account of the learners' ability to communicate clearly and logically and apply conventions where appropriate.

The three Assessment Objectives in Biology are:

A Knowledge with understanding
B Handling information and solving problems
C Practical (experimental and investigative) skills and abilities.

The following is a description of each Assessment Objective:

A KNOWLEDGE WITH UNDERSTANDING

Learners should be able to demonstrate knowledge and understanding in relation to:

A1. scientific phenomena, facts, laws, definitions, concepts and theories
A2. scientific vocabulary, terminology and conventions, (including symbols, quantities, units)
A3. scientific instruments and apparatus, including techniques of operation and aspects of safety
A4. scientific quantities and their determination
A5. scientific and technological applications with their social, economic and environmental implications.

The Learning Content defines the factual content that learners may be required to recall and explain. Questions testing these objectives will often begin with one of the following command words or phrases: define, name, list, indicate, give examples, state, describe, compare, explain, distinguish, outline and give reasons.

B HANDLING INFORMATION AND SOLVING PROBLEMS

Learners should be able, in words or using other written forms of presentation (i.e. symbolic, graphical and numerical) to:

B1. locate, select, organise and present information from a variety of sources
B2. translate information from one form to another
B3. manipulate numerical and other data
B4. use information to identify patterns, report trends and draw inferences
B5. present reasoned explanations for phenomena, patterns and relationships
B6. make predictions and hypotheses and solve problems
B7. apply knowledge, including principles, to new situations
B8 demonstrate an awareness of the limitations of biological theories and models.

These skills cannot be precisely specific in the Learning Content, because questions testing such skills are often based on information that is unfamiliar to the learner. In answering such questions, learners are required to use principles and

concepts that are within the syllabus and apply them in a logical, deductive manner to a novel situation. *Questions testing these objectives will often begin with one of the following command words or phrases: discuss, deduce, compare and discuss, find, estimate, interpret, evaluate, sketch, predict, identify, relate, suggest and calculate or determine.*

C PRACTICAL (experimental and investigative) SKILLS AND ABILITIES

Learners should be able to:

C1. Follow a sequence of instructions,using appropriate techniques, handling apparatus and materials competently and having due regard for safety

C2. make and record estimates, observations and measurements accurately

C3. handle and process experimental observations and data, including dealing with anomalous or inconsistent results

C4. apply scientific knowledge and understanding to make interpretations and to draw appropriate conclusions from practical observations and data

C5. plan, design and carry out investigations (based on concepts familiar to learners) and suggest modifications in the light of experience.

NSSCAS Biology Syllabus, NIED 2019

Year plan

This is a summary of the learning content for Namibia Biology Grade 12 and the suggested year plan. The indications of the number of lessons for each section is only a guideline or estimate.

Theme 1 Classification of living organisms				
Topic, Sub-topic and General objectives	**Specific objectives**	**Lessons**	**LB pages**	**TG pages**
Topic 1.1 Classification • Know how the hierarchical classification systems are used	• use and describe the binomial system of naming organisms • describe the use of a hierarchical classification system for living organisms • explain the concept of natural classification, based on homologous features and evolutionary relationships • construct dichotomous keys for the identification of locally occurring organisms • discuss the meaning of the term species, limited to the biological, morphological, ecological and behavioural concepts used	6	8–18	23–26
Topic 1.2 Biodiversity • Know three levels of biodiversity, the importance of random sampling and assess the distribution and abundance organisms in the local area	• define ecosystem and niche • explain that biodiversity can be assessed at different levels: » the number and range of different ecosystems and habitats » the number of species and their relative abundance » the genetic variation within each species • explain the importance of random sampling in determining the biodiversity of an area • use Simpson's Index of Diversity (D) to calculate the biodiversity of an area, and state the significance of different values of D (the formula for Simpson's Index of Diversity will be provided, as shown in the Mathematical requirements) (formula: $D = 1 - \sum(n/N)^2$) • describe and use suitable methods to assess the distribution and abundance of organisms in an area, limited to frame quadrats, line transects, belt transects and mark-release-recapture using the Lincoln index (as shown in the Mathematical requirements) • investigate the distribution and abundance of species in a local area, using the methods above/ suitable methods	10	19–29	27-31

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Topic 1.3 Conservation • Realise the importance of maintaining biodiversity and know the actions required at local, national and global levels	• discuss the reasons for the need to maintain biodiversity • explain the importance of reducing the pollution of waterways with reference to bioaccumulation and eutrophication • outline the roles of zoos, botanic gardens, conserved areas (national parks and marine parks), 'frozen zoos' and seed banks in the conservation of endangered species • explain why it may be necessary to limit the population of a species, (for example, by culling or contraception) to reduce pressure of other species • explain, using examples, the importance of controlling alien species • describe how degraded habitats may be restored, limited to local or regional examples • investigate the negative impact of rhino and elephant poaching on the tourism sector locally (Namibia) and regionally (South Africa and Botswana)	8	30–41	32–36
Theme 2 Organisation and maintenance of the organism				
Topic 2.1 The microscope • know and understand the principles of light and electron microscopy	• state and explain the principles of microscopy • explain and distinguish between resolution and magnification, with reference to a light-microscope and an electron microscope • use an eyepiece graticule and stage micrometer scale to measure cells and be familiar with units (millimetre, micrometre and nanometre) • calculate actual sizes of specimens from drawings, photomicrographs and electron micrographs • calculate the linear magnifications of drawings, photomicrographs and electron micrographs	12	44–53	37–39
Topic 2.2 Cell structure • know and understand the cellular nature of all living organisms and the difference between prokaryotic and eukaryotic cells and viruses	• identify and recognise the following parts of a eukaryotic cell and outline the functions of the: » cell surface membrane » nucleus, nuclear envelope and nucleolus » mitochondrion » ribosomes (80S in the cytoplasm and 70S in chloroplasts and mitochondria) » chloroplast » rough and smooth endoplasmic reticulum » Golgi body (Golgi apparatus or Golgi complex) » lysosomes » cell wall » centrioles » cilia » microvilli » plasmodesmata » large permanent vacuoles » tonoplast • describe and interpret the structure of plant and animal cells as seen with an electron microscope	7	54–66	40–43

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	• draw and label low-power plan diagrams of tissues and organs (including a transverse section of stems, roots and leaves) • compare the structure of a typical plant (palisade) and animal (liver) cells • make temporary slides (wet mounts) of plant and animal cells (for example: epidermal cells from a leaf or an onion, epithelial cells from the trachea of a sheep or human cheek cells) • make observations and drawings of cells as seen under a light microscope (including cells within transverse sections of stems, roots and leaves) • outline key structural features of typical prokaryotic cells as found in a typical bacterium (including: unicellular, 1–5 μm diameter, peptidoglycan cell walls, naked circular DNA, 70S ribosomes, absence of organelles bound by a double membrane) • compare and contrast the structure of prokaryotic cells with eukaryotic cells (no reference to mesosomes required) • state that ATP is produced in mitochondria and chloroplasts and outline its role in cells • state that all viruses are non-cellular and have a nucleic acid core (either DNA or RNA), a capsid made of protein, and some viruses have an outer envelope made of phospholipid			
Topic 2.3 Cell membranes and transport				
Sub-topic 2.3.1 Fluid mosaic membranes • Know and understand the structure and functions of cell surface membranes in relation to cell signalling	• describe the fluid mosaic model of membrane structure, including the components phospholipids, cholesterol, glycolipids, proteins and glycoproteins • outline the roles of the cell surface membrane • describe the roles in cell surface membranes of phospholipids, cholesterol, carrier proteins, channel proteins, cell surface receptors and cell surface antigens • outline the process of cell signalling involving the release of chemicals that combine with cell surface receptors on target cells, leading to specific responses	6	67–73	44–46
Sub-topic 2.3.2 Movement of substances into and out of cells • Understand how substances enter and exit cells by a variety of mechanisms	• describe and explain the processes of diffusion, facilitated diffusion, osmosis, active transport, endocytosis and exocytosis (no calculations involving water potential will be set) • investigate simple diffusion and osmosis using plant tissue and non-living materials, such as glucose solutions, Visking tubing and agar • calculate surface areas and volumes of simple shapes (e.g. cubes) to illustrate the principle that surface area-to-volume ratios decrease with increasing size	12	74–83	47–50

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	• explain the movement of water between cells and solutions with different water potentials and explain the different effects on plant cells (using the terms turgid, flaccid, plasmolysis) and animal cells (Movement of water should be described in terms of water potential, knowledge of solute potential is not expected. • investigate the effects of immersing plant tissues in solutions of different water potential, using the results to estimate the water potential of the tissues			
Topic 2.4 Biological molecules				
Sub-topic 2.4.1 Carbohydrates and lipids • Know the structure and properties of biological molecules and understand the relationship between molecular structures and their functions	• define the terms monomer, polymer, macromolecule, monosaccharide, disaccharide and polysaccharide • describe and draw the ring forms of α-glucose and β-glucose • describe the formation of a glycosidic bond by condensation, with reference both to polysaccharides and to disaccharides, including sucrose • describe the breakage of glycosidic bonds in polysaccharides and disaccharides by hydrolysis, with reference to the non-reducing sugar test • describe the molecular structure of the polysaccharides starch (amylose and amylopectin) and glycogen and relate their structures to their functions in living organisms • describe the molecular structure of the polysaccharide cellulose and outline how the arrangement of cellulose molecules contributes to the function of plant cell walls • describe the molecular structure of a triglyceride with reference to the formation of ester bonds and relate the structure of triglycerides to their functions in living organisms • describe the structure of a phospholipid and relate the structure to the functions of phospholipids in living organisms • describe and carry out the Benedict's test for reducing sugars, the iodine test for starch and the emulsion test for lipids • describe and carry out a semi-quantitative Benedict's test on a reducing sugar solution by standardising the test and using the results (time to first colour change or comparison to colour standards) to estimate the concentration • describe and carry out a test to identify the presence of non-reducing sugars, using acid hydrolysis and Benedict's solution • carry out a semi-quantitative Benedict's test on a reducing sugar using dilution, standardising the test and using the results (colour standards or time to first colour change) to estimate the concentration	8	84–97	51–54

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Sub-topic 2.4.2 Proteins and water • Know the basic structure of protein molecules and understand how their structures relate to their functions • Know the important roles of globular and fibrous proteins in biological processes • Know the properties of the water molecule and the role of water in living organisms	• describe the structure of an amino acid and the formation and breakage of a peptide bond • explain the meaning of the terms primary structure, secondary structure, tertiary structure and quaternary structure of proteins • describe the types of bonding (hydrogen, ionic, disulfide and hydrophobic interactions) that hold these molecules in shape • describe the molecular structure of haemoglobin as an example of a globular protein, and of collagen as an example of a fibrous protein, and relate these structures to their functions (appreciate that the haemoglobin molecule is composed of two alpha (α) chains and two beta (β) chains, although when describing the chains the terms α-globin and β-globin may be used; there should be a distinction between collagen molecules and collagen fibres) • state the importance of iron in the haemoglobin molecule • carry out biuret test to identify the content of solutions, food substances and biological specimens • explain that water is a polar molecule and explain how hydrogen bonding occurs between water molecules • relate the properties of water to its roles in living organisms (limited to solvent action, specific heat capacity and latent heat of vaporisation)	5	98–107	55–57
Topic 2.5 Enzymes				
Sub-topic 2.5.1 Mode of action of enzymes • Know how the structure of enzymes relates to their function	• explain the nature of enzymes as globular proteins that catalyse metabolic reactions • state that enzymes function as intracellular and as extracellular enzymes • explain the mode of enzyme action in terms of an active site, enzyme–substrate complex, lowering of activation energy and enzyme specificity (the lock-and-key hypothesis and the induced-fit hypothesis should be included) • investigate the progress of an enzyme-catalysed reaction by measuring formation or rates of formation of products and by-products, (for example using catalase) or rates of disappearance of substrate (for example, using amylase)	8	110–114	58–60
Sub-topic 2.5.2 Factors that affect enzyme action • Understand the importance of the factors that affect the rate of enzyme-catalysed reactions	• investigate and explain the factors that affect the rate of enzyme-catalysed reactions » temperature » pH (using buffer solutions) » enzyme concentration » substrate concentration » inhibitor concentration • explain how the maximum rate of reaction (V_{max}) is used to derive the Michaelis-Menten constant (K_m) which is used to compare the affinity of different enzymes for their substrates	6	115–126	61–64

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	• explain the effects of reversible inhibitors, both competitive and non-competitive, on the enzyme activity • investigate and explain the effect of immobilising an enzyme in alginate on its activity as compared with its activity when free in solution			
Topic 2.6 Transport in plants				
Topic 2.6.1 Structure of transport tissues • Know the structural components of xylem and phloem and relate these to their functions	• identify and label the various parts of transverse sections of stems, roots and leaves of herbaceous dicotyledonous plants, using an eyepiece graticule to show correct proportions • describe the structure of xylem vessel elements, phloem sieve tube elements and companion cells • relate the structure of xylem vessel elements, phloem sieve tube elements and companion cells to their functions • draw and label from prepared slides the structure of xylem vessel elements, phloem sieve tube elements and companion cells (use a light microscope to recognise the structures)	12	127–137	65–68
Sub-topic 2.6.2 Mechanisms of transport in plants • Understand mass flow in relation to the movement of xylem and phloem sap	• explain that transpiration involves the evaporation of water from the internal surfaces of leaves followed by diffusion of water vapour to the atmosphere • describe, in terms of water potential, the movement of water: » between plant cells » between the plant and its environment (no calculations involving water potential will be set) • investigate experimentally and explain the factors that affect transpiration rate using a simple potometer, epidermal peels and grids for determining surface area • explain how hydrogen bonding of water molecules is involved with movement in the xylem by cohesion-tension in transpiration pull and adhesion to cellulose cell walls • describe the pathways and explain the mechanisms by which water and mineral ions are transported from soil to xylem and from roots to leaves (include reference to the symplastic pathway, apoplastic pathway and Casparian strip) • make annotated drawings of transverse sections of leaves from xerophytic plants to explain how they are adapted to reduce water loss by transpiration • state how assimilates, such as sucrose and amino acids, move between sources (e.g. leaves and storage organs) and sinks, (e.g. buds, flowers, fruits, roots and storage organs) in phloem sieve tubes	12	138–152	69–72

continued on next page

	• explain how sucrose is loaded into phloem sieve tubes by companion cells using proton pumping and the co-transporter mechanism in their cell surface membranes • explain mass flow in phloem sap down a hydrostatic pressure gradient from source to sink			
Topic 2.7 Transport in animals (mammals)				
Sub-topic 2.7.1 Mammalian circulatory system • Know the structure and function of the mammalian circulatory system and the components of blood	• state that the mammalian circulatory system is a closed double circulation consisting of a heart, blood vessels and blood • observe and make plan diagrams of the structure of arteries and veins, using prepared microscope slides and be able to recognise these vessels using the light microscope or from photomicrographs • explain the relationship between the structure and function of arteries, veins and capillaries • recognise and draw the structure of red blood cells, monocytes, neutrophils and lymphocytes using prepared slides, photomicrographs and electron micrographs • state the functions of tissue fluid and describe the formation of tissue fluid in a capillary network • state and explain the differences between blood, tissue fluid and lymph • describe the role of red blood cells in carrying oxygen and carbon dioxide with reference to the role of: » haemoglobin » carbonic anhydrase » the formation of haemoglobinic acid » the formation of carbamino-haemoglobin (details of the chloride shift are not required) • describe how carbon monoxide binds with haemoglobin to form carboxy haemoglobin reducing the affinity of haemoglobin for oxygen • describe the role of plasma in the transport of carbon dioxide • describe and explain the oxygen dissociation curve of adult haemoglobin • explain the importance of the oxygen dissociation curve at partial pressures of oxygen in the lungs and in respiring tissues • describe the Bohr shift and explain the importance of the Bohr shift • describe and explain the significance of the increase in the red blood cell count of humans at high altitude	8	153–166	73–76
Sub-topic 2.7.2 Mammalian heart • Know the structure and functions of the heart	• describe the external and internal structure of the mammalian heart • observe and make plan diagrams of the external and internal structure of the mammalian heart	8	167–176	77–79

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	• explain the differences in the thickness of the walls of the: » atria and ventricles » left ventricle and right ventricle • describe the cardiac cycle (including blood pressure changes during systole and diastole) and the opening and closing of valves • interpret graphs showing the changes in blood pressure during the cardiac cycle • explain how heart action is initiated and controlled (reference should be made to the sinoatrial node, the atrioventricular node and the Purkinje tissue, but not to nervous and hormonal control)			
Topic 2.8 Disease				
Sub-topic 2.8.1 Infectious diseases • Understand the biology of pathogens and know the mode of their transmission	• define the term disease and explain the difference between an infectious disease and a non-infectious disease (limited to sickle cell anaemia and lung cancer) • state the name and type of pathogen that causes each of the following diseases: » cholera – caused by the bacterium *Vibrio cholerae* » malaria – caused by the protoctists *Plasmodium falciparum*, *Plasmodium malariae*, *Plasmodium ovale* and *Plasmodium vivax* » tuberculosis (TB) – caused by the bacteria Mycobacterium tuberculosis and *Mycobacterium bovis* » HIV/AIDS – caused by the human immunodeficiency virus (HIV) » measles – caused by Morbillivirus • explain how cholera, malaria, TB and HIV/AIDS are transmitted • discuss the biological, social and economic factors that need to be considered in the prevention and control of cholera, measles, malaria, TB and HIV/AIDS (a detailed study of the life cycle of the malarial parasite is not required) • discuss the factors that influence the global patterns of malaria distribution	6	177–184	80–83
Sub-topic 2.8.2 Antibiotics • Know that penicillin is used to control bacterial infections and know the consequences of antibiotic resistance	• describe how penicillin acts on bacteria and why antibiotics do not affect viruses and eukaryotic cells • outline how bacteria become resistant to antibiotics with reference to mutation and selection • discuss the consequences of antibiotic resistance and the steps that can be taken to reduce its impact	6	185–190	84–85

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Topic 2.9 The immune system				
Sub-topic 2.9.1 The response of the immune system to pathogens • Understand the roles of the cells and molecules of the immune system and their functions in protecting the body against infectious diseases	• describe the mode of action of phagocytes (macrophages and neutrophils) • describe the sequence of events that occurs during a primary immune response with reference to the roles of: » macrophages » B-lymphocytes, including plasma cells » T-lymphocytes, limited to T-helper cells and T-killer cells • explain what is meant by an antigen and state the difference between self-antigens and non-self-antigens • explain the role of memory cells in the secondary immune response and in long-term immunity	8	191–197	86–88
Sub-topic 2.9.2 Antibodies and vaccinations • Recognise the role of antibodies and vaccination in the prevention of infectious diseases	• relate the molecular structure of antibodies to their functions (see 2.4.2) • outline the hybridoma method for the production of monoclonal antibodies • outline the use of monoclonal antibodies in the diagnosis of disease and in the treatment of disease • describe the differences between active and passive immunity and between natural and artificial immunity • explain that vaccines contain antigens that stimulate immune responses to provide long-term immunity • explain how vaccination programmes can help to control the spread of infectious diseases	8	198–206	89–92
Topic 2.10 Human gas exchange and smoking				
Sub-topic 2.10.1 The gas exchange system • Know the gross structure of the gas exchange system and understand the function of the various parts	• describe the gross structure of the human gas exchange system • investigate and observe the gross structure of lungs and associated organs of a sheep or other mammal (dissect) • describe the distribution in the gas exchange system of cartilage, ciliated epithelium, smooth muscle, capillaries and squamous epithelium of alveoli • recognise cartilage, ciliated epithelium, smooth muscle, capillaries and squamous epithelium of alveoli in microscope slides, photomicrographs and electron micrographs • recognise trachea, bronchi, bronchioles and alveoli in microscope slides, photomicrographs and electron micrographs and make plan diagrams of transverse sections of the walls of the trachea and bronchus • describe the functions of ciliated epithelial cells, goblet cells and mucous glands in maintaining the health of the gas exchange system	8	207–214	93–96

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	• describe the functions in the gas exchange system of cartilage, smooth muscle, elastic fibres and squamous epithelium • describe the process of gas exchange between air in the alveoli and the blood in the capillaries			
Sub-topic 2.10.2 Smoking and its impact on the gas exchange and circulatory system • Understand the impact of smoking on one's health	• describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system with reference to lung cancer and chronic obstructive pulmonary disease (COPD) • describe the short-term effects of nicotine and carbon monoxide on the cardiovascular system • conduct a survey, possibly with the use of a questionnaire, on the incidence of hay fever and/or asthma	4	215–219	97–100
Theme 3 Development of the organism and the continuity of life				
Topic 3.1 Mitotic cell cycle				
Sub-topic 3.1.1 Replication and division of nuclei and cells • Acknowledge the significance of the cell cycle and replication in the uniformity of daughter cells	• describe the structure of a chromosome, limited to DNA, histone proteins, chromatids, centromere and telomeres • explain the importance of mitosis in the production of genetically identical cells, growth, cell replacement, repair of tissues and asexual reproduction • observe and draw the mitotic stages visible in temporary root tip squash preparations and in prepared slides of root tips of species such as those of *Vicia faba* and *Allium cepa* • outline the mitotic cell cycle, including interphase (growth in G_1 and G_2 phases and DNA replication in S phase), mitosis and cytokinesis • outline the significance of telomeres in permitting continued replication and preventing the loss of genes • outline the role of stem cells in cell replacement and tissue repair by mitosis • explain how uncontrolled cell division can result in the formation of a tumour	8	222–231	101–104
Sub-topic 3.1.2 Chromosome behaviour in mitosis • Know the events that occur during mitosis (cell cycle)	• describe, with the aid of photomicrographs and diagrams, the behaviour of chromosomes in plant and animal cells during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell surface membrane and the spindle, (names of the main stages of mitosis (prophase, metaphase, anaphase and telophase) are expected • interpret photomicrographs, diagrams and microscope slides of mitosis and identify the main stages of mitosis	6	232–238	105–107

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Topic 3.2 Nucleic acids and protein synthesis				
Sub-topic 3.2.1 Structure and replication of DNA • Know the structure of nucleic acids and understand their role in the storage of genetic information and how that information is used in protein synthesis	• describe the structure of nucleotides, including the phosphorylated nucleotide ATP (structural formulae are not required) • state that adenine and guanine are purines with a double-ring structure and that cytosine, thymine and uracil are pyrimidines with a single-ring structure (structural formulae for bases are not required) • describe the structure of RNA and DNA and explain the importance of base pairing and the different hydrogen bonding between bases • describe the semi-conservative replication of DNA during the S phase • design and make a model of DNA to illustrate the semi-conservative replication of DNA during interphase	6	239–246	108–111
Sub-topic 3.2.2 Protein synthesis • Understand the genetic code and how DNA codes for polypeptides	• state that a polypeptide is coded for by a gene and that a gene is a sequence of nucleotides that forms part of a DNA molecule • state the features of the genetic code • describe how the information in DNA is used during transcription and translation to construct polypeptides, including the role of messenger RNA (mRNA), transfer RNA (tRNA) and the ribosomes • state that a gene mutation is a change in the sequence of nucleotides, which may result in an altered polypeptide • explain that a gene mutation occurs by substitution, deletion or insertion of base pairs and outline how each of these types of mutation may affect the polypeptide produced • describe the way in which the nucleotide sequence codes for the amino acids sequence in a polypeptide with reference to the nucleotide sequence for Hb^A (normal) and Hb^S (sickle) alleles of the gene for β-globin polypeptide • design and make a model of RNA to contrast it with the DNA model	8	247–255	112–115

Section C Teaching guidelines

Theme 1 Classification of living organisms

TOPIC 1.1 Classification

LB pages 8–18

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know how the hierarchical classification systems are used
Specific objectives	• Use and describe the binomial system of naming organisms • Describe the use of a hierarchical classification system for living organisms • Explain the concept of natural classification, based on homologous features and evolutionary relationships • Construct dichotomous keys for the identification of locally occurring organisms • Discuss the meaning of the term species, limited to the biological, morphological, ecological and behavioural concepts
Cross-cutting issues	Environmental learning
Inclusive education	Use the activities suggested
Suggested teaching times	6 lessons
Additional resources needed	None

Introduction to this topic

This topic revisits the classification system that is used for grouping living organisms. The groups into which organisms are placed is hierarchical. The groups are arranged so that they contain an ever-decreasing number of organisms. The binomial system is also discussed with many examples given. Activities to design and use a dichotomous key are included in this topic.

Starter activity

LB page 8

Use this activity to revise the classification groups that were covered in earlier grades. Learners can also use examples of the binomial system when they give the scientific names of some indigenous plants and animals.

Suggested answers

1. kingdom, phyla, order, class, family, genus, species
2. **a) i)** *Pachypodium*; **ii)** *Oryx*; **iii)** *Aloidendron*
   b) i) *horridus*; **ii)** *erioloba*; **iii)** *africana*

Beginning these lessons

Learners covered classification in Grade 10. They found out that organisms are classified according to shared characteristics, for example all animals with backbones are classified as chordates. They discussed the binomial naming system by which organisms are given a genus and a species name. Learners were also introduced to dichotomous keys. This topic extends learners' prior knowledge.

- The binomial system of naming organisms is revisited. Try to use examples of Namibian organisms in your discussions. Make sure that learners understand what a hierarchy is.
- Distinguish between artificial and natural classification systems explaining the advantages and disadvantages of each. An understanding of natural classification using phylogeny will be useful when evolutionary relationships are explored later at tertiary level. Make sure learners understand that phylogenetic relationships are based on evidence that can change as new evidence is found. Use Activity 1 on page 13 of the Learner's Book to consolidate this concept.

- It is important that learners grasp the species concepts; the biological species concept, the morphological species concept, the ecological species concept and the behavioural species concept. Make sure that learners can distinguish between these concepts. Species diversity is discussed in Topic 1.2. The competitive exclusion principle in the next topic also requires an understanding of how different species cannot have the same niche.
- There are many useful sites on the Internet that explain the concepts in this lesson. These sites will help you prepare for teaching this topic. For example:
  https://www.sciencedirect.com/topics/earth-and-planetary-sciences/species-concept
  https://evolution.berkeley.edu/evolibrary/article/side_0_0/biospecies_01
- Although learners have probably used dichotomous keys in earlier grades, they will not have had an opportunity to design one. You may need to assist less able learners with this task by giving them other practice keys to work with. For example:
  https://uoitbio2013.wordpress.com/taxonomy/dichotomous-keys/
  https://biology-igcse.weebly.com/dichotomous-keys.html

Teaching tips

Make use of the activities to consolidate the work that is covered. Use Activity 2 on page 16 in the Learner's Book to develop observational skills as learners have to distinguish features in different pods in order to identify the trees from which they come.

Homework

Use Activity 1: Interpret a phylogenetic tree on page 13 of the Learner's Book as a homework task to make sure learners have grasped the concept of how these can be used to show evolutionary relationships.

Inclusive education

Some learners may have physical, sensory and other learning difficulties. Adapt your teaching to accommodate these learners' specific needs. For example, you can pair them with learners who understand the work well or spend time with them after the lessons to ensure that they have been able to fully grasp the content of the topic.

For learners with language difficulties, you could use the key word boxes to draw up a test. Learners have to give the meanings of the terms or alternatively give the term that matches the meaning.

Example:
Match the term in Column I with the meaning in Column II

Column I	Column II
1. binomial nomenclature	A the study and identification of organisms based on systematic grouping
2. taxonomy	B arranged in order
3. hierarchical	C giving an organism a two-part name

Answers: 1 C, 2 A, 3 B

Informal assessment

You can draw up a short test using the new terms that are used in this topic to check that learners have grasped their meanings. See the example provided above as an idea.

Self-assessment

Use the following self-assessment rubric to check that learners have understood the concepts covered in this topic.

	Very good	Good	Developing	Need help
Taking notes	I was able to take **very good** notes on the content of the lessons.	I was able to take **good** notes on the content of the lessons but sometimes missed one or two points.	I took **some** notes and I feel I am getting better at it.	I **need help** learning how to take notes.
Understanding	I understood **everything** in this topic.	I understood **almost everything** in this topic.	I did not understand **some things** in this topic.	I did not understand **anything** in this topic.
Activities	I completed all the activities **easily**.	I completed all the activities but had a **little difficulty** with one or two questions.	I did not complete all the activities and had **difficulty with many questions**.	I **need help** with most of the activities.
Co-operation with partners or group	I **never** argued with my partner or group members, I talked to them about my ideas and listened to everyone's opinions.	I **sometimes** argued with my partner or group, I sometimes talked to them about my ideas and thought about their opinions.	I **argued a lot** with my partner or group members, I **hardly** talked to them about my ideas and seldom listened to their ideas.	I **did not work at all well** with my partner or group members.

Suggested answers

Activity 1 Interpret a phylogenetic tree (LB page 13)

1. a) Carnivora
b) *Lycaon* and *Canis*
2. The leopard is more closely related to the lion than the wild dog. The lion and leopard both belong to the Felidae family whereas the wild dog belongs to a completely different family.
3. The wild dog and honey badger are more distantly related than the wild dog and jackal. The wild dog and jackal belong to the same family whereas the honey badger belongs to a completely different family.

Activity 2 Use a dichotomous key to identify indigenous thorn trees (LB page 16)

A – Vachellia erioloba
B – Vachellia tortilis
C – Vachellia sieberiana
D – Vachellia reficiens
E – Vachellia nilotica

Self-assessment (LB page 18)

1. a) Artificial classification uses easily observable features of organisms; it is convenient and simple and often used in field guides. (any 1)
b) Natural classification uses more evidence about the features of organisms and includes evidence based in evolutionary relationships. (any 1)
2. a) homologous structure – a structure in related organisms that has a similar structure but a different function (2)
b) molecular homology – similarities in the genes or DNA of related organisms (2)
c) phylogeny – the evolutionary history of an organism (1)
3. a) A 'species' using the biological species concept is defined as a group of populations whose members have the potential to interbreed in nature and produce fertile offspring. (3)
b) i) A disadvantage of using the morphological species concept is that it relies on a scientist's interpretation of structural features. (1)
ii) A disadvantage of using the biological species concept is that it

can only be applied to organisms that reproduce sexually not to organisms that are extinct or represented by fossils. (1)

4. A dichotomous key is a great tool to use in field guides as it relies on observable features such as size, colour, shape of body, etc. However, it cannot be used to show genetic similarities that would indicate evolutionary relationships. (4)

5. a) eukaryotes (1)
b) plantae and bacteria (1)
c) plantae (1)

6. a) Organisms are classified into hierarchical categories. 'Species' refers to a group that includes only a single type of organism. (2)

b)
- 'bi' refers to two
- 'nomial' refers to name
- thus, 'binomial' refers to naming organisms based on two distinct features – the genus and species name
- *Acacia* is the genus name; the species name is *erioloba*
- the organism belongs to the *acacia* genus and is an *erioloba* species. (2)

7.
- viruses belong to their own group, as they cannot live outside of the host
- they only start to replicate once they find themselves inside a host
- they do not have membrane-enclosed DNA like eukaryotic organisms
- they only have RNA as genetic material
- bacteria are larger in size than viruses but they do not have membrane-enclosed genetic material
- bacteria can multiply outside their hosts (4)

8. It is useful as it enables the description of the relationship between organisms; how organisms have been modified as new genetic and molecular evidence is found. This refines the relationship between organisms. (3)

TOPIC 1.2 Biodiversity

LB pages 19–29

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know three levels of biodiversity, the importance of random sampling and assess their distribution and abundance organisms in their locality
Specific objectives	• Define ecosystem and niche • Explain that biodiversity can be assessed at different levels: » the number and range of different ecosystems and habitats » the number of species and their relative abundance » the genetic variation within each species • Explain the importance of random sampling in determining the biodiversity of an area • Use Simpson's Index of Diversity (D) to calculate the biodiversity of an area, and state the significance of different values of D (the formula for Simpson's Index of Diversity will be provided, as shown in the Mathematical requirements) (formula: $D = 1 - \sum(n/N)^2$) • Describe and use suitable methods to assess the distribution and abundance of organisms in an area, limited to frame quadrats, line transects, belt transects and mark-release-recapture using the Lincoln index (as shown in the Mathematical requirements) • Investigate the distribution and abundance of species in a local area, using the methods above/suitable methods.
Cross-cutting issues	Environmental learning
Inclusive education	Example given for learners who struggle with mathematics
Suggested teaching times	10 lessons Field trip
Additional resources needed	Frame quadrats; string for line or belt quadrats; clipboards

Introduction to this topic

Learners were introduced to the diversity of living organisms in earlier grades. They explored various groups focusing on their external characteristics and their adaptations to survival in different environments.

In this topic, learners will find out more about biodiversity. Wherever possible use Namibian examples in your discussions and emphasise the country's rich biodiversity. Ecosystem biodiversity, species biodiversity and genetic diversity are explained.

Scientists recognise the value of studying biodiversity so they have developed ways of assessing it. Learners will find out how the distribution and abundance of species is assessed using different methods. Learners have an opportunity to apply what they have learnt in this topic when they carry out their investigation in a local area.

Starter activity

LB page 19

Use the starter activity to revise some aspects of biodiversity that were covered in earlier grades.

Suggested answers

1. a) population – a group of organisms that share many similar characteristics and can interbreed to produce fertile offspring

b) ecosystem – an area in which organisms live and interact with other organisms and their physical environment

c) species – a group of populations whose members have the potential to interbreed in nature and produce fertile offspring

d) adaptation – a characteristic that an organism has that enables it to survive better in a particular environment

e) variation – differences in the characteristics in different cells,

organisms or groups of organisms that arise by genetic or environmental changes

2. a) A – gemsbok; B – welwitschia

b) They both live in hot, dry desert environments.

c) Gemsbok can survive long periods without water and have special cooling mechanisms that involve the blood flow in their mouths and noses. Welwitschia can trap water from dew that falls on their leaves. This helps to keep them cool.

Beginning these lessons

Check learners' understanding of important ecological terms such as ecosystem, habitat, species and adaptation. Consolidate their understanding of the terms if you feel there are any gaps in their knowledge.

Teaching tips

Work through the content of the Learner's Book using the illustrations to help you.

- Make sure that learners can distinguish between ecosystem, species and genetic diversity.
- Use the example of two species of Paramecium to explain ecological niches and the competitive exclusion principle.
- Help learners to understand the difference between species richness and relative species abundance by referring to Figure 1.2.5 on page 21 in the Learner's Book. Species richness refers to the number of different species in an ecosystem whereas species abundance indicates the number of each species relative to the others in an ecosystem.
- Genetic diversity helps species to adapt to changes in their environment. As a result of a decline in population numbers the genetic diversity of cheetah in Namibia has reduced. This impacts on their overall health, makes them less able to fight disease and breed successfully. You can read more about the genetic diversity of cheetah at: https://insider.si.edu/2016/06/smithsonian-study-reveals-precipitous-decline-genetic-diversity-wild-cheetahs/
- The practical application of sampling methods brings some relief to all the theoretical aspects of this topic. Before starting to discuss each method spend time explaining why random sampling is so important. Note that for the Simpson's Index of Diversity (D) there are two possible formulae that can be used. Apart from the one used in the curriculum document, some ecologists use:

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

In this formula:

n = the number of organisms of a particular species

N = the total number of individual organisms (all species combined)

Both formulae work, so you can choose which one your learners find easier to work with.

Inclusive education

You may need to spend time explaining the Simpson's Index with learners who do not have great mathematical skills. Here is another example for them to practise:

Calculate the Simpson's index of diversity of a coastal wetland; samples are taken to determine the number of individuals of different bird species present. The table shows the number of species found in random samples at the edge of a salt pan.

Species	Number of individuals of each species
Black necked grebe	15
Common tern	2
Cape cormorant	7
Lesser flamingo	4
Total (N)	28

Answer

$$D = 1 - \left(\sum \left(\frac{n}{N}\right)^2\right)$$

$$D = 1 - \left[\left(\frac{15}{28}\right)^2 + \left(\frac{2}{28}\right)^2 + \left(\frac{7}{28}\right)^2 + \left(\frac{4}{28}\right)^2\right]$$

$= 1 - (0.29 + 0.005 + 0.063 + 0.02)$

$= 1 - 0.378$

$= 0.622$

This means that there is a 6.2% chance of randomly selecting two individuals of the same species.

Homework

You can use Activity 1 and the extra example of the Simpson's index of diversity given as homework tasks.

Informal assessment

You can draw up a short test using the new terms that are used in this topic to check that learners have grasped their meanings.

Suggested answers

Activity 1 Case study (LB page 22)

1. *Cyprinus carpio*
2. They are an invasive species; they disturb the sediment at the bottom of dams and so increase the turbidity of the water that affects other fishes' feeding; they carry fish parasites.
3. Carp are invasive which means that they rapidly reproduce in an ecosystem. The introduction of carp to a dam would affect food and oxygen availability which would impact on the indigenous species in the dam. There would be a loss of species diversity.

Activity 2 Compare three random samples in three different areas

(LB pages 24–25)

1.

Sample	Species 1 (n_1)	Species 2 (n_1)	Species 3 (n_1)	Species 4 (n_1)	Species 5 (n_1)	Species 6 (n_1)	Total (N)
1	0	15	0	2	0	13	30
2	2	15	1	1	1	10	30
3	4	7	6	3	2	8	30

2. Sample 1

3. a) (calculations to three decimal places)

Sample 1

$$D = 1 - \left[\left(\frac{0}{30}\right)^2 + \left(\frac{15}{30}\right)^2 + \left(\frac{0}{30}\right)^2 + \left(\frac{2}{30}\right)^2 + \left(\frac{0}{30}\right)^2 + \left(\frac{13}{30}\right)^2\right]$$

$D = 1 - (0 + 0.25 + 0 + 0.004 + 0 + 0.188)$

$D = 1 - 0.442$

$\underline{D = 0.558}$

Sample 2

$$D = 1 - \left[\left(\frac{2}{30}\right)^2 + \left(\frac{15}{30}\right)^2 + \left(\frac{1}{30}\right)^2 + \left(\frac{1}{30}\right)^2 + \left(\frac{1}{30}\right)^2 + \left(\frac{10}{30}\right)^2\right]$$

$= 1 - [(0.004 + 0.25 + 0.001 + 0.001 + 0.001 + 0.111)]$

$= 1 - 0.368$

$\underline{= 0.632}$

Sample 3

$$D = 1 - \left[\left(\frac{4}{30}\right)^2 + \left(\frac{7}{30}\right)^2 + \left(\frac{6}{30}\right)^2 + \left(\frac{3}{30}\right)^2 + \left(\frac{2}{30}\right)^2 + \left(\frac{8}{30}\right)^2\right]$$

$= 1 - (0.018 + 0.054 + 0.04 + 0.01 + 0.004 + 0.071)$

$= 1 - 0.197$

$\underline{= 0.803}$

Table to show results

Sample number	Simpson's Index of Diversity (*D*)
1	0.558
2	0.632
3	0.803

b) Yes, sample 1 has the lowest index of diversity so is the least diverse of the three samples.

4. a) Sample 1: 0.558 × 100 = 55.8% of randomly selecting two ants of the different species

b) Sample 3: 0.803 × 100 = 80.3% of randomly selecting two ants of the different species

5. a) Sample 3 had the greatest diversity of species. There was a high probability (80.3%) of selecting ants from different species.

b) Sample 1 had the lowest diversity of species. This sample had the lowest probability (55.8%) of selecting ants from different species.

Activity 3 Calculate the number of species in an area (LB page 25)

	Number of plants		
	Quadrat 1	**Quadrat 2**	**Quadrat 3**
Ludwigia stolonifera	10	8	9
Ammannia baccifera	5	3	4
Cyperus compressus	4	5	6

1. Average number of each species per 1 m^2
   Ludwigia stolonifera = 9; *Ammannia baccifera* = 4; *Cyperus compressus* = 5
2. Total number of each species in 100 m^2
   Ludwigia stolonifera = 900; *Ammannia baccifera* = 400; *Cyperus compressus* = 500
3. The data can be used to assess the relative numbers of each species and assess which species dominate the area.

Activity 4 Investigate the distribution and abundance of species in an area (LB page 27)

Get permission from the relevant authorities to take learners out of school for the field trip or alternatively work within the school grounds. Gather all the necessary equipment before you go on the trip. You will need:

- frame quadrats
- calculators
- clip boards with paper
- marking pens.

Learners should work in groups for this practical task. Let them spend time planning which sampling methods they are going to use. Facilitate this step to make sure that they are being realistic about their sampling method.

Go on the field trip. Make sure that you have support from other staff to monitor the learners.

You could use the following rubric for assessment:

Criteria	Excellent 4 marks	Good 3 marks	Average 2 marks	Poor 1 mark
Group work	Excellent communication; equal sharing of workload; worked independently; required no assistance.	Good communication; equal sharing of workload; worked fairly independently; required little assistance.	Some communication; some attempt to share workload equally; required a fair amount assistance.	Ineffective communication; workload not equally shared; unable to follow instructions; required a lot of assistance.
Collection of data	Appropriate sampling method chosen; accurate use of sampling equipment and collection of data.	Appropriate sampling method chosen; fairly accurate use of sampling equipment and collection of data.	Appropriate sampling method chosen; but inaccurate use of sampling equipment and collection of data.	Inappropriate sampling method chosen.
Report				
Method	Written clearly and accurately; all steps given.	Written fairly clearly but with some minor inaccuracies.	Method written but many errors.	No report written.
Recording of data	Correct, accurately and neatly recorded.	Recorded but presentation needs attention.	Recorded but incomplete.	Incorrectly recorded.
Processing data	Correct		Mostly correct	
Presentation	Neat, showing interest and care.	Fairly neat with some interest shown.	Slightly untidy with only a little interest.	Untidy; no interest shown.
				Total = 24

Self-assessment (LB page 29)

1. a) Species richness refers to the number of different species in an ecosystem whereas species abundance indicates the number of each species relative to the others in an ecosystem. (2)

b) Ecosystem diversity means the range of different ecosystems in an environment and species diversity refers to the number of different species in an ecosystem. (2)

c) A line transect is a sampling method by which a long rope is used. The number of organisms of a particular species that touch the rope is counted. A belt transect has a wider area in which organisms are counted; two parallel ropes are used that are about 1 m apart. Quadrats can be used in the area between the ropes. (4)

2. a) population – a group of organisms that share many similar characteristics and are able to interbreed to produce fertile offspring (2)

b) ecological niche – a place which has a set of conditions from which a specific species gets all its requirements to support its role in an ecosystem; only one species can occupy a particular niche (2)

c) species – a group of populations whose members have the potential to interbreed in nature and produce fertile offspring (2)

d) habitat – the place where an organism lives (2)

3. The competitive exclusion principle states that only one species can occupy an ecological niche. (2)

4. Biodiversity can be assessed at ecosystem, species and genetic levels. (3)

5. Invasive species are harmful to an environment as they compete, and often outcompete, with indigenous species for available resources. The indigenous species may be forced out of the ecosystem or not survive. (2)

6. The estimated size of the snail population is 267. See calculation below.

$$\text{Population size (N)} = \frac{\text{number of individuals first marked and released } (n_1) \times \text{total of individuals in second catch } (n_2)}{\text{number of marked individuals in second sample } (m_2)}$$

n_1 = number of individuals first marked and released = 120
n_2 = number of individuals captured in second sample = 80
m_2 = number of marked individuals in second sample = 36
N = total population

$$N = \frac{120 \times 80}{36}$$

N = 267 (approximately) (5)

7. a) Sample 1 (2)

b) i) Sample 1:

$$D = 1 - \left[\left(\frac{4}{15}\right)^2 + \left(\frac{8}{15}\right)^2 + \left(\frac{3}{15}\right)^2\right]$$
$$= 1 - (0.071 + 0.284 + 0.04)$$
$$= 1 - 0.395$$
$$= 0.605$$

Sample 2:

$$D = 1 - \left[\left(\frac{2}{15}\right)^2 + \left(\frac{10}{15}\right)^2 + \left(\frac{3}{15}\right)^2\right]$$
$$= 1 - (0.018 + 0.444 + 0.04)$$
$$= 1 - 0.502$$
$$= 0.498$$

Sample 3:

$$D = 1 - \left[\left(\frac{1}{15}\right)^2 + \left(\frac{12}{15}\right)^2 + \left(\frac{2}{15}\right)^2\right]$$
$$= 1 - (0.004 + 0.640 + 0.018)$$
$$= 1 - 0.662$$
$$= 0.338$$ (6)

ii) Sample 1 shows the highest Simpson's index of diversity. (2)

c) i) Sample 1 – 60.5%
ii) Sample 2 – 49.8% (2 × 2 = 4)

8. a) Area A has the highest biodiversity. This is because it is the highest value. (2)

b) The probability is 30% (1)

TOPIC 1.3 Conservation

LB pages 31–41

Syllabus coverage	See the syllabus grid in Section B
General objective	• Realise the importance of maintaining biodiversity and know the actions required at local, national and global levels
Specific objectives	• Discuss the reasons for the need to maintain biodiversity • Explain the importance of reducing the pollution of water ways with reference to bioaccumulation and eutrophication • Outline the roles of zoos, botanic gardens, conserved areas (national parks and marine parks), 'frozen zoos' and seed banks, in the conservation of endangered species • Explain why it may be necessary to limit the population of species, for example by culling or contraception, in order to reduce pressure of other species • Explain, using examples, the importance of controlling alien species • Describe how degraded habitats may be restored limited to local or regional examples • Investigate the negative impact of rhino and elephant poaching on the tourism sector locally (Namibia) and regionally (South Africa and Botswana)
Cross-cutting issues	Learning about the environment helps promote sustainable agricultural practice and community involvement
Inclusive education	Assist learners with sight problems by using resources such as posters
Suggested teaching times	8 lessons
Additional resources needed	Posters, graph paper, Internet

Introduction to this topic

Conservation is important in Namibia to protect wildlife and other natural resources. This topic focuses on some aspects of conservation including the necessity for conservation, community-based conservation, water pollution and ways to control it, bioaccumulation and biomagnification, eutrophication, conservation methods for endangered organisms, ways of controlling populations, alien species, restoration of degraded habitats and poaching.

There are activities that require data analysis skills. Essay writing skills can also be developed in this topic.

Starter activity

LB page 30

Use the starter activity to revise some of the terms used in the previous two topics and terms that were covered in earlier grades.

Suggested answers

1. **a)** biodiversity – the variety of life on Earth
   b) conservation – protecting and preserving natural resources
   c) ecosystem – an area in which organisms can interact with one another and their environment to form an integrated system that supports life
   d) endangered species – a species that may become extinct in the future
2. Fish – Namibia has many marine and freshwater fisheries that contribute to the economy. They provide employment for many people and so sustainable fishing and conservation of fish is important.
   Wildlife – Namibia has large natural areas with an abundance of wildlife. This valuable resource provides tourism opportunities and provides employment for many people; there are several endangered animals in Namibia such as rhino that need to be conserved.
   Minerals – Namibia has deposits of many minerals such as diamonds, gold, copper and

uranium that contribute to the economy. Since these are non-renewable resources they must be sustainably mined and not exploited.

3. **a)** Any three: Etosha National Park, Namib-Naukluft National Park, Skeleton Coast National Park, Khaudum National Park, Waterberg Plateau National Park, Sperrgebiet, Ai-Ais Richterveld Transfrontier Park, Bwabwata National Park, Nkasa Rupara National Park and Mudumu National Park

   b) National parks help to conserve biodiversity by protecting endangered species from poaching, allowing wildlife to breed and survive; they provide educational opportunities and provide employment to communities that live near the parks.

Beginning these lessons

Learners should be building their understanding of aspects of ecology. Conservation protects biodiversity (Topic 1.2).

Teaching tips

- Use the content of the Learner's Book to discuss various aspects of conservation and consolidate what is covered with the activities.
- Make sure you use Namibian examples when discussing specific conservation efforts.
- You may need to spend some time explaining graphs before learners tackle Activity 1, especially if it is set for homework.
- Make sure learners can distinguish between bioaccumulation and biomagnification.
- For Activity 3, let learners spend time researching alien species and their impact for homework. Discuss their findings with them in class.
- Use the essay in Activity 5 as practice for the essay in the assessment task. Let learners see the rubric before they start so that they can build their essay-writing skills by understanding what is required of them.

Homework

- You could use Activity 1 as a homework activity.
- For Activity 3, let learners do research on alien species and their impact for homework.

Inclusive education

Make sure that your teaching methodologies are appropriate for any learners who may have learning difficulties. For learners with language difficulties, you could use the key word boxes to draw up a test. Learners have to give the meanings of the terms or alternatively give the term that matches the meaning.

Self-assessment

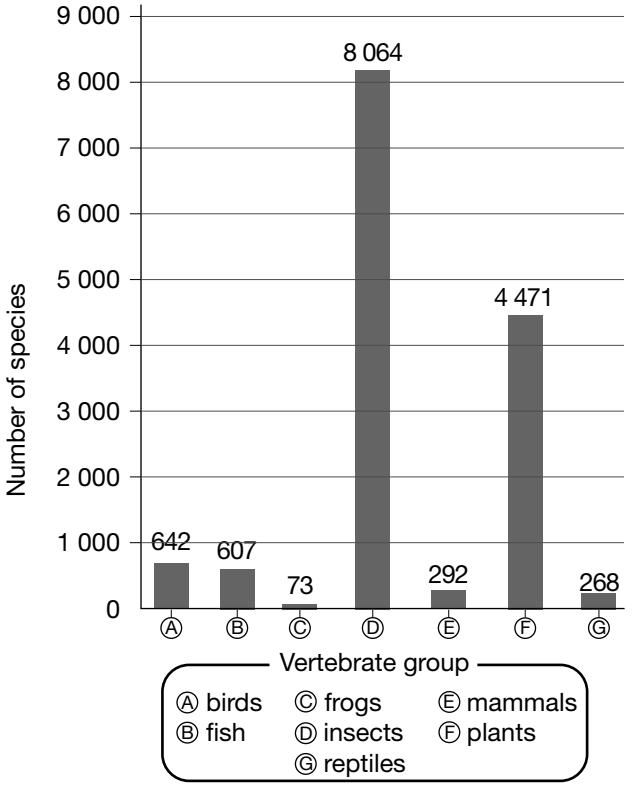
Use the following self-assessment rubric to check that learners have developed essay writing skills in this topic.

	Very good	Good	Developing	Need help
Researching	I was able to **easily find lots** of information about the topic.	I was able to **find some** information about the topic.	I was able to **find a little** information about the topic, and I feel that I am improving.	I **need help** to find information about the topic.
Organising facts	I was able to arrange the facts in a **logical** way.	I was able to arrange the facts in a **fairly logical** way.	I had **some difficulty** in arranging the facts in a logical way.	I **need help** to arrange the facts.
Using only relevant information	I used **only** relevant information.	I **mainly used** relevant information.	I **am improving** at using relevant information.	I **need help** to use only relevant information.

Suggested answers

Activity 1 Analyse data about Namibia's biodiversity (LB page 31)

1. Graph to show the number of vertebrate species in Namibia



Marking rubric for graph

Criteria	Marks
Correct type of graph (bar graph)	1
Heading	2
Labelling x-axis	1
Labelling y-axis	1
Scale for x-axis	1: correct with all bars equal; 1: equal interval between bars
Scale for y-axis	1: correct values; 1: equal intervals between values
Plotting data	7: all 7 correct; 6: 6 correct; 5: 5 correct; 4: 4 correct; 3: 3 correct; 2: 2 correct; 1: one correct; 0: none correct
Total = 16	

2. Insects

3. $\frac{292}{390}$ = approximately 75%

Activity 2 Consolidate what you learnt about water pollution (LB page 34)

1. Any three: industrial and household waste; poorly managed landfill sites; run-off from agricultural lands that contains pesticides and fertilisers; mines.

2. Solid waste disposal sites contribute to water pollution as chemicals and toxic substances seep through the soil and into the groundwater.

3. Bioaccumulation refers to the build-up of harmful chemicals in organisms' bodies and biomagnification is the increase in the concentration of chemicals in their bodies at each level of a food chain.

4. Eutrophication occurs when water run-off with high levels of fertilisers, sewage and waste high in nutrients enters dams and rivers. This leads to algal blooms. The algae reduce the amount of oxygen in the water and increase the levels of carbon dioxide. Many aquatic animals and plants die leading to a loss in biodiversity.

Activity 3 Understand the impact of alien species (LB page 38)

1. Alien species have no natural enemies; they reproduce rapidly; they can inhabit many different habitats; they colonise habitats easily.

2. Kariba weed, *Salvinia molesta; Prosopsis* species; Opuntia (prickly pear); *Mytilus galloprovincialis* (Mediterranean mussel); *Oreochromis mossambicus* (Mozambique tilapia)

3. A biocontrol agent is another organism that is used to control an invasive species. An example is a type of weevil that is used to control Kariba weed.

4. Alien species can be controlled by introducing strict laws on importing plants and animals; by removing alien animal species from the environment as quickly as possible and destroying plant species; by educating communities, farmers and other land users.

5. Learners' answers will vary depending on which alien species they have chosen to research.

Activity 4 Read about an environmental restoration project (LB page 39)

1. Conservationists face the dilemma of knowing how important mining is to the Namibian economy whilst understanding the need for the conservation of wildlife.
2. the Namdeb Diamond Corporation and the National Botanic Garden
3. Seeds and plants can be collected before mining starts and then planted once mining operations are complete. Seedlings can also be transplanted from other places.
4. Ecosystem restoration is important for the following reasons:
   - it improves the soil; prevents erosion; restores nutrient cycling in the soil
   - it accelerates reforestation
   - it reintroduces indigenous species
   - it removes alien species
   - it restores biodiversity
   - it improves the way an area looks.

Activity 5 Investigate the negative impact of poaching on the tourism sector (LB page 39)

Assess learners' essays using the following rubric:

Criteria	Excellent 5 marks	Good 4 marks	Average 3 marks	Poor 2 to 0 marks
Format: clearly and neatly written; clear thought sequence and logic	Excellent progression of relevant facts.	Facts mostly relevant and well linked.	Has attempted to link facts but many are irrelevant.	Many facts are irrelevant and illogical.
Topic adhered to throughout the essay	Excellent analysis; writing stays focused; shows insight.	Good analysis; focused work; some insight.	Fairly well analysed; a little insight.	Superficial analysis; disorganised and lacking insight.
Concise, focused sentences	Throughout	Mainly included	Adequate	Not at all
Evidence of research	Clear evidence of in-depth research on all three points.	Some evidence of research on all three points.	Evidence of research on only two points.	No research done.
Own views given	Learner's views are clearly given and substantiated.	Learner's views are given and vaguely substantiated.	Learner's views are given but not convincingly.	No views given.
Total = 25				

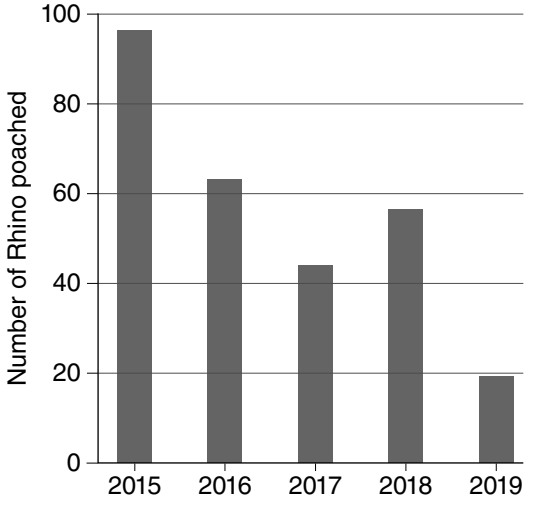
Self-assessment (LB page 41)

1. a) – v), b) – iv), c) – ii), d) – iii), e) – i) (5)

2. Assess learners' essays using the following rubric for marking:

Criteria	Excellent 5 marks	Good 4 marks	Average 3 marks	Poor 2 to 0 marks
Format: clearly and neatly written; clear thought sequence and logic	Excellent progression of relevant facts.	Facts mostly relevant and well linked.	Has attempted to link facts but many are irrelevant.	Many facts are irrelevant and illogical.
Topic adhered to throughout the essay	Excellent analysis; writing stays focused; shows insight.	Good analysis; focused work; some insight.	Fairly well analysed; a little insight.	Superficial analysis; disorganised and lacking insight.
Concise, focused sentences	Throughout	Mainly included	Adequate	Not at all
Discusses ways to conserve species; zoos, botanical gardens, national and marine parks, frozen zoos and seed banks	All five ways are discussed.	Four ways are discussed.	Three ways are discussed.	Two ways or less are discussed.
Describes population control; culling, use of contraceptives; translocation	All three controls are discussed.	Two controls are discussed.	One control is discussed.	No controls are discussed.
Own views given Learner's views are clearly given and substantiated. Learner's views are given and vaguely substantiated. Learner's views are given but not convincingly. No views given.				
				Total = 20

3. a) Graph to show number of rhino poached between 2015 and 2019. (10)



b) The data show that the number of rhino poached has decreased since 2015. (2)

c) the Ministry of the Environment, conservation organisations, conservancies and the police (3)

Marking rubric for graph

Criteria	Marks
Correct type of graph (bar graph)	1
Heading	2
Labelling x-axis	1
Labelling y-axis	1
Scale for x-axis	1: correct with all bars equal; 1: equal interval between bars
Scale for y-axis	1: correct values; 1: equal intervals between values
Plotting data	1: all correct; 0: none correct
	Total = 10

Theme 2 Organisation and maintenance of the organism

TOPIC 2.1 The microscope

LB pages 44–53

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know and understand the principles of light and electron microscopy
Specific objectives	• State and explain the principles of microscopy • Explain and distinguish between resolution and magnification, with reference to light- and electron microscope • Use an eyepiece graticule and stage micrometer scale to measure cells and be familiar with units (millimetre, micrometre and nanometre) • Calculate actual sizes of specimens from drawings, photomicrographs and electron micrographs • Calculate the linear magnifications of drawings, photomicrographs and electron micrographs
Cross-cutting issues	The use of the electron microscope particularly in combating disease
Inclusive education	Particular assistance, such as use of posters, for learners with sight problems
Suggested teaching times	12 lessons
Additional resources needed	Posters, diagrams, prepared microscope slides, graticule, photomicrographs, electron micrographs, internet

Introduction to this topic

This section of work refers to gaining knowledge of the microscope. Learners will have had some opportunity to learn about microscopes in previous grades, so the first lesson will involve revision. If the school does not have microscopes, the teacher could do the following:

- organise a visit to another school, college or university where the learners could use microscopes
- use the internet to show learners microscopes, micrographs and the parts of microscopes
- use posters and pictures of microscopes and micrographs.

Starter activity

LB page 44

The starter activity revises the parts of the microscope. If learners have not done this in previous grades, the teacher should take time to point out each part on a microscope or diagram of a microscope and explain the function of each part. Before doing the starter activity, the teacher demonstrates and points out the names and function of each part. The starter activity is completed individually or in pairs.

Suggested answers

A – eye piece/occular
B – objective lens
C – stage
D – diaphragm
E – light source
F – base
G – stage clips
H – fine focus knob
I – course focus knob
J – arm

Beginning these lessons

Point to and explain the parts of the microscope. Demonstrate the use of the microscope by showing learners how to prepare a slide and how to focus correctly in order to see the image. The Practical exercise is useful to the learners as a revision on how a microscope works.
Explain the concept of magnification by asking the learners to measure a small object such as a

pencil sharpener. Then ask the learners to draw the sharpener in real size, double and half the size. Remind the learners to use all the rules of drawing diagrams as well as to provide a scale.

Teaching tips

- Place a large poster of the metric conversions on the classroom wall where learners can access the information. Encourage learners to become familiar with the conversions.
- Use a spoon to demonstrate a real image. Explain how the image is inverted. Use a mirror to demonstrate a virtual image. Ask the learners to look at the images from both the spoon and mirror and check on which side their left and right is shown in the images. Refer to the image of the F formed in the Practical exercise on LB page 46 to explain why the image forms with the left and right on the other sides.
- Explain the difference between resolution (how much detail is seen) and magnification by showing photomicrographs with good and bad resolutions.
- If a graticule is available, demonstrate to the learners how it is used. Give the learners an opportunity to use the graticule. If a graticule is not available, use the internet (there are YouTube demonstrations available) to show the learners how it works. Pictures of a graticule will also be helpful.

Homework

Activity 1 on LB page 48 is recommended for homework as some research as well as revision is required. Activity 3 is recommended for homework.

Informal assessment

Activity 3 is useful for assessment purposes. Activity 4 is useful for assessment purposes.

Suggested answers

Practical exercise Explore the principles of microscopy (LB pages 46–47)

The F will be upside down and the wrong way around.

Activity 1 Microscopes and image formation (LB page 48)

1. ocular lens, objective lens, condenser lens
2. A virtual image is the right way up (a mirror); the light rays seem to meet.
   A real image is upside down (the eye); the light rays do meet.
3. $10 \times 40 = 400^{\times}$. The magnification is 400 times.

Activity 2 Size measurements using a graticule and stage micometer (LB page 49)

1. 100 graticule division = 50 microslide divisions
   1 graticule division = 0.5 microslide divisions
   10 microslide divisions = 1 mm/1 000 µm
   1 microslide division = 0.1 mm/100 µm
   1graticule division = $100 \times 0.5 = 50$ µm
2. $75 \times 50 = 3\,750$ µm or 3,75 mm

Activity 3 Calculate the size of a specimen from an image (LB page 50)

The length of the organism will be determined by the printed image. Let us call the actual size Y.

1. 64 mm
2. Formula: Actual size of the specimen = the image size (that you measure using a ruler) ÷ the magnification.
   Therefore, the answer is Y = 64 ÷ 40
   Y = 1.6 mm
3. 1 600 µm

Activity 4 Calculate the magnification of an image (LB page 51)

1. **a)** The length of the cells is determined by the printed image. Let us call it Y.
   b) To convert the answer to µm multiply by 1 000.
2. Formula: magnification = image size ÷ actual size
   Therefore the answer is Y ÷ 20 µm = something in µm
   To convert the answer to mm divide by 1 000.

Self-assessment **(LB page 53)**

1.

① – ocular
② – ocular holder
③ – rotating nose piece
④ – objective
⑤ – stage
⑥ – diaphragm
⑦ – light source
⑧ – base
⑨ – eye piece lens
⑩ – arm
⑪ – course focus
⑫ – fine focus (12)

2. a) 6
b) 12
c) 11
d) 4 (4)

3. 10 × 40 = 400 times (×) (3)

4. The distance between the red lines will depend on the printed image. Let us call it Y mm. The distance between the white lines depends on the printed image. Let us call it Z µm/ or Z divided by 1 000 to convert to mm. Divide Y by the Z (in millimetres)
OR convert Y to µm by multiplying by 1 000 and then Y divided by Z (in µm) (5)

5. Convert image and actual size to the same units
5 mm = 5 000 µm
Formula: magnification
= actual size ÷ image size
= 5 000 × 41.6 = 208 000× (3)

TOPIC 2.2 Cell structure

LB pages 54–66

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know and understand the cellular nature of all living organisms and the difference between prokaryotic and eukaryotic cells and viruses
Specific objectives	• Identify and recognise the following parts of a eukaryotic cell and outline the functions of the: » cell surface membrane » nucleus, nuclear envelope and nucleolus » mitochondrion » ribosomes (80S in the cytoplasm and 70S in chloroplasts and mitochondria) » chloroplast » rough and smooth endoplasmic reticulum » Golgi body (Golgi apparatus or Golgi complex) » lysosomes » cell wall » centrioles » cilia » microvilli » plasmodesmata » large permanent vacuoles and » tonoplast • Describe and interpret the structure of plant and animal cells as seen with an electron microscope • Draw and label low power plan diagrams of tissues and organs (including a transverse section of stems, roots and leaves) • Compare the structure of a typical plant (palisade) and animal (liver) cells • Make temporary slides (wet mounts) of plant and animal cells (for example: epidermal cells from a leaf or an onion, epithelial cells from the trachea of a sheep or human cheek cells) • Make observations and drawings of cells as seen under a light microscope (including cells within transverse sections of stems, roots and leaves) • Outline key structural features of typical prokaryotic cells as found in a typical bacterium (including: unicellular, 1–5 μm diameter, peptidoglycan cell walls, naked circular dna, 70s ribosomes, absence of double membrane-bound organelles) • Compare and contrast the structure of prokaryotic cells with eukaryotic cells (no reference to mesosomes required) • State that atp is produced in mitochondria and chloroplasts and outline its role in cells • State that all viruses are non-cellular and have a nucleic acid core (either dna or rna), a capsid made of protein, and some viruses have an outer envelope made of phospholipid.
Cross-cutting issues	HIV/AIDS
Inclusive education	Make sure that the classroom provides equal learning opportunities for those with physical or intellectual impairments.
Suggested teaching times	7 lessons
Additional resources needed	• microscope • microscope slides • dropper • cover slips • sharp knife or scalpel • cutting board • tweezers • plant shoots e.g. *Impatiens* • plant roots • onion

Introduction to this topic

Cell structure was taught in earlier grades, however only detail using a light microscope was covered. In this topic, the structure as seen with an electron microscope is described. Learners will also get an opportunity to prepare temporary microscope slides and view prepared slides using a light microscope.

Starter activity

LB page 55

Use the starter activity to revise the structure of plant and animal cells. The micrographs show prepared slides of epithelial cells (A) and plant epidermal cells (B). Spend time revising the functions of the cytoplasm, nucleus, chloroplast and cell wall. You could draw a mind map on the board to show this.

Suggested answers

1. Micrograph A shows animal cells and micrograph B shows plant cells. There is no cell wall in the animal cells whereas this is clearly visible in the plant cells. There are also chloroplasts visible in the plant cells but not the animal cells.
2. Learners draw a plan diagram of a cell in micrographs A and B.
3. micrograph A – 1: cytoplasm; 2: nucleus
   micrograph B – 1: chloroplast; 2: cell wall
4. The chloroplasts are the site of photosynthesis reactions.
5. A light microscope was used to view these cells at a low magnification and so not much detail is visible.

Beginning these lessons

Learners should have some background knowledge from earlier grades about cells and organelles.

In this topic, they will be introduced to some new concepts such as prokaryotic and eukaryotic cells. They will learn to distinguish between these types of cells and will need to view slides using a light microscope.

They will also work through the various organelles' structure and functions. Learners must refer to the electron micrographs provided in the Learner's Book. These will help them to develop observational skills.

Teaching tips

- Revise the difference between cells, tissues and organs and discuss levels of organisation in organisms.
- Describe the features that all cells have and then discuss the differences between prokaryotic and eukaryotic cells giving examples of each.
- Use Figure 2.2.10 on page 61 of the Learner's Book to describe the structure of a prokaryotic cell.

Inclusive education

Enlarge the micrographs for learners with visual impairment.

Homework

You could set Activity 2 as a homework task. Mark their answers in class.

Informal assessment

- Let learners work in pairs and test each other on the meaning of the terms in the 'key word' boxes. They can mark their work using the Learner's Book.
- You can mark the learners' drawings in the Practical exercise using the following rubric:

Criteria	Yes 1 mark	No No mark
Accuracy: the drawings showed what was on the slide		
All visible parts labelled		
Labels on one side of drawing		
Heading		
The drawing is neat		
Sharp HB pencil used		
		Total = 6

Remedial activity

Allow learners who are experiencing difficulties to work in pairs. Give them time to complete a mind map showing information about the organelles. Assist where necessary.

Extension activity

Work out the magnification of the chloroplast

shown in Fig 2.2.8 on page 61 of the Learner's Book if the length of the chloroplast is 5 μm.

Answer:

$$\text{Magnification of image} = \frac{\text{image size}}{\text{actual size}}$$
$$= \frac{50\ \text{mm}}{5\ \mu\text{m}}$$
$$= \frac{50\ 000\ \text{mm}}{5\ \mu\text{m}}$$
$$= 10\ 000^{\times}$$

Suggested answers

Practical exercise — Make temporary slides of plant and animal cells (LB pages 56–57)

Part A: Prepare a temporary slide

You will need to make sure that you have all the necessary materials for making temporary slides. If you do not have enough equipment for the whole class, you could do this activity as a teacher demonstration. Make sure learners understand the term 'transverse section'.

- Be careful when working with sharp scalpels or knives.
- You may need to revise how to use a light microscope.
- You may need to revise how to draw a biological diagram:
  - » Sharp HB pencil
  - » Solid lines; no sketching
  - » Pencil label lines with a ruler
  - » Heading
  - » Neat labels
- You can take in learners' tables and drawings to mark using the rubric provided in the informal assessment notes below.

Part B: Observe cells from transverse sections of a plant stem or root, or the epidermis of an onion

Observation	Plant stems	Plant roots	Epidermis of an onion
Do the cells all look the same?	No	No	Yes
Can you see a cell wall?	Yes	Yes	Yes
If so, is the cell wall the same thickness in all the cells?	No	No	Yes
Can you see any chloroplasts?	Yes	No	No

Part C: Observe and compare plant and animal cells

1. Palisade cells have chloroplasts, cell walls and vacuoles.
2. Palisade cells have a more regular, rectangular shape compared to liver cells.
3. **a)** Photosynthesis takes place in the palisade cell but not in the liver cells.
   b) Cellular respiration takes place in both these cells.
4. The nucleus is pushed to the outside of the palisade cell by the vacuole and is more centrally positioned in the liver cell.

Activity 1 — Analyse micrographs (LB page 59)

1. **a)** two
   b) Both the cell surface membrane and nuclear envelope have lipid and protein molecules.

c) The cell surface membrane is a single lipid bilayer whereas the nuclear envelope is a double membrane; there are four lipid bilayers.

2. a) Microvilli are cell membrane protrusions that increase the surface area of the cell membrane; cilia are long hair-like structures that are used in single celled organisms for motility.

b) i) microvilli are found on cells lining the small intestine

ii) cilia are found on cells lining the trachea

c) Microvilli increase the surface area for absorption of nutrient molecules from the small intestine into the blood. Cilia trap dust in mucus and sweep particles out of the air passage.

3. a) the nucleolus

b) The nucleolus is responsible for the production of ribosomal RNA.

Activity 2 Compare and contrast prokaryotic and eukaryotic cells (LB page 64)

	Eukaryotic cell	Prokaryotic cell
Nucleus with membrane	✓	
Ribosomes	80S	70S
Golgi apparatus	✓	
Cell surface membrane	✓	✓
Endoplasmic reticulum	✓	
Mitochondria	✓	
Cytoplasm	✓	✓

Self-assessment (LB page 66)

1. a) 1 – nucleus; 2 – chloroplast; 3 – cell wall (3)

b) It is the site of photosynthesis. (1)

c) The cell wall is a rigid structure made of cellulose fibres. The space between adjacent cell walls is called the middle lamella and this glues the cells together. There may be pores in the walls called plasmodesmata. (2)

2. a) 1 – nuclear envelope; 2 – mitochondria; 3 – endoplasmic reticulum; 4 – ribosomes (4)

b) Mitochondria are organelles found in all eukaryotic cells. They consist of a double membrane made up of a phospholipid bilayer with embedded proteins; the inner membrane is folded to form cristae. Inside a mitochondrion is a fluid filled compartment called the matrix. It contains enzymes, mitochondrial DNA and ribosomes. (6)

c) The endoplasmic reticulum is a membrane network. Smooth endoplasmic reticulum is involved in lipid synthesis, metabolism of carbohydrates, detoxification of poisons and drugs, and storage of calcium ions. Rough endoplasmic reticulum makes proteins such as insulin and transports them inside the cell. (8)

TOPIC 2.3 Cell membranes and transport

SUB-TOPIC 2.3.1 Fluid mosaic membranes

LB pages 67–73

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know and understand the structure and functions of cell surface membranes in relation to cell signalling
Specific objectives	• Describe the fluid mosaic model of membrane structure, including the components phospholipids, cholesterol, glycolipids, proteins and glycoproteins • Outline the roles of the cell surface membrane • Describe the roles in cell surface membranes of phospholipids, cholesterol, carrier proteins, channel proteins, cell surface receptors and cell surface antigens • Outline the process of cell signalling involving the release of chemicals that combine with cell surface receptors on target cells, leading to specific responses
Cross-cutting issues	The structure of the membrane is important for understanding transport mechanisms across it as well as aspects of the immune system.
Inclusive education	Group learners so that capable learners can help those with physical or intellectual challenges.
Suggested teaching times	6 lessons
Additional resources needed	Internet

Introduction to this topic

Membrane structure is complex. Knowledge about it has been gathered over many years and several models have been proposed. In this topic, the most accepted model, the fluid mosaic model is described.

Starter activity

LB page 67

Use the starter activity to allow learners to revise the functions of membranes in eukaryotic cells. You can ask them to discuss the statement in groups and then to write a short essay using the information that they have gathered. Alternatively, let them draw a mind map as a group and orally present their information to the class.

Suggested answers

- All eukaryotic cells have an outer surface membrane as well as membrane bound organelles.
- The cell surface membrane is selectively permeable which means that it will allow some substances to pass through it and not others. In this way, it can control the entry and exit of chemicals into and out of the cell.
- Modifications of the cell surface membrane such as cilia, microvilli and flagella are adaptations that allow specialised functions. Microvilli increase the surface area for absorption of digestive nutrients whilst cilia can trap particles in the air passages. Flagella allow for motility in some cells such as sperm cells.
- The cell's organelles are also membrane bound, for example the nucleus, chloroplast, mitochondria, endoplasmic reticulum, lysosomes and Golgi apparatus. Some organelles are bound by a double membrane and some a single membrane. These membranes also control the movement of substances. In some cases, such as in mitochondria, they are folded to increase the surface area on which chemical reactions can take place.

Beginning these lessons

Tell learners that they will be focusing on the structure of membranes. The cell surface membrane and membranes that surround organelles all have the same structure. In some cases, there is a double membrane and in others a single membrane. They will need to use the diagrams in the Learner's Book to help them understand the chemical structure of membranes.

Teaching tips

- The fluid mosaic model of membrane structure is described. Figure 2.3.1.1 on page 68 of the Learner's Book is important. You need to refer to this diagram often as you work through the various elements that make up the membrane.
- You could watch a video to assist your explanations, see link: https://www.youtube.com/watch?v=Qqsf_UJcfBc
- Discuss each component of membranes: phospholipids, cholesterol, glycolipids glycoproteins and proteins.
- Learners could draw a mind map to show the membrane proteins and their different functions.
- The information in this topic is important as it is needed for learners to understand how substances move in and out of cells and organelles. This is covered in the next sub-topic.

Homework

Ask learners to draw up a list of new terms and their meanings. Read through the components of membranes to make sure that they understand it.

Extension activity

Build a model of the fluid mosaic membrane. Use the following website for ideas: https://www.education.com/science-fair/article/build-cell-membrane-model/

Let learners work in groups to build a model of the fluid mosaic model.

Learners will need the following: plasticine, ear buds, pipe cleaners, rubber bands, drinking straws.

They can present their models to the rest of the class.

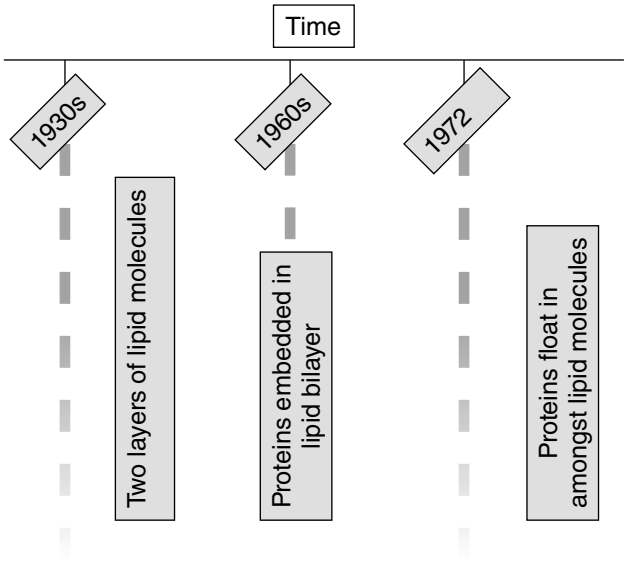
Suggested answers

Activity 1 Discuss the components of membranes (LB pages 69–70)

1. A phospholipid molecule contains a lipid and phosphate group; it has a hydrophilic end and a hydrophobic end. The lipids are hydrocarbon chains that are hydrophobic and the phosphate groups are hydrophilic.
2. The term 'fluid mosaic model' is appropriate as the membrane components are able to move around (they are fluid). Various molecules are arranged in and on the membrane so they form a mosaic pattern.
3. Cholesterol molecules are important in the membrane as they:
   - keep the hydrocarbon chains stable and prevent them from crystallising
   - reduce the fluidity of the membrane
   - reduce the permeability of the membrane to water-soluble molecules
   - keep some membrane proteins in place
   - prevent membranes from breaking up.
4. **a)** Sugar residues attach to proteins by covalent bonds.
   b) Hydrophilic means able to dissolve in water.
   c) 'Cell-cell interactions' refers to communication between cells.

Self-assessment (LB page 73)

1. **a)** chloroplasts, mitochondria and nucleus (3)
   b) Timeline to show development of model for structure of membranes: (4)



2. a) Integral proteins penetrate the bilayer and peripheral proteins are on the surface of the bilayer. (2)

b) Channel proteins are integral proteins. (1)

3. a) on the microvilli of the small intestine wall

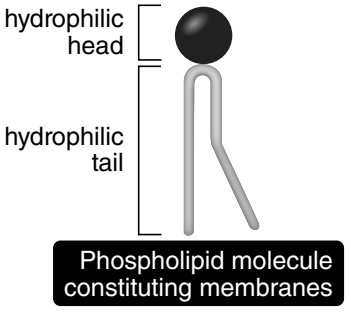
b) white blood cells

c) when a sperm and egg cell fuse (3)

4. a) ligand – cell signalling;
cell surface receptor – cell-cell recognition;
target cell – cell signalling (3)

b) ligand – a signal molecule that is bound to a membrane protein (1)
cell surface receptor – a molecule on the membrane to which other molecules attach (1)
target cell – a cell that receives signals that may bring about some type of response. For example, hormones are signal molecules that lead to a response in a target cell. (1)

5. a) Diagram to show the structure of a phospholipid molecule (4)



b) Phospholipid molecules are arranged in a bilayer; the hydrophilic phosphate head facing outwards and the hydrophilic hydrocarbon tails pointing inwards. (3)

6. a) 1 – peripheral membrane protein;
2 – cholesterol;
3 – glycoprotein;
4 – integral membrane protein (4)

b) Cholesterol:
- keeps the hydrocarbon chains stable and prevents them from crystallising
- reduces the fluidity of the membrane
- reduces the permeability of the membrane to water-soluble molecules
- keeps some membrane proteins in place
- prevents membranes from breaking up.

(any one = 1)

c) Glycoproteins allow for cells to recognise other cells, for example during the immune response (2)

Self-assessment

Use the rubric below for self-assessment

	Very good	Good	Developing	Need help
Definitions Question 4b)	I knew **all** the definitions.	I knew **two** of the definitions.	I knew only **one** definition.	I **didn't know** the meaning of these terms.
Drawing of phospholipid molecule Question 5a)	I **knew** how to draw this molecule and label all the parts.	I could draw the molecule but got **some** labels wrong.	I could draw the molecule, but I was **unable to label** the molecule.	I **could not draw** or **label** the molecule.
Labelling parts of the membrane Question 6a)	I knew all the labels **easily**.	I knew **three** of the labels.	I knew **two** of the labels.	I **need help** with the labels.
Understanding the topic	I understood **everything** in this topic.	I understood **almost everything** in this topic.	I did not understand **some things** in this topic.	I did not understand **anything** in this topic. I need help.

SUB-TOPIC 2.3.2 Movement of substances into and out of cells

LB pages 74–83

Syllabus coverage	See the syllabus grid in Section B
General objective	• Understand how substances enter and exit cells by a variety of mechanisms
Specific objectives	• Describe and explain the processes of diffusion, facilitated diffusion, osmosis, active transport, endocytosis and exocytosis (no calculations involving water potential will be set) • Investigate simple diffusion and osmosis using plant tissue and non-living materials, such as glucose solutions, Visking tubing and agar • Calculate surface areas and volumes of simple shapes (e.g. cubes) to illustrate the principle that surface area to volume ratios decrease with increasing size • Explain the movement of water between cells and solutions with different water potentials and explain the different effects on plant cells (using the terms turgid, flaccid, plasmolysis) and animal cells (movement of water should be described in terms of water potential. Knowledge of solute potential is not expected.) • Investigate the effects of immersing plant tissues in solutions of different water potential, using the results to estimate the water potential of the tissues.
Cross-cutting issues	The movement of substances into and out of cells has relevance when learning about movement of gases, nutrients and waste products between the cells and the blood; the movement of nitrogenous waste and water in the kidney tubules, movement of substances in plants and the movement of gases during gaseous exchange in the lungs and cells.
Inclusive education	Make sure that the classroom provides equal learning opportunities for those with physical or intellectual impairments.
Suggested teaching times	12 lessons
Additional resources needed	potassium permanganate crystals; water; beakers; Visking tubing; cotton thread; sucrose; funnel; capillary tube; glass rods; potatoes; knives or scalpels; 20%, 10% and 0.1% sugar solutions; rulers; electronic scale

Introduction to this topic

The movement of substances into and out of the cell is essential for their functioning. Different substances move in different ways. These include diffusion, facilitated diffusion and active transport.

Starter activity

LB page 74

Use the starter activity to check learners' understanding of concepts covered in earlier grades. Spend time consolidating if you feel they have not grasped these.

Suggested answers

1. a) Diffusion is the movement of molecules from a region where they are at a **higher** concentration to a region where they are at a **lower** concentration.

b) The energy for diffusion is due to the **kinetic** energy of the molecules.

c) **Osmosis** is the movement of **water** molecules from a region where they are at a **high** concentration to where they are at a **lower** concentration through a **selectively** permeable membrane.

2. a) Active transport is the movement of substances against a concentration gradient using energy.

b) Glucose is absorbed into the blood from the small intestine and minerals are absorbed into root hairs from the soil by active transport.

c) carrier proteins and ATP

Beginning these lessons

- Learners explored diffusion, osmosis and active transport in earlier grades. They should know the meaning of the following terms: gradient, hypotonic, hypertonic, turgid, flaccid, plasmolysis and water potential.
- They discussed the fluid mosaic membrane and the functions of its components in the previous sub-topic.
- In this sub-topic transport across membranes is described in more detail. There are some practical experiments for which you will need to prepare.

Teaching tips

- There are several new terms that learners should know the meaning of. Let them make a list of the key words as they work through the topic.
- Introduce the section by asking learners to describe diffusion, osmosis and active transport. Check whether they can give examples of different substances that move through a membrane by these methods.
- Make sure that you have organised the materials needed for the experiments well ahead of time.
- Discuss diffusion, the fact that it is passive (no energy is required) and the concept of a concentration gradient. Let learners work in pairs or groups for Experiment 1. Facilitate where necessary.
- Learners find the concept of surface area to volume ratio difficult, and this is a very important concept in Biology. Let them tackle Activity 1 in pairs.
- Remedial activity: Let learners make cubes of different sizes and work out the surface area and volume. Give them the formulae for surface area and volume:
  Surface area = area of one side × number of sides
  Volume = length × breadth × height
- Apply the mechanisms of osmosis to real life situations using Fig 2.3.2.2 to help you.
- Let learners work on Experiment 2 in groups or you could do this as a class demonstration. They could answer the questions for homework. Mark as a class.
- Learners can work in groups for Experiment 3. Let them answer the questions for homework. Mark as a class.
- Use the diagrams in the Learner's Book to assist your explanation of facilitated diffusion and active transport.

Homework

Learners can answer the questions in Experiment 2 and 3 for homework.

Informal assessment

You can mark the questions for Experiment 1, 2 and 3 as additional assessment.

Self-assessment

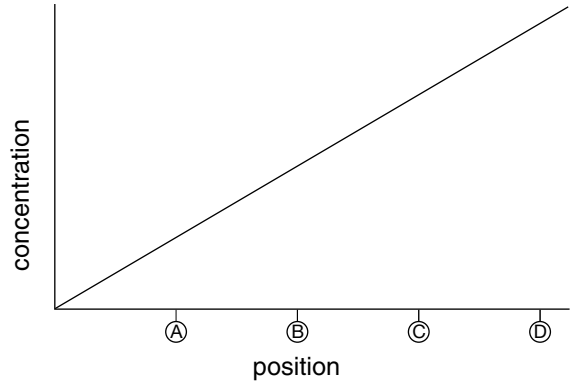
Use the following self-assessment rubric for learners to check their progress in this topic.

	Very good	Good	Developing	Need help
Taking notes	I was able to take very good notes on the content of the lessons.	I was able to take good notes on the content of the lessons but sometimes missed one or two points.	I took some notes and I feel I am getting better at taking notes.	I need help learning how to take notes.
Understanding	I understood everything in this topic.	I understood almost everything in this topic.	I did not understand some things in this topic.	I did not understand anything in this topic.
Activities	I completed all the activities easily.	I completed all the activities but had a little difficulty with one or two questions.	I did not complete all the activities and had difficulty with many questions.	I need help with most of the activities.
Co-operation with partners or group	I never argued with my partner or group members, I talked to them about my ideas, and I listened to everyone's opinions.	I sometimes argued with my partner or group, I sometimes talked to them about my ideas, and I thought about some opinions.	I argued a lot with my partner or group members, I hardly talked to them about my ideas, and hardly listened to their ideas.	I did not work at all well with my partner or group members.

Suggested answers

Experiment 1 Investigate diffusion (LB page 75)

1. Graph to show the concentration gradient of molecules from A to D



Activity 1 Understand the surface area-to-volume ratio (LB page 76)

1. a) surface area of a cube = surface area of one face × 6

b) volume of a cube = length × breadth × height

2.

Cube	Length of side (cm)	Surface area (cm2)	Volume (cm3)	Area: ratio
A	1	6	1	6:1
B	2	24	8	3:1
C	3	54	27	2:1

3. As the size of the cube increases, the surface area-to-volume ratio decreases.

4. The ratio shows that small organisms have a large surface area relative to their volume and larger organisms have a small surface area to volume ratio. Diffusion will, therefore, be more efficient in smaller organisms compared to larger organisms.

Experiment 2 Investigate osmosis (LB pages 78–79)

1. a) The level in the capillary tube rose as water moved into the tubing by osmosis.

b) The level of the water in the beaker dropped slightly and the bag swelled.

2. The sugar solution has a higher tonicity than the water in the beaker; it is hypertonic to the water.

3. There is a higher water potential outside the tubing compared to inside. This means water will move by osmosis into the tubing by osmosis.
4. **a)** There would be no net movement of water.
   b) Water would move out of the tubing into the beaker and the bag would shrink.
5. **a)** Visking tubing has pores in it that only allows the movement of water molecules; it is selectively permeable.
   b) the cell membrane

Experiment 3 Investigate osmosis in plant tissue (LB page 79)

1. You could repeat the experiment with more potato cubes; repeat it with larger cubes; use a greater range of sugar solution concentrations.
2. When the mass of the cubes did not change it would mean that they were in an isotonic solution and so the water potential in the sugar solution and inside the cells would be the same.

Self-assessment (LB page 83)

1. **a)** A piece of potato will change in length and mass when placed in a sugar solution. (2)
   b) After an hour, potato strip A will have increased in mass and length, potato strip B will have decreased in mass and length. Water will have moved into potato strip A and out of potato strip B. Strip A is surrounded by a hypotonic solution and strip B by a hypertonic solution. (3)
   c) The initial lengths of the potato strips; the time left in the test tubes. (2)
2. **a)** active transport – the movement of substances against a concentration gradient; energy is required (2)
   b) facilitated diffusion – the movement of substances through the membrane using transport proteins; no energy is required (2)
3. **a)** exocytosis – the secretion of insulin from pancreatic cells (1)
   b) osmosis – during osmoregulation in animal cells (1)
4.

	Hypotonic solution	Isotonic solution	Hypertonic solution
Plant cell	becomes turgid	flaccid	plasmolysed
Animal cell	bursts	normal	shrivelled

(6)

5. B (1)
6. A (1)

TOPIC 2.4 Biological molecules

SUB-TOPIC 2.4.1 Carbohydrates and lipids

LB pages 84–97

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know the structure and properties of biological molecules and understand the relationship between molecular structures and their functions
Specific objectives	• Define the terms monomer, polymer, macromolecule, monosaccharide, disaccharide and polysaccharide • Describe and draw the ring forms of α-glucose and β-glucose • Describe the formation of a glycosidic bond by condensation, with reference both to polysaccharides and to disaccharides, including sucrose • Describe the breakage of glycosidic bonds in polysaccharides and disaccharides by hydrolysis, with reference to the non-reducing sugar test • Describe the molecular structure of the polysaccharides starch (amylose and amylopectin) and glycogen and relate their structures to their functions in living organisms • Describe the molecular structure of the polysaccharide cellulose and outline how the arrangement of cellulose molecules contributes to the function of plant cell walls • Describe the molecular structure of a triglyceride with reference to the formation of ester bonds and relate the structure of triglycerides to their functions in living organisms • Describe the structure of a phospholipid and relate the structure to the functions of phospholipids in living organisms • Describe and carry out the Benedict's test for reducing sugars, the iodine test for starch and the emulsion test for lipids • Describe and carry out a semi-quantitative Benedict's test on a reducing sugar solution by standardising the test and using the results (time to first colour change or comparison to colour standards) to estimate the concentration • Describe and carry out a test to identify the presence of non-reducing sugars, using acid hydrolysis and Benedict's solution • Carry out a semi-quantitative Benedict's test on a reducing sugar using dilution, standardising the test and using the results (colour standards or time to first colour change) to estimate the concentration
Cross-cutting issues	This syllabus forms the basis of understanding food and diet. Include discussions regarding a balanced diet and good eating practises.
Inclusive education	Learners with hearing and sight problems can sit in the front of the class. Groups need to be inclusive and organised so that the capable learners can help those with physical or intellectual challenges.
Suggested teaching times	8 lessons
Additional resources needed	Pictures, internet and posters. Different sized, colour and shaped beads or coloured modelling clay

Introduction to this topic

Introduce the topic by referring to previous knowledge and personal experience regarding the organic nutrients that make up human food. Some possible questions to ask learners regarding prior knowledge are:

1. What is food made of?
2. What are carbohydrates, proteins and lipids?
3. Why do we need carbohydrates, proteins and lipids in food?

Draw a table on the board, an example is shown below, and ask the learners to call out answers to complete it. You can then get an idea of how much they remember.

Table for revision of organic nutrients

Organic nutrient	Smallest unit making up the nutrient	Function of the nutrient	Example of a type of food containing a high percentage of the nutrient
Protein	1 point	2 points	1 point
Carbohydrate	1 point	2 points	1 point
Lipid	2 points	2 points	1 point

Table solutions

Organic nutrient	Smallest unit making up the nutrient	Function of the nutrient	Example of a type of food containing a high percentage of the nutrient
Protein	amino acids	structure (muscles) and function (enzymes and hormones)	e.g. meat, lentils, soya
Carbohydrate	glucose	quick energy and structure (plant cell walls)	e.g. mielie meal (corn), bread
Lipid	fatty acids and glycerol	insulation and stored energy	e.g. meat, avocado pear, nuts

Starter activity

LB page 84

This activity tests learners' ability to remember. Remove the answers from the table on the board and ask the learners to complete the starter activity.

Suggested answers

1. **a)** amino acids, glucose, fatty acids and glycerol
   b) amino acids: structure (muscles, hair, nails) metabolic functions as hormones and enzymes
   glucose: instant energy
   fatty acids: long term energy storage, insulation, shock absorption, storage of fat soluble vitamins
   glycerol: short term storage of energy
2. Water is a solvent because there are spaces between the water molecules that allow small particles to dissolve (fit in the spaces).
3. Plants contain starch.
4. Glycogen is stored in the muscles and liver.

Beginning these lessons

- Remind the learners that organic nutrients consist of oxygen, carbon AND hydrogen. Inorganic nutrients do not consist of ALL THREE of these elements. Ask learners for examples of organic molecules (proteins, carbohydrates and lipids) and inorganic molecules (water, carbon dioxide, etc.).
- Explain that this topic deals particularly with carbohydrates and lipids.
- Deal with each organic nutrient separately, ensuring that the activities are completed so that learners are aware of their level of knowledge for each nutrient.
- Explain that the learners need to know the following for each nutrient:
  1. the structure and differences between molecules belonging to that organic nutrient group
  2. the function
  3. the process of bonding (condensation reaction) and breaking bonds (hydrolysis)
  4. the practical tests involving proof of the existence of the nutrients.

Teaching tips

- Learners create a list while working through this sub-topic of all the new terminology and give an explanation for each.
- It is helpful to explain carbohydrates as being a family with different individuals belonging to that family.
- Learners list the nutrients and monomers of each and draw diagrams for each.
- Use beads and/or modelling clay to demonstrate the structure of the nutrients. The learners can work in groups to create models of the nutrients.
- Use modelling clay to demonstrate hydrolysis and condensation reactions.
- There are practical investigations in this syllabus. Ensure that the necessary equipment is available for each investigation. The learners can be grouped in pairs or threes for the investigations. If there is not enough equipment for the learners, the investigations need to be demonstrated to the class.
- Ensure that the learners understand the procedure and purpose of each investigation. Read the instructions with them. Encourage questions and explain the procedures. Read through the questions they will need to answer and provide explanations where necessary.
- Do each investigation yourself before the lesson to make sure you are prepared.

Homework

Activities 1, 2 and 3 are suitable for homework. Alternatively, the learners can start each activity in class, where you can provide assistance, and then complete the work at home.

Suggested answers

Activity 1 Terminology check (LB page 86)

1. d	**3.** b	**5.** h	**7.** i	**9.** j
2. g	**4.** e	**6.** a	**8.** c	**10.** f

Activity 2 Understand the structure of carbohydrates (LB page 90)

1. Refer to LB page 85.
2. glucose, fructose, galactose, ribose
3. a) glucose and fructose
b) condensation reaction
c) water
d) glycosidic bond
4. a) Starch is found in plants.
b) Glycogen is found in animals.
c) Cellulose is found in plant cell walls.
5. a) amylose and amylopectin
b) Amylose is an unbranched chain of glucose. Amylopectin has many branches but less than glycogen.

Activity 3 Understand the structure of lipids (LB page 91)

1. a) fatty acid and glycerol
b) 4
2. a) in the blood and in the fat cells under the skin and around organs
b) in the cell membranes
3. a) water hating
b) water loving

Experiment 2 Determine the concentration of glucose in a solution (LB page 94)

1. a) 50% (answer must have the % sign)
Tips: To calculate percentage concentration: mass of solute divided by volume of solvent multiplied by 100

The *dilution factor* or the *dilution* is the initial volume divided by the final volume.

$DF = ViVf$

Serial dilution: You multiply the original concentration by the dilution factors for each dilution.

b)

Beaker	Concentration of glucose solution (%)
A	4
B	2
C	1
D	0.5
E	0.25
F	0

2. About 0.5% concentration (answer must have the % sign)

3. Test tube F is the control. It is used to compare the results because it contains no glucose.

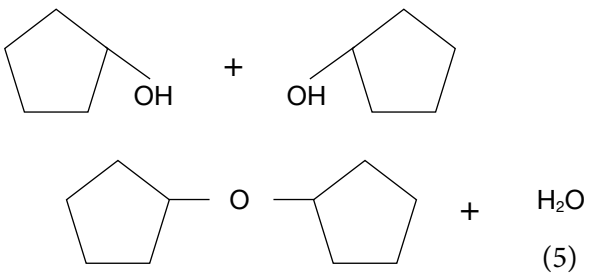
Self-assessment (LB page 97)

1. The molecule is a phospholipid. (1)

2. 1 is the phosphate head, 2 is the lipid tail. (2)

3. condensation reaction (1)

4.



(5)

5. sucrose (1)

6.

Biological molecule	Indicator chemical	Initial colour	Final colour
Starch	**A** Iodine	Yellow-brown	**B** Blue-black
C Glucose/reducing sugar	**D** Benedict's indicator	Blue	Brick red
Oil	Ethanol and water	Clear	**E** Fatty stain

(5)

7.
- Lactose is not a reducing sugar and will not change the colour of Benedict's indicator.
- Place 5 ml (one teaspoon) of glucose (reducing sugar) into test tube A.
- Add 5 ml of water.
- Place 5 ml (one teaspoon) of lactose (non-reducing sugar) into test tube B.
- Add 5 ml of water.
- Add 2.5 ml of diluted hydrochloric acid to test tube B and stir well.
- Bring test tube B to the boil using a Bunsen burner.
- Place each test tube in a test tube rack and wait for 10 minutes.
- Taking care because of fizz, slowly add 3 ml of baking soda to test tube B.
- Leave until there is no more fizz.
- The solution is now neutral (pH 7).
- Add 3 ml of Benedict's indicator to each test tube.
- Place the test tubes in a beaker of boiling water and wait for 5 minutes.
- Check the colour changes. (6)

8. a) Function of amylose – a form of starch (energy storage) found in legumes – digests slowly (1)

b) Function of amylopectin – a form of starch (energy storage) in plants – digests easily (1)

c) Function of glycogen – a form of energy storage in animals (1)

SUB-TOPIC 2.4.2 Proteins and water

LB pages 98–107

Syllabus coverage	See the syllabus grid in Section B
General objectives	• Know the basic structure of protein molecules and understand how their structures relate to their functions • Know the important roles of globular and fibrous proteins in biological processes • Know the properties of the water molecule and the role of water in living organisms
Specific objectives	• Describe the structure of an amino acid and the formation and breakage of a peptide bond • Explain the meaning of the terms primary structure, secondary structure, tertiary structure and quaternary structure of proteins • Describe the types of bonding (hydrogen, ionic, disulfide and hydrophobic interactions) that hold these molecules in shape • Describe the molecular structure of haemoglobin as an example of a globular protein, and of collagen as an example of a fibrous protein and relate these structures to their functions (appreciate that the haemoglobin molecule is composed of two alpha (α) chains and two beta (β) chains, although when describing the chains the terms α-globin and β-globin may be used. There should be a distinction between collagen molecules and collagen fibres) • State the importance of iron in the haemoglobin molecule • Carry out biuret test to identify the content of solutions, food substances and biological specimens • Explain that water is a polar molecule and explain how hydrogen bonding occurs between water molecules • Relate the properties of water to its roles in living organisms (limited to solvent action, specific heat capacity and latent heat of vaporisation)
Cross-cutting issues	The use of enzymes in industry and medicine is of critical importance.
Inclusive education	Learners with hearing and sight problems can sit in the front of the class. Groups need to be inclusive and organised so that capable learners can assist those with physical or intellectual challenges.
Suggested teaching times	5 lessons
Additional resources needed	Pictures, internet and posters. Different sized, colour and shaped beads or coloured modelling clay and wool

Introduction to this topic

As with carbohydrates and lipids (dealt with in Sub-topic 2.4.1), proteins are also organic nutrients found in food. Together with carbon, hydrogen and oxygen, proteins all contain nitrogen. It is interesting to link the presence of nitrogen in protein with the difficulty of extracting nitrogen from the atmosphere. Only specific bacteria in the soil (nitrogen fixing bacteria) and lightning can convert atmospheric nitrogen into nitrates. Plants absorb nitrogen in the form of nitrates. The only way humans and other animals obtain nitrogen is through food. We need nitrogen to build muscles as well as hormones and enzymes.

Ask the learners what they can remember from previous grades about the structure and function of proteins. Use terminology from Sub-topic 2.4.1 in the questions. For example: What is the monomer of protein?

Starter activity

LB page 98

The starter activity is designed to help learners revise previous knowledge. The learners can use the questions to determine how much they remember about proteins and water.

Suggested answers

1. False – they are **large** molecules.
2. True
3. False – water is **inorganic** (no carbon).
4. True
5. True
6. False – water is made of hydrogen and **oxygen**.
7. True
8. True
9. False – all **enzymes** are **proteins**.
10. True

Beginning these lessons

- Proteins are very important organic molecules not only because so much of our body structure consists of protein but also because much of our body functions depend on protein. Discuss the role of protein in rhino horns. The protein called keratin makes up our hair and nails as well as the horn of rhinos. People in eastern countries such as China and Vietnam believe that rhino horn has special properties that can heal sickness and provide sexual prowess. Ask the learners if this is true and if eating their own hair is the same as eating rhino horn.
- Enzymes and hormones are proteins. Ask the learners what the functions of enzymes and hormones are. Ask learners if they know what the term 'steroid hormone' means.
- Learners can use modelling clay to understand the differences between the primary, secondary, tertiary and quaternary structures of protein.
- Discuss the importance of water for life. The human body consists of 70–85% water. We are formed in amniotic fluid in the uterus. The amniotic fluid is a good place to develop because the water acts as a shock absorber, the water does not change temperature rapidly, and the water provides resistance for the developing muscles.
- Discuss the miracle of water in terms of the expansion of water when cooled. This means that ice floats. Discuss what would happen to life in the ocean at the polar regions if ice did not float. The sea would become solid and life would be impossible.

Teaching tips

- Modelling clay is good for learners to use to understand the structure of proteins.
- Modelling clay is used to show the process of hydrolysis and condensation reaction.
- Learners use a microscope to look at permanent slides of red blood cells (containing haemoglobin), hair (containing keratin) and skin or tendons (containing collagen).
- Show the learners diagrams and pictures of haemoglobin and collagen from the internet.
- Use beads and two different colour wools to construct models of water. One colour wool illustrates the hydrogen bonds and the other colour illustrates the covalent bonds. Show the learners how small particles can fit in the gaps between the water molecules and explain that this is the process of dissolving and forming a solution.

Extra diagnostic activity

Learners draw a table like the one below for revision and self- assessment:

Table showing the differences between the different structures of protein

Structure of protein	Possible shapes	Types of bonds	Examples
Primary			
Secondary			
Tertiary			
Quaternary			

Homework

Learners can complete Activity 1 for homework.

Suggested answers

Activity 1 Revise protein structure (LB page 103)

1. hydrogen, oxygen, carbon and nitrogen
2. amino acids
3.
   - A water molecule is split into a hydrogen and a hydroxyl (OH).
   - The peptide bond between amino acids is broken by an enzyme.
   - The hydrogen bonds with the carboxyl group of the one amino acid.
   - The hydroxyl bonds with the amino group of the other amino acid.
4. **a)** vi) **c)** iv) **e)** i)
   b) iii) **d)** v) **f)** ii)

Experiment 1 Perform the biuret test (LB page 104)

Consult the rubrics for experiments provided in Section D.

Self-assessment (LB page 107)

1. Refer to Learner's Book page 104. (5)
2. Refer to Learner's Book page 98. (4)
3. **a)** Haemoglobin bonds with oxygen in the blood. It transports oxygen to the cells and carbon dioxide from the cells to the lungs. (1)
   b) Collagen is a protein that binds the skin to the underlying muscle. It gives strength and flexibility to the skin, bones, teeth and organs. (1)
4. It means that more kinds of solute can dissolve in water than any other solvent/ medium. (2)
5. The latent heat of vaporisation of water is the amount of energy needed for water to change from a liquid to a gas. (2)
6. The specific heat capacity of water is the amount of energy needed to raise the temperature of 1 gram of water by 1°C. (2)
7. To test white bread for the presence of protein:
   Cut a 1 cm × 1 cm cube of white bread (without crust) and stir it into 20 ml of water.
   Add 5 ml of Biuret A and 1 ml of Biuret B and stir.
   Place the container in a beaker of hot water.
   If the Biuret solutions turn from a blue to a purple colour, then the white bread contains protein. (3)

TOPIC 2.5 Enzymes

SUB-TOPIC 2.5.1 Mode of action of enzymes

LB pages 108–114

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know how the structure of enzymes relates to their function
Specific objectives	• Explain the nature of enzymes as globular proteins that catalyse metabolic reactions • State that enzymes function as intracellular and as extracellular enzymes • Explain the mode of enzyme action in terms of an active site, enzyme-substrate complex, lowering of activation energy and enzyme specificity (the lock and key hypothesis and the induced fit hypothesis should be included) • Investigate the progress of an enzyme-catalysed reaction by measuring formation or rates of formation of products and by-products, (for example using catalase) or rates of disappearance of substrate (for example, using amylase)
Cross-cutting issues	The role of enzymes in industry and medicine
Inclusive education	Learners with hearing and sight problems can sit in the front of the class. Groups need to be inclusive and organised so that more capable learners can assist those with physical or intellectual challenges.
Suggested teaching times	8 lessons
Additional resources needed	Internet, posters, pictures, cardboard, scissors, Bunsen burner, matches

Introduction to this topic

Enzymes are all proteins but not all proteins are enzymes! Ask the learners to explain that statement in their own words.

Refer to Sub-topic 2.4.2 and the structure of proteins. Ask the learners questions to refresh their knowledge on the structure and functions of proteins.

Explain that enzymes are functional proteins. That enzymes are needed whenever a chemical reaction happens in a living body.

Ask the learners to give examples of chemical reactions in a living body. Lead them to think of cellular respiration, photosynthesis, DNA replication and even protein synthesis. Explain that there are specific enzymes involved in specific reactions.

Explain that enzymes can only function at particular temperatures and at a specific pH range. Otherwise the structure of the enzyme changes and it can no longer function. It is denatured.

Starter activity

LB page 108

The starter activity tests the learners' prior knowledge and their listening skills.

Suggested answers

1. A catalyst is a chemical that speeds up a chemical reaction and lowers the activation energy of a reaction.
   An enzyme is a biological catalyst. It is a protein in a living body that speeds up a reaction and lowers the activation energy needed to start a reaction.
2. As this assesses prior knowledge, learners' answers will vary. Guide them and cement their base knowledge in this area as they set about transitioning into a deeper understanding of this topic.

Beginning these lessons

Explain that chemical reactions need energy to either break or make bonds between molecules. You can demonstrate this by lighting a fire or

Bunsen burner. The gas is undergoing a chemical reaction to form heat, carbon dioxide and water. You needed to use a match to start the reaction. This is the activation energy. When an enzyme is present, less activation energy is needed to start the reaction.

Teaching tips

- Use a template such as the ones provided below. The learners draw three of each of the shapes on cardboard and then use them to explain to each other how the lock and key model of enzyme action works.

- Learners work in groups of three for the investigations.

Homework

Activity 1 is suitable for homework. The questions related to Experiment 1 can be completed at home.

Suggested answers

Activity 1 Understand enzyme action (LB page 111)

1. Activation energy is the energy needed to start a reaction.
2. A reaction without an enzyme will need more energy to get started and the reaction will take longer than a reaction with an enzyme.
3. **a)** Reaction A is a lock and key theory of enzyme action and reaction B is an induced fit theory of an enzyme action.
   b) In reaction A, the enzyme does not change at all before, during or after the reaction, but reaction B shows the enzyme changing slightly when bonded to the substrate – the enzyme bends inwards.

Experiment 1 Investigate the progress of an enzyme-catalysed reaction using catalase (LB page 112)

1. When the glowing splint was added to both beaker A and B, the glow burned brighter or burst into flame proving that oxygen was produced.
2. The enzyme is catalase.
3. The substrate is hydrogen peroxide.
4. The products are oxygen and water.
5. The hydrogen peroxide molecules fit into the activation site of the catalase. The catalase enzyme molecules therefore bond to the hydrogen peroxide. When bonded a reaction takes place and oxygen is removed forming water and oxygen.
6. There is less catalase in yeast than in liver. Therefore, the reaction in the yeast (beaker B) is slower.
7. Beaker B contains yeast. The yeast has less catalase than the liver in beaker A, therefore less oxygen is produced. The oxygen causes the foam, therefore there is less foam in beaker B.

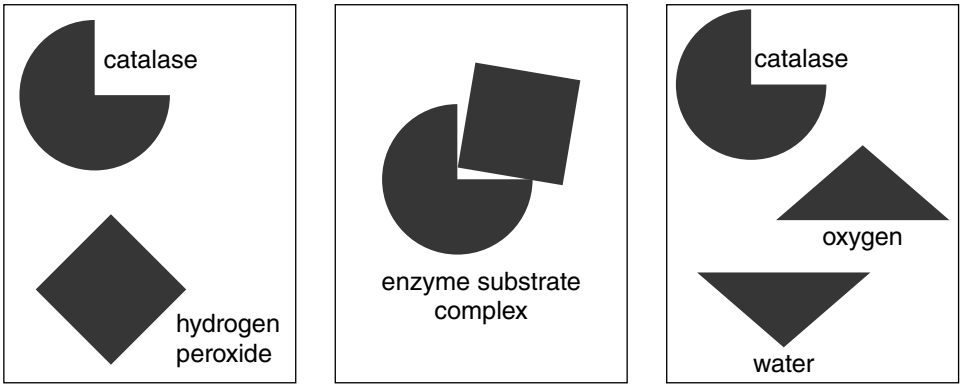
Self-assessment (LB page 114)

1. An enzyme is a protein that has a tertiary structure. It is a globular protein consisting of two strands of amino acids that are twisted together in a particular shape so that there is a specific activation site that can attach to a substrate. (2)
2. **a)** A biological catalyst is an enzyme. Enzymes are found in biological bodies. The enzymes lower the activation energy of a reaction and speed up the reaction. (2)
   b) Activation energy is the energy needed to start a chemical reaction. (2)
   c) The activation site is a particular arrangement of the enzyme structure that enables a particular substrate to bond. Rather like a jigsaw puzzle. (2)
   d) A substrate is the chemical or molecule before the reaction takes place. (2)
   e) A product is the changed substrate after a reaction. (2)
3. Learners to draw something similar to the diagrams as shown on page 111 of the Learner's Book.
   Give marks for correct headings, labels and diagram shapes. (6)

4. a) Catalase breaks down hydrogen peroxide into water and oxygen. (3)

b) Catalase is an intracellular enzyme because it works inside the cells of living organisms. (2)

c)



(5)

SUB-TOPIC 2.5.2 Factors that affect enzyme action

LB pages 115–126

Syllabus coverage	See the syllabus grid in Section B
General objective	Understand the importance of the factors that affect the rate of enzyme-catalysed reactions
Specific objectives	• Investigate and explain the factors that affect the rate of enzyme catalysed reactions » temperature » pH (using buffer solutions) » enzyme concentration » substrate concentration » inhibitor concentration • Explain how the maximum rate of reaction (V_{max}) is used to derive the Michaelis-Menten constant (K_m) which is used to compare the affinity of different enzymes for their substrates • Explain the effects of reversible inhibitors, both competitive and non-competitive, on the enzyme activity. • Investigate and explain the effect of immobilising an enzyme in alginate on its activity as compared with its activity when free in solution
Cross-cutting issues	The role of enzymes in industry and medicine
Inclusive education	• Provide assistance to those with physical or intellectual challenges. • Hearing impaired learners can sit at the front of the class.
Suggested teaching times	6 lessons
Additional resources needed	None

Introduction to this topic

Remind the learners of the structure and nature of proteins. Refer to Sub-topic 2.4.2. Remind the learners of the structure and nature of enzymes. Refer to Sub-topic 2.5.1

Ask the learners questions such as:

1. What is the function of an enzyme? (to reduce the activation energy of a chemical reaction)
2. What is a substrate? (the substance that an enzyme changes in the chemical reaction)
3. What does it mean that an enzyme is substrate specific? (enzymes work on specific substrates – each enzyme works on one specific substrate only)
4. What can denature an enzyme? (increased temperature and a change of pH)
5. Why can an enzyme no longer function if it is denatured? (because there is a change in its structure)
6. Explain how an enzyme functions (something related to the lock and key theory or jigsaw puzzle idea).

Starter activity

LB page 115

The starter activity is designed to get learners thinking. Organise the learners into groups of four. Ensure that each group is of mixed ability.

Each group presents at least one answer to the class. The class decides whether the answer is correct or not. Guide the learners to the correct answer.

Suggested answers

1. hydrogen peroxide
2. The reaction time will be different because there is less substrate. The enzyme will therefore bond with more or all of the substrate in the given time.
3. **a)** The reaction time will be halved/less/quicker.
   b) The reaction time will be quicker because the amount of enzyme is increased/doubled. More enzyme will bond with more substrate in the given time.

4. **a)** Cooking the liver will denature the enzymes as they are heat sensitive. The enzymes will not work and no reaction with hydrogen peroxide will take place.
   b) If the temperature were cooled to 5 °C, the reaction time will be longer. There is less energy.

Beginning these lessons

- Revise the concept of rate. It is a measurable activity over time. In the case of enzyme action, it will be the time it takes for a reaction to happen.
- Ask the learners to list all the factors they can think of that would speed up or slow down an enzyme catalysed reaction. Write the list on the board. Guide the learners to the answers. You may need to remind the learners that one enzyme needs to bond with one substrate molecule at a time for the reaction to take place.
- The Michaelis-Menten constant is calculated to show just how quickly and strongly an enzyme bonds with a substrate. Explain that the work affinity can also mean how much someone likes someone else or how much a person likes doing something. An example is that John has an affinity for Mathematics. In other words, he enjoys doing Mathematics and does it well.
- There are some chemicals or substances that can interfere with the affinity one enzyme has with a substrate. These are inhibitors. An inhibitor can stop a reaction by preventing an enzyme bonding with a substrate. Some toxins and poisons are inhibitors and can lead to death.
- The learners will do a number of investigations. Ensure that they read the instructions carefully and know exactly what they are doing and why they are doing the investigations. Allow the learners to work in small groups to complete the investigations. Each learner needs to complete the questions associated with an investigation individually in order to assess how well they understand the work.

Teaching tips

- Draw an enzyme activated reaction on the board. Remind the learners that one enzyme bonds with one substrate molecule at a time.
- Remind the learners that an enzyme can be used over and over again.

Extra diagnostic activity

Learners work in pairs. Each pair researches inhibitors. They can choose one kind of inhibitor to research. The learners create a poster illustrating how the inhibitor prevents a chemical reaction. The poster must include the use of the inhibitor to life, industry or medicine. They can present their posters in class and display them on the walls.

Homework

Activity 1 is suitable for homework. The questions related to the experiments can be completed at home.

Suggested answers

Activity 1 Understand the effect of temperature on enzyme action (LB page 116)

1. **a)** red
   b) The enzyme works at its best at 37 °C. This is the temperature of a human body.
2. 4 °C
3. Cellular respiration – it provides energy.

Experiment 1 Investigate the effect of temperature on the rate of an enzyme-catalysed reaction (LB page 117)

1. the control
2. **a)** pineapple
   b) gelatin in jelly
3. **a)** Table showing the state of jelly setting at various temperatures.

Temperature of the pineapple and jelly °C	State of setting of the jelly
5	Does not set
20	Does not set
40	Thickens
90	Sets

   b) The enzymes in the pineapple placed in cold and cool water will not denature. When jelly is added, the enzymes will break down the protein called gelatin and the jelly will not set.

The enzymes in the pineapple placed in the 40 ^{0}C water will partially denature and when jelly is added it will not set properly.
The enzymes in the pineapple placed in the 90 ^{0}C water will denature. The enzymes will therefore not break down the gelatin in the jelly and the jelly will set.

5. The enzyme breaks down the protein.

Experiment 2 Investigate the effect of pH on the rate of an enzyme-catalysed reaction (LB page 118)

1. **b)** The fruit were in distilled water, so nothing.
   c) Enzymes turn the fruit brown.
   A change of pH will denature the enzymes. If there is no change of pH the enzyme will continue to function and turn the fruit brown.
2. **a)** Beaker A
   b) The fruit was in the acid medium.
   c) The enzyme is most sensitive to acid. Acid denatures the enzyme completely and quickly.
3. pH of 7/neutral

Experiment 4 Investigate the effect of enzyme or substate concentration on the rate of an enzyme-catalysed reaction (LB page 120)

1. catalase
2. hydrogen peroxide
3. high, medium, low
4. The higher the concentration of the enzyme catalase, the faster the reaction time for foam to form. There is no difference in the height of foam because there was an equal amount of substrate (hydrogen peroxide) and enzymes can be used over and over again.
5. The rate of a chemical reaction increases with increased enzyme concentration.

Experiment 6 Immobilise the enzyme lactase in alginate (LB page 124)

1. Results table:

Time in minutes	Original colour of Benedict's solution	Colour of Benedict's after testing milk	Approximate amount of glucose in sample (little, some or much)
0	Sky blue	Blue	None
5	Sky blue	Blue/green	Little
10	Sky blue	Green/yellow	Some
15	Sky blue	Orange/brown	Much
20	Sky blue	Red/brown	Much

2. The beads bond with the enzyme lactase and keep the enzyme in the test tube for re-use.
3. The enzyme lactase hydrolyses (breaks down) lactose into glucose and galactose.
4. Lactose is found in milk.
5. The lactose is the substrate.
6. Galactose and glucose are the products.
7. Benedict's solution will change from blue to a range of colours (green/yellow/orange/brown) in the presence of different concentrations of glucose.
8. The 20-minute sample. It changed to a red/brown colour.

Self-assessment (LB page 126)

1. **a)** *y*-axis: V is the rate of reaction.
   x-axis: [*S*] is the substrate concentration.
   A: V_{max} is the highest possible reaction rate that can happen when there is sufficient concentration of substrate. This is the value of the saturation point.
   B: ; B = $\frac{1}{2} V_{max}$
   C: K_m is the Michaelis constant. (5)
   b) A competitive inhibitor is a reversible inhibitor. It attaches to the active site of the enzyme, and so competes with the substrate. (2)

c) A non-competitive inhibitor does not fit into the same site on the substrate as the enzyme. It bonds to another part of the substrate. This burdens the reaction and causes the rate of reaction to decrease/slows the reaction. (2)

d) This reduces the rate of the reaction. However, if the substrate concentration is high enough, the action of the inhibitor is overcome. (1)

e) It increases. The competitive inhibitor attaches to the active site of an enzyme and so blocks the substrate from binding. (3)

f) A non-competitive inhibitor. Revise Learner's Book pages 121–122 with the learners. (2)

2. a) 1 = substrate; 2 = competitive inhibitor; 3 = non-competitive inhibitor; 4 = product (4)

b) **i)** A – normal reaction with no inhibitor

ii) B – reaction with competitive inhibitor

iii) C – reaction with a non-competitive inhibitor (3)

TOPIC 2.6 Transport in plants

SUB-TOPIC 2.6.1 Structure of transport tissues

LB pages 127–137

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know the structural components of xylem and phloem and relate these to their functions
Specific objectives	• Identify and label the various parts of the transverse sections of stems, roots and leaves of herbaceous dicotyledonous plants, using an eyepiece graticule to show correct proportions • Describe the structure of xylem vessel elements, phloem sieve tube elements and companion cells • Relate the structure of xylem vessel elements, phloem sieve tube elements and companion cells to their functions • Draw and label from prepared slides the structure of xylem vessel elements, phloem sieve tube elements and companion cells (use a light microscope to recognise the structures)
Cross-cutting issues	Environmental education
Inclusive education	Try to include visually impaired learners in groups with learners who can help or guide them in practical activities. Hearing impaired learners can sit in the front of the class.
Suggested teaching times	12 lessons
Additional resources needed	Posters or models of sections though the root, stem and leaf of a dicotyledonous plant. Photomicrographs of transverse sections (TS) of dicotyledonous roots, stems and leaves as well as transverse and longitudinal sections of xylem and phloem. Look for these on the internet or in other textbooks to provide different examples for your learners.

Introduction to this topic

The focus of this topic is the structure, function and location of the transport tissues (xylem and phloem) in a plant. Learners will learn about the vascular tissue and its organisation in the root, stem and leaf. They build on what that they learnt in Grades 10 and 11 and use this information to interpret photomicrographs of transverse sections of a dicotyledonous root, stem and leaf.

Starter activity

LB page 127

Let the learners do the starter activity after you have had a general class discussion to find out how much they remember about the structure of a plant and its tissues from Grades 10 and 11. Go through the answers with them making sure that you clear up any mistakes or misconceptions.

Suggested answers

1. Epidermis
2. Cuticle
3. Root hairs
4. Cortex
5. Vascular bundles
6. Stomata
7. Palisade parenchyma or mesophyll
8. Spongy parenchyma or mesophyll

Beginning these lessons

Ask the learners what they remember about the structure of a dicotyledonous root, stem and leaf from Grades 10 and 11.

Use a plant or poster of a plant (e.g. a tree) to point out the different organs and see if the learners can tell you what the main functions of each of the plant organs (root, stem and leaf) are and how each organ is specialised for that function.

Ask the learners to name the different kinds of tissues found in plants. Write their answers on the board. Ask them to give the main function or functions of each tissue. Quickly sketch a few cells of some of the important tissues (e.g. epidermis, parenchyma and phloem) and find out if the learners recognise these tissues. Alternatively show photomicrographs or diagrams of these tissues from more advanced textbooks or the internet.

It is always worth mentioning how important plants are to the general health of our planet and all the organisms that live in it. Learners often tend to dismiss plants as uninteresting and unimportant whereas the opposite is true. They are vital to the continued existence of animals and humans and this is particularly important today, as many plant habitats are being damaged or destroyed by human development.

Teaching tips

- Before you start this topic, collect some good resources that will help you make this topic more visual. Find a selection of plants, photographs, diagrams or posters of plants showing their structure.
- Also look for a range of good photomicrographs of transverse sections of dicotyledonous roots, stems and leaves as well as good, clear micrographs of xylem and phloem tissue. If you laminate the photomicrographs they can be used for several classes or for classes from one year to the next.
- Look for additional questions and worksheets for support or extension activities, especially any sections that you know your learners might struggle with.
- Make sure that you have the prepared slides that you will need for practical exercises. If there is another High School nearby you might be able to share prepared slides to keep costs down.

Homework

After learners have completed the section on the structure of the dicotyledonous root, stem and leaf, give them the following exercise for homework.

1. Draw a flow diagram to show the path of water from the soil into the root, up the stem and out of the leaf, mentioning all the tissues that it passes through.
2. Draw a flow diagram to show the path of food that is manufactured in the leaves, down the stem and into the roots where it is stored.

Suggested answers

1. soil water → root hair → epidermis → cortex → endodermis → xylem (in root) → xylem (in stem) → xylem (in leaf) → spongy mesophyll → intercellular air space → stoma → air/atmosphere
2. spongy or palisade parenchyma → phloem (in leaf) → phloem → in stem → phloem (in root) → endodermis → cortex

Informal assessment

Use the starter activity and class exercises and activities for informal assessment. Go over the answers with the class for these exercises and activities and identify any misconceptions or common mistakes that have been made (diagnostic assessment).

You could use the Practical exercise on page 135 to assess the learners' drawing skills and give them feedback on how well they are doing (diagnostic assessment).

Additional support

If you think that your learners need additional support, provide extra questions in worksheets based on diagrams of the root, stem and leaf as well as xylem and phloem tissue – there are many available on the internet. Learners often need different diagrams to identify and label so they learn to recognise basic structures that may vary from one example to another.

Self-assessment

Use the questions on page 137 of the Learner's Book for self-assessment. Encourage the learners to identify any gaps in their knowledge or weaknesses in their skills or understanding and help them to work out what they need to do to improve.

Suggested answers

Practical exercise **Identify and label transverse sections of a dicotyledonous stem, root and leaf (LB page 131)**

- This practical exercise can only be carried out if you have all the resources available. Ensure that the microscopes, slides and eyepiece graticules are ready for each group before the lesson.
- Remind learners to follow the rules for biological drawings when drawing the sketches of the root, stem and leaf and to show the ARRANGEMANT of tissues. Tell them NOT to draw the detail of the cells. Their diagrams need to look more like a map or plan than a detailed representation of what they see. Check the learner's drawings for correct headings and labels.
- In this experiment learners use an eyepiece graticule to measure the size of the different regions of the tissues to get their correct proportions. Before the practical lesson remind them to go over how to use an eyepiece graticule (Topic 2.1).
- Check the learner's calculations of the width of a vascular bundle in the stem, the vascular cylinder in the root and the main vascular bundle (the midrib) in the leaf.

Activity 1 **Identify and label photomicrographs of transverse sections of a dicotyledonous stem, root and leaf (LB page 132)**

1. a) Stem is micrograph B – reasons: that there are vascular bundles and they are arranged in a circle.

b) Root is micrograph C – reasons: the centre of the diagram shows the vascular tissue. There is a large cortex area.

c) Leaf is micrograph A – reasons: stomata is evident. There are palisade cells for photosynthesis. Airspaces are visible.

2. 1 – upper epidermis of leaf
2 – palisade mesophyll of leaf
3 – intercellular air space of leaf
4 – cortex of stem
5 – vascular bundle of stem
6 – cuticle of stem
7 – pith of stem
8 – root hair of root
9 – endodermis of root
10 – xylem of root

Practical exercise **Draw and label the structure of xylem and phloem from prepared slides (LB page 135)**

- This experiment can only be carried out if you have all the resources available. Ensure that the microscopes and slides are ready before the lesson.
- Remind the learners to follow the rules for biological drawings when drawing the cells that they observe under the microscope.
- In this exercise learners draw and label cells from xylem and phloem tissue that they observe on a microscope slide. Check the learner's drawings for size, accuracy and correct heading and labels.
- If you don't have the slides for the learners to see, they could complete the activity using the photomicrographs on page 132 in the Learner's Book or photomicrographs that you have found from other sources, e.g. textbooks or the Internet. Alternatively, you could use Bioviewer slides.

1. b) Refer to Learner's Book page 133.
2. b) Refer to Learner's Book page 134.

Self-assessment **(LB page 137)**

1. a stem (1)

2. A – multicellular hair
B – cuticle
C – epidermis
D – endodermis
E – phloem
F – xylem
G – pith (7)

3. E and F (2)

4. The phloem tissue is specialised for the translocation of substances as follows:
- the sieve tube elements have fewer cell contents (1) and have perforated sieve plates (1) which allow substances to easily pass from one cell to another (1)
- companion cells have plasmodesmata (1) between sieve tube elements and companion cells (1) that allow efficient communication between the two types of cells. (1) (6)

5. The xylem tissue is specialised for the transport of water and mineral salts as follows:
- it consists of long, continuous (1), hollow tubes (1) to allow the unrestricted movement of its contents (1)
- the lignin in the secondary cell walls (1) provides strength and support for the plant (1)
- lignin also prevents the collapse of the hollow xylem vessel elements due to the suction pressure of transpiration pull (1) that draws the water upwards from the roots to the leaves. (1) (6)

6. Learners must draw a similar diagram (with labels) to Figure 2.6.1.7 Structure of a phloem sieve tube element and a companion cell on page 134 of the Learner's Book. (6)

7. $\text{magnification} = \frac{\text{image size}}{\text{actual size}}$ (1)

$\text{magnification} = \frac{15}{0.1}$ (1)

magnification = ×150 (1)

8. a) trichomes – reflect excess light, reduce water loss or defend the plant against insects (3)

b) waxy cuticle – prevents water loss from the plant (1)

c) stomata – allow gases to pass into or out of the leaf (2)

d) spongy mesophyll – promotes diffusion of gases through the leaf (1)

SUB-TOPIC 2.6.2 Mechanisms of transport in plants

LB pages 138–152

Syllabus coverage	See the syllabus grid in Section B
General objective	• Understand mass flow in relation to the movement of xylem and phloem sap
Specific objectives	• Explain that transpiration involves the evaporation of water from the internal surfaces of leaves followed by diffusion of water vapour to the atmosphere • Describe, in terms of water potential, the movement of water: » between plant cells » between the plant and its environment (no calculations involving water potential will be set) • Investigate experimentally and explain the factors that affect transpiration rate using simple potometer, epidermal peels and grids for determining surface area • Explain how hydrogen bonding of water molecules is involved with movement in the xylem by cohesion-tension in transpiration pull and adhesion to cellulose cell walls • Describe the pathways and explain the mechanisms by which water and mineral ions are transported from soil to xylem and from roots to leaves (include reference to the symplastic pathway, apoplastic pathway and Casparian strip) • Make annotated drawings of transverse sections of leaves from xerophytic plants to explain how they are adapted to reduce water loss by transpiration • State how assimilates, such as sucrose and amino acids, move between sources (e.g. leaves and storage organs) and sinks, (e.g. buds, flowers, fruits, roots and storage organs) in phloem sieve tubes • Explain how sucrose is loaded into phloem sieve tubes by companion cells using proton pumping and the co-transporter mechanism in their cell surface membranes • Explain mass flow in phloem sap down a hydrostatic pressure gradient from source to sink
Cross-cutting issues	Environmental education
Inclusive education	Learners with hearing and sight problems can sit in the front of the class. Groups need to be inclusive and organised so that more capable learners can assist those with physical or intellectual challenges.
Suggested teaching times	12 lessons
Additional resources needed	Internet, posters, pictures

Introduction to this topic

Remind the learners of the structure of a plant, with specific attention to the leaf. Briefly discuss the vascular tissue and ask learners the names and functions of xylem and phloem. Ask the learners what structural differences there are between xylem and phloem and lead them to the answers.

- Xylem has two forms: the xylem vessel and xylem tracheid with its taped ends. The waterproof cell wall of xylem is not continuous but can be arranged with pits, or in spirals or circles. The cells have no cross walls and form a continuous tube. Xylem transports water from roots to leaves.
- Phloem is also a tube shape but has perforated (with pits) transverse walls that serve as a sieve. Hence the name sieve tube. Each sieve tube has a fully functional companion cell. Phloem transports nutrients from the leaves to the rest of the plant body.

Starter activity

LB page 138

Ask the learners what they understand by the following terms. Write the answers on the board. Before the Starter activity wipe the board clean. The learners can then do the activity and test their ability to remember.

- Wilting
- Water potential
- Photosynthesis
- Xylem
- Diffusion
- Translocation
- Osmosis
- Phloem
- Transpiration

Suggested answers

1. C	**3.** F	**5.** A	**7.** D	**9.** E
2. I	**4.** B	**6.** J	**8.** H	**10.** G

Beginning these lessons

Talk to the learners about perspiration/sweat and why humans sweat. Plants do not perspire but they do lose water from tiny holes in the leaves called stoma. The process of water loss from leaves is called transpiration. The process is NOT about cooling the plant, although that may well happen. The process allows water to flow through the plant from the soil to the leaves.

Ask the learners why plants need water. Lead them to the answers of a) for photosynthesis and b) as support for the plant. Explain that the plant uses water as a hydrostatic skeleton. Perhaps you could show them a pot plant that has not been watered for some time and is wilting. Give the plant water and leave for 15 minutes. Show the learners what the plant looks like now that water is in the vacuoles of the cells. The plant cells are now turgid and the plant stands upright.

Water moves up the plant (against gravity) because of three forces called transpirational pull, capillarity and root water pressure. Transpirational pull involves some water evaporating from the stoma.

Show the learners photographs of forests – almost always there is mist above the trees. The mist is the water that has transpired from the stoma of the leaves. Transpired water affects the climate as the mist is blown elsewhere where it may precipitate as rain. This is a reason why cutting down forests affects the climate.

Teaching tips

- There are two experiments in this sub-topic. Ensure you have all the equipment needed for them before the lessons. It is a good idea to do the practical exercises yourself before the lessons.
- Allow the learners to work in small groups when doing the experiments.

Homework

Activity 1 is suitable for homework. The questions after some of the experiments can also be completed for homework.

Suggested answers

Practical exercise **Use a potometer to investigate atmospheric conditions that affect the rate of transpiration (LB pages 140–141)**

1. The air bubble shows the movement of the water. One can see the air bubble against the ruler.

2. The reservoir refills the water in the capillary tube and moves the air bubble back to its original position.

3. Rate = distance/time. The rate of transpiration is calculated by measuring the distance the air bubble moved (final position-original position) over the time it moved.

4. The plant and potometer placed in the cool, windless room is the control.

5. The control is used to compare the results. The plant in the cool, windless room is not likely to transpire, therefore any transpiration that takes place in the investigation will be due to the changes in the environmental conditions – hot and windy.

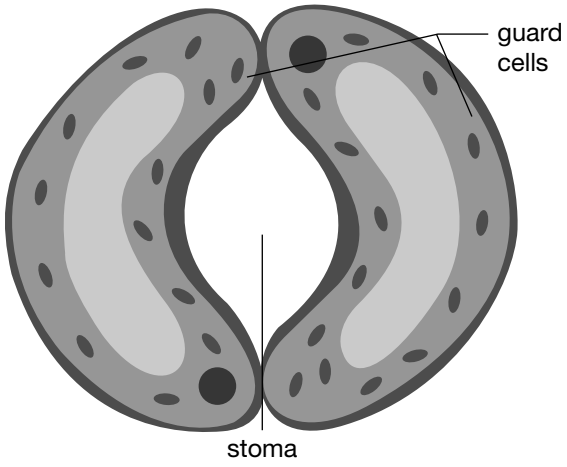
6. a) An increase in temperature resulted in an increase in the rate of transpiration.

b) An increase in wind resulted in an increase in the rate of transpiration.

c) An increase in humidity will decrease the rate of transpiration.

7. A hair dryer blowing hot air will further increase the rate of transpiration (more than cool air from the dryer).

Practical exercise — Use an epidermal peel and a grid to determine the surface area of a leaf and the number of stomata on different leaves (LB pages 141–142)

1. The nail varnish makes an impression of the surface of the leaf including the stomata and guard cells. It is easy to see under the microscope in order to count the stomata.
2. 

3. **a)** There are more stomata on the lower surface of a leaf.
   b) The upper surface of a leaf is more exposed to heat and wind than the lower surface. Having more stomata on the lower surface prevents unnecessary transpiration which will dehydrate the plant.
4. **a)** Leaf A had the most stomata.
   b) Leaf A grows in a cool, moist environment.
5. **a)** All plants need to transpire so that water can be moved upwards from the roots. The plant in the cool, moist environment is not in danger of dehydration. However, it may struggle to transpire enough water so there would be more stomata.
   b) The more stomata the more transpiration.

Activity 1 — Make annotated drawings of transverse sections of leaves from xerophytic plants (LB page 147)

Ensure that the learners' plan diagrams show only the different layers of cells, not the cells themselves.

Activity 2 — Consolidate your knowledge of transport processes in plants (LB page 150)

1. Sugar is made in the leaves of plants.
2. Proteins are made in all the organs of the plants.
3. These organs are regarded as sources.
4. Water is transported from the roots to the rest of the plant particularly the leaves.
5. Nutrients are transported from the leaves to the rest of the plant. Or they are transported from where they are stored (roots, stems and leaves) to the rest of the plant where they are needed.
6. transpiration
7. translocation
8. **and 9.** Assess the learners' diagrams for accuracy of structure and labels.

Self-assessment (LB page 152)

1. **a)** Transpiration is the loss of water from stomata of leaves.
   b) Translocation is the movement of organic nutrients from the source to the sink of plants.
   c) Water potential is the ability for water to move from one system to another through a membrane depending on the concentration of solute in the water.
   d) Assimilates are the products of the monomers of organic nutrients such as glucose forming starch.
   e) Phloem sap is the solution of water and nutrients being translocated in the phloem sieve tubes. (5)
2. **a)** A –apoplastic, B –symplastic, C – vacuolar (3)
   b) D – plasmodesmata, E – vacuole, F- cytoplasm (3)
3. **a)** adhesion/cohesion (2)
   b) The water molecules bond with the inner surface of the tube and 'crawl' upwards in adhesion. The water molecules bond with one another and form a surface tension in cohesion. (4)

c) The water molecules bond with the surface of the tube (adhesion) and as they crawl upwards they hold onto other water molecules (cohesion) and pull them along. In this way, the water is able to move upward. This only can happen if the tube is sufficiently thin. (4)

d) Transpirational pull occurs because the evaporation of water from the stomata of the leaves causes a vacuum to form in the air spaces between the cells of the leaves. There is a higher pressure down below in the xylem of the roots and the water therefore moves from high pressure to low pressure. (4)

4. a) sucrose
b) hydrogen
c) carrier protein
d) low water potential
e) water (5)

TOPIC 2.7 Transport in animals (mammals)

SUB-TOPIC 2.7.1 Mammalian circulatory system LB pages 153–166

Syllabus coverage	See the syllabus grid in Section B
General objective	Know the structure and function of the mammalian circulatory system and the components of blood
Specific objectives	• State that the mammalian circulatory system is a closed double circulation consisting of a heart, blood vessels and blood • Observe and make plan diagrams of the structure of arteries and veins, using prepared microscope slides and be able to recognise these vessels using the light microscope or from photomicrographs • Explain the relationship between the structure and function of arteries, veins and capillaries • Recognise and draw the structure of red blood cells, monocytes, neutrophils and lymphocytes using prepared slides, photomicrographs and electron micrographs • State the functions of tissue fluid and describe the formation of tissue fluid in a capillary network • State and explain the differences between blood, tissue fluid and lymph • Describe the role of red blood cells in carrying oxygen and carbon dioxide with reference to the role of: » haemoglobin » carbonic anhydrase » the formation of haemoglobinic acid » the formation of carbamino-haemoglobin (details of the chloride shift are not required) • Describe how carbon monoxide binds with haemoglobin to form carboxy haemoglobin reducing the affinity of haemoglobin for oxygen • Describe the role of plasma in the transport of carbon dioxide • Describe and explain the oxygen dissociation curve of adult haemoglobin • Explain the importance of the oxygen dissociation curve at partial pressures of oxygen in the lungs and in respiring tissues • Describe the Bohr shift and explain the importance of the Bohr shift • Describe and explain the significance of the increase in the red blood cell count of humans at high altitude
Cross-cutting issues	This topic links with aspects of microscopy as well as the movement of substances in and out of cells.
Inclusive education	• Provide assistance to those with physical or intellectual challenges. Some learners may have difficulty with Activity 1 so pair them with a more able learner. Visually impaired learners will need help with images. Use large micrographs so that they can see the different sections. • Hearing impaired learners can sit at the front of the class.
Suggested teaching times	8 lessons
Additional resources needed	Microscope; prepared slide of a section through an artery; prepared slide of a section through a vein; prepared slide of a section through capillaries; sharp pencils, erasers and rulers; plain white paper, micrographs

Introduction to this topic

Mammals, such as human beings, have developed circulatory systems for transporting nutrients, respiratory gases and metabolic wastes around their bodies. The mammalian circulatory system is a closed system which means that blood is kept within a network of different blood vessels of different size and wall thickness. In this type of system, the heart pumps blood through the vessels.

The mammalian circulatory system is a double circulation system. Blood flows through the heart twice; from the heart to the lungs and back to the heart and then flows to the body and back to the heart. The contraction of the cardiac muscles in the heart creates pressure in its different chambers. This pressure is important in the cardiac cycle.

Starter activity

LB page 153

Use the starter activity to determine how much learners can remember about this topic from previous grades. Go through the answers in class and spend time consolidating if necessary.

Suggested answers

1.

	Arteries	Veins	Capillaries
Structure of wall	Thick wall with an outer layer of connective tissue, a middle muscle layer and an inner layer of epithelium.	Similar to arteries but with a thinner middle muscle layer.	Single layer of epithelium. No muscle in wall.
Main vessels	Aorta; pulmonary artery	Superior and inferior venae cavae; pulmonary vein	Found throughout the body.
Functions	Transport blood away from the heart.	Transport blood to the heart.	Allow for diffusion of substances into and out of the blood and cells.

2. A double circulatory system refers to the flow of blood from the right side of the heart to the lungs and back via the pulmonary circuit and the flow from the left side of the heart to the body and back via the systemic circuit.
3. The main components of blood are plasma, red blood cells, white blood cells, and platelets..

Beginning these lessons

The components of the human circulatory system have been covered in earlier grades, such as the structure and functioning of the heart, blood vessels and blood. Health problems related to the circulatory system such as heart attacks were also covered. Learners should be familiar with the components of blood and their various functions.

Learners will now learn about the circulatory system in more detail. They will make plan diagrams of sections of different blood vessels and identify the components of blood using micrographs. Transport of respiratory gases is also important and they will cover more biochemical details. Oxygen dissociation in the lungs and tissues will be described as well as the effects of high altitude on dissociation.

Teaching tips

- After completing the starter activity, use Figure 2.7.1.1 in the Learner's Book on page 154 to revise the concept of a double circulatory system. Make sure learners can describe the pulmonary and systemic circuits in relation to blood flow through the heart.
- You will need to prepare for the Practical exercise in the Learner's Book on page 156 ahead of the lesson. If you do not have enough slides for group work, set up the slides and let groups take turns to view them.
- When teaching the structure of blood vessels, make sure that the focus is on structure related to function. This will be important when you teach blood pressure in different vessels later in the topic.
- When describing the components of the blood plasma, you will need to also mention tissue

fluid, lymph and lymph vessels. Make sure learners can distinguish tissue fluid from lymph.
- Tissue fluid is plasma that is forced out of the blood capillaries. It supplies the cells with nutrients and gases. Some tissue fluid forms lymph when it drains into lymph vessels. Use Figures 2.7.1.5 (LB page 158) and Table 2.7.1.1 (LB page 159) to help you explain this.
- For Activity 2, some learners may need help with drawing. Revise the requirements of a biological drawing.
- The transport of respiratory gases is quite complex, and some learners may find it tricky. Explain this carefully, spending time first on the transport of carbon dioxide and then the transport of oxygen. The dissociation curves will need careful explanation.

Inclusive education

Some learners may have difficulty with Activity 1. Make sure that they are paired up with a more able learner.

Homework

You could use Activity 2 as a homework task.

Informal assessment

Let learners work in pairs and test each other on the meaning of the terms in the Key word boxes. They can mark their work using the Learner's Book.

Self-assessment

Use the following self-assessment rubric to check that learners have understood the concepts covered in this topic.

	Very good	Good	Developing	Need help
Taking notes	I was able to take very good notes on the content of the lessons.	I was able to take good notes on the content of the lessons but sometimes missed one or two points.	I took some notes and I feel I am getting better at taking notes.	I need help learning how to take notes.
Understanding oxygen dissociation	I understood everything.	I understood almost everything.	I did not understand some things.	I did not understand anything.
Bar chart	I completed the bar chart easily.	I completed the bar chart but had a little difficulty with one or two questions.	I did not complete the bar chart and had difficulty with many questions.	I need help with the bar chart and questions.
Drawings	I was able to do very good drawings.	I was able to do good drawings.	I was able to do fair drawings.	I need help with drawings.

Suggested answers

Practical exercise 1 Examine the structure of blood vessels (LB page 156)

2. Use the checklist above to mark learners' drawings.
3. They are all cross or transverse sections.
4. a) lumen – arteries have a small lumen and veins a larger one
b) walls – walls of arteries are much thicker than those of veins
5. a) The middle layer was the thickest in the section of the artery.
b) The elastic tissue layer was the thickest in the section of the vein.

Activity 1 Analyse data about blood flow in different blood vessels (LB pages 156–157)

1. a) Capillaries have the highest cross-sectional area.
b) Blood flows slowly in these vessels; the narrow diameter restricts blood flow.

c) When blood flows slowly, there is time for exchange of substances between the blood and tissue fluid.

2. a) Blood pressure is highest in the aorta. Blood is pumped from the left ventricle under high pressure into the aorta.

b) A vein or the vena cava would not have the same structure as the aorta. Blood is not under as much pressure when it returns from the body to the right side of the heart. The table shows that the blood pressure in larger veins and the vena cava is less than in larger arteries and the aorta.

3. a) Large arteries have the highest blood speed.

b) The blood is forced out of the heart under high pressure.

4. Veins need valves as they have a large internal area, the blood flows slowly and is under low pressure; it is therefore easy for it to flow in the wrong direction.

5. a) and b) Assess the learners' graphs in terms of:

- neatness and legibility
- heading
- labels of axes
- correctness of units used
- accuracy

c) Blood vessels closer to the heart such as the aorta and vena cavae have a smaller cross-sectional area than the blood vessels such as capillaries that are further away from the heart. This occurs because the greater area allows for greater diffusion of substances between these blood vessels and the tissue fluid and cells.

Activity 2 Identify types of blood cells (LB page 160)

Use this as a homework activity. Use the checklist to mark learners' drawings.

Checklist:

	Yes	No
HB, sharp pencil		
Heading given		
Correct identification of red blood cell		
Correct identification of platelets		
Five types of white blood cell (monocyte, basophil, eosinophil, neutrophil and lymphocyte) identified		

Activity 3 Case study (LB page 164)

1. People from the Andes, as well as Tibetans and Nepalese live at high altitudes.

2. They produce more haemoglobin so can carry more oxygen and have better lung expansion so that they can inhale more air.

3. People living in the mountains in Nepal and Tibet have adapted to the altitude by breathing faster so they take in more air. They also have wider arteries and capillaries so that their blood flows faster.

4. Genetic analysis has shown that Tibetans who live at high altitude have several oxygen-processing genes not found in people who live at lower altitudes.

Self-assessment (LB page 166)

1. Refer to Learner's Book page 160.

2. 1 – artery, 2 – vein, 3 – red blood cell, 4 – neutrophil (4)

3. a) At pH 7.2 the percentage saturation of haemoglobin is 50% and at pH 7.4 it is 70% (2)

b) The pH drops when there is an increase in the concentration of carbon dioxide. (3)

c) The percentage saturation of haemoglobin decreases when the pH drops; more oxygen dissociates from haemoglobin and is released into plasma. (3)

d) the Bohr shift (2)

SUB-TOPIC 2.7.2 Mammalian heart

LB pages 167–176

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know the structure and functions of the heart
Specific objectives	• Describe the external and internal structure of the mammalian heart • Observe and make plan diagrams of the structure of the external and internal structure of the mammalian heart • Explain the differences in the thickness of the walls of the: » atria and ventricles » left ventricle and right ventricle • Describe the cardiac cycle (including blood pressure changes during systole and diastole) and the opening and closing of valves • Interpret graphs showing the changes in blood pressure during the cardiac cycle • Explain how heart action is initiated and controlled (reference should be made to the sinoatrial node, the atrioventricular node and the Purkinje tissue, but not to nervous and hormonal control)
Cross-cutting issues	Knowledge of the heart is important in health education.
Inclusive education	• Group learners so that capable learners can help those with physical or intellectual challenges. • Some learners may not wish to dissect the heart; allow them to watch the dissection on the Internet if preferred. • Visually impaired learners will need help with images. Use large micrographs so that they can see the different sections.
Suggested teaching times	8 lessons
Additional resources needed	a sheep or pig's heart; a dissecting board or shallow dish; pins; a sharp knife or scalpel; scissors; forceps. You could watch the heart dissection on the Internet

Introduction to this topic

The heart is central to the mammalian circulatory system. Although it was discussed in earlier grades, it was done so on a less in-depth level; they learnt about the overall structure of the heart. In this sub-topic, the structure of the heart is revised but there is greater emphasis on functioning. Learners will also have an opportunity to dissect a heart.

Starter activity

LB page 167

Use the starter activity to check how well learners remember the parts of the heart. Spend time consolidating if you feel they have not understood these.

Suggested answers

1. vena cava
2. right atrium
3. right ventricle
4. pulmonary arteries
5. pulmonary veins
6. left atrium
7. left ventricle
8. aorta

Beginning these lessons

The learners have already learnt that the heart is divided into four chambers; the left and right atria at the top and the left and right ventricles at the bottom. A muscular plate called the septum separates the heart into two halves and ensures that oxygenated and deoxygenated blood do not mix. The walls of the heart are made from cardiac muscle. Several blood vessels enter and leave the heart. The valves of the heart control the flow of blood through it. There are also semi-lunar valves at the base of the blood vessels that leave the heart.

They prevent blood flowing back into the heart when the heart relaxes.

What the learners will now learn is that the heart pumps blood during the cardiac cycle. This is a sequence of events during which cardiac muscle alternately contracts and relaxes. The pressure and volume of blood inside the heart changes during the cardiac cycle. The sinoatrial node (SAN) is the place where electrical impulses originate to cause muscular contractions. It is situated in the wall of the right atrium. It is the natural pacemaker of the heart. A wave of electrical stimulation passes through the heart to the atrioventricular node (AVN) and from there to the apex of the heart via Purkinje fibres.

Teaching tips

- Discuss the internal and external structure of the heart using the diagrams to help you. There are many terms in this topic that learners may know from earlier grades but they will need to be reminded of these.
- Make sure that you prepare ahead of the lesson for the dissection. You can get a pig's or sheep's heart from a butcher. You can do the dissection as a teacher demonstration.
- For practical purposes, it is probably a good idea to teach the internal and external structure of the heart before doing the practical exercises. You can then do two practical exercises in the same lesson.
- Discuss the cardiac cycle by explaining the difference between systole and diastole using the diagrams in the Learner's Book to help you.
- Figure 2.7.2.5 (LB page 172) is important. You need to spend some time explaining each line on the graph and what it represents. You could get learners to copy the graph on to a large piece of paper and discuss it in groups.

Homework

Use Activity 2 as a homework task to make sure that learners have understood the control of heart rate.

Informal assessment

Use Activity 1 as an informal assessment task. Mark learner's answers in class and discuss anything that they are unsure of.

Extension activity

Learners could research how the cardiac pacemaker was developed and how it shows how technology has advanced.

Suggested answers

Practical exercise **Observe the external structure of the mammalian heart (LB page 168)**

3. Learners should draw a neat labelled diagram to show the external structure of the heart. They should label the atria and ventricles, coronary vessels, aorta, pulmonary vessels.
4. Learner's answers will vary.
5. Learner's answers will vary.

Practical exercise **Observe the internal structure of the mammalian heart (LB page 170)**

5. The walls of the atria are wider.
6. The walls of the left ventricle are wider – they need to pump blood around the body.

Activity 1 **Analyse a graph about the cardiac cycle (LB page 173)**

1. a) the pressure increases
b) the atrium contracting
c) 0.1 s
2. a) the pressure increases
b) 16 mmHg
c) The pressure must be high so that there is sufficient force to push blood out of the heart into the aorta and all the way around the body.
d) 0.3 s
3. Pressure decreases when diastole occurs and the muscles relax.
4. atrial and ventricular diastole is 0.4 s
5. 0.8 s
6. heart rate = $\frac{60}{0.8}$ = 75 beats per minute
7. The blood pressure in the aorta decreases during atrial systole, increases during the initial part of ventricular systole, decreases slightly until the semi-lunar valves open and then it increases slightly before decreasing during atrial and ventricular diastole.

Activity 2 Consolidate your knowledge about the control of heart rate (LB page 174)

The sinoatrial node (SAN) initiates the contraction of cardiac muscle; the impulses cause the walls of the atria to contract.

Impulses travel towards the atrioventricular node (AVN) which is situated between the right atrium and right ventricle. It acts as a relay station and sends impulses down between the right and left ventricles via the bundle of His.

Purkinje tissue from the bundle of His directs impulses to the ventricles' walls. Both the ventricles contract.

Self-assessment (LB page 176)

1. a) The tricuspid valve is situated on the right side of the heart between the right atrium and right ventricle. The bicuspid valve is situated on the left side of the heart between the left atrium and left ventricle. (4)

b) A systole is a contraction of the heart; a diastole is the relaxation of the heart. (2)

2. a) 1 – ventricular systole; 2 – atrial and ventricular diastole (2)

b) As the walls of the atria relax the atrial chambers increase in volume and the blood pressure decreases. (2)
As the walls of the ventricles contract the ventricle chambers decrease in volume and the blood pressure inside them increases. (2)

c) The walls of the atria remain relaxed and blood starts flowing into the atrial chambers so the pressure increases slightly. (2)
As the walls of the ventricles relax the ventricle chambers increase in volume and the blood pressure inside them decreases. (2)

d) 3 – the bicuspid valve closes
4 – semi-lunar valves close
5 – semi-lunar valves open
6 – the bicuspid valve opens (4)

e) $\frac{60}{0.8}$ = 75 beats per minute (2)

3. a) D – vena cava, E – aorta,
F – pulmonary artery,
G – pulmonary vein (4)

b) G (1)

c) F (1)

d) A – sinoatrial node, B – atrioventricular node, C – bundle of His (3)

e) The sinoatrial node (SAN) initiates contractions of cardiac muscle; impulses cause the walls of the atria to contract. Impulses travel towards the atrioventricular node (AVN) which is situated between the right atrium and right ventricle. It acts as a relay station and sends impulses down between the right and left ventricles via the bundle of His.
Purkinje tissue from the bundle of His directs impulses to the ventricles' walls so both the ventricles contract. (6)

TOPIC 2.8 Disease

SUB-TOPIC 2.8.1 Infectious diseases

LB pages 177–184

Syllabus coverage	See the syllabus grid in Section B
General objective	• Understand the biology of pathogens and know the mode of their transmission
Specific objectives	• Define the term disease and explain the difference between an infectious disease and a non-infectious disease (limited to sickle cell anaemia and lung cancer) • State the name and type of pathogen that causes each of the following diseases: » cholera – caused by the bacterium *Vibrio cholerae* » malaria – caused by the protoctists *Plasmodium falciparum*, *Plasmodium malariae*, *Plasmodium ovale* and *Plasmodium vivax* » tuberculosis (TB) – caused by the bacteria Mycobacterium tuberculosis and *Mycobacterium* bovis » HIV/AIDS – caused by the human immunodeficiency virus (HIV) » measles – caused by *Morbillivirus* • Explain how cholera, malaria, TB and HIV/AIDS are transmitted • Discuss the biological, social and economic factors that need to be considered in the prevention and control of cholera, measles, malaria, TB and HIV/AIDS (a detailed study of the life cycle of the malarial parasite is not required) • Discuss the factors that influence the global patterns of distribution of malaria
Cross-cutting issues	Infectious diseases of concern this year such as coronavirus, Ebola, HIV
Inclusive education	Learners may have or had relatives with any of these diseases. Note to be respectful at all times and to be sensitive to the issues particularly relating to the transmission of these diseases.
Suggested teaching times	6 lessons
Additional resources needed	Access to YouTube on the internet, posters, internet

Introduction to this topic

This topic is about infectious diseases also called communicative diseases because they pass from one person to another. However, discussions about important non-communicative diseases is also relevant particularly those that are caused by life-style choices. Discuss with the learners the causes of any disease and help them understand that lifestyle choices including eating healthy food, cleanliness and lack of stress can help prevent disease. There are some diseases that are of international concern this year but are not listed in this section. Discuss these diseases by researching them from the list given under the heading 'Extra diagnostic activity' below.

Starter activity

LB page 177

This activity revises diseases and the causes of disease. Ask the learners about local diseases. Ask the learners if they know what causes these diseases. Ask what precautions they and their families may take to prevent diseases. A pathogen is a disease-causing organism. Remind learners of the different kinds of pathogens: viruses, bacteria, protists and fungi.

Suggested answers

1. An infectious disease is one that can be passed from an infected person to another person.
2. **a)** tuberculosis, cholera, tetanus, thyphoid, leprosy, bubonic plague, lymes disease, meningitis, syphilis

b) HIV/AIDS, flu, the common cold, measles, chicken pox, small pox
c) candida, ringworm, candidias, fingernail infection, valley fever

3. Organisms that cause diseases are pathogens.
4. **a)** Answers will vary but may include pneumonia, colds, flu, bilharzia, malaria.
   b) Answers will vary but may include traditional medicines and/or antibiotics.

Beginning these lessons

Discuss the differences between communicable and non-communicable diseases. Ask the learners what they know about the five diseases listed in the syllabus. Refer to pages 179–180 in the Learner's Book. Ask the learners why they think those particular diseases are in the syllabus. Ask the learners whether a school in Europe or North America would have the same diseases listed in their syllabus.

This section of work will involve a lot of discussion. Lead the discussions and encourage learners to find the relevant information from the Learner's Book, other reliable sources of information and their own knowledge.

Teaching tips

- Encourage learners to use politically correct terminology and sensitive language when discussing diseases particularly those that may be prevalent in the community.
- Discuss current diseases that have been in the news in recent years such as HIV, Ebola, SARS and coronavirus. Discuss the chances of getting these diseases. Discuss how to prevent getting these diseases.
- Link diseases to healthy eating, lifestyle choices and cleanliness.
- If possible, use YouTube videos to show the learners information about the diseases listed in the syllabus as well as any others of concern.

Homework

Research a disease from the list given under the heading 'Extra diagnostic activity'.

Extra diagnostic activities

1. Learners work in pairs. They choose one disease from the list below that is currently of international concern. The learners are required to research the causes, symptoms, areas and preventions of the disease. They present the information in the form of a poster.
   - Chikungunya
   - Cholera
   - Crimean-Congo haemorrhagic fever
   - Ebola virus disease
   - Hendra virus infection
   - Influenza (pandemic, seasonal, zoonotic)
   - Lassa fever
   - Marburg virus disease
   - Meningitis
   - MERS-CoV
   - Monkeypox
   - Nipah virus infection
   - Novel coronavirus (2019-nCoV; Covid-19)
   - Plague
   - Rift Valley fever
   - SARS
   - Smallpox
   - Tularaemia
   - Yellow fever
   - Zika virus disease

Use the rubric below for assessment purposes.

	3	2	1
Presentation of the poster	Excellent	Good	Untidy
Causes	Complete and well presented	A few errors	Incomplete and with errors
Symptoms	Complete and well presented	A few errors	Incomplete and with errors
Preventions	Complete and well presented	A few errors	Incomplete and with errors
Areas of the disease	Complete and well presented	A few errors	Incomplete and with errors
			Total = 15

2. Discuss the dangers of communicable diseases compared to lifestyle diseases. Discuss changes that learners can make in their homes or in their behaviour to increase their health and lower their chances of getting sick or dying.

Suggested answers

Activity 1 Consolidate your knowledge about infectious diseases (LB page 180)

1. This means that the virus/bacteria/fungus/germ can be passed from one person to another. It will cause that person to become sick. (2)

Self-assessment (LB page 184)

1. (20)

Disease	Pathogen causing the disease	Factors that contribute to the spread of the disease	Prevention
TB (Tuberculosis)	Bacteria – *Mycobacterium tuberculosis* *Mycobacterium bovis*	Saliva	Isolate infected patients, cough into a tissue. Use separate eating utensils.
Cholera	Bacterium – *Vibrio cholerae*	Infected water	Boil water before use. Drink clean water.
Measles	Virus – *Morbillivirus*		Isolate patient
HIV/AIDS	Virus – *Human Immunodeficiency virus*	Body fluids	Practise safe sex. Do not share injection needles. Screen donated blood. Use gloves if dealing with human blood.
Malaria	Protists – *Plasmodium falciparum* *Plasmodium malariae* *Plasmodium ovale* *Plasmodium vivax*	Mosquitoes	Use a mosquito net at night. Use mosquito repellent creams or sprays. Do not leave water lying about in containers in which mosquitoes can breed.

2. Economic factors: Diseases cost money. Money needs to be spent by governments and individuals on preventing diseases. For example, a person needs to buy condoms to practise safe sex. Governments need to spend money on water cleaning systems as well as the supply of safe drinking water to the people. Hospitals and clinics need to be built. Professional health carers need to be educated and employed. Medicines need to be supplied and bought. (3)

3. Social factors: The manner in which people behave can help prevent the spread of disease. For example, keeping a clean home and disposing of human and animal faeces correctly. Cooking should be done using clean utensils. Water should be boiled. The body needs to be washed regularly. Eating healthy food also prevents disease. (3)

4. Biological factors: These frequently involve the knowing about a disease, the pathogen and how to prevent the spread of the disease.

2. malaria (1)

3. by sexual contact, from mother's milk, blood transfusions (3)

4. tuberculosis and measles (2)

5. The water systems are disrupted and people drink dirty water or rivers become contaminated. (3)

6. Preventing water from lying around in containers, mosquito nets, pills, spraying water systems, body sprays or creams to stop mosquitoes from biting. (4)

7. The chemicals got into the water systems and poisoned animals and humans. (2)

8. rash, cough, fever (2)

9. tuberculosis (1)

Education as well as indigenous knowledge is important in this process. (3)

5. An infectious disease can be passed from one person to another. An example is flu, HIV AIDS and Tuberculosis. A non-infectious disease that is not passed directly from one person to another, for example is malaria. You cannot get malaria from another person. (2)
6. **a)** Examples of bacterial diseases are tuberculosis, syphilis, tetanus, typhoid.
   b) Examples of viral diseases are HIV and AIDS, measles, smallpox, chickenpox.
   c) Examples of mutation diseases are colour blindness, albinism, sickle cell anaemia, dwarfism, Down's syndrome.
   d) Examples of environmental diseases are cancer, sunstroke, poisoning, snake bite. (4)
7. **a)** A bacterium causes cholera. (1)
   b) diarrhoea, vomiting (2)
   c) Whenever clean water is not available – a flood, national disaster, war, etc. (2)
   d) in water (1)

   Revise what has been covered in this topic relating to Cholera. Access the internet and provide the learners with extra information.

SUB-TOPIC 2.8.2 Antibiotics

LB pages 185–190

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know that penicillin is used to control bacterial infections and know the consequences of antibiotic resistance
Specific objectives	• Describe how penicillin acts on bacteria and why antibiotics do not affect viruses and eukaryotic cells • Outline how bacteria become resistant to antibiotics with reference to mutation and selection • Discuss the consequences of antibiotic resistance and the steps that can be taken to reduce its impact
Cross-cutting issues	The over-use of antibiotics and the effect this has on humans all over the world
Inclusive education	Sensitivity in the use of language when referring to diseases and the manner in which diseases are controlled
Suggested teaching times	6 lessons
Additional resources needed	Internet, posters showing antibiotic resistance.

Introduction to this topic

Remind the learners about what they learnt in Sub-topic 2.8.1 of the Learner's Book in which they studied a variety of infectious and non-infectious diseases. Ask the learners what a pathogen is. Ask the learners to list types of pathogens. Ask the learners to state which pathogens causes diseases such as HIV/AIDS, coronavirus, athletes' foot, ringworm, measles, TB, cholera and malaria.

Starter activity

LB page 185

This activity serves to check the learners' baseline knowledge. The learners may use the Internet or books to help them with the answers.

Suggested answers

1. An antibiotic is a medicine/chemical that kills bacteria in a living body.
2. A pathogen is any disease causing organism.
3. **a)** Answers will vary, examples are tuberculosis or syphilis.
   b) any disease caused by a bacterium
4. Any diseases not caused by bacteria, but caused by other pathogens such as viruses or fungi, examples are influenza, athlete's foot.
5. **a)** Penicillin is an antibiotic.
   b) See Self-assessment Question 2.

Beginning these lessons

The discovery of substances that kill bacteria changed the world. The fact that this discovery was during the time of the Second World War had a significant effect on the outcome of the war. The story is interesting because Fleming, although the first person to find that penicillin kills bacteria, did not realise the importance of his discovery. About ten years later, Howard Florey and Ernst Chain proved that penicillin could kill bacteria and scientists took notice. All three received Nobel Peace Prizes.

The next story of the over-use of antibiotics is interesting and important for learners to know. Help learners understand that they personally need to use antibiotics and sterilising substances such as antiseptics responsibly in order to prevent the evolution of super bugs.

Teaching tips

- Use films and YouTube videos to show learners the stories behind the discovery of antibiotics.
- Make a connection between the evolution of super bugs/drug resistant bacteria to Darwin's theory of Natural Selection.

Homework

Activity 1 is suitable for homework.

Suggested answers

Activity 1 Understand how antibiotics work (LB page 187)

1. A virus is sub cellular – a bacterium is cellular but does not have a nuclear membrane.
A virus has no cell wall or cell membrane – a bacterium has a cell wall and membrane.
A virus has no cytoplasm – a bacterium has cytoplasm.
A virus has a protein capsule – a bacterium has a cell wall and membrane.

2. A bacterium has a cell wall – an animal cell has no wall.
A bacterium has no nuclear membrane – an animal cell has a membrane.
A bacterium DNA is arranged in circular plasmids – an animal cell has chromosomes.

3. An antibiotic interferes with the metabolism of a bacterium, or it destroys the cell wall. These are things that a virus does not have.

4. Penicillin stops the growth of cell walls in bacteria. This prevents the bacterium from reproducing as they reproduce by dividing. The weakened cell wall no longer protects the contents of the cell so the cells start to die.

Self-assessment (LB page 190)

1. Alexander Fleming discovered the first antibiotic. (1)

2. Alexander Fleming was growing bacteria in a petri dish. The contents of the dish became infected with a fungus and the bacteria all died. (3)

3. *Penicillium* (1)

4. Antibiotic resistance develops when a colony of bacteria in a body are attacked by an antibiotic. The antibiotic kills the weakest bacteria first. If no more antibiotic is taken, the stronger bacteria that are left will reproduce. The next generation of bacteria are stronger and do not get killed by the antibiotic. The antibiotic is now ineffective against those strong bacteria. (5)

5. Learners can take inspiration from the diagram in the Learner's Book on page 188. (4)

6. a) Any two, answers may vary:
- Animals are given antibiotics but resistance occurs. Humans eat the meat and consume the resistant bacteria.
- Faeces carrying the resistant bacteria land on the soil and the bacteria get into the water and soil. Crops are grown in the soil and irrigated by the water and the crops carry the bacteria to humans when they eat the crops. (2)

c) Answers may vary: Humans carrying resistant bacteria can contaminate handles or toilets in the hospital. (1)

d) Humans carrying resistant bacteria go home and contaminate the home and community. (2)

e) Answers may vary: Antibiotic resistance can spread from animals to humans if the resistant bacteria remain in food or water. (2)

f) Answers may vary. Accept any two. (2)

TOPIC 2.9 The immune system

SUB-TOPIC 2.9.1 The response of the immune system to pathogens

LB pages 191–197

Syllabus coverage	See the syllabus grid in Section B
General objective	• Understand the roles of the cells and molecules of the immune system and their functions in protecting the body against infectious diseases
Specific objectives	• Describe the mode of action of phagocytes (macrophages and neutrophils) • Describe the sequence of events that occurs during a primary immune response with reference to the roles of: » macrophages » B-lymphocytes, including plasma cells » T-lymphocytes, limited to T-helper cells and T-killer cells • Explain what is meant by an antigen and state the difference between self antigens and non-self-antigens • Explain the role of memory cells in the secondary immune response and in long-term immunity
Cross-cutting issues	The immune system, health and disease
Inclusive education	Learners may have relatives with diseases or may be infected themselves. Be very sensitive of this . Use sensitive and caring language.
Suggested teaching times	8 lessons
Additional resources needed	Modelling clay, internet access, posters

Introduction to this topic

This topic builds on what was covered in the previous topic (Sub-topics 2.8.1 and 2.8.2) about diseases. This sub-topic is about how the body defends itself against invading pathogens. Suggest or ask learners about ways that pathogens can enter the body. The skin, particularly when burnt or cut, can be vulnerable to pathogens. Any orifice, such as the anus, penis, vagina, urethra, eyes, ears, nose and mouth, can be a place where pathogens invade. Some pathogens such as cholera can move across the intestinal lining into the blood. What happens in the body when a pathogen has invaded? Remind the learners of the functions of blood cells. Ask the learners what two types of blood cells exist, namely the red (ethyrocytes) and white (leucocytes) blood cells.

Ask the learners the functions of the two types of blood cells. The learners will now understand that leucocytes defend the body against disease. Draw the various types of leucocytes on the board and ask the learners to remember or research the names and functions of each.

Starter activity

LB page 191

Suggested answers

1. the skin
2. Keeping the body clean. Drinking and eating clean water and food. Cleaning teeth. Washing hands regularly and after using the toilet.
3. Because pathogens can get into the body through a wound.
4. Because there is an increase in blood flow to the wound and an increase in tissue fluid. This is to bring white blood cells to the wound to destroy any pathogens that may have entered the wound.
5. A – monocyte
   B – basophil
   C – eosinophil
   D – neutrophil
   E – lymphocyte

Beginning these lessons

The learners know that there are different types of leucocytes. They know that leucocytes defend the body against pathogenic invasion. Ask the learners if they know how the leucocytes destroy pathogens and how they provide, in most cases, immunity for a long time. Learners generally know something about immunity and antibodies but seldom know the details. Explain that this topic deals with how immunity works.

Teaching tips

- Use modelling clay to make the different leucocytes.
- Modelling clay can also be used to demonstrate the process of phagocytosis.

Extra diagnostic activity

Ask the learners to work in pairs. Each pair researches an auto-immune disease. They must organise and display information about the causes, symptoms and treatment of the disease on a poster. The learners then present their posters to the class. Allocate marks for information given, attractiveness of the poster and speaking ability.

Homework

Activity 1 is suitable for homework.

Suggested answers

Activity 1 Understand the role of phagocytic cells (LB page 193)

1. phagocytosis
2. neutrophils and macrophages
3. diagrams to show the process of phagocytosis

Self-assessment (LB pages 197)

1.

Table comparing a primary and secondary immune response

Primary immune response	Secondary immune response
Slow	Fast
Few antibodies produced	Many antibodies produced
Response to a first pathogenic invasion	Response to a second pathogenic invasion
The person gets sick	The person does not get sick

(8)

2. Primary immune response:
   - A pathogen invades a body.
   - Sometimes a macrophage engulfs the pathogen by phagocytosis.
   - The macrophage releases a protein/antigen of the pathogen.
   - The CD4 lymphocytes respond to the protein of the pathogen. They recognise that the proteins are not part of the body; that the protein is foreign.
   - The CD4 lymphocytes activate B lymphocytes.
   - The B lymphocytes replicate themselves rapidly making many identical plasma cells.
   - The plasma cells produce special proteins called antibodies.
   - The antibodies are secreted into the blood plasma where they circulate throughout the body.
   - Antibodies combine with antigens on the surface of the pathogen.
   - The antibodies destroy the pathogen.
   - Killer cells recognise foreign protein and kill any cells invaded by viruses. They also kill cancer cells. (6)
3. Secondary immune response:
   - B lymphocytes respond to a pathogen invasion by replicating themselves to become plasma cells.
   - Some of the plasma cells produce antibodies that bind to antigens and then destroy them. Other plasma cells remain in the blood plasma for long periods of time or even for life.

- These are memory cells.
- If that type of pathogen attacks the body at another time, the immune system does not need to go through the primary response.
- Antibodies are produced immediately, and the pathogen is destroyed before it has time to replicate and cause sickness.
- The person is then immune to that pathogen.
- Every time the immune system responds to that pathogen, more memory cells are produced, and the person has a stronger resistance to the sickness. (4)

4. Process of phagocytosis.
- A white blood cell grows extensions called pseudopodia around the pathogens.
- The pseudopodia eventually meet and the cell membrane fuses.
- A small bubble called a phagosome forms with the pathogens inside.
- In the cytoplasm of the white blood cell, a lysosome (a vesicle containing digestive enzymes) fuses with the phagosome.
- The enzymes destroy and break down the pathogen. (4)

5. T-killer cells recognise foreign protein and kill any cells invaded by viruses. They also kill cancer cells. (3)

6. A self-antigen is a protein in the body. The immune system should not respond to that protein but does. This results in an auto-immune disease.
A non-self antigen is a protein found on a pathogen. The immune system responds to the protein and destroys the pathogen. (2)

7. An auto-immune disease develops when the immune system attacks its own body. The immune system responds to a protein in the body and mistakes it for a foreign protein. The immune system then destroys the cells that have that protein. (3)

SUB-TOPIC 2.9.2 Antibodies and vaccinations

LB pages 198–206

Syllabus coverage	See the syllabus grid in Section B
General objective	• Recognise the role of antibodies and vaccination in the prevention of infectious diseases.
Specific objectives	• Relate the molecular structure of antibodies to their functions • (see 2.4.2) • Outline the hybridoma method for the production of monoclonal antibodies • Outline the use of monoclonal antibodies in the diagnosis of disease and in the treatment of disease • Describe the differences between active and passive immunity and between natural and artificial immunity • Explain that vaccines contain antigens that stimulate immune responses to provide long-term immunity • Explain how vaccination programmes can help to control the spread of infectious diseases
Cross-cutting issues	The importance of vaccines to world health
Inclusive education	Sensitivity towards those learners with illnesses or sick family members. Sensitivity towards religions or cultures that disallow vaccines
Suggested teaching times	8 lessons
Additional resources needed	Internet, posters

Introduction to this topic

The previous sub-topic (Sub-topic 2.9.1) discussed the role of different leucocytes in the process of fighting pathogens. Antigens are foreign proteins. Antigens stimulate the immune system. The immune response can be in the form of phagocytosis and/or the production of antibodies. This topic deals with the production of antibodies. This includes using vaccines to combat certain diseases.

Antibodies destroy pathogens in various ways. Some antibodies remain in the body for life, providing life-long immunity. Some viruses, particularly the HIV can mutate (change) easily and rapidly. Ask the learners what that would mean in terms of immunity. Lead them to the understanding that if a pathogen mutates then the immune system will not be able to build life immunity because the antigen is different for each infection.

Starter activity

LB page 198

This activity revises prior knowledge of infectious diseases. This knowledge is a foundation to this topic. Learners need to be confident in their knowledge of infectious diseases and the various leucocytes that form part of the immune system.

Suggested answers

1.
   - pathogen – D
   - macrophage – G
   - B-lymphocyte – E
   - T-helper cells – B
   - T-killer cells – I
   - plasma cells – H
   - antibody – A
   - antigen – J
   - non-self antigen – C
   - self-antigen – F
2. To fight invading pathogens so that a sick person can get better and be able to resist getting that disease again in the future.
3. Antibodies are secreted when the immune system comes into contact with a pathogen/ when the T Lymphocytes identify foreign antigens and send chemical messages to the B lymphocytes.
4. This means that there are permanent antibodies in the body that will destroy the

pathogen causing a specific disease. The person cannot get that disease again.

5. This means that it is the clever, sensible and responsible thing to do, to make sure your children are vaccinated. Vaccinated children are less likely to get sick or spread sickness.

Beginning these lessons

This section focuses on immunity. There is a difference between immunity that the body creates and immunity obtained from an artificial source outside the body. Ask the learners for two examples of obtaining immunity from an artificial source. Remind them to think of the previous topic and how antibodies are made in a laboratory.

The essential ingredient in immunity is the antibody. Ask learners what they know about antibodies. What are they? Where are they produced? What cells make antibodies?

Discuss how a person can get better from a sickness without having taken medicine. Ask the learners if they are vaccinated against diseases.

You could ask the learners to go home and find the information to complete the table below:

Table of information regarding a learner's personal history of vaccinations

Disease for which there is a vaccine	Date of vaccination	Date of booster vaccine	Side effects (if any remembered)

Homework

Activities 1, 2 and 3 are suitable for homework.

Extra diagnostic activity

1. Learners can research the common diseases for which there are vaccines. They can use their research to complete a table. An example of a table is below:

Table of information regarding a variety of vaccines

Name of diseases that have vaccines	Stage in life for vaccination, e.g. birth, puberty, etc.	Compulsory for Namibians living in Namibia (yes or no)	Length of time of immunity	Side effects of the vaccine

2. Learners research which diseases are common in other countries. Learners choose three other countries. Learners research the vaccines that are compulsory for visitors to those countries. The learners use their research to complete a table. An example of a table is alongside.

Table of information regarding diseases of countries other than Namibia

Country	Name of disease	Length of time of immunity	Side effects of the vaccine

Suggested answers

Activity 1 Understand the process of hybridoma technology (LB page 201)

Steps involved in hybridoma technology:
- A mouse is injected with a specific antigen
- The mouse produces antibodies in response to the antigen.
- The plasma cells containing the antibodies are extracted.
- The plasma cells are fused with long living cancer cells forming a hybridoma
- The hybridoma are kept in a special medium called HAT in a petri dish.
- HAT stimulates the replication of the hybridoma.
- The antibodies are harvested and used to make vaccines. (5)

Activity 2 Differentiate between active and passive immunity (LB pages 202–203)

1. Active immunity (diagrams A and B) develops when antibodies are produced by the body. Diagram A shows antibodies produced because of a pathogen invasion. Diagram B shows antibodies produced because a vaccine injected antigens into the body.
   Passive immunity (diagrams C and D) takes place when antibodies are introduced into the body. Diagram C shows that antibodies are injected into a body. The antibodies were made by the hybridoma cells. Diagram D shows that breast milk contains antibodies from the mother and they are then transferred to the baby.
2. Active immunity is created by the body. The response is slower than passive immunity where antibodies are introduced into the body. Because no memory cells are created with passive immunity, the person can become sick with that disease again. Active immunity produces memory cells.
3. **a)** passive
   b) passive
   c) active
   d) passive

Activity 3 Analyse results from a vaccination programme (LB page 204)

1. There were always more than 50 000 cases but the numbers fluctuated. Firstly the number of cases increased from about 50 000 to 170 000 in one year. Then the numbers dropped to about 60 000 and then slowly rose again. (2)
2. about 1956 (give or take a year) (1)
3. 50 000 people (1)
4. dropped and were never higher than 50 000 people infected (2)
5. Many people stopped taking the vaccine – the percentage of those taking the vaccine dropped and then the number of infected cases increased from very few up to about 50 000 again. (2)
6. There is a direct link to the number of infected people and the percentage of the population taking the vaccine. When, in 1960, the percentage of people taking the vaccine dropped from about 80% to about 40%, the increase in infections increased by about 50 000. Before vaccinations the number of infected people was always higher than 50 000 but after vaccinations the number of infected people was never more than 50 000. It is important for the health of a population to be vaccinated. (5)
7. 94 – 81 = 13 lowest uptake about 40% (5)
8. Table showing the relationship between the percentage uptake of vaccine and the people infected by whooping cough in three different years. (5)

Year	Vaccine uptake %	Infected persons (100s)
1970	About 82	About 10
1980	About 40	About 40
1990	About 78	About 10

Self-assessment (LB page 206)

1. A – spleen cells/B lymphocytes
   B – myeloma/cancer cells
   C – fusion
   D – hybridomas
   E – culture in HAT medium
   F – harvest monoclonal antibodies (6)
2. To inject into a person sick with that disease for a rapid response. (2)

3.
- Vaccines contain tiny quantities of dead or deactivated pathogen.
- Only a small quantity of pathogenic antigen is required to start an immune response in a body.
- The small quantity of pathogenic antigen does not make the person or animal sick but does cause antibodies to be produced.
- If the pathogen were then to invade, the antibodies are already there waiting to destroy the pathogen.
- The response is very quick and the person or animal does not get sick. (4)

4. a) This means that the scientist will be looking for a reaction/response. (2)

b) antibodies. (1)

c) a virus. (1)

d) to fight the invasion of the virus/to fight the infection. (2)

e) An antigen is a protein found on a pathogen or foreign body. The body reacts to this foreign protein by producing antibodies. The antibodies destroy the antigens and neutralize the effects of the pathogen, therefore fighting the infection. (2)

TOPIC 2.10 Human gas exchange and smoking

SUB-TOPIC 2.10.1 The gas exchange system

LB pages 207–214

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know the gross structure of the gas exchange system and understand the function of the various parts
Specific objectives	• Describe the gross structure of the human gas exchange system • Investigate and observe the gross structure of lungs and associated organs of a sheep or other mammal (dissect) • Describe the distribution in the gas exchange system of cartilage, ciliated epithelium, smooth muscle, capillaries and squamous epithelium of alveoli • Recognise cartilage, ciliated epithelium, smooth muscle, capillaries and squamous epithelium of alveoli in microscope slides, photomicrographs and electron micrographs • Recognise trachea, bronchi, bronchioles and alveoli in microscope slides, photomicrographs and electron micrographs and make plan diagrams of transverse sections of the walls of the trachea and bronchus • Describe the functions of ciliated epithelial cells, goblet cells and mucous glands in maintaining the health of the gas exchange system • Describe the functions in the gas exchange system of cartilage, smooth muscle, elastic fibres and squamous epithelium • Describe the process of gas exchange between air in the alveoli and the blood in the capillaries
Cross-cutting issues	This topic is important in understand how the gas exchange process and health of the lungs are related.
Inclusive education	• Some learners may not wish to dissect the lungs; allow them to watch the dissection on the Internet if preferred. • Visually impaired learners will need help with images. Use large micrographs so that they can see the different sections. • Learners with hearing impairment should sit at the front of the class.
Suggested teaching times	8 lessons
Additional resources needed	Internet access

Introduction to this topic

Gaseous exchange is the movement of oxygen from the environment into the body of an organism and the movement of carbon dioxide out of it. Gaseous exchange takes place by diffusion across a gaseous exchange surface.

Terrestrial organisms, such as humans, get oxygen from the atmosphere. Carbon dioxide is produced and must be removed because if it accumulates, it is toxic to cells.

To function efficiently, a gaseous exchange surface must have the following features:

- be permeable so that gases can pass through
- be thin because diffusion is more efficient over short distances
- be moist because gases diffuse more easily in solution
- have a large surface area so that sufficient amounts of gases can be exchanged
- have a good blood supply and ventilation system so that a steep diffusion gradient is maintained
- be protected from physical damage and dehydration.

In humans, gaseous exchange takes place inside the lungs, between the air inside the lungs and the blood. It also takes place between the blood and the body cells.

Starter activity LB page 207

Use this activity to check learners' understanding of concepts covered in earlier grades. Spend time consolidating if you feel they have not grasped these.

Suggested answers

1. breathing – a mechanical process of moving air into and out of an organism; sometimes called ventilation
   respiration – a chemical process in which energy-rich molecules such as glucose, combine with oxygen and are gradually broken down to release energy, carbon dioxide and water
   gas exchange – the movement of oxygen from the environment into the body of an organism and the movement of carbon dioxide out of it .
2. Gas exchange takes place by diffusion.
3. the lungs
4. Inspired air contains more oxygen than expired air; it also contains less carbon dioxide than expired air.

Beginning these lessons

Learners have already learnt about the process of diffusion in terms of kinetic energy. They also discussed factors that influence diffusion such as surface area, concentration gradients and distance. They have learnt about the importance of diffusion of gases.

They have also learnt about the human gas exchange structure with focus on the features of a gas exchange system, the functions of the intercostal muscles and cartilage in the trachea and the difference in composition of inspired and expired air.

New knowledge: In this sub-topic learners will learn about the structure of the human gas exchange system, the process of gas exchange and the tissues involved in the human gas system.

Teaching tips

- There are several new terms that learners should get to know. Let them make a list of the key words as they work through the sub-topic.
- Introduce the section by asking learners to explain what ventilation is and to name the structures involved in gas exchange in humans.
- Discuss each of the parts of the human gas exchange system; the air passages, the trachea, bronchi, bronchioles and alveoli.
- Link your discussion to the types of tissues found in the different parts, for example, ciliated epithelium, cartilage and smooth muscle.
- Make sure that you have organised the materials needed for dissection well ahead of time. You can do this as a class demonstration.
- Describe how gas exchange takes place in the lungs and in the tissues. Use the diagrams in the Learner's Book to help you.
- The following websites contain information to help you with the preparation of your lessons:
  https://www.youtube.com/watch?v=AJpur6X-Uiq4
  https://www.youtube.com/watch?v=qDrV33r-ZlyA
  https://www.s-cool.co.uk/a-level/biology/gas-exchange/revise-it/gas-exchange-in-humans
  https://www.livescience.com/26825-human-body-system-respiration-infographic.html

Remedial activity

Learners who have difficulty with the different parts of the gas exchange system can copy Figure 2.10.1.1.

Homework

You can ask learners to draw a mind map to summarise the information about the structure of the gas exchange system.

Informal assessment

You could mark learners' plan diagrams in Activity 1.

Self-assessment

Use the following self-assessment rubric for learners to check their progress in this sub-topic.

	Very good	Good	Developing	Need help
Taking notes	I was able to take very good notes on the content of the lessons.	I was able to take good notes on the content of the lessons but sometimes missed one or two points.	I took some notes and I feel I am getting better at it.	I need help learning how to take notes.
Understanding	I understood everything in this topic.	I understood almost everything in this topic.	I did not understand some things in this topic.	I did not understand anything in this topic.
Activities	I completed all the activities easily.	I completed all the activities but had a little difficulty with one or two questions.	I did not complete all the activities and had difficulty with many questions.	I need help with most of the activities.
Co-operation with partners or group	I never argued with my partner or group members. I talked to them about my ideas and listened to everyone's opinions.	I sometimes argued with my partner or group. I sometimes talked to them about my ideas and thought about some of their opinions.	I argued a lot with my partner or group members. I hardly talked to them about my ideas or hardly listened to their ideas.	I did not work at all well with my partner or group members.

Suggested answers

Activity 1 Draw plan diagrams of the trachea and a bronchus (LB page 209)

You can assess learners' plan diagrams using the following checklist:

	Yes	No
Sharp HB pencil used		
Heading		
All parts correctly identified		
Proportions of various layers correct		

Practical exercise Dissect lungs (LB pages 210–211)

- Set this up as a class demonstration.
- Let learners wear gloves when handling the lungs.
- Discuss the surface area of the outside of the lungs and talk about how the lungs are structurally modified to increase the surface area.
- Identify the trachea and discuss the cartilage rings, their function in keeping the airway open and their position in relation to the oesophagus. Insert a tube down it to show how the lungs inflate when you blow into the tube.
- Examine the spongy lung tissue and let learners view a small piece of it using a microscope. They should see some air spaces and squamous epithelium. You can explain how the internal surface area is increased.
- Show learners the bronchi entering the lungs and how the air passages become increasingly smaller.
- If the diaphragm is present, show learners this muscular sheet that plays an important role in ventilation.

Activity 2 Observe tissues of the gas exchange system (LB page 212)

1. Slide A – micrograph shows section through alveoli;
   Slide B – micrograph shows ciliated epithelium
2. Alveoli are found in the lung tissue; ciliated epithelium is found lining the trachea.
3. Learners' answers will vary depending on which magnification they used.

Self-assessment (LB page 214)

1. An efficient gas exchange surface should be permeable, thin, moist, have a large surface area, have a good blood supply and be protected. (any 5)

2. a) ciliated epithelium – traps dust and mucus; prevents particles entering the lungs (2)

b) squamous epithelium – a thin layer of cells making up alveoli that form the gas exchange surface (2)

c) cartilage – found in the trachea and keeps airways open (2)

d) capillaries – gas exchange takes place between the blood in capillaries and the air in the alveoli (2)

3. a) 1 – ciliated epithelium; 2 – cartilage; 3 – squamous epithelium (3)

b) ciliated epithelium – lining of trachea; cartilage – in trachea; squamous epithelium – in alveoli (3)

4. B (1)

5. C (1)

SUB-TOPIC 2.10.2 Smoking and its impact on the gas exchange and circulatory system

LB pages 215–219

Syllabus coverage	See the syllabus grid in Section B
General objective	• Understand the impact of smoking on one's health
Specific objectives	• Describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system with reference to lung cancer and chronic obstructive pulmonary disease (COPD) • Describe the short-term effects of nicotine and carbon monoxide on the cardiovascular system • Conduct a survey, possibly with the use of a questionnaire, on the incidence of hay fever and/or asthma
Cross-cutting issues	Health education
Inclusive education	Group learners so that capable learners can help those with physical or intellectual challenges.
Suggested teaching times	4 lessons
Additional resources needed	Internet

Introduction to this topic

Research has shown that smoking leads to several diseases of both the gas exchange and cardiovascular systems. The harmful chemicals in tobacco smoke including tar, nicotine, carbon monoxide and lead, can cause bronchitis, asthma, emphysema and cancer. Smoking also damages the blood vessels leading to angina and coronary heart disease.

Starter activity

LB page 215

Use this activity to get learners to discuss the dangers of smoking based on the information that they learnt in previous grades.

Suggested answers

- bronchitis, eye diseases, various types of cancer (throat, oesphageal, lung, cervical), strokes, asthma, pneumonia, coronary obstructive pulmonary disease (COPD), osteoporosis and emphysema.
- Smoking leads to the following diseases that affect the cardiovascular system – angina, coronary heart disease such as atherosclerosis and coronary obstructive pulmonary disease (COPD) as well as bronchitis and peripheral artery disease (PAD).

Beginning these lessons

Learners have learnt about the effects of smoking on the human gas exchange system in previous grades and focused on carbon monoxide, nicotine and tar.

This sub-topic explains the impact of dangerous chemicals, including many carcinogens, contained in tobacco smoke, as well as the addictive nature of some chemicals.

Teaching tips

- Discuss the different chemicals contained in tobacco smoke and how they affect the body.
- Explain how chronic obstructive pulmonary diseases such as emphysema occur. Mention how they can lead to strokes and heart disease.
- Let learners work in pairs on Activity 1. They can do their research at home for homework or in the library. You can assess their slide presentations.

- Let learners work in groups for Activity 2 to research asthma. They will need to draw up a questionnaire and present their results as a report. You can assess these.

Homework

Let learners do research for Activity 1 at home. They can bring their information to school and work with their partner to prepare the slide presentation.

Suggested answers

Activity 1 Find out about risks of smoking (LB page 217)

Answers will vary.

1. a) The types of cancer caused by smoking include lung, throat, liver, colon, mouth, bladder stomach, pancreas and cervix cancers, amongst many others. https://www.cancer.org/latest-news/study-smoking-causes-almost-half-of-deaths-from-12-cancer-types.html

b) The direct effects of smoking on the lungs, heart and blood vessels should be discussed.

2. A chronic disease is a disease that affects a person for a long time.

You could use the rubric below to assess learners' slide presentations.

	5	4	3	2
Pair work	Excellent communication; worked independently; did not require assistance.	Good communication; required very little assistance.	Fair communication; required some assistance.	Ineffective communication; required a lot of assistance.
Slide presentation				
Information	All information about types of cancer included.	Most information about types of cancer included.	Some information about types of cancer included.	Little or no information about types of cancer included.
Ordering of slides	Slides carefully and logically ordered.	Slides ordered well but better ordering needed.	Slides show some logical order.	Slides illogically ordered; more work required.
Creativity	Excellent use of text and colour.	Good use of text and colour.	Reasonable use of text and colour.	Poor use of text and colour.
				Total = 20

Activity 2 Conduct a survey (LB page 217)

Answers will vary.
The following website gives information about using questionnaires:
https://www.betterevaluation.org/en/evaluation-options/questionnaire

You could use the following rubric to assess learners' surveys.

	5	4	3	2
Group work	Excellent group communication; worked independently; did not require assistance.	Good group communication; required very little assistance.	Fair group communication; required some assistance.	Ineffective group communication; required a lot of assistance.
Questionnaire				
Length		Concise		Too long or too short
Questions	Well worded and clear.	Mostly well worded and clear.	Many questions not well worded and clear.	Questions poorly constructed and not clear.
Survey				
Administration		Used sufficient respondents; well administered.		Did not use sufficient respondents; not well administered.
Analysis of results		Accurate analysis of results.		Inaccurate analysis of results.
Report	Excellent report with all aspects of survey included.	Good report with most aspects of survey included.	Average report with some aspects of survey omitted.	Poor report with many aspects of survey omitted.

Self-assessment (LB page 219)

1. a) tar (1)
b) bronchitis, cancer (2)

2. a) chronic obstructive pulmonary disease (1)
b) emphysema (1)

3. When the lining of blood vessels is damaged by smoking, there is a build-up of fatty substances that narrow the diameter of the blood vessels. This makes a person's heart beat faster and leads to an increase in blood pressure. The heart may not receive enough blood causing pain in the chest called angina. (4)

4. a) i) United States (2)
ii) China (2)
b) The global data shows that there was an increase in the percentage of deaths caused by smoking from 2012 to 2016, but it then remained constant. (2)

Marking rubric for graph

Criteria	Marks
Correct type of graph (line graph)	1
Heading	2
Labelling x-axis	1
Labelling y-axis	1
Scale for x-axis	1 – correct values; 1 – equal intervals between values
Scale for y-axis	1 – correct values; 1 – equal intervals between values
Plotting data	3 – plots all points; 2 – plots most points correctly; 1 – plots many points incorrectly; 0 – plots no points correctly
	Total = 12

Self-assessment

Use the rubric below for self-assessment.

	Very good	Good	Developing	Need help
Trends	I identified the trends in the global data.	I could not accurately identify the trends.	I only partly identified the trends.	I did not identify the trends.
Line graph	I was able to draw the graph correctly.	I was able to draw the graph but missed some data or labels.	I was able to draw the graph but missed a lot of the points and labels.	I needed help drawing the graph.
Understanding the topic	I understood everything in this topic.	I understood almost everything in this topic.	I did not understand some things in this topic.	I did not understand anything in this topic. I need help.

Theme 3 Development of the organism and the continuity of life

TOPIC 3.1 Mitotic cell cycle

SUB-TOPIC 3.1.1 Replication and division of nuclei and cells

LB pages 222–231

Syllabus coverage	See the syllabus grid in Section B
General objective	• Acknowledge the significance of the cell cycle and replication in the uniformity of daughter cells
Specific objectives	• Describe the structure of a chromosome, limited to DNA, histone proteins, chromatids, centromere and telomeres • Explain the importance of mitosis in the production of genetically identical cells, growth, cell replacement, repair of tissues and asexual reproduction • Observe and draw the mitotic stages visible in temporary root tip squash preparations and in prepared slides of root tips of species such as those of Vicia faba and Allium cepa • Outline the mitotic cell cycle, including interphase (growth in G_1 and G_2 phases and DNA replication in S phase), mitosis and cytokinesis • Outline the significance of telomeres in permitting continued replication and preventing the loss of genes • Outline the role of stem cells in cell replacement and tissue repair by mitosis • Explain how uncontrolled cell division can result in the formation of a tumour
Cross-cutting issues	Environmental education Technology
Inclusive education	Visually impaired learners need assistance engaging with images. Use models to let them feel what is happening (e.g. use pipe cleaners to let them model mitosis instead of looking at pictures). Try to include visually impaired learners in groups with learners who can help or guide them in practical activities. Hearing impaired learners can sit in the front of the class.
Suggested teaching times	8 lessons
Additional resources needed	Photomicrographs of cells undergoing mitosis (animal and plant cells) obtained from the internet. Articles or data obtained from newspapers or the internet on cancer or on new research into telomeres or the use of stem cells in medicine.

Introduction to this topic

Learners studied cell division (mitosis and meiosis) in Grades 10 and 11 so they should be familiar with the basic process of mitosis and its importance to living organisms. In this topic, they will find out more about mitosis and its importance in the health and development of the human body.

Starter activity

LB page 222

Ask the learners to recall what they learnt about the structure of the cell in Topic 2.2 and what they remember about cell division from Grades 10 and 11. Ask simple, straightforward questions such as name the organelles found in an animal cell and state their functions. Record their answers on the board.

Let the learners answer the questions in the starter activity and go through the answers with them making sure that you clear up any misconceptions (diagnostic assessment).

Suggested answers

1. **a)** Learners should draw an animal cell with the following labels: cell membrane, cytoplasm, nucleus (nuclear envelope, nuclear pore, nucleolus), endoplasmic reticulum, mitochondria, centrosome, Golgi apparatus, ribosome.
   b) **(i)** Animal cells have a centrosome, plant cells do not.
   (ii) Plant cells have a cell wall but animal cells do not.
2. **a)** Mitosis is the type of nuclear division that gives rise to genetically identical daughter cells so that the chromosome number is maintained.
   b) During mitosis new cells are made when the nuclei of older cells (mother cells) divide. When the nuclei of mother cells divide by mitosis, they produce new cells (daughter cells) that carry exactly the same hereditary information as the mother cells.

Beginning these lessons

Ask the learners why a cell needs to divide to give rise to more cells. Write their answers on the board.

Ask them what they remember about cell division from Grades 10 and 11 and why mitosis is so important for living organisms. The learners should remember that mitosis is the type of cell division that gives rise to identical daughter cells – identical to each other and identical to the original cell. Ask them why it is important that these cells are identical (carry exactly the same hereditary information). Explain that a multicellular organism such as a human being needs to consist of cells that carry the identical information so that the organism functions as one unit. If all the cells of our body were different they would each work on their own and not together.

Ask learners what part of the cell carries hereditary information. Explain that they will learn more about the way hereditary information is organised on chromosomes (in this topic) and the molecular structure of the chromosomes (in Topic 3.2).

Teaching tips

- The processes of the cell cycle (including mitosis) is quite complex. You may want to read up on the process in more detail before you teach your learners. There are some good websites and YouTube videos that provide good explanations and discussions of current applications in the fields of biotechnology and medicine. Keeping up to date will help you answer some of the questions about the content that may come up in your lessons.
- Teach the content of the topic using the information and diagrams in the Learner's Book.
- Use additional resources to supplement the material in the Learner's Book, such as models or posters of cell structure and cell division, photomicrographs from the internet or other textbooks, Bioviewer slide strips on cell division and videos from YouTube. Find articles relating to this topic (e.g. cancer, telomeres, stem cell research) in newspapers or scientific journals that can be used to provide context for the learners and data which can be used for questions in worksheets or tests.
- The resources needed for the activities are listed in the Learner's Book. Collect the resources at the start of the topic so that they are ready when you get to the activities. Sometimes a lesson goes more quickly than anticipated and an activity can be started before the lesson that it is originally planned for.
- You will need a number of prepared microscope slides for one of the activities. If there is another High School nearby you might be able to share your resources (such as prepared slides) to keep costs down.

Homework

If you need more time in the lessons for practical work, Activity 1 and Activity 2 could be given for homework as they present the learners with questions that consolidate the material that is covered in the lessons.

You could also give supplementary questions to learners that need additional support or extension questions for more able learners.

- Supplementary questions could be simple questions using vocabulary in a comprehension type exercise or copying diagrams to practise drawing skills.

- Extension questions could be data response questions or analytical questions based on a case study.

Extension activity

If you have time, a good extension activity is to give your class a research project on cancer.

- Divide your class into groups.
- Let each group research a topic related to cancer, using articles, books and the Internet.
- Possible topics could include:
  - » Types of cancer found in Namibia and prevalence of the different types
  - » Causes of cancer
  - » Current treatment of cancer in Namibia
  - » Future treatment of cancer (current research on treatment)
- Use a lesson for each group to present their findings to the rest of the class. Give each group 5–10 minutes depending on how many groups there are and how long your lesson is.

Informal assessment

Use Activity 1 and Activity 2 and any homework questions for informal assessment. Go over the answers to the questions with the learners and let them correct their own work. Identify any misconceptions or common mistakes and fill in any gaps in understanding before you proceed with the next lesson (diagnostic assessment).

You could use Practical exercise 1 to assess the learners practical skills and give them feedback on how well they are doing or what they need to improve. You could also assess their drawings (diagnostic assessment).

Self-assessment

Use the questions at the end of the sub-topic on page 231 of the Learner's Book for self-assessment. Encourage the learners to identify any gaps in their knowledge or weaknesses in their skills or understanding and help them to work out what they need to do to improve.

Suggested answers

Activity 1 Revise chromosome structure (LB pages 224–225)

1. Histone proteins are proteins that DNA is wrapped around. As the DNA wraps around the histone protein it is coiled up like thread around a cotton reel and this helps to make the chromosome much shorter.

2. A chromosome needs to be shorter and thicker in order to move easily around the cell. If it were long and thin the strands of DNA would be tangled up like long pieces of cotton thread all mixed up together. By coiling the cotton thread around cotton reels they do not tangle up and are easy to separate from one another.

3. a) DNA – carries hereditary information and transmits it from one generation to the next

b) centromere – the structure that joins two identical strands of DNA/sister chromatids together and that attaches the chromosomes or sister chromatids to the spindle during mitosis

c) telomere – prevents genetic or hereditary information on chromosomes from being lost when DNA replicates

4. Sister chromatids are two identical chromatids joined by a centromere whereas daughter chromosomes are what the two identical chromatids become when they are separated from one another during mitosis.

Activity 2 Understand the mitotic cell cycle (LB page 227)

If the diagram of the cell cycle is regarded as a pie chart with the segments representing the different stages, then the size of each segment (in degrees) will give an indication of the relative amount of time needed for each stage. The segment for interphase is much greater than the segment for mitosis therefore interphase will take much longer than mitosis.

Note: Discuss the answer to this question with the class. Most learners should be able to work it out but might not be able to explain how they did it.

Practical exercise Observe and draw mitotic stages in the root tip of *Allium cepa* as seen under the microscope (LB page 228)

- This practical activity can only be carried out if you have all the resources available. Collect the apparatus or equipment that you need before the lesson – preferably before you start to teach the topic.

- About 10–12 days before the lesson, suspend an onion above water in a glass jar so that its roots are just touching the surface of the water. The onion can be suspended using toothpicks to hold it in position on the rim of the glass jar.
- Learners should have already done this practical task in Grade 10 or 11 so they should not find it difficult to do in Grade 12.
- Tell the learners to work carefully and to take safety precautions when handling the stain and the hot plate.
- Remind the learners to follow the rules for biological drawings when drawing the cells that they observe under the microscope.
- If it is not possible to do the practical exercise or if resources are scarce you can let the learners draw cells from the photomicrograph on page 227 of the Learner's Book or a photomicrograph that you provide for your learners.

Note: As the learners have not yet learnt the stages of mitosis (prophase, metaphase, anaphase and telophase) they are only expected to draw the different stages of the cell cycle (interphase, mitosis and cytokinesis).

Self-assessment (LB page 231)

1. A centromere is the structure that joins two identical strands of DNA/sister chromatids together and that attaches the chromosomes or sister chromatids to the spindle during mitosis (1) whereas a centrosome is a region in an animal cell which consists of two centrioles and is involved in the formation of a spindle during the process of mitosis (1). (2)

2. Interphase G_1 → Interphase S → Interphase G_2 → Mitotic phase Mitosis → Mitotic phase Cytokinesis → Interphase G_1
(1 mark for each correct label and 2 marks for the correct sequence) (8)

3. G_1– During this phase of the cell cycle the cell is growing and accumulating the materials needed for cell division (1) but the amount of DNA remains the same (1).
S – During this phase the DNA in the cell replicates (1) so the amount of DNA in the cell doubles (1).
G_2 – During this phase there is more growth but no increase or decrease in the amount of DNA (1) which therefore stays the same (1).
M – During this phase the amount of DNA stays the same as mitosis occurs (1) but at the end of mitosis the cell separates into two during cytokinesis and the DNA is shared between two daughter cells so is reduced to the normal amount found in a typical body cell (1). (8)

4. a) When the DNA of a chromosome is replicated, some of the DNA at the ends of the chromosome is lost. If this information is important hereditary information in the form of genes, then this information would be lost by the cell. (1) Telomeres at the end of the chromosomes do not have any hereditary information so if some of the DNA from a telomere is lost it will not affect the functioning of the cell (1). (2)

b) Stem cells are the cells in the body that can divide by mitosis to produce more cells or to develop into many different types of cell types e.g. skin cells, nerve cells or blood cells (1). The new cells that are produced by stem cells replace dead or dying cells and are used to repair and replace worn out tissues (1). (2)

5. a) Certain cells in the body start reproducing rapidly, in an uncontrolled way, producing a mass of cells called a tumour. (3)

b) Leukemias (1)

c) Renal tumours and soft tissue sarcomas (1)

d) 100 – (22.5 + 12.0 + 5.2 + 16.2 + 13.6 + 13.6) = 11.5 (3)

SUB-TOPIC 3.1.2 Chromosome behaviour in mitosis

LB pages 232–238

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know the events that occur during mitosis/cell cycle
Specific objectives	• Describe, with the aid of photomicrographs and diagrams, the behaviour of chromosomes in plant and animal cells during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell surface membrane and the spindle (names of the main stages of mitosis, prophase, metaphase, anaphase and telophase, are expected) • Interpret photomicrographs, diagrams and microscope slides of mitosis and identify the main stages of mitosis
Cross-cutting issues	Environmental education
Inclusive education	Visually impaired learners need assistance engaging with images and microscope slides. Try to find a podcast that explains what is happening during mitosis that they can listen to. Try to include visually impaired learners in groups with learners who can help or guide them in practical activities. Hearing impaired learners can sit in the front of the class.
Suggested teaching times	6 lessons
Additional resources needed	Photomicrographs of cells undergoing mitosis and cytokinesis (animal and plant cells) obtained from the internet or other text books to show different examples.

Introduction to this topic

Learners learnt about the cell cycle in Sub-topic 3.1.1. In this sub-topic, they will learn more detail about the events that occur during mitosis and cytokinesis in both animal and plant cells. This sub-topic also develops the learner's interpretive skills through analysis of photomicrograph and micrograph slides.

Starter activity

LB page 232

Give the learners time to read though Sub-topic 3.1.1 again or to go through their notes and then give them time to answer the questions in this activity. Go through the answers with them making sure that you clear up any mistakes or misconceptions.

Suggested answers

1. **a)** Nucleosomes
   b) Histones
   c) Sister chromatid
   d) Centrosome
   e) Interphase
   f) Mitotic phase
2. A – sister chromatid
   B – chromosome
   C – centromere
   D – telomere

Beginning these lessons

Ask the learners if they have any questions or queries relating to Sub-topic 3.1.1. Tell them that in this sub-topic they will learn more about the details of the process of mitosis and that they will carry out various practical activities that will develop their interpretive and analytical skills. You can tell them that these skills are important in certain jobs in the medical field, for example pathologists need to interpret slides of human tissues to identify various diseases or abnormalities.

Teaching tips

- Before you start this topic, read up about the details of the processes of mitosis. There are some excellent websites on the internet with some good diagrams that you may want to use to supplement the information in the Learner's

Book. Look for additional questions and worksheets that you could use for support or extension activities.
- Teach the content of the sub-topic using the information and diagrams in the Learner's Book.
- Use additional resources such as models or posters or photomicrographs from the Internet or other textbooks, Bioviewer slide strips on cell division and videos from YouTube. Look for YouTube videos that show cells actively dividing by mitosis so the learners can see what happens throughout the process. This helps them to visualise it more accurately.
- Find some good photomicrographs for Activity 2 if you don't want to use the ones provided in the Learner's Book. If you laminate the photomicrographs they can be used for many classes or for classes from one year to the next.
- Make sure that you have the resources needed for Activity 3 at the beginning of the sub-topic so that they are ready when you get to the activity. You will need prepared microscope slides for Activity 3. If there is another High School nearby you might be able to share your resources (such as prepared slides) to keep costs down.

Homework

After the learners have learnt about the different stages of mitosis (prophase, metaphase, anaphase and telophase) as well as cytokinesis, let them draw diagrams of each of the stages for homework. They can copy the diagrams from the Learner's Book (with the same number of chromosomes) or you could get them to draw the different stages with a different number of chromosomes, for example 4 chromosomes or 8 chromosomes. This encourages the learners to apply their understanding of what is happening in the cell. You could use this exercise as a diagnostic assessment to check their understanding of the process.

When you have completed the process of mitosis and cytokinesis in both animal and plant cells, tell learners to draw and annotate all the different stages of mitosis and cytokinesis in a plant cell with 2 chromosomes. Learners need to apply their knowledge of the difference in mitosis and cytokinesis in animal and plant cells as they complete their diagrams. Check that they include a cell wall and that there are no centrosomes in their drawings of the different stages of mitosis and that cytokinesis is correct for a plant cell. You could use this exercise as a diagnostic assessment to check their understanding.

Informal assessment

Use the homework activities for informal assessment. Draw each of the diagrams on the board and let the learners correct their own work or their partner's work. Go around the class and check to see the learner's corrected homework and identify any misconceptions or common mistakes they have made. Explain what these are and provide additional explanations or questions before you proceed with the next lesson.

You could use Activity 3 to assess the learners' practical skills and give them feedback on how well they are doing (diagnostic assessment). You could also assess their drawings of micrographs and microscope slides in Activity 2 and Activity 3 (diagnostic assessment).

Additional support

If you think that your learners need additional support, provide extra questions or worksheets that give them other opportunities to engage with the process of mitosis. There are lots of worksheets on mitosis available on the Internet.

Self-assessment

Use the questions at the end of the sub-topic on page 238 of the Learner's Book for self-assessment. Encourage the learners to identify any gaps in their knowledge or weaknesses in their skills or understanding and help them to work out what they need to do to improve.

Suggested answers

Activity 1 Compare the mitotic phase in plant and animal cells (LB page 235)

When you have finished explaining the processes of mitosis and cytokinesis in animal and plant cells let the learners complete this activity.

	Animal cell	Plant cell
Mitosis	Centrosomes are present and help to form the spindle.	No centrosomes are present and the spindle forms from microtubules in the cytoplasm.
Cytokinesis	Protein fibres form a contractile ring beneath the cell membrane. This starts to shrink inwards forming a cleavage furrow which deepens until the cell is pinched into two.	Vesicles from the Golgi apparatus join to form a cell plate. This eventually fuses with the cell membrane. The contents of the cell plate form a new cell wall on the outside of the new cell membrane of the two new daughter cells.

Activity 2 Interpret photomicrographs of cells undergoing mitosis (LB page 236)

1. A – prophase
B – telophase or anaphase
C – metaphase
D – cytokinesis

2. Remind the learners to follow the rules for biological drawings when drawing the cells in the micrographs. Check the learner's drawings for size, accuracy and correct labels.

Activity 3 Interpret a prepared microscope slide of onion cells undergoing mitosis (LB page 236)

- This practical activity can only be carried out if you have all the resources available. Ensure that the microscopes and slides are ready before the lesson.
- Remind the learners to follow the rules for biological drawings when drawing the cells that they observe under the microscope.
- In this activity, learners draw and label cells from a microscope slide. Check the learner's drawings for size, accuracy and correct headings and labels.
- Go over the explanations that the learners give for identifying each stage and correct any mistakes.

Self-assessment (LB page 238)

1. a) A – prophase
B – telophase
C – anaphase
D – metaphase (4)

b) Early prophase → prophase → metaphase → anaphase → telophase (2 for correct sequence) (2)

c) X is a centrosome (1) which helps to form the spindle (1). (2)

d) 4 chromosomes (1). Even though they are not distinct in this phase there will be the same number of chromosomes as can be seen in the next stage of mitosis (metaphase) where 4 chromosomes are clearly visible. (1) (2)

2. Mark allocations for diagram:
- cell wall (1)
- pole (1)
- daughter chromosome (1)
- spindle fibre (1)
- equator of spindle (1)
- 6 daughter chromosomes present (1)
- daughter chromosomes in correct position (1)
- accurate and neat diagram (1) (8)

3.
- The process is called cleavage. (1)
- A ring of protein filaments called the contractile ring forms just beneath the cell membrane at the widest part of the cell also called the equator of the spindle. (1)
- The contractile ring starts to shrink inwards pulling the cell membrane inwards to form a cleavage furrow. (1)
- The cleavage furrow deepens. (1)
- The original cell is pinched into two giving separate daughter cells. (1)

(5)

TOPIC 3.2 Nucleic acids and protein synthesis

SUB-TOPIC 3.2.1 Structure and replication of DNA

LB pages 239–246

Syllabus coverage	See the syllabus grid in Section B
General objective	• Know the structure of nucleic acids and understand their role in the storage of genetic information and how that information is used in protein synthesis
Specific objectives	• Describe the structure of nucleotides, including the phosphorylated nucleotide ATP (structural formulae are not required) • State that adenine and guanine are purines with a double ring structure and that cytosine, thymine and uracil are pyrimidines with a single ring structure (structural formulae for bases are not required) • Describe the structure of RNA and DNA and explain the importance of base pairing and the different hydrogen bonding between bases • Describe the semi-conservative replication of DNA during the S phase • Design and make a model of DNA to illustrate the semi-conservative replication of DNA during interphase.
Cross-cutting issues	This topic forms the basis of understanding genetics as well as genetic diseases
Inclusive education	• Assist learners who have difficulty with this sub-topic by finding a video on the Internet that show the processes described. • Learners with hearing impairment should sit at the front of the class.
Suggested teaching times	6 lessons
Additional resources needed	Access to the Internet

Introduction to this topic

Nucleic acids store, transmit and express heredity information in living organisms. The sequence of amino acids in a protein is determined by the unit of inheritance which is a gene. Genes are made of DNA which belong to a group of molecules called nucleic acids. Nucleic acids are large polymers and their sub-units or monomers are called nucleotides.

There are two types of nucleic acids, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). DNA stores genetic information and can replicate itself to provide new cells with this information. RNA controls protein synthesis which is discussed in the next sub-topic.

Starter activity

LB page 239

The starter activity revises some terms used in earlier grades as well as the basic structure of DNA. Use the activity to get learners thinking about cell division and DNA.

Suggested answers

1. **a)** mitosis – a type of cell division during which two identical cells are produced from a parent cell
   b) interphase – the tie during the cell cycle when DNA replication occurs
   c) mitotic cell cycle – a series of events that take place when the cell prepares for cell division
   d) gene – a unit of inheritance found on DNA molecules
2. **a)** Deoxyribonucleic acid molecules consist of many different atoms joined together
   b) It is a double helix.
   c) DNA is found in the nucleus.
   d) DNA is important as it carries the genetic code for the production of proteins. It also passes on hereditary information to offspring.

Beginning these lessons

The structure of DNA was discussed in earlier grades. The shape of the DNA molecule is a double helix. The learners also learnt about base pairing and the importance of the sequence of base pairs. The following are covered in this sub-topic:

- biochemical details of the molecular structure of DNA in terms of nitrogen bases (cytosine, adenine, guanine and thymine) hydrogen bonding between bases
- the structure of ribonucleic acid (RNA)
- the differences and similarities between DNA and RNA
- DNA replication using the semi-conservative model.

Teaching tips

- Use the starter activity to check learners' understanding of the cell cycle and the structure of DNA. If learners seem unsure of the answers to the questions, spend time discussing DNA. You could use the following information to help you and perhaps set a short comprehension using the basics given here: https://www.livescience.com/37247-dna.html
- Use the diagrams in the Learner's Book to describe the structure of nucleotides. Nucleotides are phosphorylated as they contain a phosphate group. Adenosine triphosphate is also a phosphorylated nucleotide that is produced during the reactions of cellular respiration. Distinguish between purine and pyrimidine bases.
- Describe the structure of DNA starting on a macro level and working down to a molecular level. Use as many charts and diagrams as possible. This section is important as learners will need to understand the double helix shape and bonding when they discuss replication.
- Move on to describe ribonucleic acid emphasising how it differs from DNA.
- You will need to make sure that you have the necessary items for the two practical exercises. Let learners work in groups and they can assess their models using the rubric provided with the answers.
- DNA replication can be quite tricky for learners, but if you explain slowly in a step by step manner, it will be easier for them to understand. Building a model will consolidate it for them. You could use the following to help learners with this section: https://www.youtube.com/watch?v=5qSrmeiWsuc

Homework

You could use Activity 1 for homework and mark together with learners in class.

Suggested answers

Activity 1 Analyse the structure of a DNA molecule (LB page 242)

1. **a)** deoxyribose sugar and phosphates
   b) nitrogenous bases
2. **a)** The repeating units are the monomers called nucleotides.
   b) They all consist of a sugar, a phosphate group and a nitrogenous base.
   c) They each have one of four different nitrogenous bases: adenine, thymine, guanine and cytosine.
3. Cytosine always bonds to guanine; adenine always bonds to thymine.
4. **a)** hydrogen bonds
   b) They are not the same; there are three hydrogen bonds between cytosine and guanine and two hydrogen bonds between adenine and thymine.

Practical exercise Make a model to compare the structure of DNA and RNA (LB page 243)

- 1. a) and b) Learners need to make a model of both DNA and RNA using the materials provided. This will clarify the structure of these molecules.
- The liquorice strips (two different colours) represent the DNA strands; one colour represents the phosphate groups and one colour the deoxyribose.
- The round jelly sweets of different colours represent nitrogenous bases; learners should use four colours that can be paired.
- The toothpicks are for holding two jelly sweet pairs together.
- The needle and thread are to sew two colours of liquorice strips together

2. a)

DNA	RNA
Double stranded	Single stranded
Has the sugar deoxyribose	Has the sugar ribose
Contains adenine, cytosine, thymine and guanine	Contains adenine, cytosine, uracil and guanine
Only found in the nucleus	Found in the nucleus and cytoplasm

b) Both DNA and RNA consist of nucleotides made up of a sugar, nitrogen base and phosphate group. Both can be found in the nucleus.

They can assess their models using the rubric on page 111.

Practical exercise — Make a model of DNA replication (LB page 244)

Using the same idea as in the previous exercise, learners will make a model to show DNA replication. Facilitate where necessary. Ask them to use their model to explain DNA replication to you. They can also take turns explaining it to their group members.

Self-assessment (LB page 246)

1. D nucleus and cytoplasm

2. D adenine and thymine (2 × 2 = 4)

3. a) DNA replication (2)

b)
- 1: The DNA molecule unwinds to form a ladder-like shape. (2).
- 2: The hydrogen bonds between the complementary nitrogen bases break, which lets the two strands 'unzip'. (2)
- Each parental DNA strand now acts as a template for a new complementary DNA strand.
- 3: Free DNA nucleotides in the nucleus line up with their complementary nucleotides on the open strand (2)
- 4: Bonds form between the sugar of one nucleotide and the phosphate of the adjacent one. This results in a sugar–phosphate chain that forms the backbone of a new DNA strand. (2)
- 5: Hydrogen bonds form between the complementary bases: adenine pairs with thymine and cytosine pairs with guanine. (2)

(5 × 2 = 10)

c) The two DNA strands twist up into a double helix again. (1)

d) DNA replication ensures that there are sufficient DNA molecules for the new cells that are produced after cell division. (2)

e) DNA replication is called semi-conservative because one strand of DNA is used to make a new strand. (2)

	5	4	3	2
Group work	Excellent group communication; worked independently; did not require assistance.	Good group communication; required very little assistance.	Fair group communication; required some assistance.	Ineffective group communication; required a lot of assistance.
Model				
	Used the materials appropriately to represent the parts of molecules.			Did not use the materials appropriately to represent the parts of molecules.
	Able to show differences between DNA and RNA.			Unable to show differences between DNA and RNA.
				Total = 15

Self-assessment

Use the checklist below to assess how well learners managed the assessment.

	Yes	Partly	No
I was able to answer both multiple-choice questions.			
I identified the process shown in the diagram.			
I was able to describe the process accurately.			
I can explain the semi-conservative method of replication.			

SUB-TOPIC 3.2.2 Protein synthesis

LB pages 247–255

Syllabus coverage	See the syllabus grid in Section B
General objective	• Understand the genetic code and how DNA codes for polypeptides
Specific objectives	• State that a polypeptide is coded for by a gene and that a gene is a sequence of nucleotides that forms part of a DNA molecule • State the features of the genetic code • Describe how the information in DNA is used during transcription and translation to construct polypeptides, including the role of messenger RNA (mRNA), transfer RNA (tRNA) and the ribosomes • State that a gene mutation is a change in the sequence of nucleotides that may result in an altered polypeptide • Explain that a gene mutation occurs by substitution or deletion or insertion of base pairs and outline how each of these types of mutation may affect the polypeptide produced • Describe the way in which the nucleotide sequence codes for the amino acids sequence in a polypeptide with reference to the nucleotide sequence for Hb^A (normal) and Hb^S (sickle) alleles of the gene for β-globin polypeptide • Design and make a model of RNA to contrast it with the DNA model
Cross-cutting issues	This topic forms the basis of understanding genetics as well as genetic diseases.
Inclusive education	• Assist learners who have difficulty with this Topic by finding video on the Internet that show the processes described. • Learners with hearing impairment should sit at the front of the class.
Suggested teaching times	8 lessons
Additional resources needed	Access to the Internet

Introduction to this topic

Proteins are macromolecules that are essential for the life processes of all organisms. For example, enzymes are proteins that are used to catalyse biochemical reactions in cells. Proteins are synthesised using the genetic code on DNA molecules as a template. There are two processes that take place; transcription in the nucleus and translation at the ribosomes. Transcription is the copying of the sequence of nitrogen bases in DNA into molecules of messenger ribonucleic acid (mRNA). Translation is the production of polypeptides using amino acids in the cytoplasm and transfer RNA.

Starter activity

LB page 247

Use this activity to check learners' understanding of protein structure. This was covered in Sub-topic 2.4.4. Refer back to this sub-topic if learners struggle with the levels of structure.

Suggested answers

1. **a)** a globular protein – haemoglobin
   b) a fibrous protein – collagen
2. Peptide bonds join amino acids together in a polypeptide.
3. The primary structure refers to the way that amino acids are joined together in a chain; the secondary structure is the three dimensional arrangement of atoms in a polypeptide chain; the tertiary structure refers to the folding of the polypeptide chains into each other and the quaternary structure is the linking together of one or more polypeptide chains (see Fig 2.4.2.3 on page 100 in the Learner's Book).
4. The shape of a protein molecule is so important because it determines how it functions.

Beginning these lessons

The learners have covered the synthesis of proteins from amino acids in earlier grades. They should be familiar with the role of proteins in living organisms and the structure of proteins was explained in Sub-topic 2.4.2.

The learners will now learn about the relationship between DNA, genes and proteins. They will cover how proteins are produced using the genetic code, the process of protein synthesis using DNA and RNA, and about transcription and translation. Gene mutations are important in genetics. Discuss the different types of mutation and highlight the example of haemoglobin S (sickle cell anaemia).

Teaching tips

- Start off your lesson by referring to the diagram in Figure 3.2.2.1 of the Learner's Book. Discuss the ladder-like structure of DNA found in the chromosomes of the nucleus that is used to make polypeptide chains before letting learners tackle the Starter activity.
- Some learners find this section quite tricky so explain it slowly. Break down the process into steps; first look at transcription and its steps and then look at translation and its steps.
- Use Figures 3.2.2.2 and 3.2.2.4 to explain the two processes. You will need to explain the terms template, mRNA, codons and triplets.
- Explain transcription in detail. Make sure that learners recognise that uracil replaces thymine in RNA.
- Explain translation in detail taking time to show how the triplets in the codon of mRNA match with those of the anticodons of tRNA. Each tRNA anticodon is used to pick up a particular amino acid from a pool of amino acids in the cytoplasm. For example, the anticodon UAC on a tRNA shown in Figure 3.2.2.4 codes for the amino acid Met (methionine) and UGC codes Thr (threonine). Peptide bonds form between the amino acids.
- Consolidate by getting learners to complete Activity 1.
- When the genetic code is altered, a mutation occurs. Substitution, deletion and insertion mutations are covered next. Mention the substitution mutation that results in abnormal haemoglobin production (HbS) that leads to sickle cell anaemia. Let learners complete Activity 2.

Homework

- You could use Activity 1 for homework and mark it in class.
- Let learners research information about genetic disorders caused by gene mutations for Activity 2 and bring this to class.

Extension activity

Let learners who show an interest in this topic find out about gene therapy and the hope it offers people with genetic diseases caused by defective genes. They could give a short presentation of their findings to the class.

Self-assessment

Use the following self-assessment rubric for learners to check their progress in this topic.

	Very good	Good	Developing	Need help
Taking notes	I was able to take very good notes on the content of the lessons.	I was able to take good notes on the content of the lessons but sometimes missed one or two points.	I took some notes and I feel I am getting better at it.	I need help learning how to take notes.
Understanding	I understood everything in this topic.	I understood almost everything in this topic.	I did not understand some things in this topic.	I did not understand anything in this topic.
Activities	I completed all the activities easily.	I completed all the activities but had a little difficulty with one or two questions.	I did not complete all the activities and had difficulty with many questions.	I need help with most of the activities.
Co-operation with partners or group	I never argued with my partner or group members. I talked to them about my ideas and listened to everyone's opinions.	I sometimes argued with my partner or group. I sometimes talked to them about my ideas and thought about some of their opinions.	I argued a lot with my partner or group members. I hardly talked to them about my ideas or listened to their ideas.	I did not work at all well with my partner or group members.

Suggested answers

Activity 1 Consolidate protein synthesis (LB page 251)

1. **a)** anticodon – the triplet of base pairs found in a transfer RNA molecule that codes for a particular amino acid
   b) template – something that is used to copy a pattern, in this case DNA acts as a template for mRNA
   c) stop codon – a triplet of base pairs that signals the completion of translation when a polypeptide chain is being assembled
   d) peptide bond – the type of chemical bond that binds amino acids together in a polypeptide chain
2. **a)** in the nucleus
   b) in the cytoplasm
   c) nuclear pore
   d) at the ribosomes
3. **a)** Codon – UGC; anticodon – ACG
   b) adenine, cytosine, guanine

Activity 2 Learn more about gene mutations (LB page 253)

Learners will work in groups for this activity. Give them a homework task to gather information about each disease. When they return to class, they can work in their groups to collate their information using the headings given.

They can write the essay in class or as a homework activity.

Suggested Internet sites:
https://www.cff.org/What-is-CF/About-Cystic-Fibrosis/
https://www.healthline.com/health/tay-sachs-disease
https://www.healthline.com/health/thalassemia
https://hdsa.org/what-is-hd/overview-of-huntingtons-disease/

Self-assessment (LB page 255)

1. **a)** A gene is part of a DNA molecule that codes for a particular protein; the genetic code refers to all the genes in organisms' cells. (2)
   b) A codon is a triplet of bases on a messenger RNA molecule and an anticodon is a triplet of bases on a transfer TNA molecule. (2)
   c) A deletion mutation occurs when a nucleotide pair is lost and an insertion mutation occurs when a nucleotide pair is added in a gene. (2)

2. a) in the nucleus (1)
b) in the cytoplasm (1)
c) at the ribosomes (1)
3. a) translation (1)
b) A – peptide bond; B – codon; C – amino acid; D – ribosome; E – polypeptide chain; F – messenger RNA; G – anticodon (7)
c) K – adenine; uracil; guanine; L – guanine; guanine; uracil (6)
4. a) A – substitution; B – substitution; C – deletion (6)
b) Deletion – three amino acids are affected. (1)

Self-assessment

Use the checklist below to assess how well learners managed the assessment.

	Yes	Partly	No
I could distinguish between the terms.			
I knew the parts of the cell where the processes took place.			
I understand translation and was able to correctly identify A to G.			
I could correctly work out the base sequences.			

Lesson plan template

Use this lesson plan template, or adapt it to suit your needs, to help you prepare for specific lessons.

<table>
<tr><th colspan="3">Subject: Biology</th></tr>
<tr><td colspan="3">Cross-curricular links:</td></tr>
<tr><td>Topic:</td><td>Sub-topic:</td><td>Time allocation:</td></tr>
<tr><td colspan="3">General and specific objectives:</td></tr>
<tr><td colspan="2">Preparation:</td><td>Resources:</td></tr>
<tr><td colspan="3">Teaching guidelines:</td></tr>
<tr><td colspan="3">Comments/Follow-up:</td></tr>
</table>

Group work comment sheet

Date: _____

Activity: _____

Names of learners in group: _____

Checklist	Yes	No
Did the learners listen to each other?		
Did the learners ask each other questions?		
Did the learners help and encourage each other?		
Did the learners stay on topic?		
Did the learners complete the task?		

Further notes

Individual learner record sheet

Compile a sheet like this for each learner. Make notes about the type of task and tick if the learners have achieved the knowledge, understanding and skills associated with each task.

Date: _____

Subject/Activity: _____

Learner's name: _____

Date	Experiment	Comment	Suggestions or notes

Memoranda for practice papers

Paper 1: Multiple choice questions

(LB page 261)

1. C
2. D
3. A
4. C
5. B
6. A
7. C
8. D
9. A
10. D
11. B
12. B
13. A
14. A
15. D
16. D
17. A
18. C
19. A
20. B
21. D
22. A
23. C
24. B
25. B
26. D
27. D
28. C
29. A
30. A
31. B
32. B
33. A
34. D
35. B
36. A
37. B
38. B
39. D
40. C

TOTAL = 40 MARKS

Paper 2: Structured questions (LB page 270)

Question 1

1.1 The wall of the left ventricle has to pump blood all around the body/much further (1) than the wall of the right ventricle that only has to pump blood to the nearby lungs (1).

1.2

1.2.1 General diastole (1)

1.2.2 Atrial walls contract (1) and blood pressure increases in the atria (1). This causes the atrioventricular valves to open (1) and blood flows through them into the ventricles (1). The walls of the ventricles are relaxed (1) and the semi-lunar valves are closed. (1)

(ANY 5)

1.3 Sinoatrial node/pacemaker (1)

[9]

Question 2

2.1 Replication of DNA (1)

2.2 1 – base/guanine (1)
2 – base/guanine (1)
3 – deoxyribose sugar (1)
4 – phosphate (1)

2.3 Information is carried as groups of 3 bases or triplets (1). Each triplet of bases on a strand of a DNA molecule will result in a codon on a mRNA (1) molecule that codes for a specific amino acid (1). Different triplets or codons code for different amino acids (1). The DNA therefore determines the sequence of amino acids in a polypeptide through the sequence of its bases.

(ANY 3)

2.4 A mutation is a change in the order of the bases/nucleotides in a DNA molecule that can be due to insertions (1), deletions (1) or substitutions (1) of bases/nucleotides.

2.5 A mutation changes the order of bases in a DNA molecule (1) and this can result in a different set of codons giving a different sequence of amino acids in a polypeptide (1).

[13]

Question 3

3.1 E (1)

3.2 These are the areas where the antibiotic has killed the bacteria. (1)

3.3 The larger the concentration of antibiotic (1) the larger the diameter of the circle where no bacteria are growing. (1)

3.4 Fungus (1)

3.5 Use the **same concentration** of the 3 different types of antibiotics. (1)
Place the **same amount** of each antibiotic on 3 paper discs (1) – label them A, B and C.
Place them onto the **same culture of bacteria** on a Petri dish and incubate them for 2 days. (1)
Compare the size/diameter of the circles where no bacteria are growing around each disc. (1)

(ANY 3)

[8]

Question 4

4.1 total population = number of individuals in first sample x number of individuals in second sample/number of marked individuals in second sample (1)

OR N = $\frac{n_1 \times n_2}{m_2}$ (1)

2015: $24 \times \frac{30}{12} = 60$ (1)

2016: $13 \times \frac{25}{3} = 108$ (1)

2017: $34 \times \frac{27}{6} = 153$ (1)

4.2 The population of the water snail increased in size over the three year period. (1)

4.3 The biodiversity decreased in this period. (1)

4.4 Invasive species like the water snail can cause major disruptions and destroy the natural balance in ecosystems. (1) They can outcompete indigenous species. This can lead to a decrease in biodiversity. (1) This is supported by the data here showing a decrease in biodiversity as the snail population increases. (1)

[9]

Question 5

5.1 It is a protein. (1) It is made up of amino acids as there is a carboxyl and amino group at opposite ends of the molecule/all enzymes are proteins. (1)

5.2 Amino acids (1)

5.3 Disulphide bond (1) – helps to determine a proteins structure/stabilises a proteins structure (1)

5.4 The shape is important as it determines the shape of the active site (1) that a specific substrate molecule will fit into (1) like a key into a lock (1). When the enzyme and substrate come together in an enzyme-substrate complex (1) the enzyme causes bonds to be made or to be broken (1) and a product to be released (1). The enzyme is unchanged and can be used again and again. (1) **(ANY 5)**

[10]

Question 6

6.1

6.1.1 $15.1 - 13.3 = 1.8$ g 100 cm^{-3} (1)

$\frac{1.8}{13.3} \times 100 = 13.53\%$ (1)

6.1.2 At high altitudes the air pressure is lower (1) and there is less oxygen taken in with each breath, (1) To compensate, the body manufactures more red blood cells (1) so more of the oxygen in the air can be picked up with each breath (1) to give the body the amount of oxygen that it needs. Athletes (who have trained at high altitudes) with higher red blood cell counts can pick up more oxygen at sea level and so can compete more successfully. (1) (ANY 3)

6.2

	Blood plasma	Tissue fluid
composition	water, proteins, glucose, amino acids (1)	same as blood plasma but fewer proteins (1)
cells	red blood cells, white blood cells, platelets (1)	white blood cells (1)
pressure	high (1)	low (1)

[11]

TOTAL = 60 MARKS

Paper 3: Advanced practical skills (LB page 276)

Question 1

1.

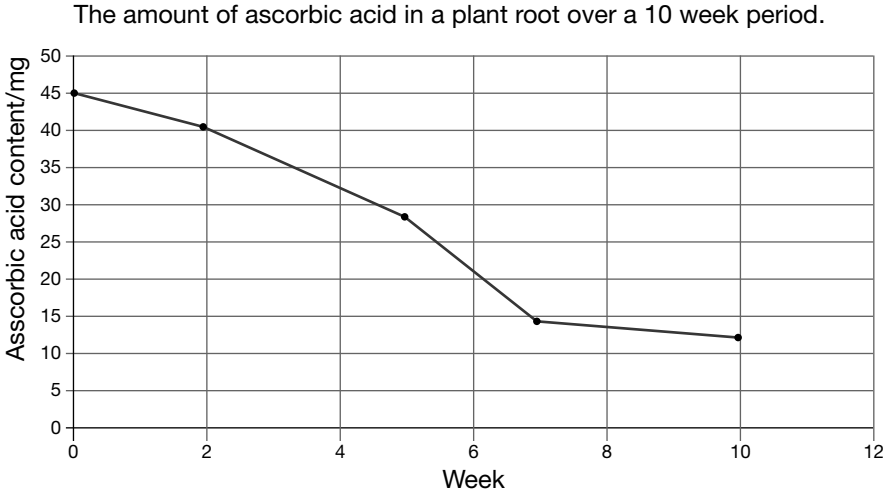
Liquid added to Solution X	Volume of liquid added (cm^3)
0.1% ascorbic acid (N)	
Fruit juice 1 (O)	
Fruit juice 2 (P)	

Note: Work out the volumes for each liquid by carrying out the experiment before you give it to the learners.
1 mark for each correct column (with units where applicable) in the table (2)
1 mark for each correct volume in the table (3)

2. **Note:** When you carry out the experiment yourself you will find out which liquid has the highest concentration of ascorbic acid.
Solution (N/O/P) (you need to find this out) (1)
It is the liquid/solution with the smallest volume needed to turn solution X colourless (1). The more ascorbic acid in a solution/the more concentrated the ascorbic acid in a solution, the less volume is needed to change the colour of solution X. (1)

3. Accept any reasonable answer e.g. the drops were not all the same size/volume so not accurate comparison, difficult to tell exactly when the dye turned colourless, washing the syringe may have left some water inside which affected the concentration of the next liquid/solution that was drawn up into it. (1)

4. **a)** 1 mark for a line graph (not for a bar graph) (1)
1 mark for each correctly labelled axis (with units where applicable) (2)
2 marks for each accurate plotting of coordinates (2)



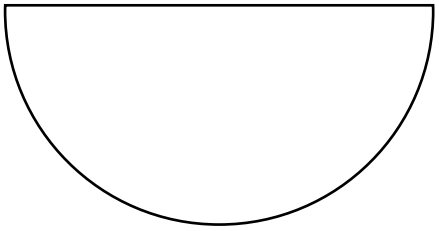
b) Approximately 32 mg (1) mark for line drawn up to the plotted line at 4 weeks on the graph (1)
c) Any value greater than 10 mg and less than 12 mg (1)

5. **a)** Place the fruit juice into a test tube, add Benedict's solution (1) and heat over a Bunsen burner (1). A change in colour from blue to green/brick red indicates the presence of a reducing sugar.(1)

b) It is possible to compare the concentration of a reducing sugar in fruit juice 1 and fruit juice 2. If the same quantity of two fruit juices give a different colour change when tested with Benedict's solution (1) this shows that they have different concentrations of a reducing sugar. (1)
OR Benedict's solution can be used as a semi-qualitative test. (2)

Question 2

1. a) The plan diagram must show **half** of the root and be an accurate representation of the arrangement of the tissues (epidermis, cortex, vascular cylinder, xylem and phloem).
1 mark for accuracy (1)
1 mark for following the rules for biological drawings (1)
1 mark for a suitable heading (1)
1 mark for each correct label for xylem (1) and phloem (1)



b) Xylem – thick lignified walls, hollow/dead/no cytoplasm (1)
Phloem – presence of companion cells or sieve plates (1)

c) Learners will use the eyepiece graticule to work out the width or diameter of the vascular cylinder of the root. If you have checked each slide beforehand compare their answer with yours. 2 marks for an accurate measurement. (2) (Give 1 mark for a near measurement or if the correct units have not been given).

2. a) The drawings of the three cells must be different and an accurate representation of what they can see on the micrograph. The different stages of mitosis must be clearly visible in the three cells.
1 mark for accuracy (1)
1 mark for following the rules for biological drawings (1)
1 mark for each correctly drawn cell and its correct heading/label (3) (the stage and correct heading must match up for each mark)

b) Magnification = size of image/real size of specimen (1) then 2 marks for showing calculation and final answer. (2)] (3)
Note: Use the diagram in the Learner's Book to calculate the correct magnification yourself. The answer could be rounded off or to the first or second decimal point.

c) Cell plate that occurs during cytokinesis indicates that this is a plant cell. (1)

TOTAL = 40 MARKS